

Purchasing Power Parity

Instructor: David Jenkins¹

Date: Oct. 6, 2014

¹I wish to acknowledge Battista Severgnini for providing last year's slides to me. His generosity saved me much time, and these slides are partially based on his. Any errors are of course my own.

Last Time

- ▶ Chapter 15

- ▶ Money

- ▶ What is special about it?
 - ▶ How is it measured?
 - ▶ What determines how much people want?

- ▶ A Short-run model of the money market

- ▶ Adjustment in the Long-run

- ▶ Why exchange rates are so volatile

- ▶ Chapter 16

- ▶ The law of one price

- ▶ Purchasing Power Parity

- ▶ Relative vs. Absolute PPP

This time

- ▶ Chapter 16:
 - ▶ Purchasing Power Parity
 - ▶ The law of one price
 - ▶ Relative vs. Absolute PPP
 - ▶ Exchange rates and PPP
 - ▶ Long-run, monetary approach
 - ▶ Clash of predictions
 - ▶ Fisher effect
 - ▶ Empirical evidence on PPP
 - ▶ It bad
 - ▶ Why it bad
 - ▶ A generalized PPP model
 - ▶ Real exchange rate
 - ▶ Interest and the real exchange rate
 - ▶ Real interest rate parity

But first a review

Chapter 16: Price Levels and the Exchange Rate in the Long Run

This chapter: More long run models

- ▶ In Chapter 15, we saw short run and long run models of money supply and exchange rate
 - ▶ One-time change in money supply
 - ▶ No long run change in real money supply
 - ▶ No long run change in interest rate
- ▶ In this chapter, permanent changes in the interest rate and exchange rates
 - ▶ Only possible if the growth rate of the money supply changes
 - ▶ Different instrument, no change in current money supply
 - ▶ Long-run: increase in growth rate leads to depreciation of currency
 - ▶ Model based on something called Purchasing Power Parity

How we are going to get there

1. What is PPP?
2. Model based on PPP

The Law of One Price

The prices of identical goods sold in different countries must be the same when expressed in terms of the same currency.

- ▶ The same doner kebab has to be the same price anywhere on Jagtsvej in Nørrebro
 - ▶ Otherwise hipsters would mostly go to the cheapest kebab shop
 - ▶ CBS students would buy kebab from the cheap shop, and sell outside the expensive shop for a profit
- ▶ Technically only works if customers have time and don't mind walking

Beer

- ▶ Price of a Carlsberg can't be too different on opposite sides of the Danish-German border
- ▶ If we ignore transport and other border costs, *law of one price*:

$$P_{DK}^{\text{beer}} = (E_{DKK/EURO}) \times (P_E^{\text{beer}})$$

- ▶ where:
 - ▶ P_{DK}^{beer} is the DKK price of a Carlsberg when sold in DK
 - ▶ P_E^{beer} is the corresponding Euro price in the Euro zone
 - ▶ $(E_{USD/EURO})$ is the DKK/Euro exchange rate

Purchasing Power Parity

- ▶ PPP is the application of the law of one price across countries:
 - ▶ Price of a basket goods should be independent of currency
 - ▶ Compares general price level across countries
 - ▶ Neither implies nor requires law of one price to hold
- ▶ PPP predicts a DKK/Euro exchange rate of

$$E_{DKK/EURO} = \frac{P_{DK}}{P_E}$$

- ▶ where
 - ▶ P_{DK} is the DKK price of a reference commodity basket sold in Denmark
 - ▶ P_E is the euro price of the same basket in the Euro zone

Purchasing Power Parity (PPP)

- ▶ PPP predicts a DKK/Euro exchange rate of

$$E_{DKK/EURO} = \frac{P_{DK}}{P_E}$$

- ▶ Rearranging,

$$P_{DK} = (E_{DKK/EURO}) \times (P_E)$$

- ▶ People have the same purchasing power with their currency regardless of country
- ▶ Prices twice as high only if currency half as valuable

PPP & Law of One Price

- ▶ The law of one price applies to individual commodities
- ▶ PPP applies to the general price level
- ▶ PPP neither implies nor requires law of one price
- ▶ But, law of one price both implies and requires PPP to hold
 - ▶ If the law of one price holds true for every commodity \Rightarrow PPP must hold for the same reference baskets across countries
 - ▶ If PPP holds, this does not mean that law of one price is respected

