# Purchasing Power Parity

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Date: Oct. 6, 2014

[1]I 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

# The Demand for Currency

- Most important determinant of demand: belief about future value
  1. Expected rate of return
  2. Expected future exchange rate
- Rate of return definitions:
  - **Rate of return:** the % change in value that an asset offers during a time period
  - **Real rate of return:** inflation-adjusted rate of return
  - if inflation=0 $\Rightarrow$ rate of return=real rate of return

# Comparing assets

Example: Should we invest in a Danish bond or a Euro bond?

- Return of 1 DKK in DK bonds in DKK
  $\Rightarrow R_{DKK,t}$
- Return of 1 DKK in Euro bonds in DKK:
  $\Rightarrow \left( \frac{E^e_{DKK/EURO,t+1}}{E_{DKK/EURO,t}} \right) (1 + R_{EURO,t}) - 1$

# A convenient approximation

- Return of 1 DKK in Euro bonds in DKK:
$$\left(\frac{E^e_{DKK/EURO,t+1}}{E_{DKK/EURO,t}}\right)(1+R_{EURO,t})-1$$
- Some algebra: $R_{EURO,t}+\frac{E^e_{DKK/EURO,t+1}-E_{DKK/EURO,t}}{E_{DKK/EURO,t}}+$
$$R_{EURO,t}\frac{E^e_{DKK/EURO,t+1}-E_{DKK/EURO,t}}{E_{DKK/EURO,t}}$$
- Final term is usually small
- Return of 1 DKK in Euro bonds in DKK is approximately
$$R_{EURO,t}+\frac{E^e_{DKK/EURO,t+1}-E_{DKK/EURO,t}}{E_{DKK/EURO,t}}$$
- Euro interest rate plus the rate of depreciation of the Kroner against the Euro

# Using our approximation

- Approximation $R_{EURO,t} + \dfrac{E^e_{DKK/EURO,t+1} - E_{DKK/EURO,t}}{E_{DKK/EURO,t}}$
- Buy the DKK bond if:

$$R_{DKK,t} - R_{EURO,t} - \frac{E^e_{DKK/EURO,t+1} - E_{DKK/EURO,t}}{E_{DKK/EURO,t}} > 0$$

# Interest rate parity

- In equilibrium, all assets should give the same expected return
- Why?
- Using our approximation:

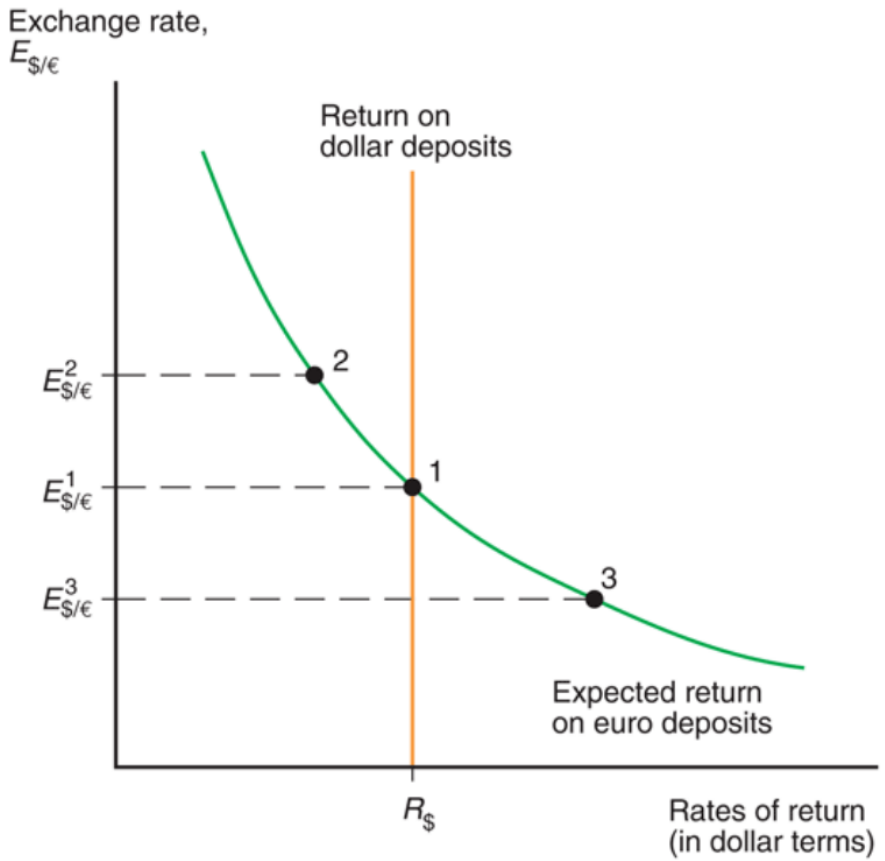
$$R_{DKK,t} = R_{EURO,t} + \frac{E^e_{DKK/EURO,t+1} - E_{DKK/EURO,t}}{E_{DKK/EURO,t}}$$

# Effect of current exchange rates on return

- All else equal (including future exchange rate)
  - Current depreciation of *DKK* lowers the *DKK* return on Euro bonds
  - Appreciation of *DKK* raises the *DKK* return on Euro bonds
- Intuitive, because depreciation means one can buy less Euros today!

# Equilibrium exchange rate

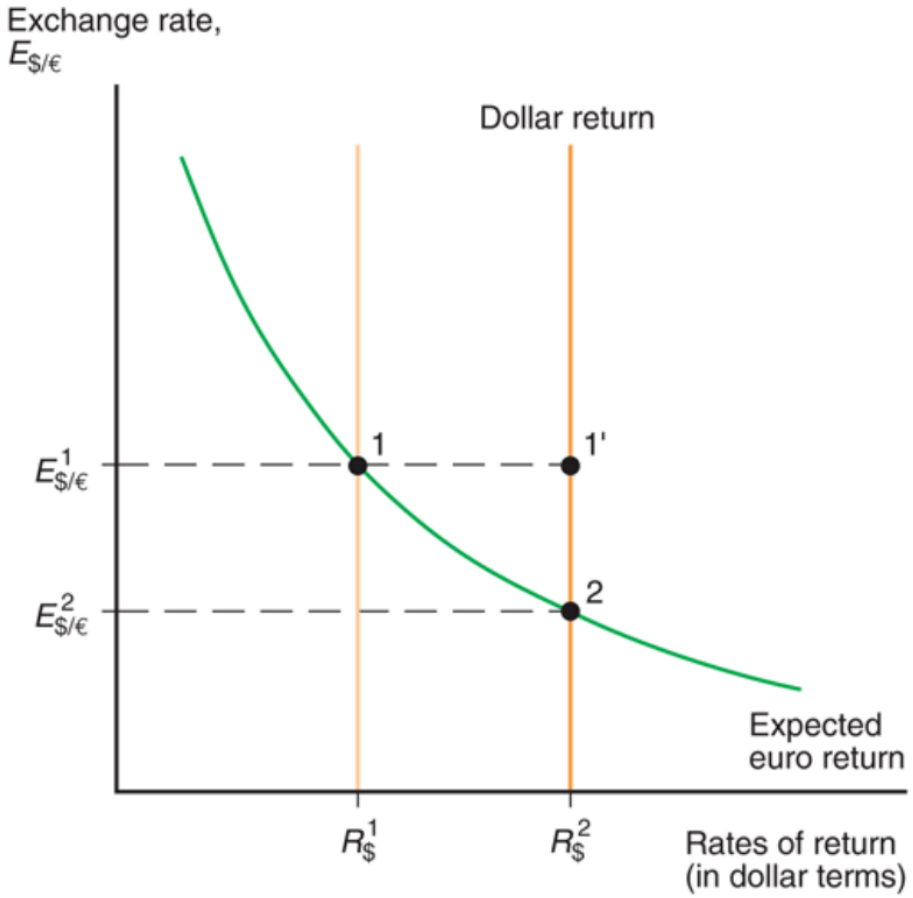
$$R_{DKK,t} = R_{EURO,t} + \frac{E^e_{DKK/EURO,t+1} - E_{DKK/EURO,t}}{E_{DKK/EURO,t}}$$



# Changing interest rates and exchange rate

$$R_{DKK,t} = R_{EURO,t} + \frac{E^e_{DKK/EURO,t+1} - E_{DKK/EURO,t}}{E_{DKK/EURO,t}}$$

- Rise in interest rate results in current currency appreciation



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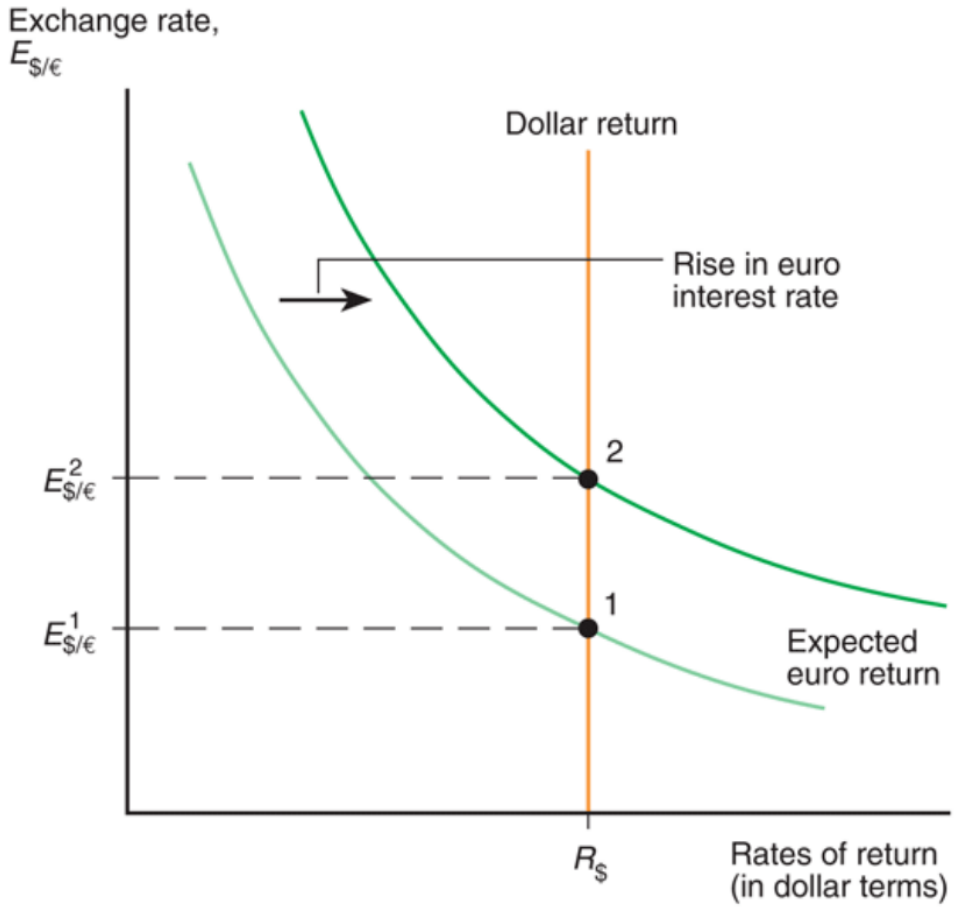
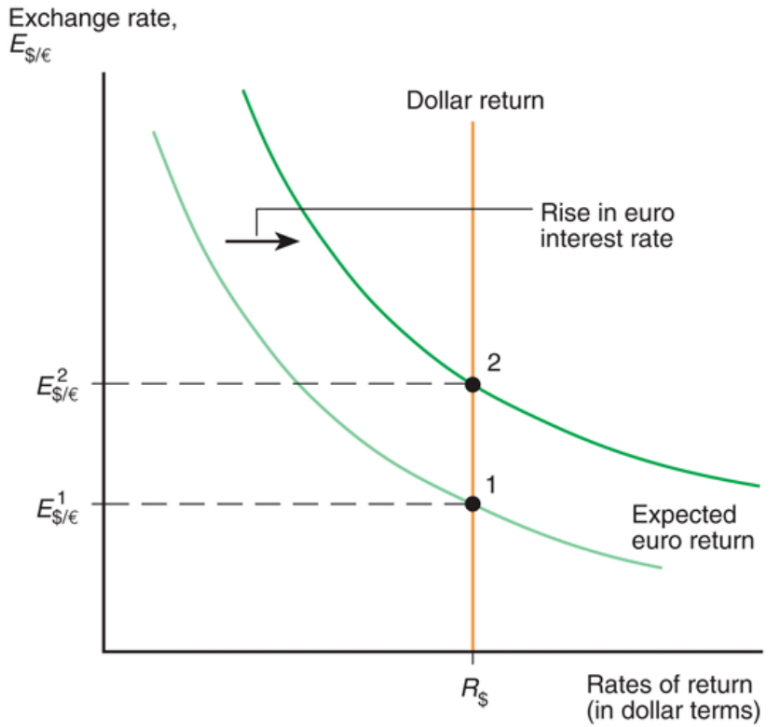


