INTERNATIONAL ECONOMICS
(INTERNATIONAL FINANCE)

Lecture 2

Exchange Rate Determination in the Long Run:
PPP and the Real Exchange Rate
An Introduction to the Monetary Approach
Some empirical evidence

Georges Hortareas

Readings:
Feenstra and Taylor, *International Macroeconomics*:
Ch. 3

Topics of today's lecture

- The law of one price
- Purchasing power parity
- Exchange rates in the long run
- The real exchange rate
- Overvaluation, undervaluation and the Big Mac index
- Interest rates and inflation in the long-run
- Empirical evidence
- Money, Prices, and Exchange Rates in the Long Run
- Money Growth, Inflation, and Depreciation

Exchange Rate Determination in the Long Run: PPP and the Real Exchange Rate

Exchange Rate Essentials

The exchange rate: Appreciations and Depreciations

Notation in the textbook:

- Say that the dollar value of the euro is
  $E_{\$/€,t} = \$1.298$

- If at time $t + 1$, the dollar value of the euro becomes
  $E_{\$/€,t+1} = \$1.318$.

Then we say that the dollar depreciated, and the euro appreciated.

Purchasing Power Parity and Goods Market Equilibrium

The Law of One Price

$$\underbrace{q^{g}_{US/EUR}}_{\text{Relative price of good } g \text{ in Europe versus U.S.}} = \underbrace{(E_{\$/€} P^{g}_{EUR})}_{\text{European price of good } g \text{ in \$}} / \underbrace{P^{g}_{US}}_{\text{U.S. price of good } g \text{ in \$}}$$

The Law of One Price

We can rearrange the equation for price equality

$$E_{\$/€} P^g_{EUR} = P^g_{US}$$

$$\underbrace{E_{\$/€}}_{\text{Exchange rate}} = \underbrace{P^g_{US} / P^g_{EUR}}_{\text{Ratio of goods' prices}}$$

Purchasing Power Parity

Consider the relative price of the two baskets of goods in each location:

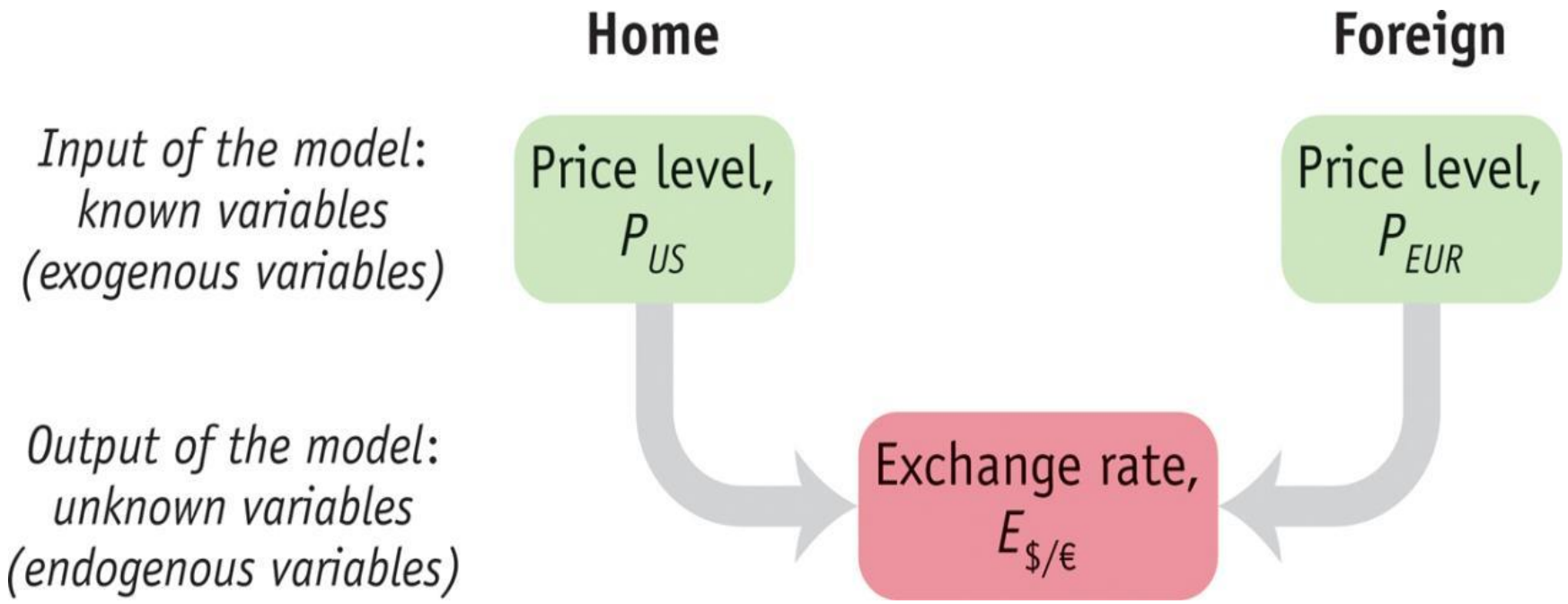
$$\underbrace{q_{US/EUR}}_{\substack{\text{Relative price}\\ \text{of basket}\\ \text{in Europe}\\ \text{versus U.S.}}} = \underbrace{(E_{\$/€} P_{EUR})}_{\substack{\text{European price}\\ \text{of basket}\\ \text{expressed}\\ \text{in \$}}} / \underbrace{P_{US}}_{\substack{\text{U.S. price}\\ \text{of basket}\\ \text{expressed}\\ \text{in \$}}}$$