Flavors of Purchasing Power Parity

1. Absolute PPP: exchange rates equal relative price levels

$$E_{DKK/EURO} = \frac{P_{DK}}{P_E}$$

2. Relative PPP: the percentage change in the exchange rate between two currencies equals the difference between the percentage changes in national price levels.

$$\frac{(E_{DKK/EURO,t} - E_{DKK/EURO,t-1})}{E_{DKK/EURO,t-1}} = \pi_{DK,t} - \pi_{E,t}$$

where π_t = inflation rate from period $t - 1$ to t

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

- Relative PPP is an approximation of the following relation:

$$\frac{E_{DKK/EURO,t}}{E_{DKK/EURO,t-1}} = \frac{\frac{P_{DK,t}}{P_{E,t}}}{\frac{P_{DK,t-1}}{P_{E,t-1}}}$$

Absolute & Relative PPP

- ▶ Relative PPP is an approximation of the following relation:

$$\frac{E_{DKK/EURO,t}}{E_{DKK/EURO,t-1}} = \frac{\frac{P_{DK,t}}{P_{E,t}}}{\frac{P_{DK,t-1}}{P_{E,t-1}}}$$

- ▶ If absolute PPP holds \Rightarrow relative PPP holds

Absolute & Relative PPP

Not the other way around!

- ▶ Relative PPP is an approximation of the following relation:

$$\frac{E_{DKK/EURO,t}}{E_{DKK/EURO,t-1}} = \frac{\frac{P_{DK,t}}{P_{E,t}}}{\frac{P_{DK,t-1}}{P_{E,t-1}}}$$

- ▶ Relative PPP does not imply absolute PPP

$$\frac{8}{4} = \frac{4}{2} \not\rightarrow 8 = 4$$

Pause

- ▶ We have defined the law of one price
- ▶ We have defined absolute PPP
 - ▶ Law of one price \rightarrow absolute PPP
 - ▶ Absolute PPP \nrightarrow law of one price
- ▶ We have defined relative PPP
 - ▶ Absolute PPP \rightarrow relative PPP
 - ▶ Relative PPP \nrightarrow absolute PPP
- ▶ Does law of one price imply relative PPP?
 - ▶ Each condition weaker than the last
- ▶ Next: how do changes in inflation affect exchange rate?

Long-Run Model with absolute PPP

- ▶ *Monetary approach* to the exchange rate
- ▶ Switch to USD and Euro to use plots from text
- ▶ Money demand and supply as previous:

1. In the United States:

$$P_{US} = \frac{M_{US}^s}{L(R_{USD}, Y_{US})}$$

2. In Europe:

$$P_E = \frac{M_E^s}{L(R_{EURO}, Y_E)}$$

PPP and Money Market

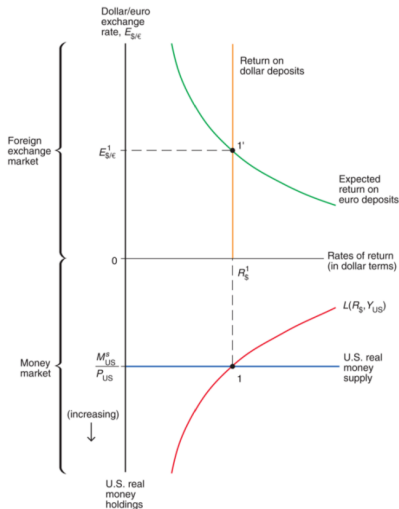
$$E_{USD/EURO} = \frac{P_{US}}{P_E} = \frac{\frac{M_{US}^s}{L(R_{USD}, Y_{US})}}{\frac{M_E^s}{L(R_{EURO}, Y_E)}}$$

Specific Predictions:

1. Money supplies: if $M_{US}^s \uparrow \Rightarrow$ long-run depreciation of the dollar against the euro
2. interest rates: if $R_{USD} \uparrow \Rightarrow$ causes a depreciation of the dollar against the euro
3. Output levels: a rise if $Y_{US} \uparrow \Rightarrow$ causes an appreciation of the dollar against the euro.