# Changing future exchange rate and current exchange rate

$$R_{DKK,t} = R_{EURO,t} + \frac{E^e_{DKK/EURO,t+1} - E_{DKK/EURO,t}}{E_{DKK/EURO,t}}$$

- Rise in future exchange rate results in current currency appreciation



- We have the relationship between interest rate and exchange rate
- Now money supply and exchange rate

# Money

- Why do we need it?
  1. Medium of exchange
  2. Unit of account
  3. Store of value

# What is money?

- More difficult question than it seems!

| Type of money | M0 | MB | M1 | M2 | M3 | MZM |
|---|---|---|---|---|---|---|
| Notes and coins in circulation (outside Federal Reserve Banks and the vaults of depository institutions) (currency) | ✓[9] | ✓ | ✓ | ✓ | ✓ | ✓ |
| Notes and coins in bank vaults (Vault Cash) | | ✓ | | | | |
| Federal Reserve Bank credit (required reserves and excess reserves not physically present in banks) | | ✓ | | | | |
| Traveler's checks of non-bank issuers | | | ✓ | ✓ | ✓ | ✓ |
| Demand deposits | | | ✓ | ✓ | ✓ | ✓ |
| Other checkable deposits (OCDs), which consist primarily of Negotiable Order of Withdrawal (NOW) accounts at depository institutions and credit union share draft accounts. | | | ✓[10] | ✓ | ✓ | ✓ |
| Savings deposits | | | | ✓ | ✓ | ✓ |
| Time deposits less than $100,000 and money-market deposit accounts for individuals | | | | ✓ | ✓ | |
| Large time deposits, institutional money market funds, short-term repurchase and other larger liquid assets[11] | | | | | ✓ | |
| All money market funds | | | | | | ✓ |

- M1 is the most liquid
- In this book, *money supply* is M1

# Money Supply & Demand

- **money supply** controlled by Central Bank
  - Actually process a bit complicated, see Chpt. 18
  - For now just assume M1 chosen by Central Bank
- **money demand** represents the amount of monetary assets that people are willing to hold. This is based on:
  1. Interest rates/expected rates of return
  2. Risk/inflation
  3. Liquidity

# Expected return and interest

- M1 pays no interest (to a first approximation)
- If hold cash, lose interest gained by holding illiquid asset
- The higher the interest rate, the higher opportunity cost of holding cash
  - One safe way of earning interest is a risk-free bond
  - Classic example, American T-Bill
  - The higher the return on T-Bill, the less demand for cash

# Individual demand for money

- Decreasing in the interest rate on other assets
- Mostly unrelated to risk
- Increasing in the amount of daily purchases

# Aggregate Money Demand

- Sum up all individual demand
- The aggregate demand of real money can be expressed as:

$$M^d = PL(R, Y)$$

where:

- $P$ is the price level: higher prices, more cash needed
- $Y$ is real national income: more stuff, more purchases
- $R$ is a measure of interest rates on non-monetary assets
- $L(R, Y)$ is the aggregate demand of real monetary assets

# Aggregate Demand of Real Money

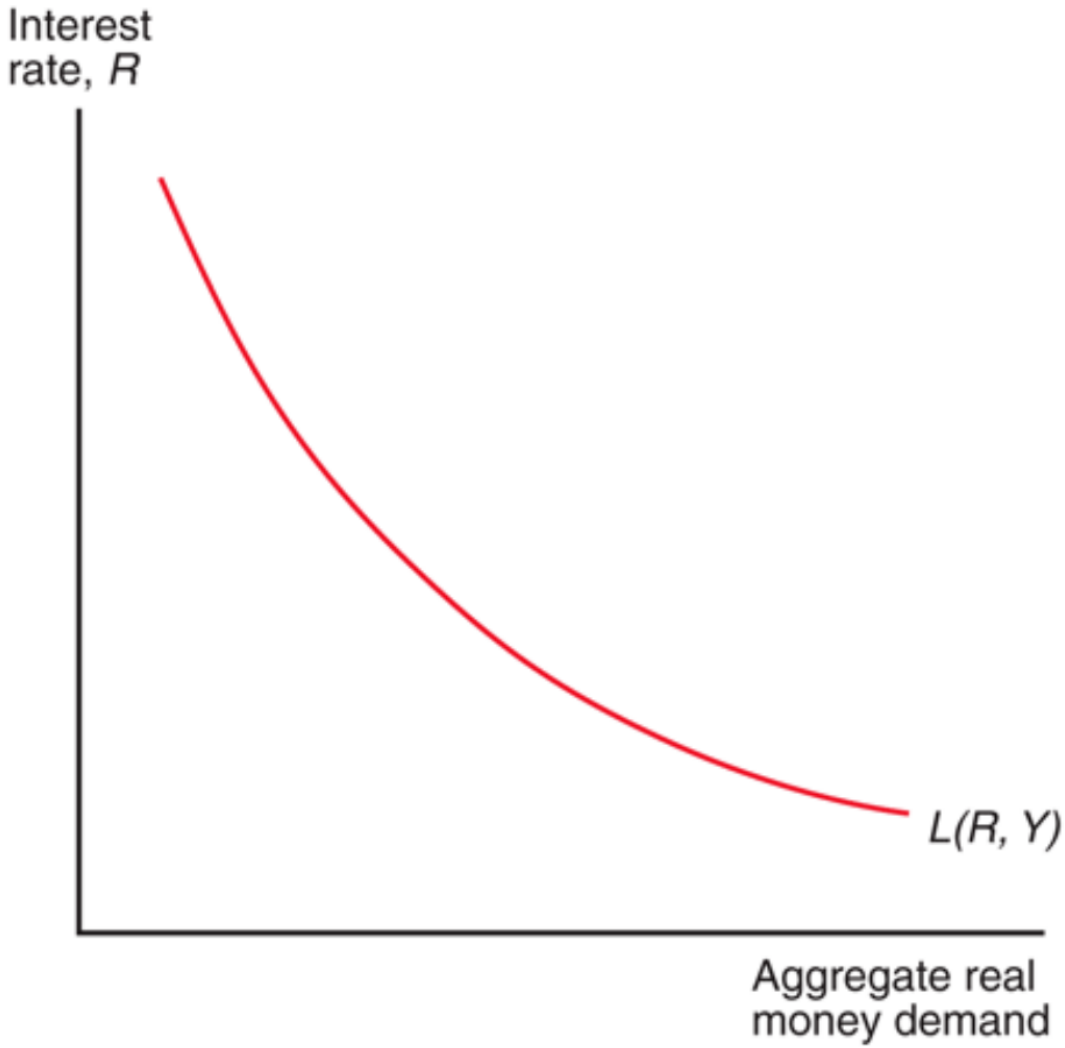
$$\frac{M^d}{P} = L(R, Y)$$

- $M^d$ scales perfectly with $P$
- If all prices double, need twice as much cash
- Demand for real money

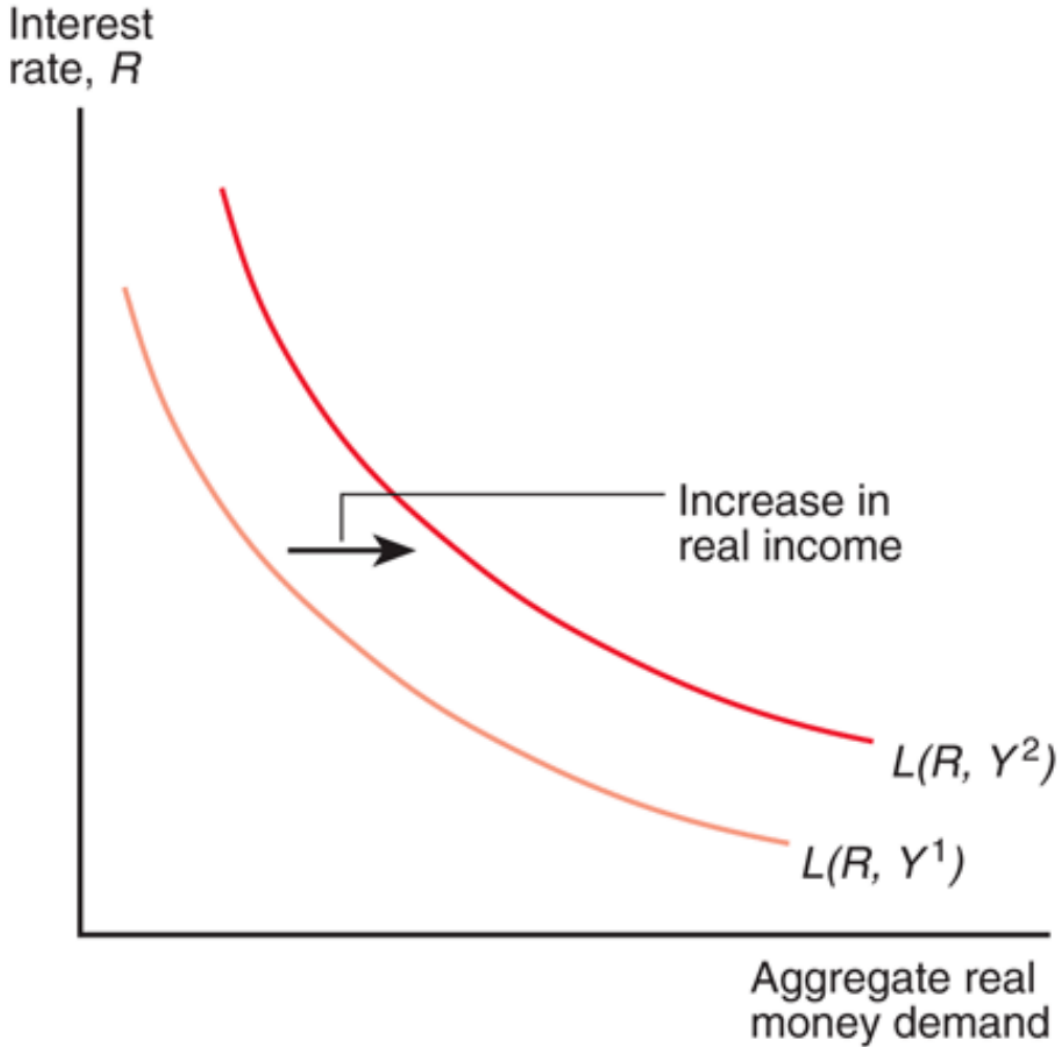
$$\frac{M^d}{P} = L(R, Y)$$

- The L function is demand for holding real value in liquid form

# Money demand and interest rate



# Shift in National Product



# A Short-run Model of the Money Market

- Assume that changes in money supply do not affect:
  1. Price level
  2. GNP level
- Changes do affect interest rate of other assets
- In equilibrium:

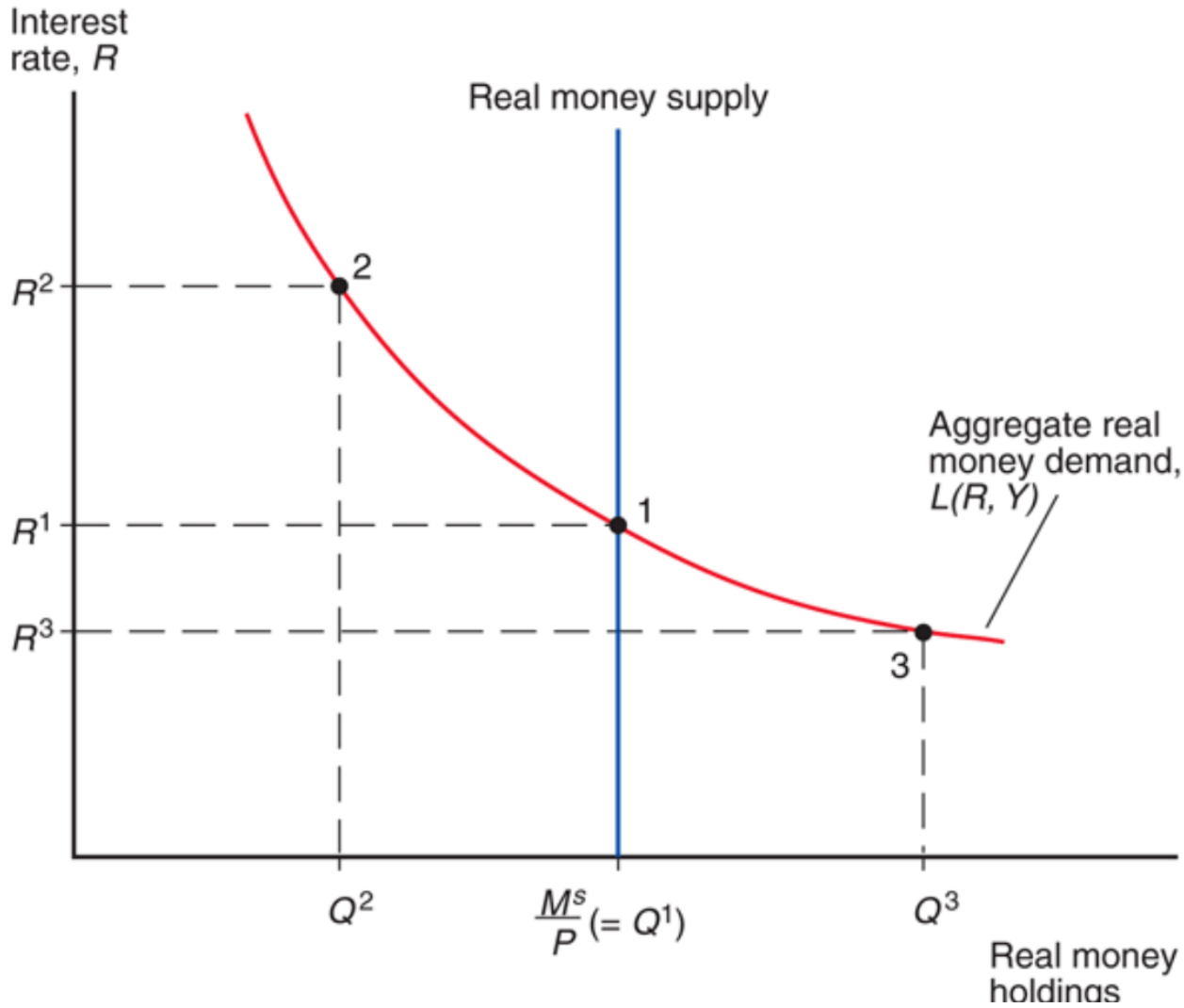
$$M^s = M^d$$

- Plug in our formula for money demand, in equilibrium

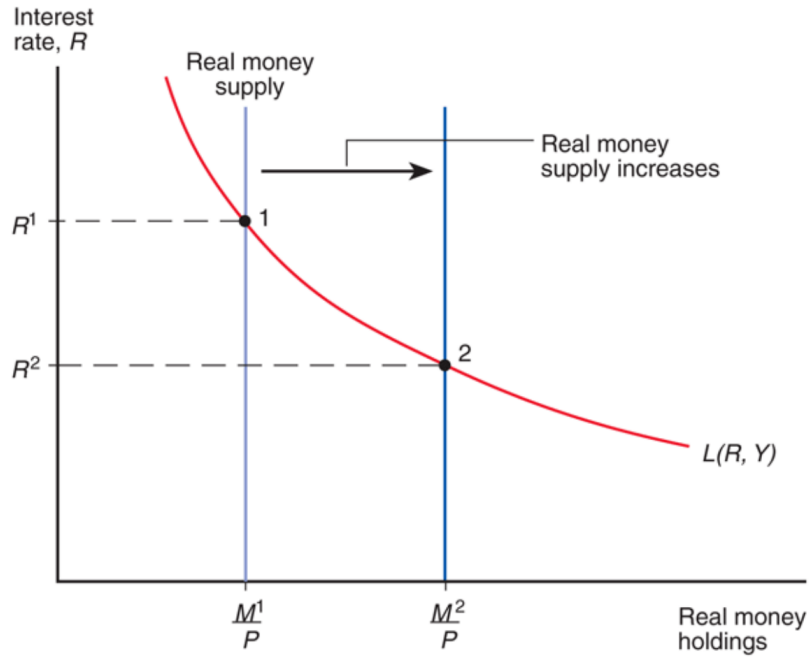
$$\frac{M^s}{P} = L(R, Y)$$

- Real money supply (LHS) equals real money demand (RHS)
- Higher money supply $\Rightarrow$ lower interest rate

# Determination of the Equilibrium Interest Rate



# Effect of an Increase in the Money Supply on the Interest Rate

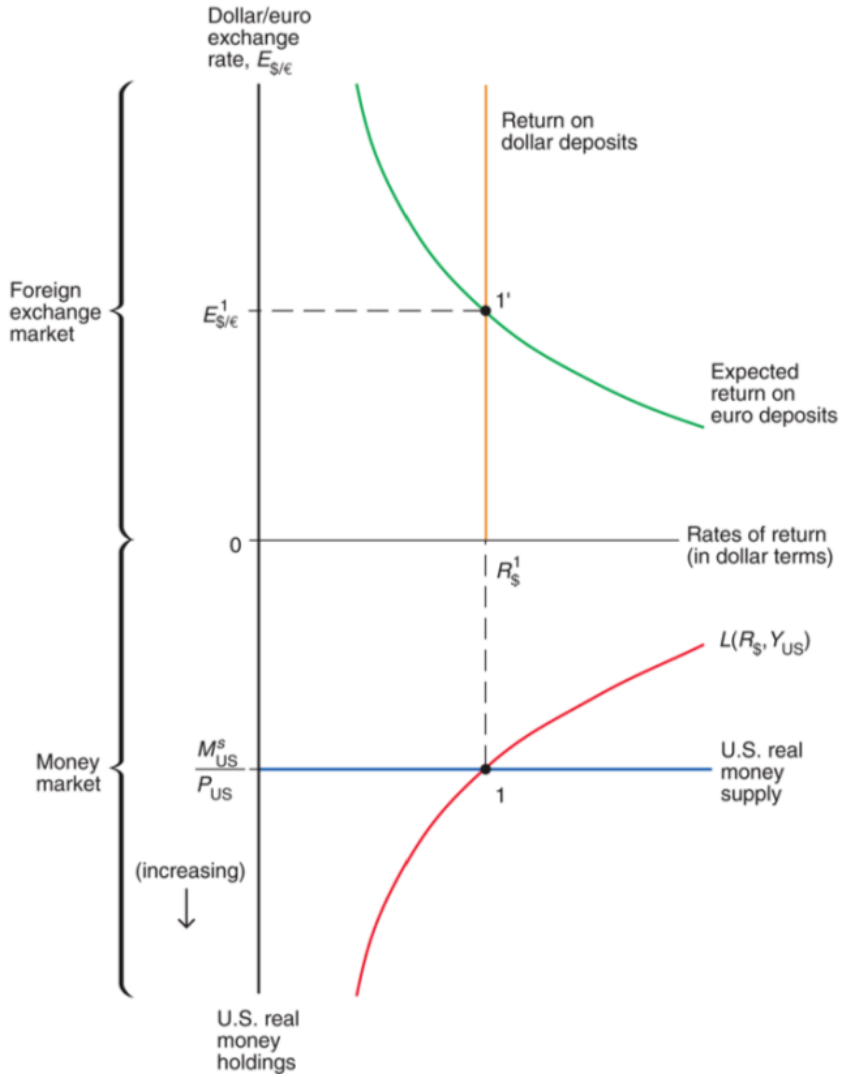



- Short run: Central bank can lower interest rate by increasing money supply
- Short run: Central bank can raise interest rate by decreasing money supply

