University of Warsaw
Faculty of Economic Sciences

Exchange Rates I: The Monetary Approach in the Long Run Part 1

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Introduction

The goal of this lecture is to set out the long-run relationships between money, prices, and exchange rates.

The theory we will develop has two parts:

- The first involves the theory of purchasing power, linking the exchange rate to price levels in each country in the long run.
- The second involves how price levels are related to monetary conditions in each country.
- Combining the monetary and purchasing power theories we will develop a long-run theory known as the **monetary approach to exchange rates**.

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

Arbitrage can occur in international goods markets just as in international financial markets. Therefore, the prices of goods in different countries expressed in a common currency may have a tendency to be equalized.

- Applied to a single good, this type of equalization is referred to as the **law of one price**.
- Applied to an entire basket of goods, it is called the theory of **purchasing power parity**.
- We will develop a simple theory based on an idealized world of *frictionless trade* where transaction costs can be neglected.
- We start with single goods and the law of one price then move baskets of goods and purchasing power parity.

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

The Law of One Price

The law of one price **(LOOP)** states that in the absence of trade frictions and under free competition and price flexibility, identical goods sold in different locations must sell for the same price when expressed in a common currency.

We can state the law of one price as follows, for the case of any good ***g*** sold in two locations:

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

where $E_{\$/€}$ is the exchange rate, and LOOP holds if and only if this expression is equal to 1.

The Law of One Price

We can rearrange the equation for price equality

$$E_{\$/€}\ P^{g}_{EUR} = P^{g}_{US}$$

to show that the exchange rate must equal the ratio of the goods' prices expressed in the two currencies:

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

Purchasing Power Parity

The principle of purchasing power parity **(PPP)** is the macroeconomic counterpart to the microeconomic law of one price (LOOP). To express PPP algebraically, we can compute the relative price of the two baskets of goods in each location:

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

- There is no arbitrage when the basket is the same price in both locations, that is, when $q_{US/EUR} = 1$.
- PPP then holds: price levels in two countries are equal when expressed in a common currency. This is called **absolute PPP**.

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

The Real Exchange Rate

The **real exchange rate** is the relative price of the baskets.

- The U.S. real exchange rate $q_{US/EUR} = E_{\$/€} P_{EUR} / P_{US}$ tells us how many U.S. baskets are needed to purchase one European basket.
- The exchange rate for currencies is a *nominal* concept. The real exchange rate is a *real* concept.

The real exchange rate has terminology similar to the nominal exchange rate:

- If the real exchange rate rises (more Home goods are needed in exchange for Foreign goods), Home has experienced a **real depreciation**.
- If the real exchange rate falls, Home has experienced a **real appreciation**.

Absolute PPP and the Real Exchange Rate

Purchasing power parity (Absolute PPP) requires that the real exchange rate $q_{US/EUR}$ is equal to 1.

- If the real exchange rate $q_{US/EUR}$ is below 1, then Foreign (European) goods are cheap relative to Home (U.S.) goods.
  - In this case, the U.S. dollar is said to be *strong,* the euro is *weak,* and we say the euro is **undervalued**.
- If the real exchange rate $q_{US/EUR}$ is above 1, then Foreign goods are relatively expensive.
  - In this case, the U.S. dollar is said to be *weak,* the euro is *strong,* and we say the euro is **overvalued**.

Absolute PPP, Prices, and the Nominal Exchange Rate

We can rearrange the no-arbitrage equation for the equality of price levels, $E_{\$/€}\ P_{EUR} = P_{US}$ to allow us to solve for the exchange rate that would be implied by absolute PPP:

Absolute PPP:

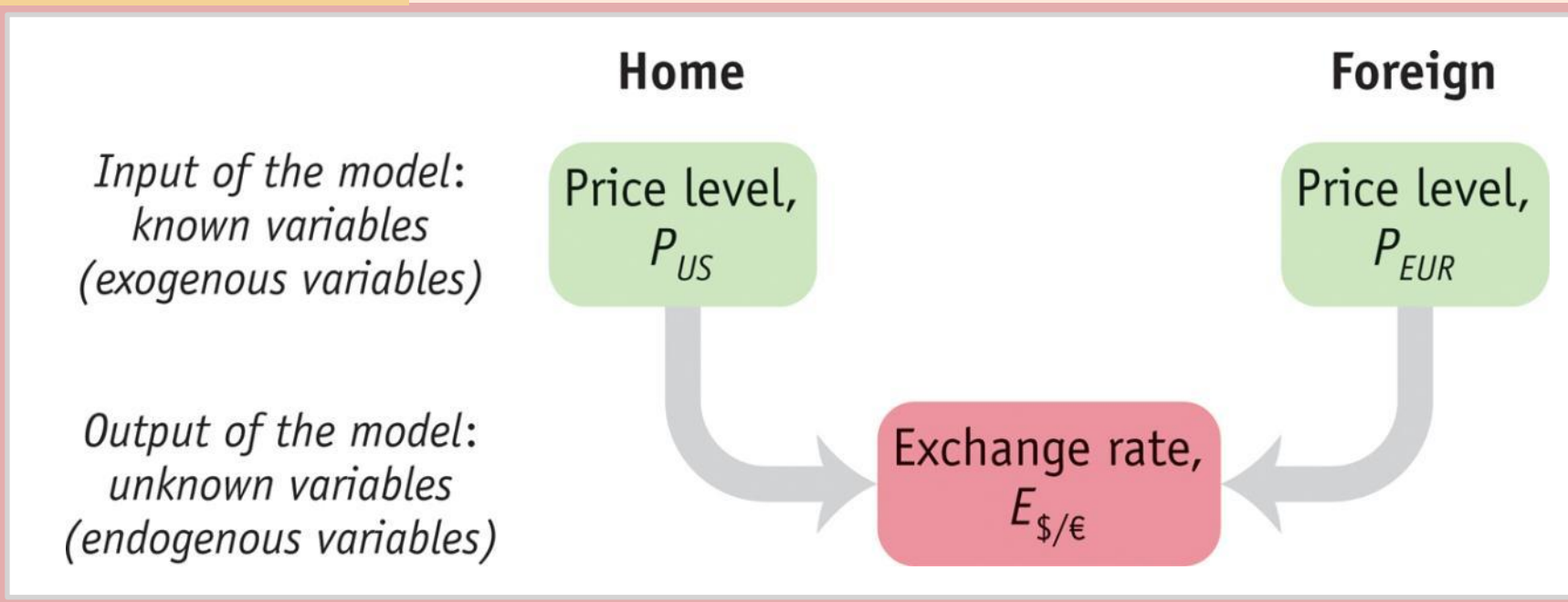
$$\underbrace{E_{\$/€}}_{\text{Exchange rate}} = \underbrace{P_{US} \,/\, P_{EUR}}_{\text{Ratio of price levels}} \qquad (3\text{-}1)$$

Purchasing power parity implies that the exchange rate at which two currencies trade equals the relative price levels of the two countries.

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

Absolute PPP, Prices, and the Nominal Exchange Rate

FIGURE 3-1



Building Block: Price Levels and Exchange Rates in the Long Run According to the PPP Theory In this model, the price levels are treated as known exogenous variables (in the green boxes). The model uses these variables to predict the unknown endogenous variable (in the red box), which is the exchange rate.

Relative PPP, Inflation, and Exchange Rate Depreciation

We now examine the implications of PPP for the study of **inflation** (the rate of change of the price level) using 3-1.

$$\underbrace{E_{\$/€}}_{\text{Exchange rate}} = \underbrace{P_{US} / P_{EUR}}_{\text{Ratio of price levels}} \qquad (3\text{-}1)$$

On the left-hand side, the rate of change of the exchange rate in Home is the rate of exchange rate depreciation in Home given by

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

Relative PPP, Inflation, and Exchange Rate Depreciation

We now examine the implications of PPP for the study of **inflation** (the rate of change of the price level) using 3-1.

$$\underbrace{E_{\$/€}}_{\text{Exchange rate}} = \underbrace{P_{US} / P_{EUR}}_{\text{Ratio of price levels}} \qquad (3\text{-}1)$$

On the right, the rate of change of the ratio of price levels equals the rate of change of the numerator minus that of the denominator:

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

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

Relative PPP, Inflation, and Exchange Rate Depreciation

If Equation (3-1) holds for *levels* of exchange rates and prices, then it must also hold for *rates of change* in these variables. By combining the last two expressions, we obtain:

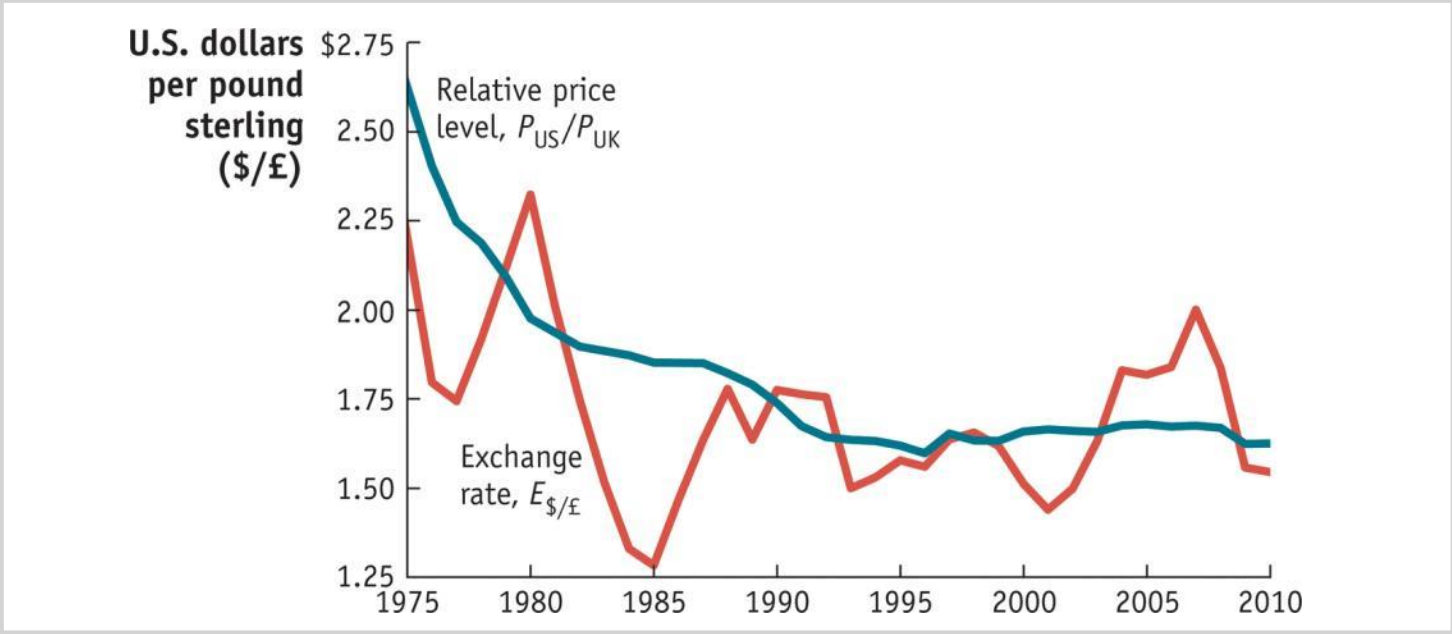
$$\underbrace{\frac{\Delta E_{\$/€,t}}{E_{\$/€,t}}}_{\text{Rate of depreciation of the nominal exchange rate}} = \underbrace{\pi_{US,t} - \pi_{EUR,t}}_{\text{Inflation differential}} \qquad (3\text{-}2)$$

This way of expressing PPP is called **relative PPP**, and it implies that the rate of depreciation of the nominal exchange rate equals the difference between the inflation rates of two countries **(sutable for small inflation differentia)**.

APPLICATION

Evidence for PPP in the Long Run and Short Run

FIGURE 3-4



Exchange Rates and Relative Price Levels Data for the United States and the UK from 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.

How Slow Is Convergence to PPP?

- Research shows that price differences—the deviations from PPP—can be quite persistent.
- Estimates suggest that these deviations may die out at a rate of about 15% per year. This kind of measure is often called a *speed of convergence*.
- Approximately half of any PPP deviation still remains after four years: Economists refer to this as a four-year *half-life*.
- Such estimates provide a rule of thumb that is useful as a guide to forecasting real exchange rates.

What Explains Deviations from PPP?

There could be a variety of reasons PPP fails in the short run:

- *Transaction costs.* These include costs of transportation, tariffs, duties, and other costs due to shipping and delays associated with developing distribution networks and satisfying legal and regulatory requirements in foreign markets. On average, they are more than 20% of the price of goods traded internationally.
- *Nontraded goods.* Some goods are inherently nontradable; they have infinitely high transaction costs. Most goods and services fall somewhere between tradable and nontradable.