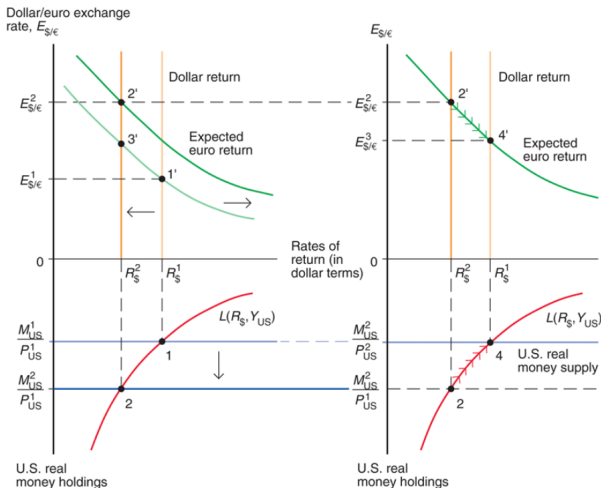
Whoops!

- interest rates: if $R_{USD} \uparrow \Rightarrow$ causes a depreciation of the dollar against the euro



Not as bad as it seems

- ▶ Comparing short run with long-run
- ▶ In previous chapter, long-run interest rate cannot move



(a) Short-run effects

(b) Adjustment to long-run equilibrium

Long-run interest rate changes

- ▶ What could cause a permanent (long-run) change in the interest rate?
- ▶ Solution: a change in the growth rate of money supply (inflation)

Inflation

- ▶ Central banks in the real world typically gradually increases the money supply
 - ▶ Money supply grows at a constant rate
 - ▶ Price inflation at the same rate

Inflation and interest rates

- ▶ Interest rate parity still has to hold:

$$R_{USD,t} = R_{EURO,t} + \left(\frac{E_{USD/EURO,t+1}^e - E_{USD/EURO,t}}{E_{USD/EURO,t}} \right)$$

- ▶ Relative PPP holds (implied by absolute PPP)

$$\frac{(E_{USD/EURO,t} - E_{USD/EURO,t-1})}{E_{USD/EURO,t-1}} = \pi_{US,t} - \pi_{E,t}$$

$$R_{USD} - R_{EURO} = \pi_{US}^e - \pi_E^e$$

or

$$R_{USD} - \pi_{US}^e = R_{EURO} - \pi_E^e$$

- ▶ *Real* interest rates are the same

The Fisher Effect

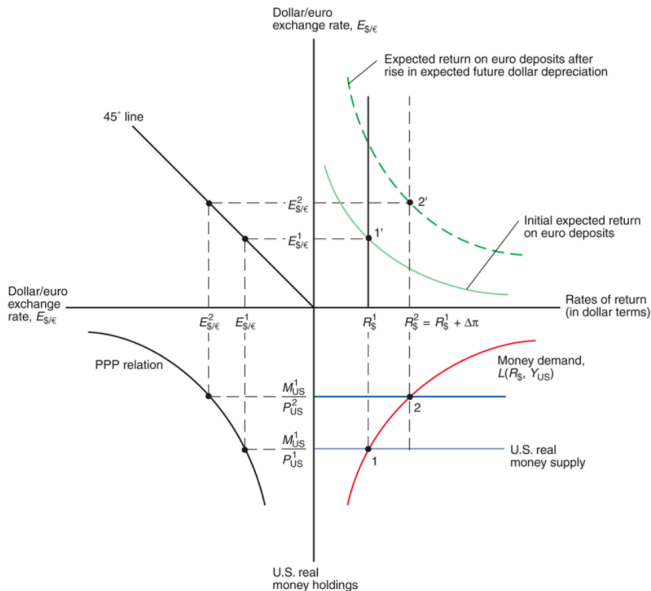
$$R_{USD} - R_{EURO} = \pi_{US}^e - \pi_E^e$$

- ▶ A rise in a country's expected inflation rate will eventually cause an equal rise in the interest rate that deposits of its currency offer
 - ▶ In the long run, purely monetary developments should have no real effects (neutrality of money)
 - ▶ Expected growth in money supply affects the interest rate through inflation