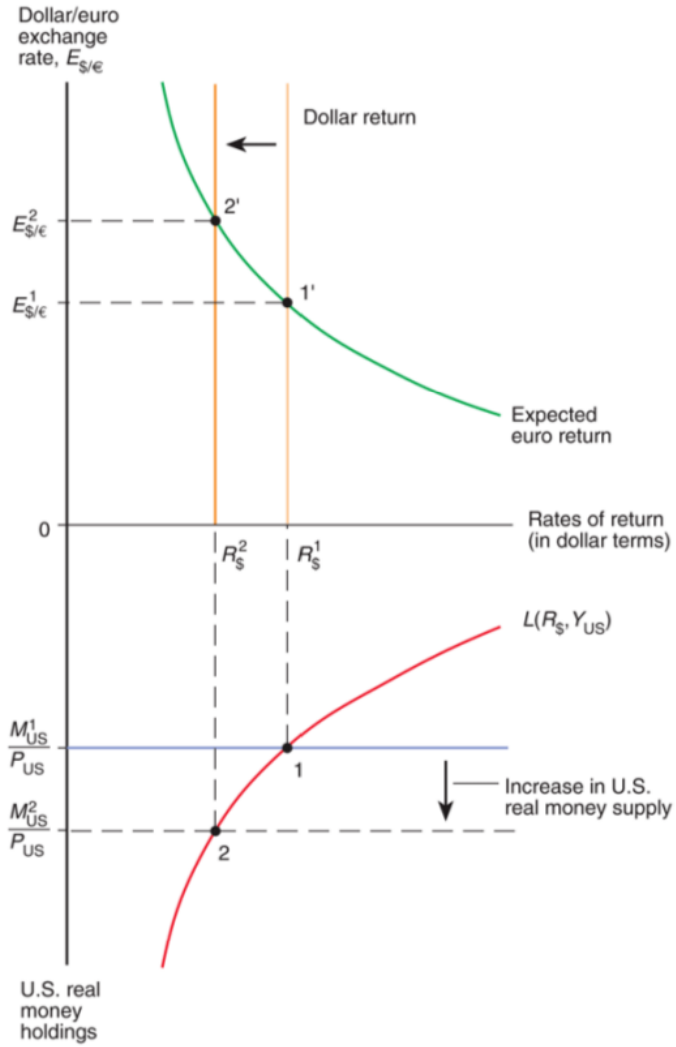
# Money supply and exchange rate

- Suppose Central Bank ups money supply
- Interest rate goes down as people buy bonds
- Dollar depreciates to maintain interest parity

# Money supply and exchange rate



# Increase in dollar supply



# Long & Short Run

- Affect of more money supply
- **Short run:** Prices are sticky, real money supply rises
- **Long run:** Prices adjust so that real money supply falls to its original level

# Money supply, output and interest

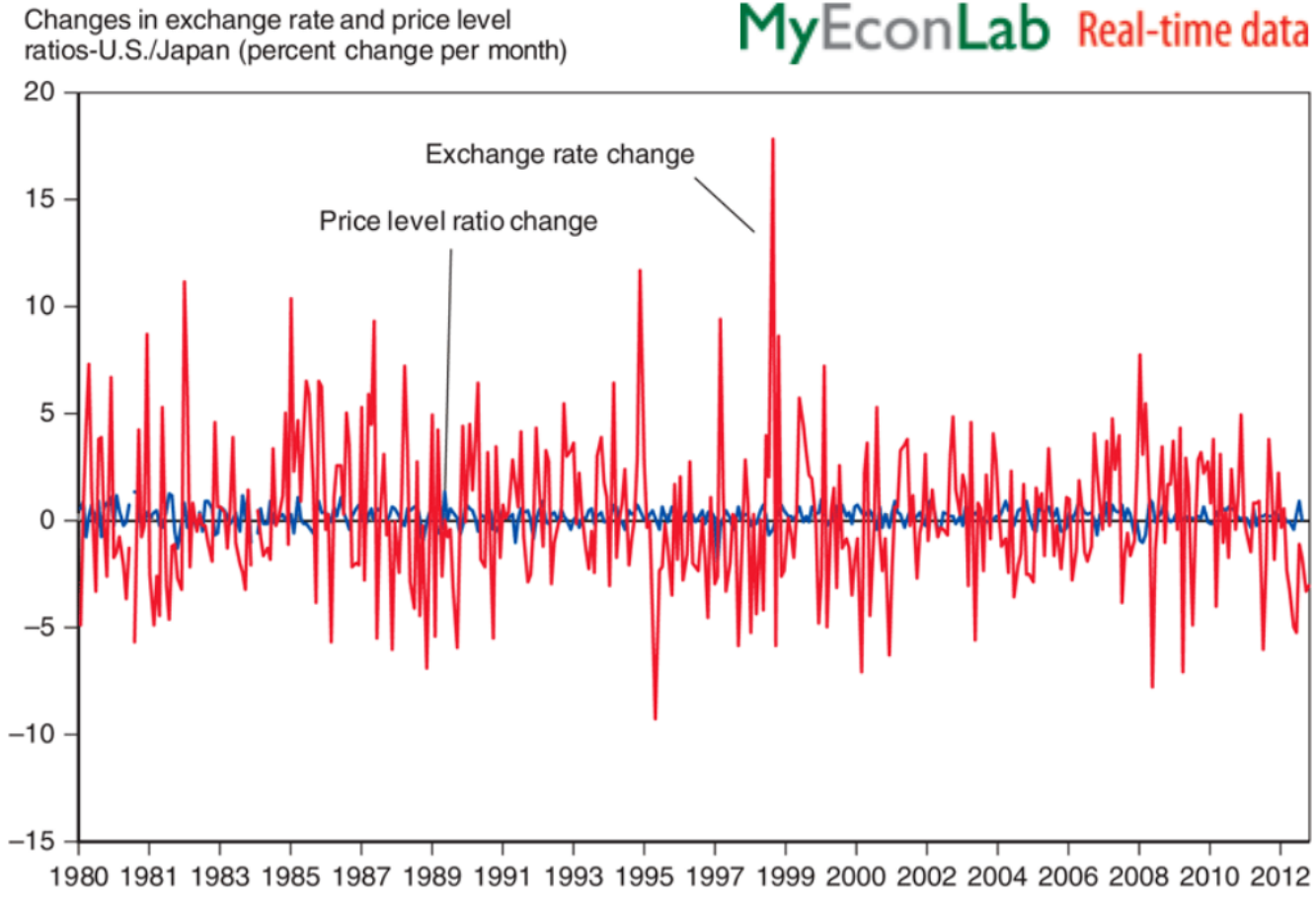
- Money supply has no long run effecton output and interest rates
- Intuition
  - A currency reform: Turkish millionaires
  - 2005, new Turkish lira, divide old lira by one million
  - For a period, both lira could be used
  - Everything in the country lost six zeros
  - No effect on output or interest
- Central Bank actions are similar
- Double the money, halve the prices

# Short run and Long run

- Money cannot shift prices immediately
  - Long-term contracts
  - Menu costs

# Exchange Rates vs Price Level

- In short-run example, we let exchange rates adjust, not prices;
- This assumption seems reasonable for US and Japan

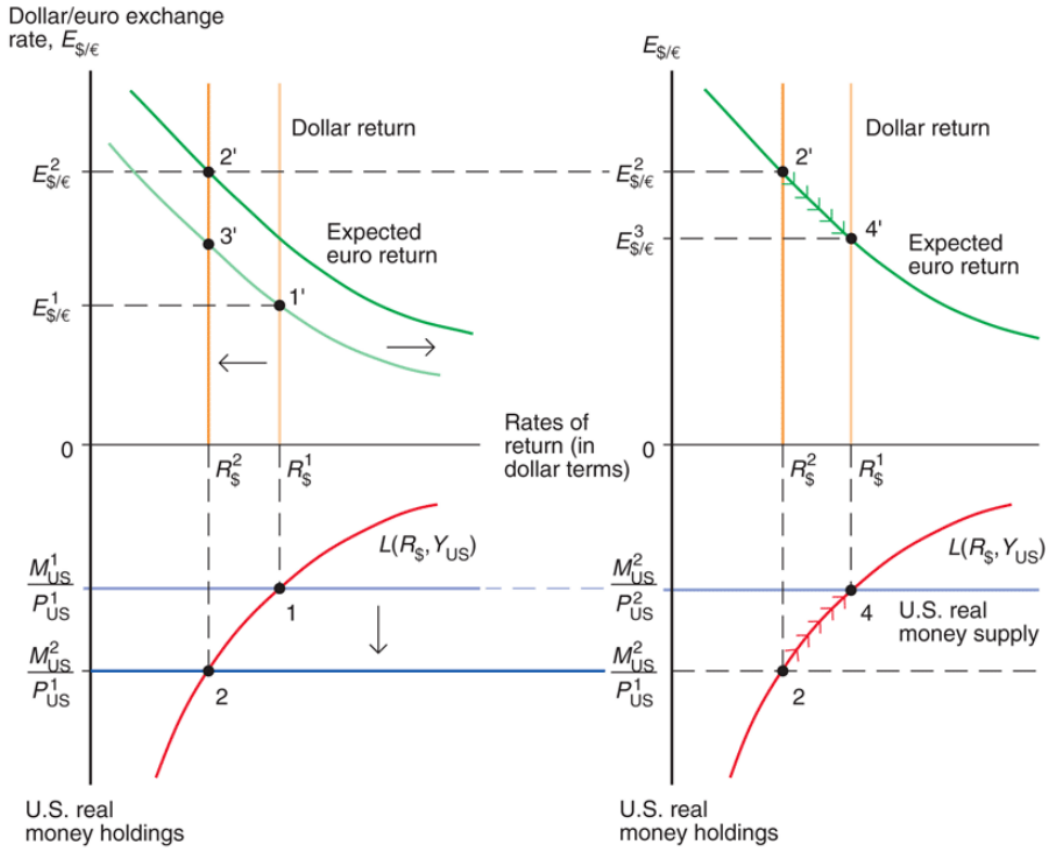



**Source:** Price levels from International Monetary Fund, *International Financial Statistics*. Exchange rate from Global Financial Data.