- no arbitrage condition….

Absolute PPP, Prices, and the Nominal Exchange Rate

$$\underbrace{E_{\$/€}}_{\text{Exchange rate}} = \underbrace{P_{US} / P_{EUR}}_{\text{Ratio of price levels}}$$

Absolute PPP, Prices, and the Nominal Exchange Rate



Relative PPP, Inflation, and Exchange Rate Depreciation

$$\underbrace{E_{\$/€}}_{\text{Exchange rate}} = \underbrace{P_{US} / P_{EUR}}_{\text{Ratio of price levels}}$$

$$\frac{\Delta E_{\$/€,t}}{E_{\$/€,t}} = \underbrace{\frac{E_{\$/€,t+1} - E_{\$/€,t}}{E_{\$/€,t}}}_{\text{Rate of depreciation of the nominal exchange rate}}$$

Relative PPP, Inflation, and Exchange Rate Depreciation

$$\frac{\Delta(P_{US}/P_{EUR})}{(P_{US}/P_{EUR})} = \frac{\Delta P_{US,t}}{P_{US,t}} - \frac{\Delta P_{EUR,t}}{P_{EUR,t}}$$

$$= \underbrace{\left(\frac{P_{US,t+1}-P_{US,t}}{P_{US,t}}\right)}_{\text{Rate of inflation in U.S. } \pi_{US,t}} - \underbrace{\left(\frac{P_{EUR,t+1}-P_{EUR,t}}{P_{EUR,t}}\right)}_{\text{Rate of inflation in Europe } \pi_{EUR,t}} = \pi_{US} - \pi_{EUR}$$

Relative PPP, Inflation, and Exchange Rate Depreciation

$$\underbrace{\frac{\Delta E_{\$/€,t}}{E_{\$/€,t}}}_{\text{Rate of depreciation of the nominal exchange rate}} = \underbrace{\pi_{US,t} - \pi_{EUR,t}}_{\text{Inflation differential}}$$

The Real Exchange Rate

The **real exchange rate**

$$q_{US/EUR} = E_{\$/€} P_{EUR}/P_{US}$$

real depreciation.