Interest and Monetary Policy

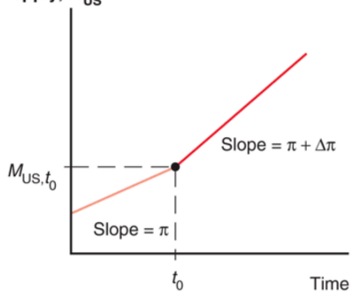
- ▶ If growth in M_{US}^s changes permanently from π to $\pi + \Delta\pi$ (and M_E^s is constant) such that $\pi_{US,t}$ and π_{US}^e increases from π to $\pi + \Delta\pi$
- ▶ R_{US} increases by $\Delta\pi$ (and R_e is unchanged)

Money growth and exchange rates

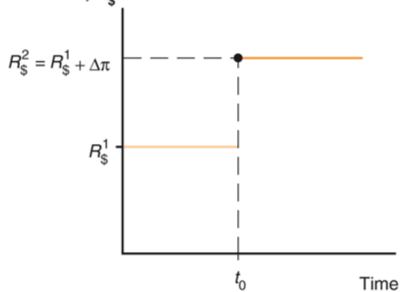


(Long-term) Time trends following a change in growth rate

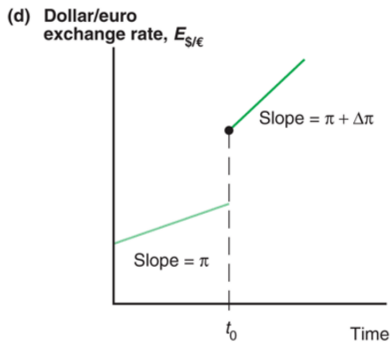
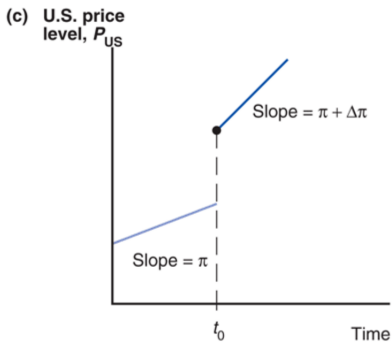
(a) U.S. money supply, M_{US}



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



(Long-term) Time trends following a change in growth rate



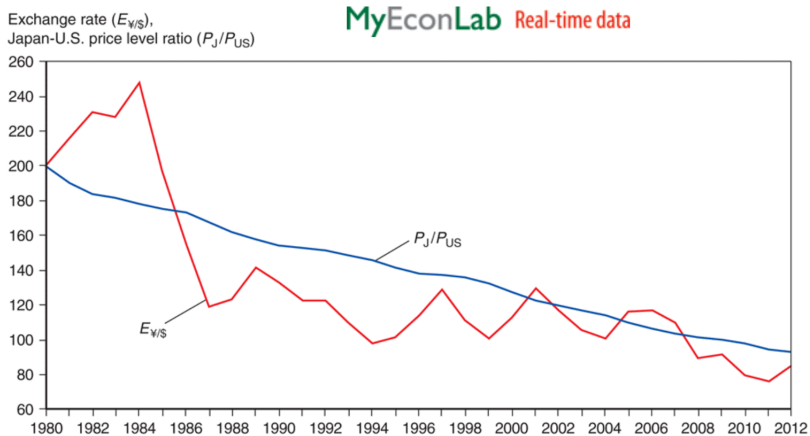
Pause

- ▶ We defined Purchasing Power Parity
- ▶ We derived the inflation rate/rate of return connection
- ▶ We saw the three predictions of the PPP long-run model
 - ▶ $M_{US}^s \uparrow \Rightarrow E_{\$/\epsilon} \uparrow$
 - ▶ $R_{USD} \uparrow \Rightarrow E_{\$/\epsilon} \uparrow$
 - ▶ $Y_{US} \uparrow \Rightarrow E_{\$/\epsilon} \downarrow$
- ▶ Next empirical evidence on the PPP long-run model
 - ▶ Preview: Not good

Empirical Evidence on PPP (1)