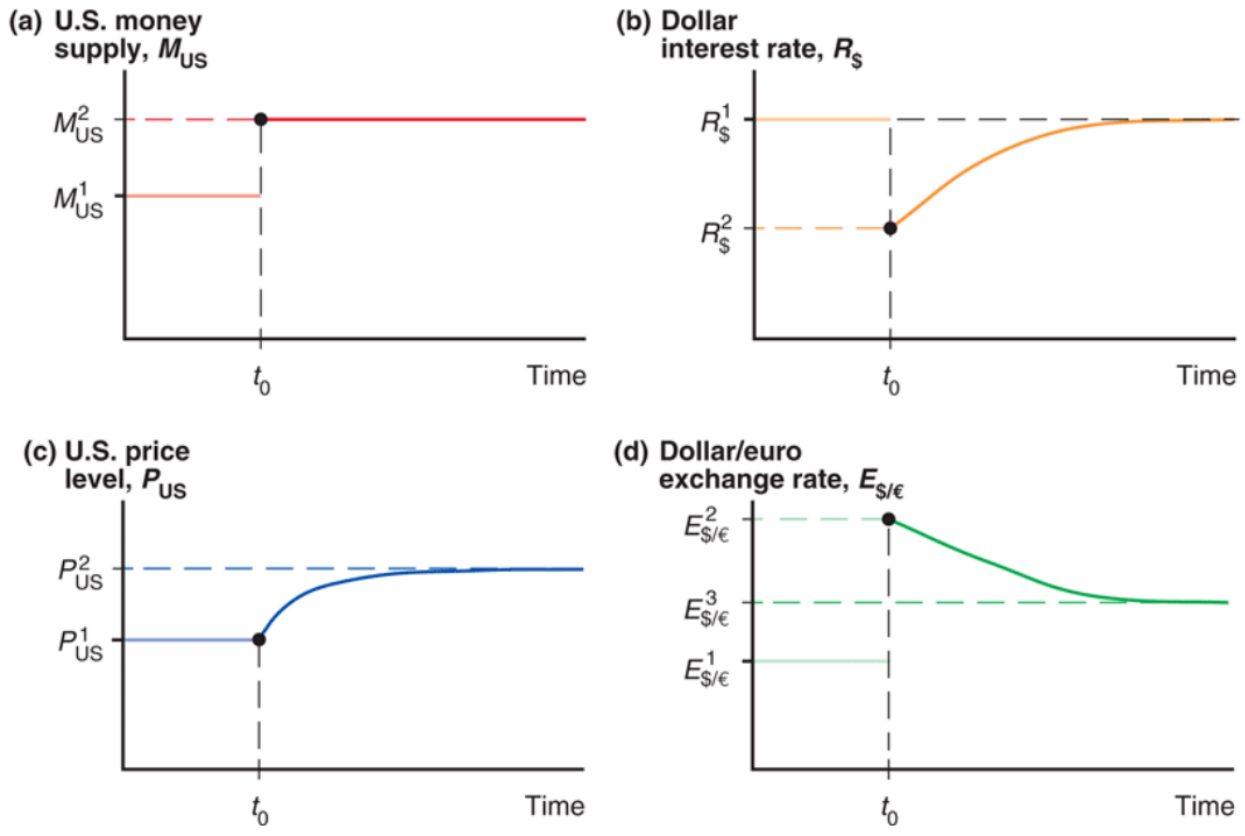
# Increase in money supply and exchange rate, long-run

- Initially:
  - Money supply goes up, interest rate falls, depreciation
  - Money supply goes up, expected depreciation, more depreciation
- Then:
  - Prices adjust to long run real money supply level
  - Real money supply falls, interest rate rises, appreciation
  - Exchange rate settles level depreciated relative to initial level
- The double depreciation followed by appreciation: *exchange rate overshoot*

# Money, Prices, Exchange Rates, and Expectations



# Money, Prices, Exchange Rates, and Expectations



# Review

- End 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
- Also in this chapter
  - A pure Purchasing Power Parity model does not fit data
  - Also add real demand and supply shocks to a general model of exchange rate

# How we are going to get there

1. What is PPP?
2. Model based on PPP
3. Evidence on PPP
4. Generalized 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*:

$$P_{DK}^{\text{beer}} = \left(E_{DKK/EURO}\right) x \left(P_{E}^{\text{beer}}\right)$$

- where:
  - $P_{DK}^{\text{beer}}$ is the DKK price of a Carlsberg when sold in DK
  - $P_{E}^{\text{beer}}$ is the corresponding Euro price in the Euro zone
  - $\left(E_{USD/EURO}\right)$ 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,

$$P_{DK} = \left(E_{DKK/EURO}\right) x \left(P_E\right)$$

- 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.

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

where $\pi_t$ = 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 $\not\rightarrow$ law of one price
- We have defined relative PPP
  - Absolute PPP $\rightarrow$ relative PPP
  - Relative PPP $\not\rightarrow$ 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:

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

2. In Europe:

$$P_E = \frac{M^s_E}{L(R_{EURO}, Y_E)}$$

# PPP and Money Market

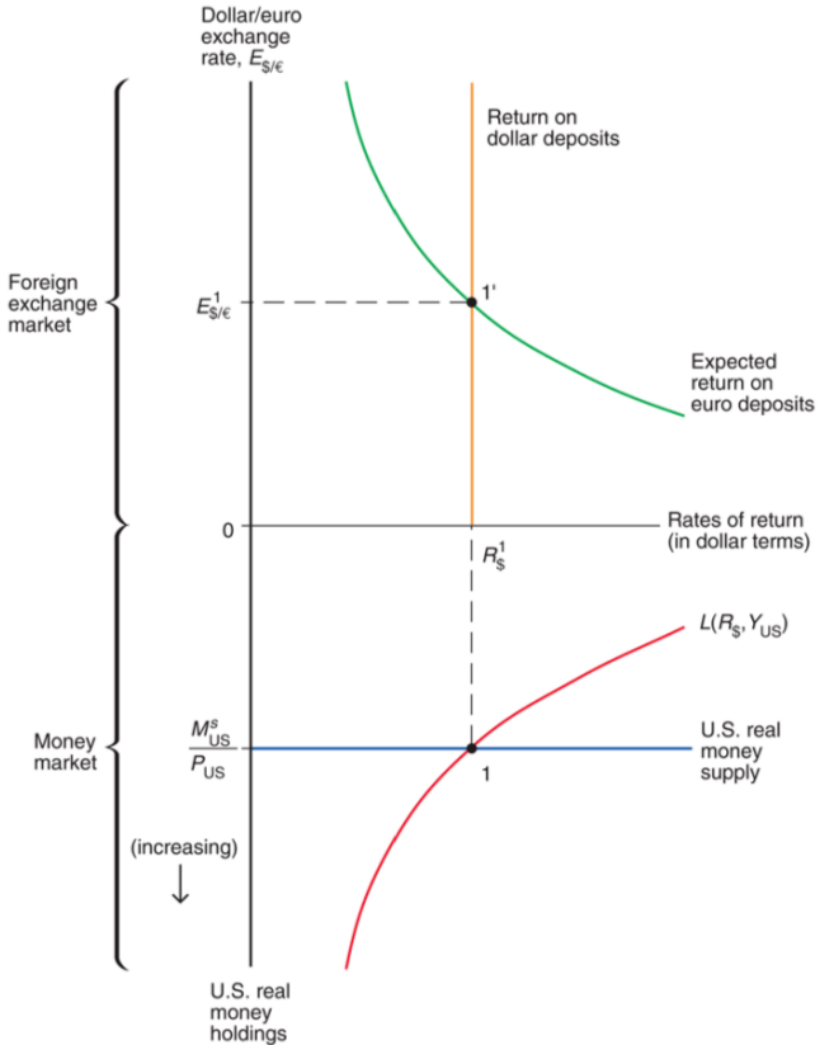
$$E_{USD/EURO} = \frac{P_{US}}{P_E} = \frac{\frac{M^s_{US}}{L(R_{USD}, Y_{US})}}{\frac{M^s_E}{L(R_{EURO}, Y_E)}}$$

Specific Predictions:

1. Money supplies: if $M^s_{US} \Uparrow \Rightarrow$ 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.

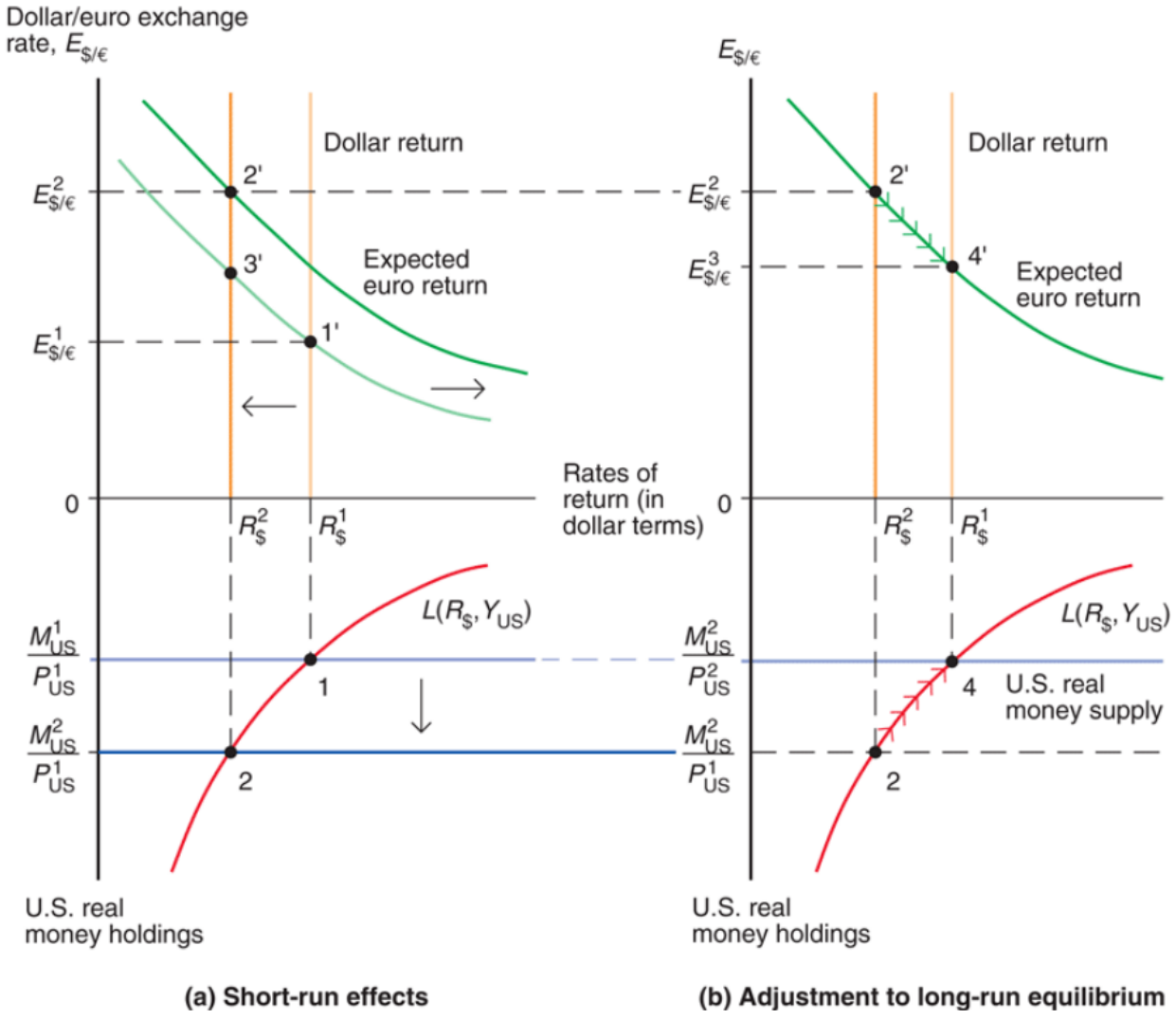
# Whoops!