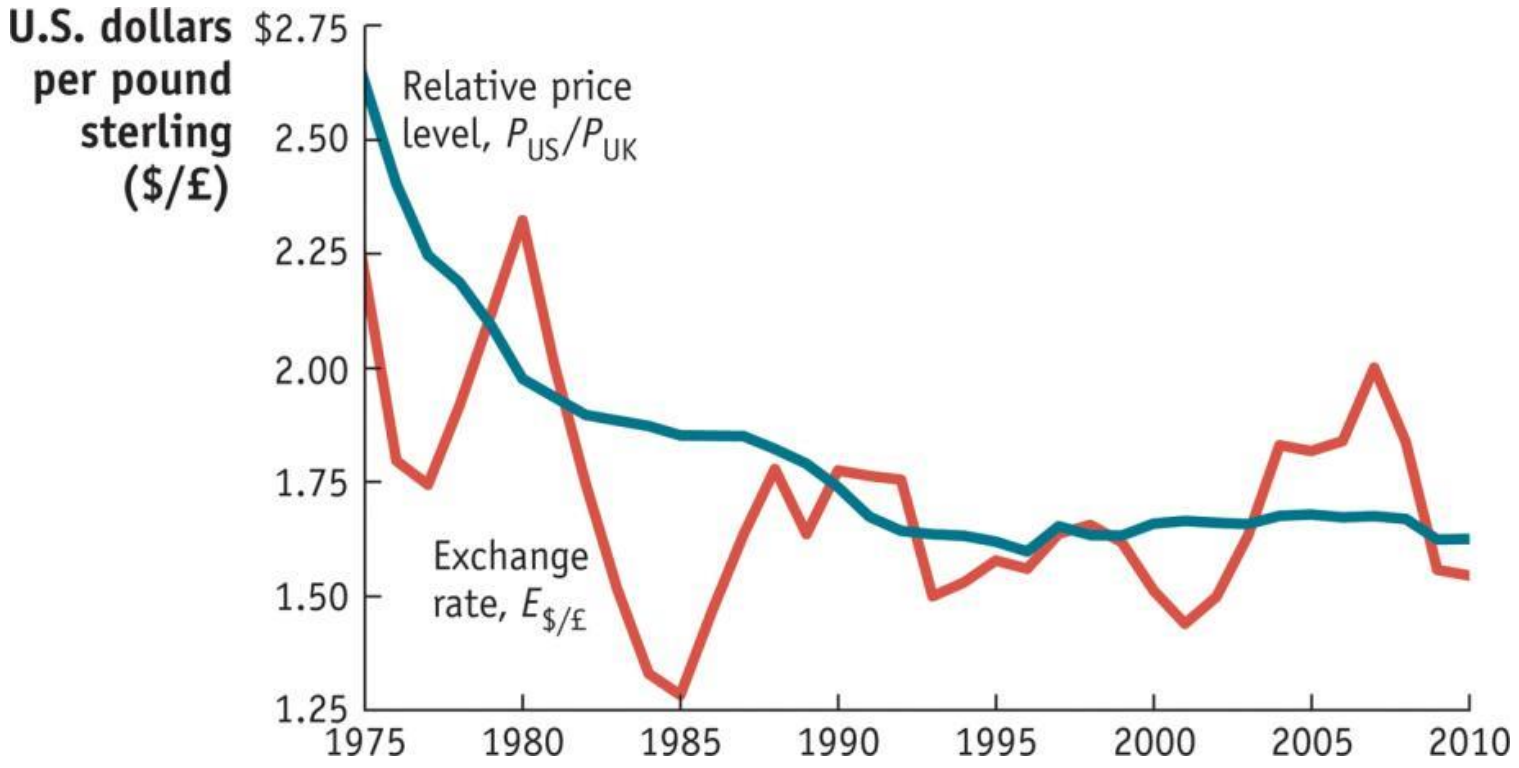
real appreciation.

Absolute PPP and the Real Exchange Rate

- If the real exchange rate $q_{US/EUR}$ is below 1 then Foreign goods are relatively cheap.
  - In this case, the Home currency is said to be *strong,* the euro is *weak,* and we say the euro is **undervalued**.

APPLICATION

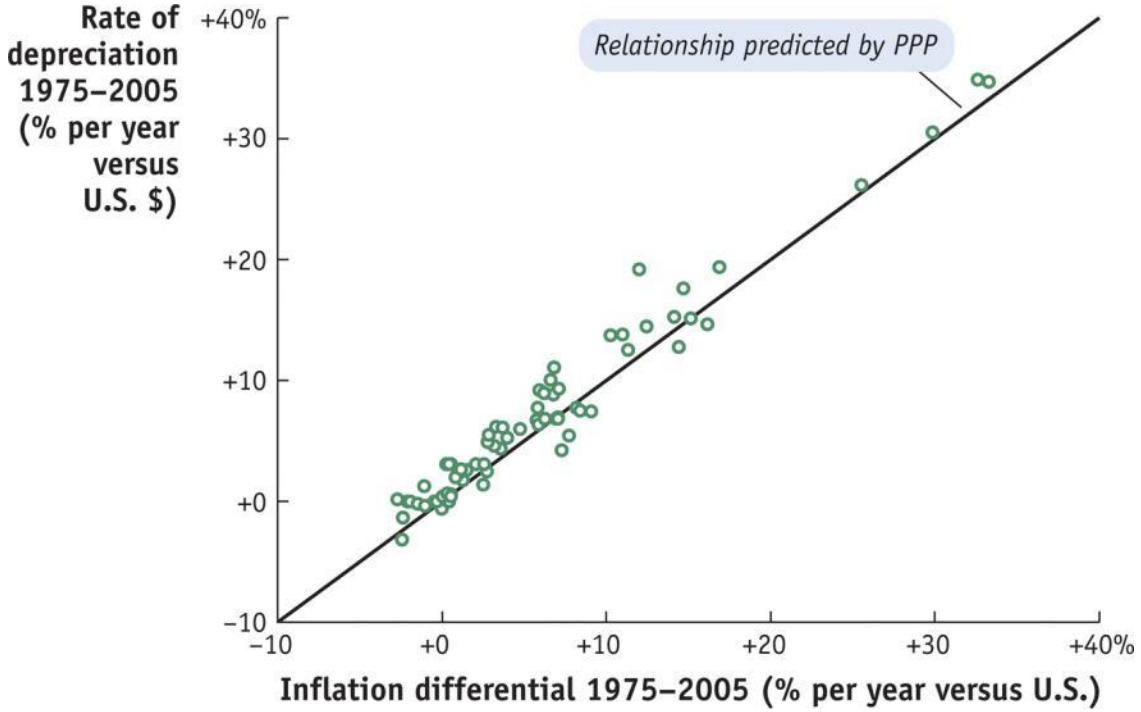
Evidence for PPP in the Long Run and Short Run



Exchange Rates and Relative Price Levels Data for the U.S. and the UK for 1975 to 2010 show that the exchange rate and relative price levels do not always move together in the short run. Relative price levels tend to change slowly and have a small range of movement; exchange rates move quickly and experience large fluctuations. Therefore, relative PPP does *not* hold in the short run. It is a better guide to the long run, and we can see that the two series do tend to drift together over the decades.