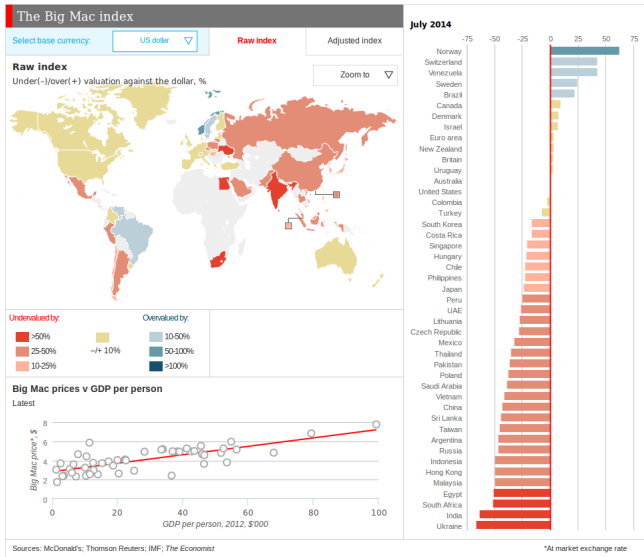
- ▶ The empirical support for PPP and the law of one price is weak.
- ▶ The prices of identical commodity baskets, when converted to a single currency, differ substantially across countries.
- ▶ Relative PPP also performs poorly.

The Yen/Dollar Exchange Rate and Relative Japan-U.S. Price Levels, 1980-2012

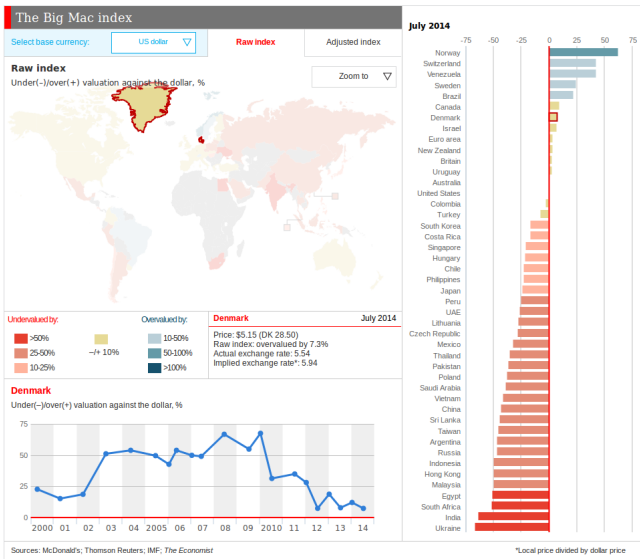


Source: IMF, *International Financial Statistics*. Exchange rates and price levels are end-of-year data.

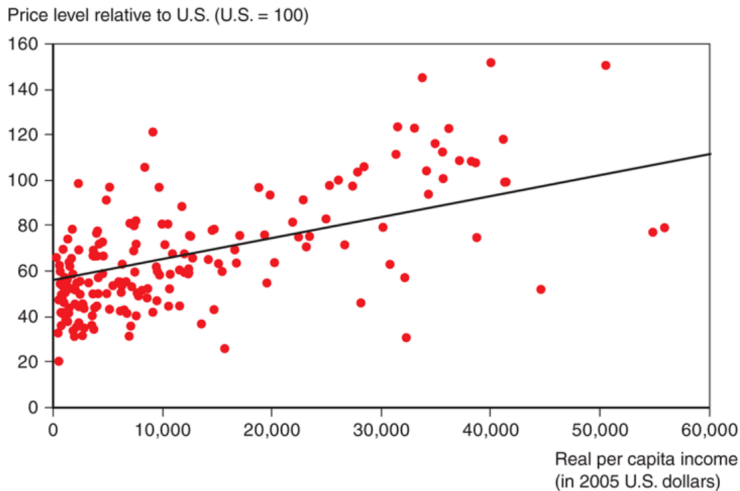
Big Mac Index



Big Mac Index - Denmark



Balassa Samuelson theory



Source: Penn World Table, version 7.1.

Why does PPP do so badly

1. Trade barriers and non-tradable products
2. Imperfect competition
3. Differences in measures of average prices for baskets of goods and services

Trade barriers and non-tradables

- ▶ Trade policy – trade barriers drive a wedge between prices
- ▶ Transport costs are a non-negligible trade barrier
- ▶ Non-tradables enter consumption basket, cheaper in developing countries
- ▶ This explains departure from absolute PPP, but not relative PPP!