- 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



# 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:

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

- Relative PPP holds (implied by absolute PPP)

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

$$R_{USD} - R_{EURO} = \pi^e_{US} - \pi^e_E$$

or

$$R_{USD} - \pi^e_{US} = R_{EURO} - \pi^e_E$$

- *Real* interest rates are the same

# The Fisher Effect

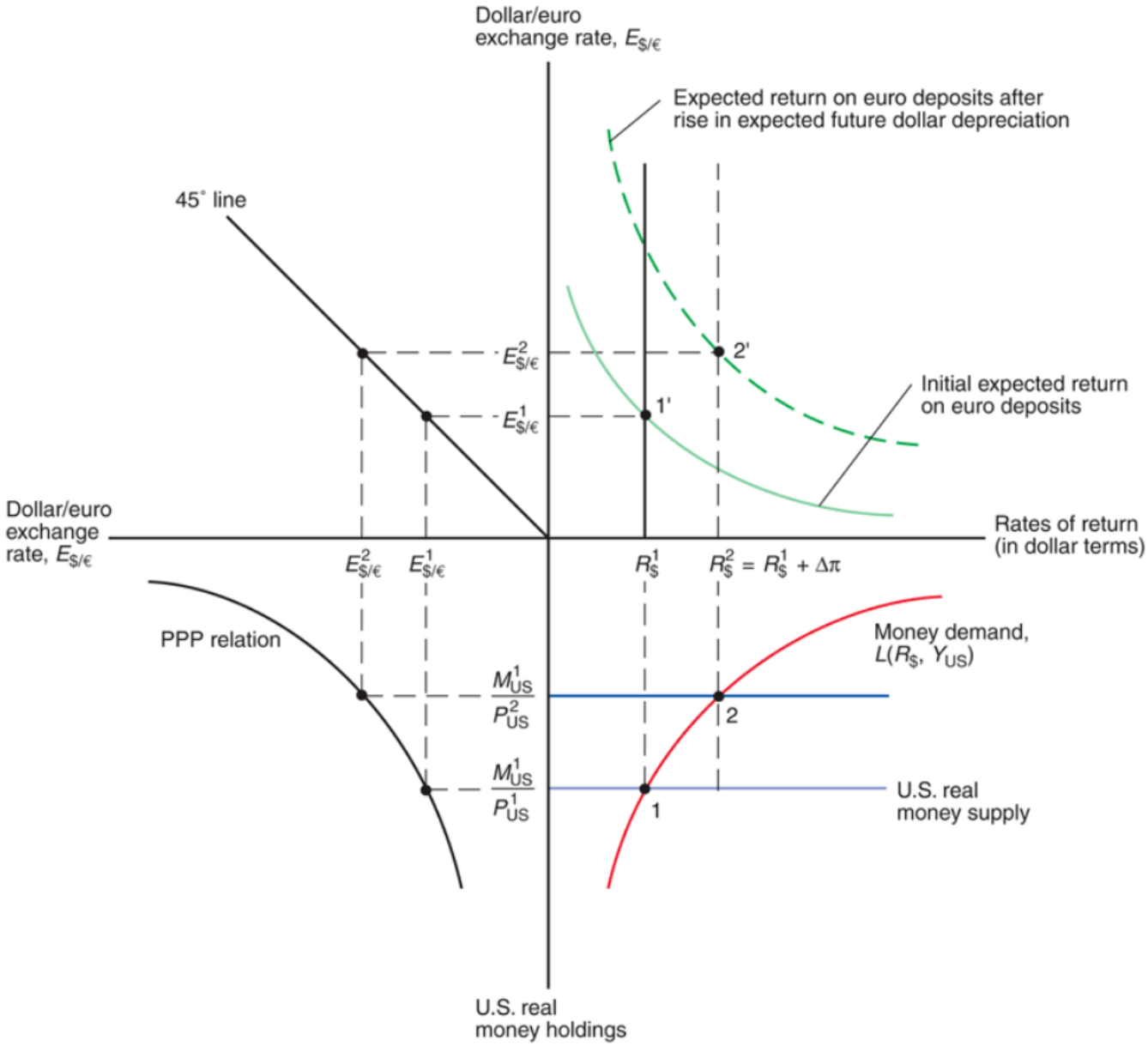
$$R_{USD} - R_{EURO} = \pi^e_{US} - \pi^e_E$$

- 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

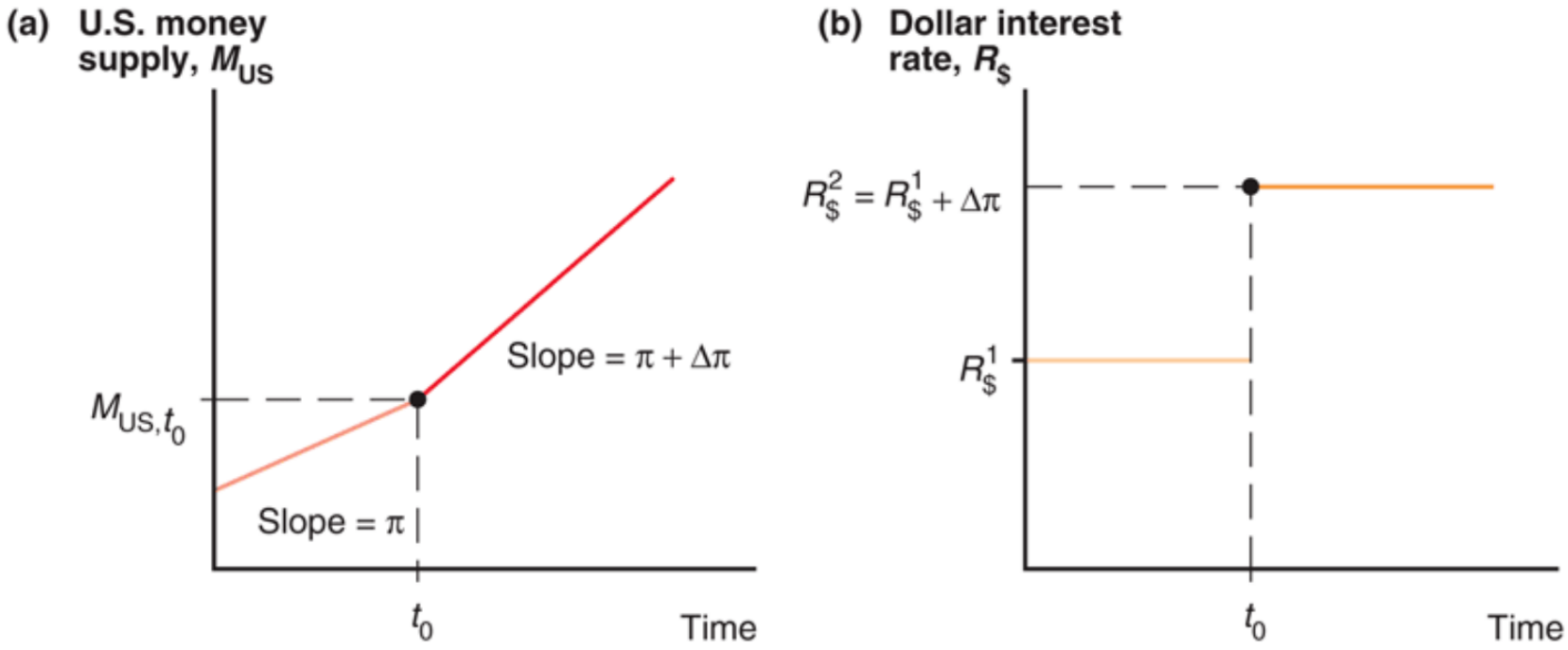
# Interest and Monetary Policy

- If growth in $M^s_{US}$ changes permanently from $\pi$ to $\pi + \Delta\pi$ (and $M^s_E$ is constant) such that $\pi_{US,t}$ and $\pi^e_{US}$ increases from $\pi$ 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



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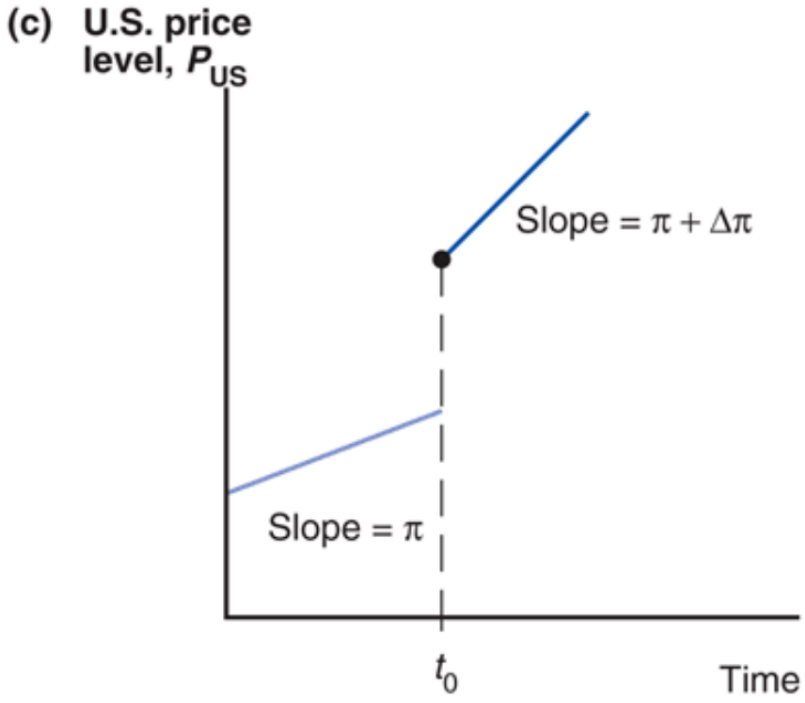
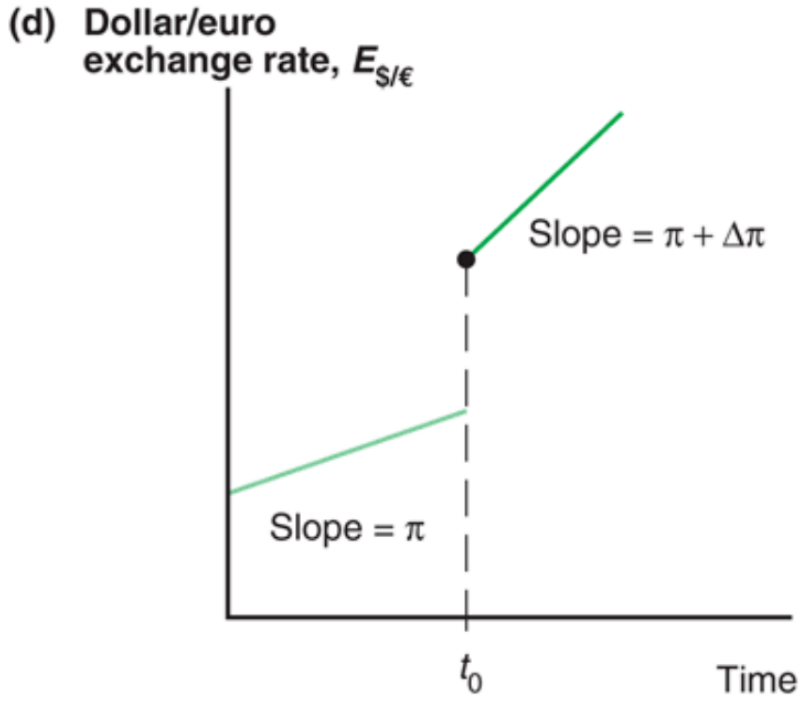