APPLICATION

Evidence for PPP in the Long Run and Short Run



Inflation Differentials and the Exchange Rate, 1975-2005 This scatterplot shows the relationship between the rate of exchange rate depreciation against the U.S. dollar and the inflation differential against the United States over the long run, for a sample of 82 countries. The correlation between the two variables is strong and bears a close resemblance to the prediction of PPP that all data points would appear on the 45-degree line.

The Law of One Price: some empirical evidence

APPLICATION

Examine local currency catalogue prices for 119 identical goods sold in 25 countries by IKEA over the years 1995 - 1998. the following Table reports 1998 prices of three mirrors in European IKEA stores (in USD)

Table 1. *European Prices (1998, in US$)*

	Alg Mirror [1]	Krabb Mirror [2]	Ratio of Alg to Krabb [3]	Guldros Mirror [4]
Netherlands	20	20	1.03	100
United Kingdom	25	30	0.83	114
Belgium	22	27	0.80	110
Switzerland	19	27	0.72	68
Finland	13	19	0.70	93
Spain	22	33	0.65	110
France	21	33	0.64	99
Sweden	15	23	0.64	91
Italy	22	43	0.52	78
Austria	24	48	0.49	114
Norway	12	26	0.46	79
Germany	22	51	0.44	96
Denmark	12	30	0.40	104

Notes: Alg: square mirror, 45 × 60 cm, 2 tiles. *Guldros*: round mirror, 59 × 78 cm, beveled glass. *Krabb*: designer mirror, 44 × 40 cm. *Source:* IKEA. Exchange rate: annual average (series rf) from IMF *International Financial Statistics*.

Two key findings:

- Large deviations from the LOP for identical goods
- Rankings of absolute prices across countries not the same across different types of mirrors.
- Suggests that differences in local distribution costs (e.g., rents and labour costs) and local taxes (e.g., VAT) do not explain the deviations from the LOP.

Haskel, J. and H. Wolf (2001): The law of one price. A case study. The Scandinavian Journal of Economics, vol 103, 545-558

How Slow Is Convergence to PPP?

- Research shows that price differences—the deviations from PPP—can be quite persistent.
- *speed of convergence*.
- *half-life*.

What Explains Deviations from PPP?

Economists have found a variety of reasons why PPP fails in the short run:

- *Transaction costs.*
- *Nontraded goods.*
- *Imperfect competition and legal obstacles.*
- *Price stickiness.*

Purchasing Power Parity and the Real Exchange Rate

We expressed PPP algebraically as the relative price of the two baskets of goods in each location:

$$\underbrace{q_{US/EUR}}_{\text{Relative price of basket in Europe versus U.S.}} = \underbrace{(E_{\$/€} P_{EUR})}_{\text{European price of basket expressed in \$}} / \underbrace{P_{US}}_{\text{U.S. price of basket expressed in \$}}$$

- Under absolute PPP it is implied that $q_{US/EUR} = 1$.

HEADLINES

The Big Mac Index

For more than 20 years, *The Economist* newspaper has engaged in a whimsical attempt to judge PPP theory based on a well-known, globally uniform consumer good: the McDonald's Big Mac. The over- or undervaluation of a currency against the U.S. dollar is gauged by comparing the relative prices of a burger in a common currency, and expressing the difference as a percentage deviation from one:

Home of the undervalued burger?

$$\text{Big Mac Index} = q^{\text{Big Mac}} - 1 = \left(\frac{E_{\$/\text{local currency}} P_{\text{local}}^{\text{Big Mac}}}{P_{\text{US}}^{\text{Big Mac}}} \right) - 1$$

The Big Mac Index

"The Big Mac index is an absurdly imperfect attempt to measure purchasing power parity, but then no other yardstick is very precise as an indicator of whether a currency is relatively cheap or dear. In their latest binge, writers from The Economist bravely ate their way through burgers in 55 countries, and concluded that sterling is 27 per cent undervalued against the dollar.".

(*Financial Times*, 18/1/2019, Neil Collins, Apocalypse now…..)