Pricing to market

- ▶ Companies that export charge each country a different price
- ▶ Strong evidence that this is happening
- ▶ Markups are complicated

Basket differences

- ▶ Data on price levels based on government baskets
- ▶ Governments use baskets to make CPI
- ▶ Baskets differ between countries
- ▶ Baskets also differ over time!
- ▶ Can screw up both relative and absolute PPP

Swedish-Finish duty free

- ▶ Paper by Marcus Asplund, my colleague
- ▶ Sweden to Finland ferry duty free
 - ▶ Duty free catalogue printed only occasionally
 - ▶ Exchange rate fluctuations made PPP violations
 - ▶ Still Swedes paid kroner, and Finns paid markka
 - ▶ Even when printing, some pricing to market
- ▶ Empirical evidence that prices are sticky
- ▶ Empirical evidence of pricing to market

Pause

- ▶ We defined Purchasing Power Parity
- ▶ We derived the inflation rate/rate of return connection
- ▶ We saw the three predictions of the PPP long-run model
 - ▶ $M_{US}^s \uparrow \Rightarrow E_{\$/\epsilon} \uparrow$
 - ▶ $R_{USD} \uparrow \Rightarrow E_{\$/\epsilon} \uparrow$
 - ▶ $Y_{US} \uparrow \Rightarrow E_{\$/\epsilon} \downarrow$
- ▶ PPP doesn't do so well empirically. Why?
 1. Trade barriers and non-tradable products
 2. Imperfect competition
 3. Differences in measures of average prices for baskets of goods and services
- ▶ Next: Build a model allowing deviations from PPP

A General Model of Long-Run Exchange Rates

The Real Exchange Rate

- ▶ Measure of the prices of one country's goods and services relative to the other's.
- ▶ The real exchange rate is the dollar price of the European basket relative to that of the US price:

$$q_{US/E} = \frac{(E_{USD/EURO} \times P_E)}{P_{US}}$$

- ▶ Absolute PPP only holds for $q_{US/E} = 1$
- ▶ Relative PPP only holds for $\frac{q_{US/E,t}}{q_{US/E,t-1}} = 1$
- ▶ In other words, relative PPP holds if $q_{US/E}$ is a constant

A General Model of Long-Run Exchange Rates

The Real Exchange Rate

- ▶ Under *PPP*: let $E_{USD/EURO}$ and price levels, but must obey PPP
- ▶ If real exchange rate $q_{US/E}$ is not constant, PPP is violated
- ▶ If q moves around, change in relative real value of good baskets!
- ▶ If $q_{US/E}$ goes down, American goods suddenly worth more European goods

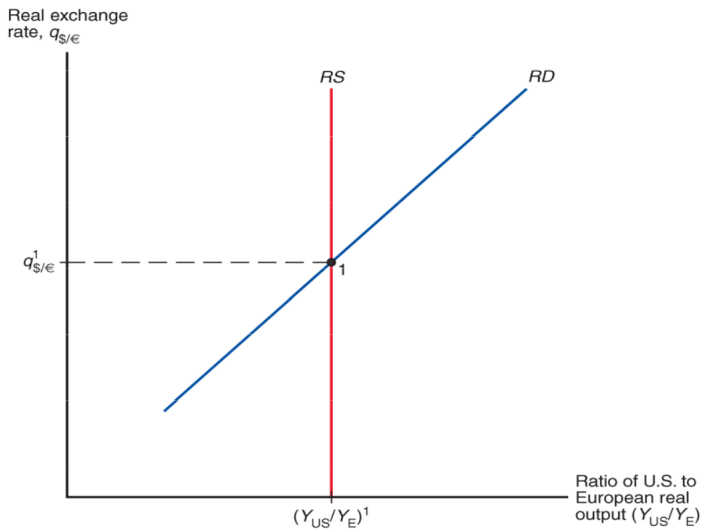
A General Model of Long-Run Exchange Rates

- ▶ Real depreciation (q increases): US basket worth less European goods
- ▶ Real appreciation (q falls): If US basket worth more European goods
- ▶ PPP Exchange rate relation $E_{\$/\epsilon} = \frac{P_{US}}{P_E}$
- ▶ Real exchange rate relation $E_{\$/\epsilon} = q_{US/E} \frac{P_{US}}{P_E}$
- ▶ Looks suspiciously like adding an error term...