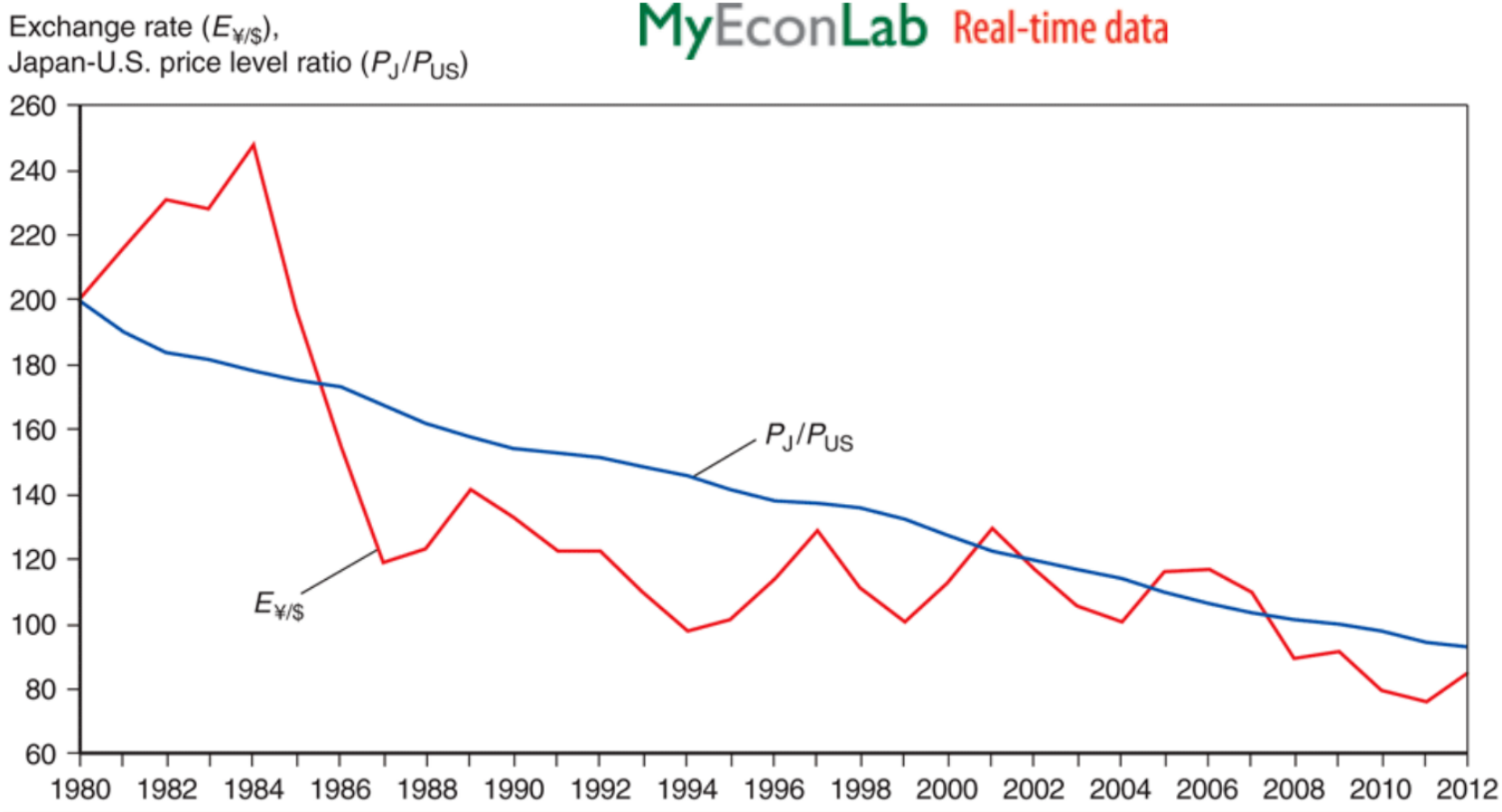
# Pause

- 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
  - $M^s_{US} \Uparrow \Rightarrow E_{\$/€} \Uparrow$
  - $R_{USD} \Uparrow \Rightarrow E_{\$/€} \Uparrow$
  - $Y_{US} \Uparrow \Rightarrow E_{\$/€} \Downarrow$
- Next empirical evidence on the PPP long-run model
  - Preview: Not good

# Empirical Evidence on PPP (1)

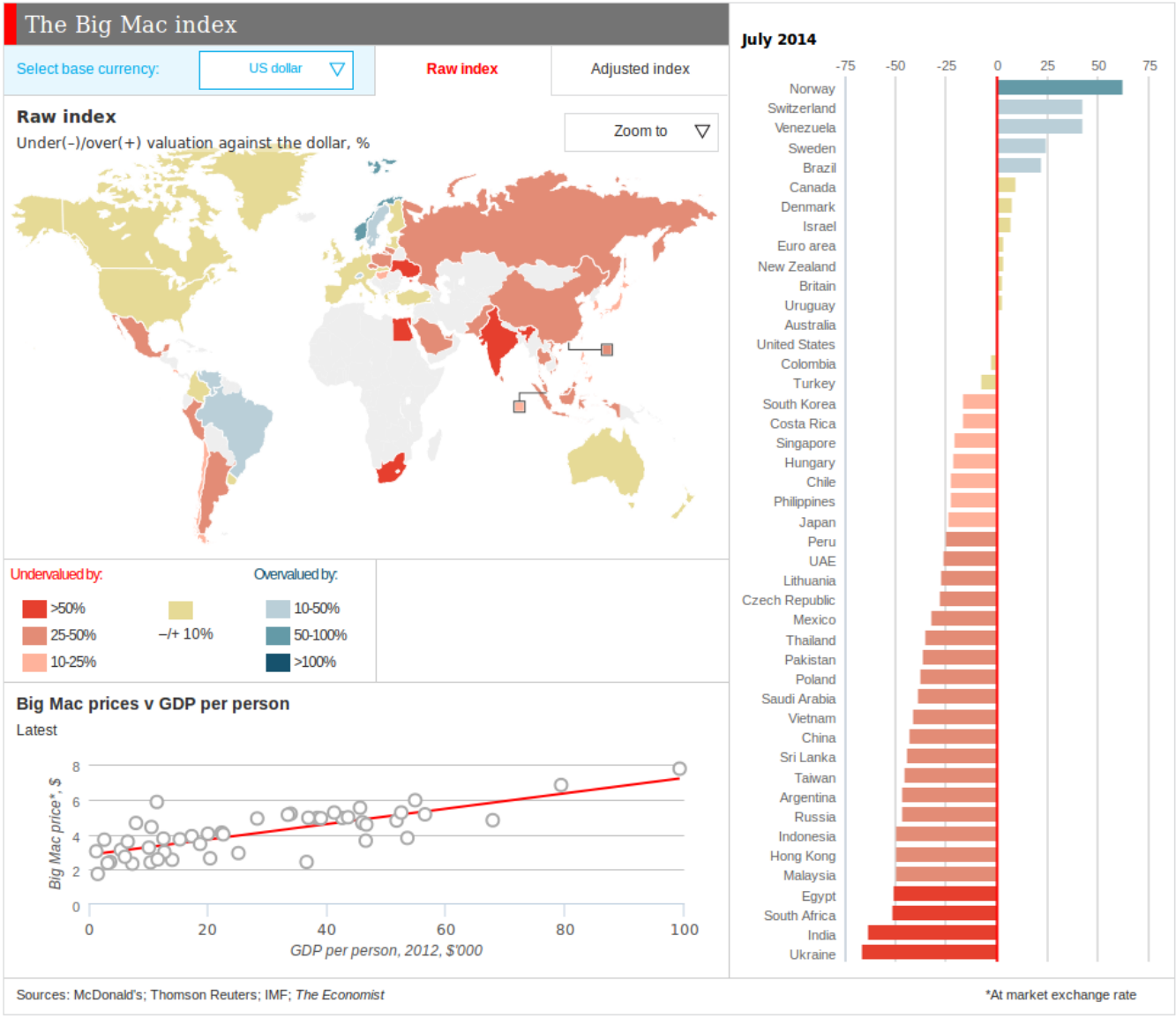
- The empirical support for PPP and the law of one price is weak.
- The prices of identical commodity baskets, when converted to a single currency, differ substantially across countries.
- Relative PPP also performs poorly.