The Big Mac Index

The table shows the price of a Big Mac in July 2012 in local currency (column 1) and converted to U.S. dollars (column 2) using the actual exchange rate (column 4). The dollar price can then be compared with the average price of a Big Mac in the United States ($3.22 in column 1, row 1). The difference (column 5) is a measure of the overvaluation (+) or undervaluation (−) of the local currency against the U.S. dollar. The exchange rate against the dollar implied by PPP (column 3) is the hypothetical price of dollars in local currency that would have equalized burger prices, which may be compared with the actual observed exchange rate (column 4).

	Big Mac Prices		Exchange rate (local currency per U.S. dollar)		Over (+)/ under (−) valuation against dollar, %
	In local currency (1)	In U.S. dollars (2)	Implied by PPP (3)	Actual, July 25th (4)	(5)
United States	$ 4.33	4.33	—	—	—
Argentina	Peso 19	4.16	4.39	4.57	−4
Australia	A$ 4.56	4.68	1.05	0.97	8
Brazil	Real 10.08	4.94	2.33	2.04	14
Britain	£ 2.69	4.16	0.62	0.65	−4
Canada	C$ 3.89	3.82	0.90	1.02	−12
Chile	Peso 2050	4.16	473.71	493.05	−4
China	Yuan 15.65	2.45	3.62	6.39	−43
Colombia	Peso 8600	4.77	1987.29	1804.48	10
Costa Rica	Colones 1200	2.40	277.30	501.02	−45
Czech Republic	Koruna 70.33	3.34	16.25	21.05	−23

The Big Mac Index

	Big Mac Prices		Exchange rate (local currency per U.S. dollar)		Over (+)/ under (–) valuation against dollar, %
	In local currency (1)	In U.S. dollars (2)	Implied by PPP (3)	Actual, July 25th (4)	(5)
Denmark	DK 28.5	4.65	6.59	6.14	7
Egypt	Pound 16	2.64	3.70	6.07	–39
Euro area	€ 3.58	4.34	0.83	0.83	0
Hong Kong	HK$ 16.5	2.13	3.81	7.76	–51
Hungary	Forint 830	3.48	191.80	238.22	–19
India	Rupee 89	1.58	20.57	56.17	–63
Indonesia	Rupiah 24200	2.55	5592.00	9482.50	–41
Israel	Shekel 11.9	2.92	2.75	4.08	–33
Japan	Yeo 320	4.09	73.95	78.22	–5
Latvia	Lats 1.69	2.94	0.39	0.57	–32
Lithuania	Litas 7.8	2.74	1.80	2.85	–37
Malaysia	Ringgit 7.4	2.33	1.71	3.17	–46
Mexico	Peso 37	2.70	8.55	13.69	–38
New Zealand	NZS 5.1	4.00	1.18	1.27	–7
Norway	Kroner 43	7.06	9.94	6.09	63
Pakistan	Rupee 285	3.01	65.86	94.61	–30

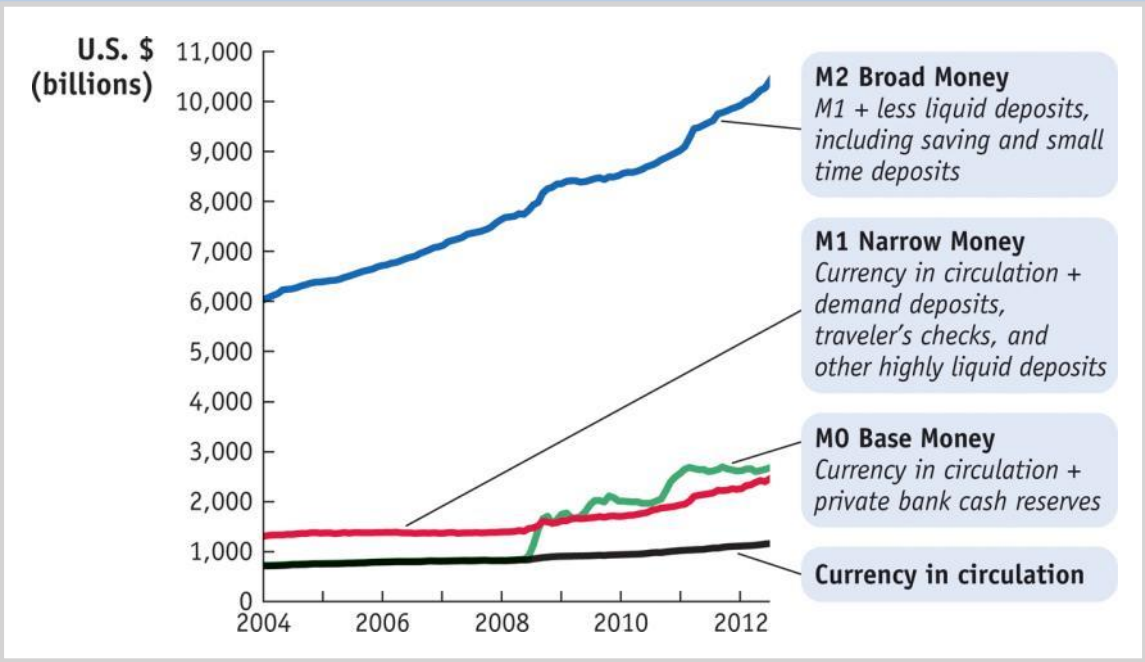
- Money, Prices, and Exchange Rates in the Long Run