Changes in the real exchange rate

- ▶ What could change $q_{US/E}$?
 1. Change in world relative demand for US products
 - ▶ People want the American basket more
 - ▶ value rises relative to EU basket
 - ▶ q goes down
 2. Change in world relative supply
 - ▶ US can suddenly produce more
 - ▶ More US baskets, decrease in value relative to EU basket
 - ▶ q goes up

Changes in real exchange rate



Exchange rates in the general model

$$E_{USD/EURO} = q_{US/E} \frac{P_{US}}{P_E}$$

- ▶ Changes in money supply
 - ▶ Will not affect q as money is neutral
 - ▶ One-time increase in money supply (Chpt. 15)
 - ▶ Long-run: Prices and exchange rates adjust
 - ▶ Change in money growth rate
 - ▶ Changes interest rate, price level, and exchange rate
- ▶ Changes in demand and supply
 - ▶ Will affect q as well as other prices
 - ▶ Change in relative output demand
 - ▶ Will not affect price levels (doesn't change either GNP or interest rate)
 - ▶ Will change q and also the exchange rate
 - ▶ Exchange rate responds to non-monetary stuff
 - ▶ Change in relative output supply
 - ▶ Suppose American productivity increases
 - ▶ Causes rise in $q_{US/E}$
 - ▶ But also increases demand for liquid assets, lowering P_{US}
 - ▶ Ambiguous total effect

Money Supply, Output, and Exchange Rate

- ▶ Next class will use these results for long-run effects on exchange rate

Change	Effect on the Long-Run Nominal Dollar/Euro Exchange Rate, $E_{\$/\epsilon}$
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

Interest rates and real exchange rates

- ▶ We defined relative PPP as:

$$\frac{E_{USD/EURO}^e - E_{USD/EURO}}{E_{USD/EURO}} - (\pi_{US}^e - \pi_{EURO}^e)$$

- ▶ That is, the expected depreciation of USD equals the difference in USD and Euro growth rates
- ▶ We argued that q is a constant if relative PPP holds
- ▶ We might think of changes in q as deviations from relative PPP

$$\frac{q_{US/E}^e - q_{US/E}}{q_{US/E}} = \frac{E_{USD/EURO}^e - E_{USD/EURO}}{E_{USD/EURO}} - (\pi_{US}^e - \pi_{EURO}^e)$$

- ▶ In words, the part of the change in the nominal exchange rate not explained by inflation is change in the real exchange rate

Interest rates and real exchange rates

$$\frac{q_{US/E}^e - q_{US/E}}{q_{US/E}} = \frac{E_{USD/EURO}^e - E_{USD/EURO}}{E_{USD/EURO}} - (\pi_{US}^e - \pi_{EURO}^e)$$

- ▶ Remember interest parity?

$$R_{USD} - R_{EURO} = \frac{E_{USD/EURO}^e - E_{USD/EURO}}{E_{USD/EURO}}$$

- ▶ Combine:

$$R_{USD} - R_{EURO} = \frac{q_{US/E}^e - q_{US/E}}{q_{US/E}} + (\pi_{US}^e - \pi_{EURO}^e)$$

- ▶ Long run difference in interest rates is a combination of money growth rates and expected change in real exchange rates

Real Interest parity

- ▶ Define expected real interest rate:

$$r^e = R - \pi^e$$

- ▶ Real interest rate is the nominal interest rate we have been studying, net of inflation
- ▶ We can write:

$$r_{US}^e - r_E^e = R_{USD} - \pi_{USD}^e - (R_{EURO} - \pi_{EURO}^e)$$

- ▶ Now combine with the relation between interest rates and real exchange rates from last slide:

$$r_{US}^e - r_{EU}^e = \frac{(q_{US/EU}^e - q_{US/EU})}{q_{US/EU}}$$

- ▶ This is real interest parity
- ▶ Differences in real interest rates are equal to the expected real exchange rate depreciation