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

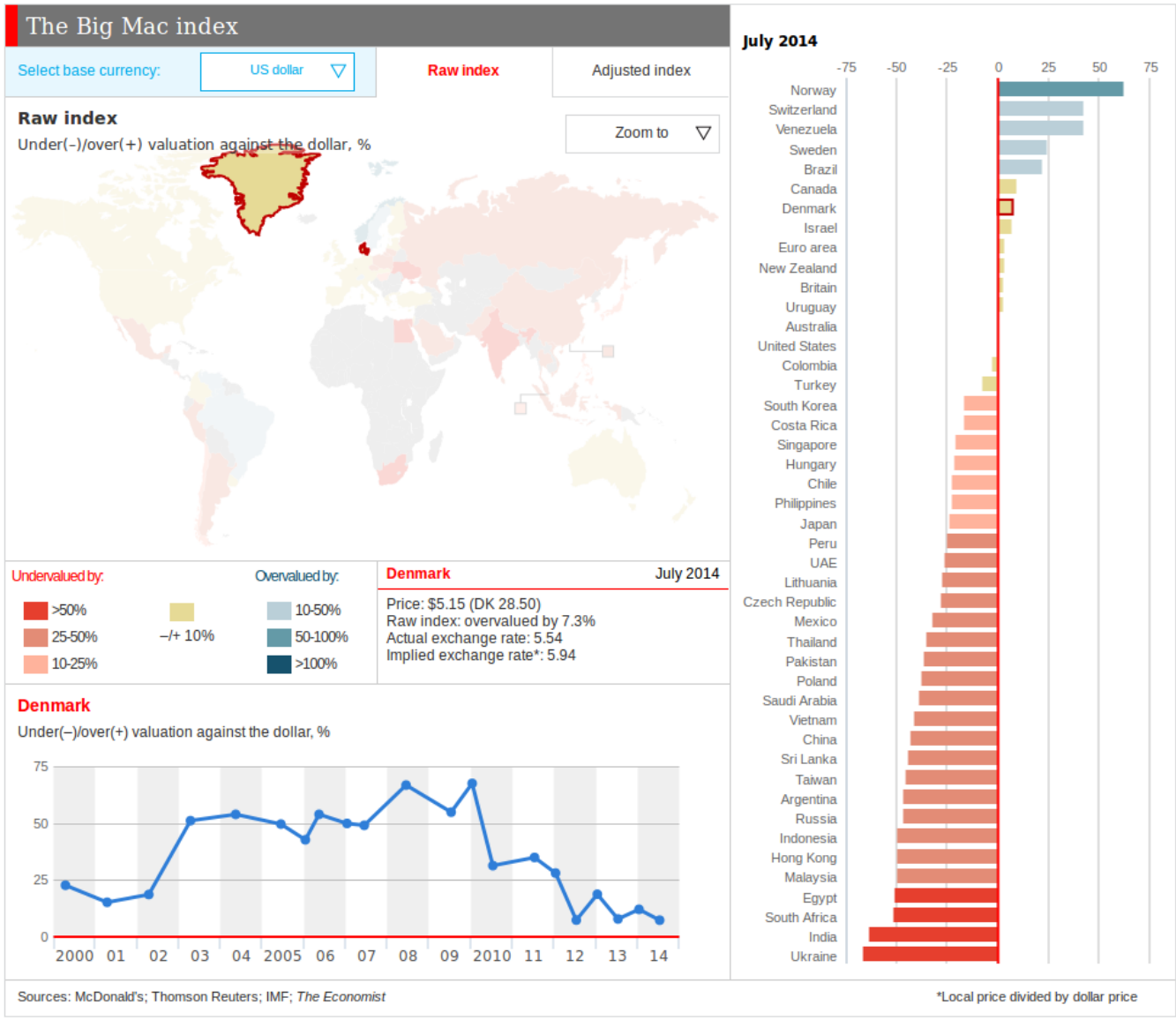



**Source:** IMF, *International Financial Statistics*. Exchange rates and price levels are end-of-year data.

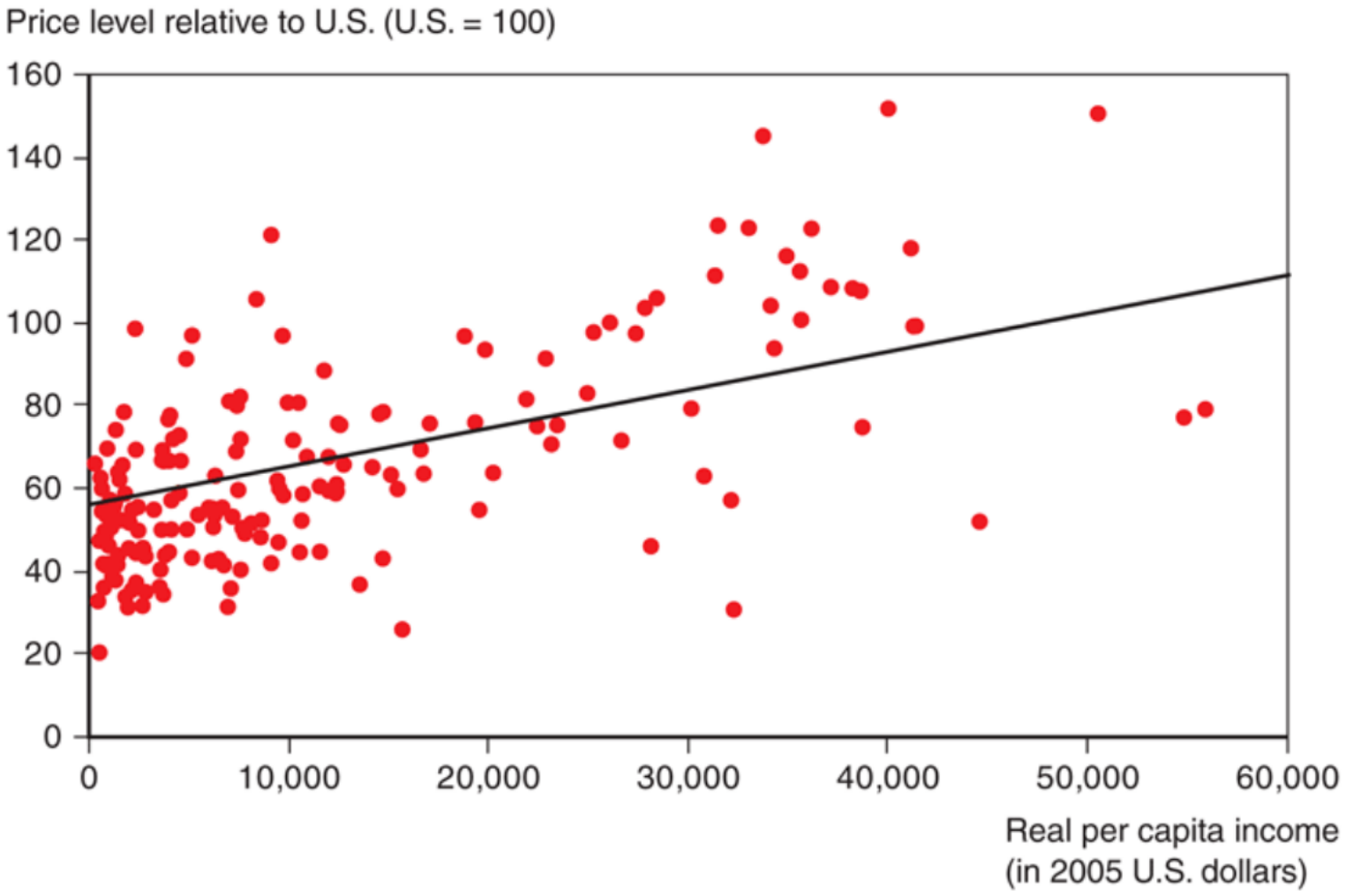
# Big Mac Index



# 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 catelogue printed only occassionally
  - 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
  - $M^s_{US} \Uparrow \Rightarrow E_{\$/€} \Uparrow$
  - $R_{USD} \Uparrow \Rightarrow E_{\$/€} \Uparrow$
  - $Y_{US} \Uparrow \Rightarrow E_{\$/€} \Downarrow$
- 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:

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

- 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

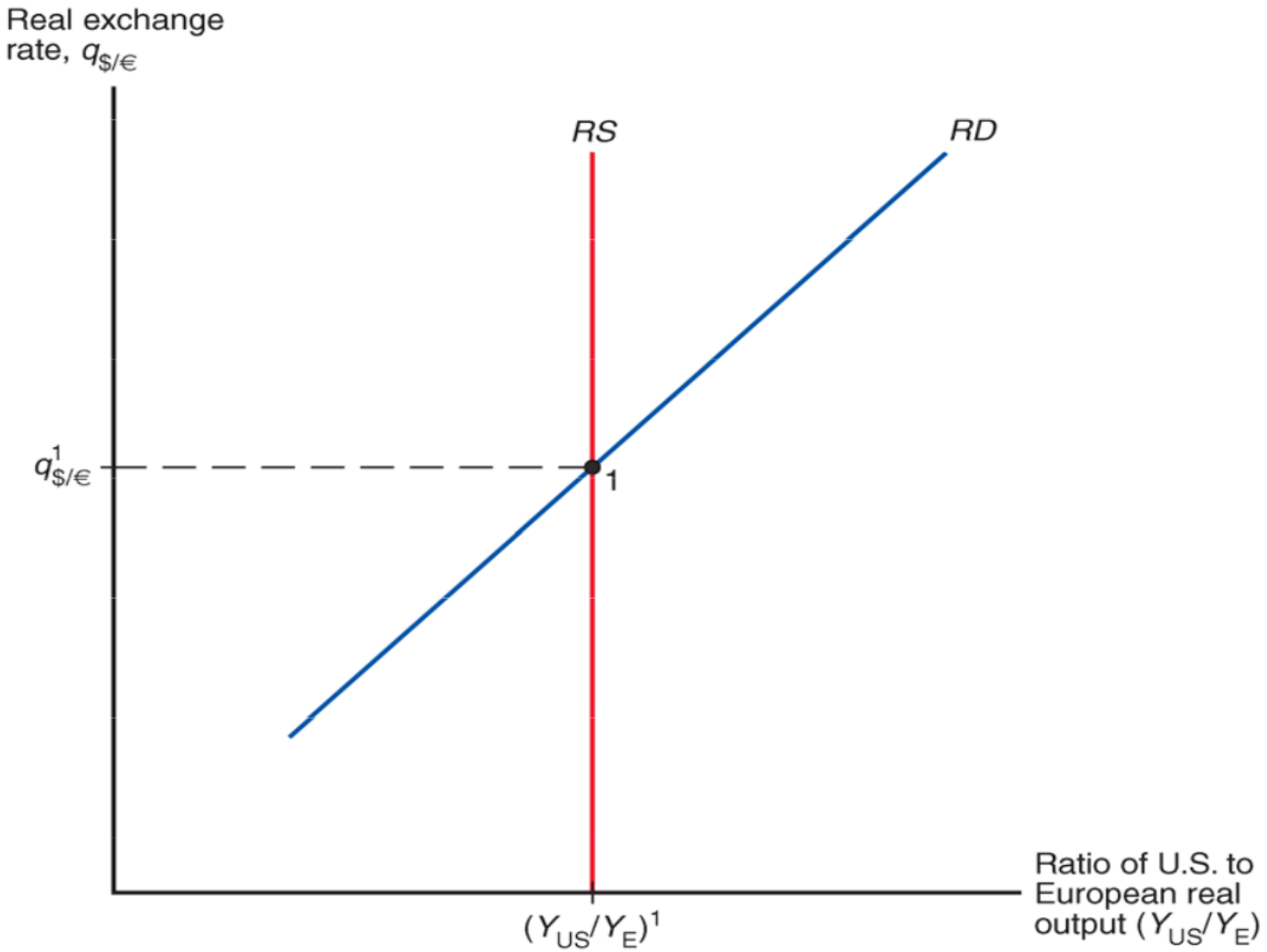
# A General Model of Long-Run Exchange Rates

- 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 $E_{\$/€} = \frac{P_{US}}{P_E}$
- Real exchange rate relation $E_{\$/€} = q_{US/E}\frac{P_{US}}{P_E}$
- 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
     - Americans richer, demand more European stuff
     - Americans more productive produce more US stuff
     - Excess supply of 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, $E_{\$/€}$ |
|---|---|
| **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:

$$\frac{E^e_{USD/EURO} - E_{USD/EURO}}{E_{USD/EURO}} - (\pi^e_{US} - \pi^e_{EURO})$$

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

$$\frac{q^e_{US/E} - q_{US/E}}{q_{US/E}} = \frac{E^e_{USD/EURO} - E_{USD/EURO}}{E_{USD/EURO}} - (\pi^e_{US} - \pi^e_{EURO})$$

- 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

$$\frac{q^e_{US/E} - q_{US/E}}{q_{US/E}} = \frac{E^e_{USD/EURO} - E_{USD/EURO}}{E_{USD/EURO}} - (\pi^e_{US} - \pi^e_{EURO})$$

- Remember interest parity?

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

- Combine:

$$R_{USD} - R_{EURO} = \frac{q^e_{US/E} - q_{US/E}}{q_{US/E}} + (\pi^e_{US} - \pi^e_{EURO})$$

- 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:

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

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

$$r^e_{US} - r^e_{EU} = \frac{\left(q^e_{US/EU} - q_{US/EU}\right)}{q_{US/EU}}$$

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

# Summary

- Purchasing Power Parity
  - The law of one price
  - Relative vs. Absolute PPP
- Exchange rates and PPP
  - Long-run, monetary approach
  - Fisher effect
- Empirical evidence on PPP
  - It bad
  - Why it bad
    1. Non-tradables
    2. Pricing to market
    3. Different baskets
- A generalized PPP model
  - Real exchange rate
  - Interest and the real exchange rate
  - Real interest rate parity

# Next time

- We know money's short and long-run effect on exchange rates
- We know real demand and supply shocks long-run effect on exchange rate
- Next time: Short-run effect of real demand and supply shocks

# Overall trade review