- Money Growth, Inflation, and Depreciation

Money, Prices, and Exchange Rates in the Long Run: Money Market Equilibrium in a Simple Model

- : *What determines those price levels?*
- Monetary theory supplies an answer

The Measurement of Money



The Measurement of Money This figure shows the major kinds of monetary aggregates (currency, M0, M1, and M2) for the United States from 2004 to 2012. Normally, bank reserves are very close to zero, so M0 and currency are virtually identical, but reserves spiked up during the financial crisis in 2008, as private banks sold securities to the Fed and stored up the cash proceeds in their Fed reserve accounts.

The Supply of Money: In practice, a country's **central bank** controls the **money supply**. We make the simplifying assumption that the central bank's indirectly, but accurately, control the level of M1.

The Demand for Money: A Simple Model

- We assume **money demand** is motivated by the need to conduct transactions in proportion to an individual's income and we infer that the aggregate money demand will behave similarly (known as the **quantity theory of money**).

$$\underbrace{M^d}_{\substack{\text{Demand} \\ \text{for money (\$)}}} = \underbrace{\overline{L}}_{\text{A constant}} \times \underbrace{PY}_{\substack{\text{Nominal} \\ \text{income (\$)}}}$$

The Demand for Money: A Simple Model

$$\underbrace{\frac{M^d}{P}}_{\substack{\text{Demand} \\ \text{for real} \\ \text{money}}} = \underbrace{\overline{L}}_{\text{A constant}} \times \underbrace{Y}_{\text{Real income}}$$

Equilibrium in the Money Market

$$M = \bar{L}PY$$

and, equivalently,

$$\frac{M}{P} = \bar{L}Y$$

A Simple Monetary Model of Prices

$$P_{US} = \frac{M_{US}}{\overline{L}_{US} Y_{US}} \qquad P_{EUR} = \frac{M_{EUR}}{\overline{L}_{EUR} Y_{EUR}}$$

- These two equations are examples of the **fundamental equation of the monetary model of the price level**.

A Simple Monetary Model of the Exchange Rate

$$\underbrace{E_{\$/EU}}_{\text{Exchange rate}} = \underbrace{\frac{P_{US}}{P_E}}_{\text{Ratio of price levels}} = \frac{\left(\frac{M_{US}}{\bar{L}_{US}Y_{US}}\right)}{\left(\frac{M_{EUR}}{\bar{L}_{EUR}Y_{EUR}}\right)} = \underbrace{\frac{(M_{US}/M_{EUR})}{(\bar{L}_{US}Y_{US}/\bar{L}_{EUR}Y_{EUR})}}_{\substack{\text{Relative nominal money supplies} \\ \text{divided by} \\ \text{relative real money demands}}}$$

This is the **fundamental equation of the monetary approach to exchange rates**.

Money Growth, Inflation, and Depreciation

$$\mu_{US,t} = \underbrace{\frac{M_{US,t+1} - M_{US,t}}{M_{US,t}}}_{\text{Rate of money supply growth in U.S.}}$$

$$g_{US,t} = \underbrace{\frac{Y_{US,t+1} - Y_{US,t}}{Y_{US,t}}}_{\text{Rate of real income growth in U.S.}}$$

Money Growth, Inflation, and Depreciation

Therefore, the growth rate of $P_{US} = M_{US}/\bar{L}_{US}Y_{US}$ equals the money supply growth rate μ_{US} minus the real income growth rate g_{US}. The growth rate of P_{US} is the inflation rate π_{US}.

$$\pi_{US,t} = \mu_{US,t} - g_{US,t}$$

$$\pi_{EUR,t} = \mu_{EUR,t} - g_{EUR,t}$$

Money Growth, Inflation, and Depreciation

$$\underbrace{\frac{\Delta E_{\$/€t}}{E_{\$/€,t}}}_{\text{Rate of depreciation of the nominal exchange rate}} = \underbrace{\pi_{US,t} - \pi_{EUR,t}}_{\text{Inflation differential}} = \left(\mu_{US,t} - g_{US,t}\right) - \left(\mu_{EUR,t} - g_{EUR,t}\right)$$

$$= \underbrace{\left(\mu_{US,t} - \mu_{EUR,t}\right)}_{\substack{\text{Differential in} \\ \text{nominal money supply} \\ \text{growth rates}}} - \underbrace{\left(g_{US,t} - g_{EUR,t}\right)}_{\substack{\text{Differential in} \\ \text{real output} \\ \text{growth rates}}}.$$

intuition …….

APPLICATION

Hyperinflations

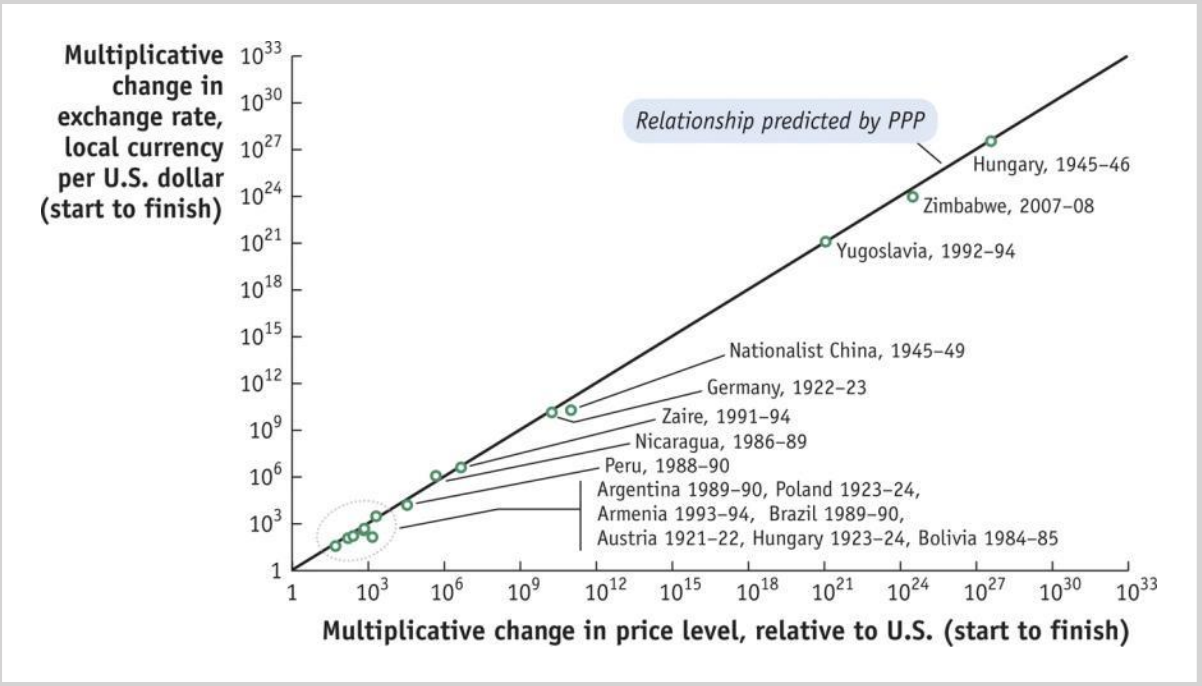
The monetary approach assumes long-run PPP, which generally works poorly in the short run. There is one notable exception to this general failure of PPP in the short run: **hyperinflation**.

- Economists traditionally define a hyperinflation as a sustained inflation of more than 50% *per month* (which means that prices are doubling every 51 days).
- In common usage, some lower-inflation episodes are also called hyperinflations. An inflation rate of 1,000% *per year* is a common rule of thumb (22% per month).
- Hyperinflations usually occur when governments face a budget crisis, are unable to borrow to finance a deficit, and instead choose to print money.

APPLICATION

Hyperinflations

PPP in Hyperinflations



Purchasing Power Parity during Hyperinflations The scatterplot shows the relationship between the cumulative start-to-finish exchange rate depreciation against the U.S. dollar and the cumulative start-to-finish rise in the local price level for hyperinflations in the twentieth century. Note the use of logarithmic scales.

The data show a strong correlation between the two variables and a *very* close resemblance to the theoretical prediction of PPP that all data points would appear on the 45-degree line.

Money, Interest Rates, and Prices in the Long Run: A General Model

The trouble with the **quantity theory** we studied earlier is that it assumes that the *demand for money is stable*, and this is implausible.

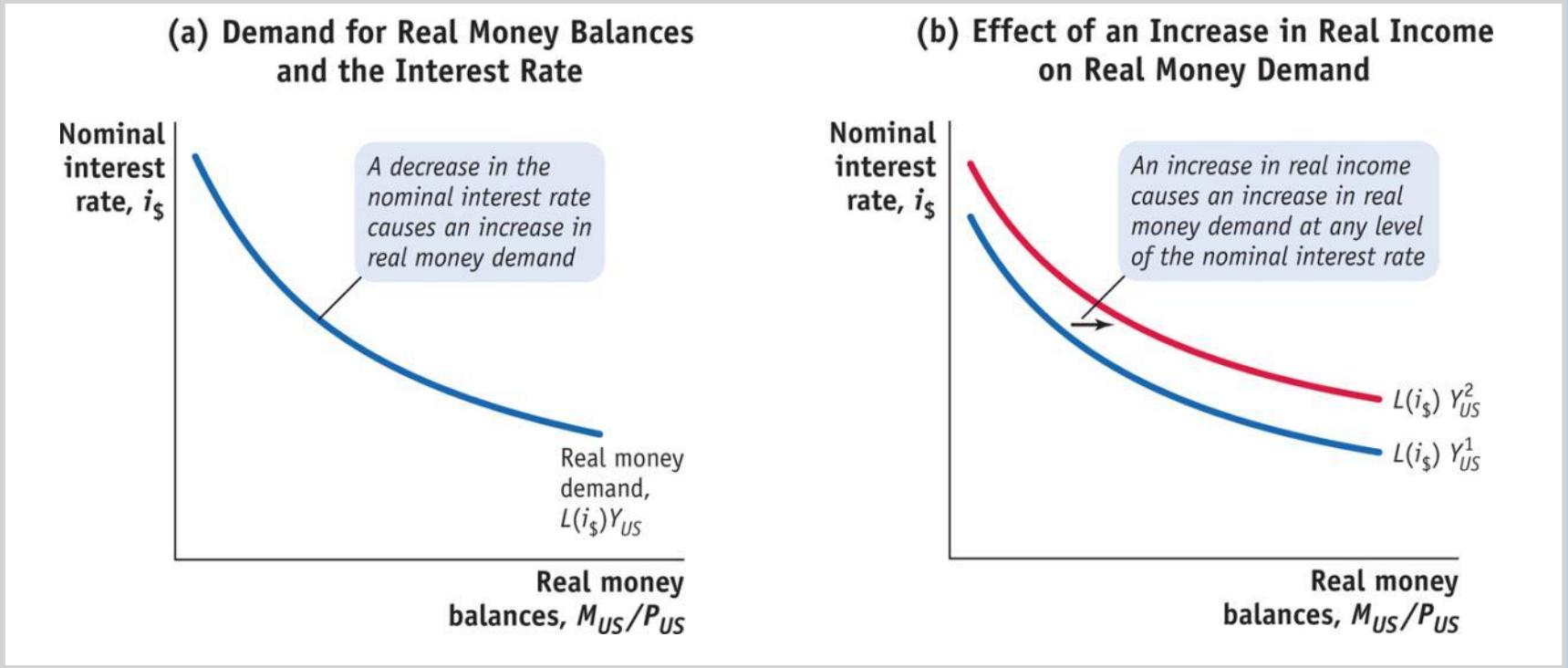
The Demand for Money: The General Model

$$\underbrace{M^d}_{\substack{\text{Demand} \\ \text{for money (\$)}}} = \underbrace{L(i)}_{\substack{\text{A} \\ \text{decreasing} \\ \text{function}}} \times \underbrace{P \times Y}_{\substack{\text{Nominal} \\ \text{income (\$)}}}$$

$$\underbrace{\frac{M^d}{P}}_{\substack{\text{Demand} \\ \text{for real money}}} = \underbrace{L(i)}_{\substack{\text{A} \\ \text{decreasing} \\ \text{function}}} \times \underbrace{Y}_{\substack{\text{Real} \\ \text{income}}}$$

The Demand for Money: The General Model

The Standard Model of Real Money Demand



Panel (a) shows the **real money demand function** for the United States. The downward slope implies that the quantity of real money demand rises as the nominal interest rate $i_\$$ falls. Panel (b) shows that an increase in real income from Y^1_{US} to Y^2_{US} causes real money demand to rise at all levels of the nominal interest rate $i_\$$.

The Fundamental Equation Under the General Model

- This model differs from the simple model (the quantity theory) by allowing L to vary as a function of the nominal interest rate i.

$$\underbrace{E_{\$/€}}_{\text{Exchange rate}} = \underbrace{\frac{P_{US}}{P_{EUR}}}_{\text{Ratio of price levels}} = \frac{\left(\frac{M_{US}}{L_{US}(i_{\$})Y_{US}}\right)}{\left(\frac{M_{EUR}}{L_{EUR}(i\ )Y_{EUR}}\right)} = \underbrace{\frac{\left(M_{US}/M_{EUR}\right)}{\left(L_{US}(i_{\$})Y_{US}/L_{EUR}(i\ )Y_{EUR}\right)}}_{\begin{array}{c}\text{Relative nominal money supplies}\\ \text{divided by}\\ \text{Relative real money demands}\end{array}}$$

- When nominal interest rates change the general model has different implications from the simple model.

The end