What Explains Deviations from PPP?

- *Imperfect competition and legal obstacles.* Many goods are not simple undifferentiated commodities, as LOOP and PPP assume. Differentiated goods create conditions of *imperfect competition* because firms have some power to set the price of their good, allowing firms to charge different prices not just across brands but also across countries.

- *Price stickiness.* Prices do not or cannot adjust quickly and flexibly to changes in market conditions.

HEADLINES

The Big Mac Index

For more than 25 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:

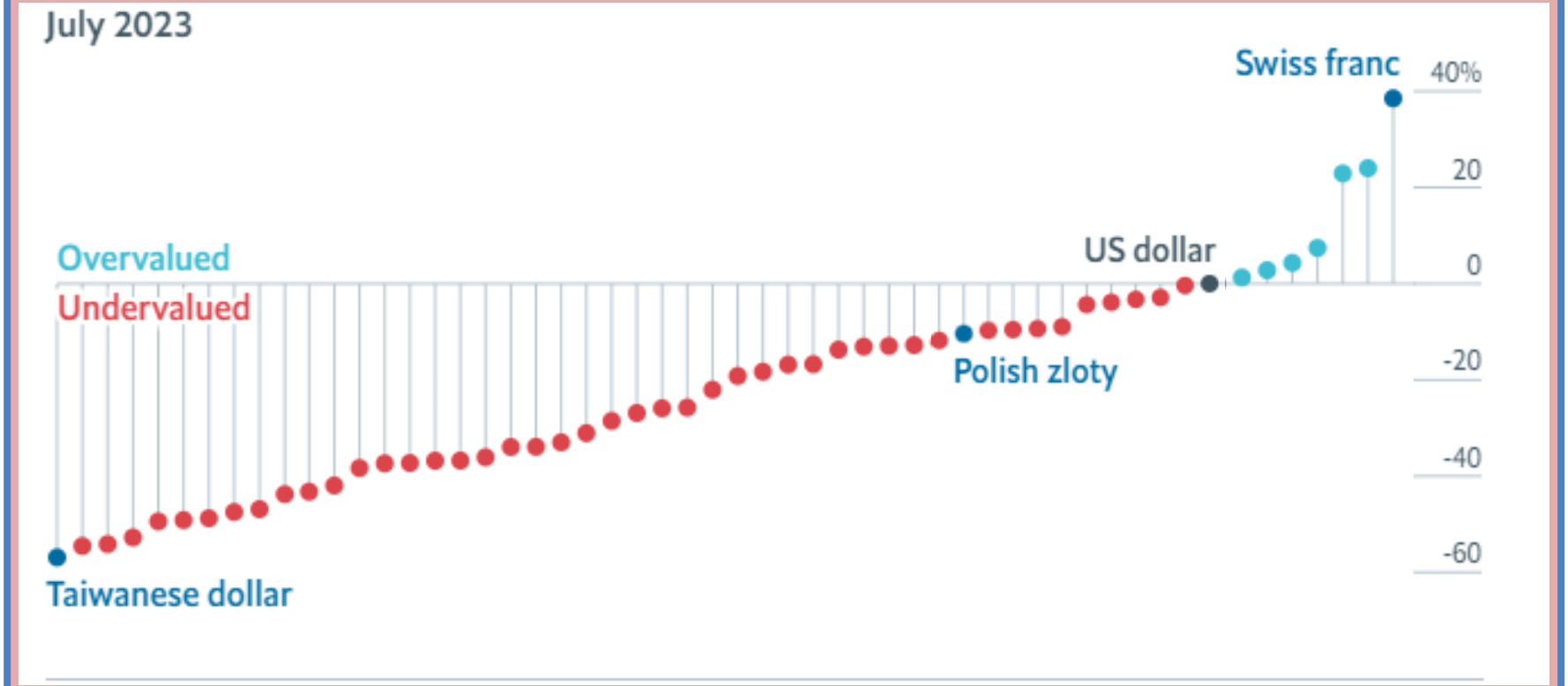
Home of the undervalued burger?

AP Photo/Greg Baker

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

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

FIGURE 3-5 (1 of 2) The Big Mac Index

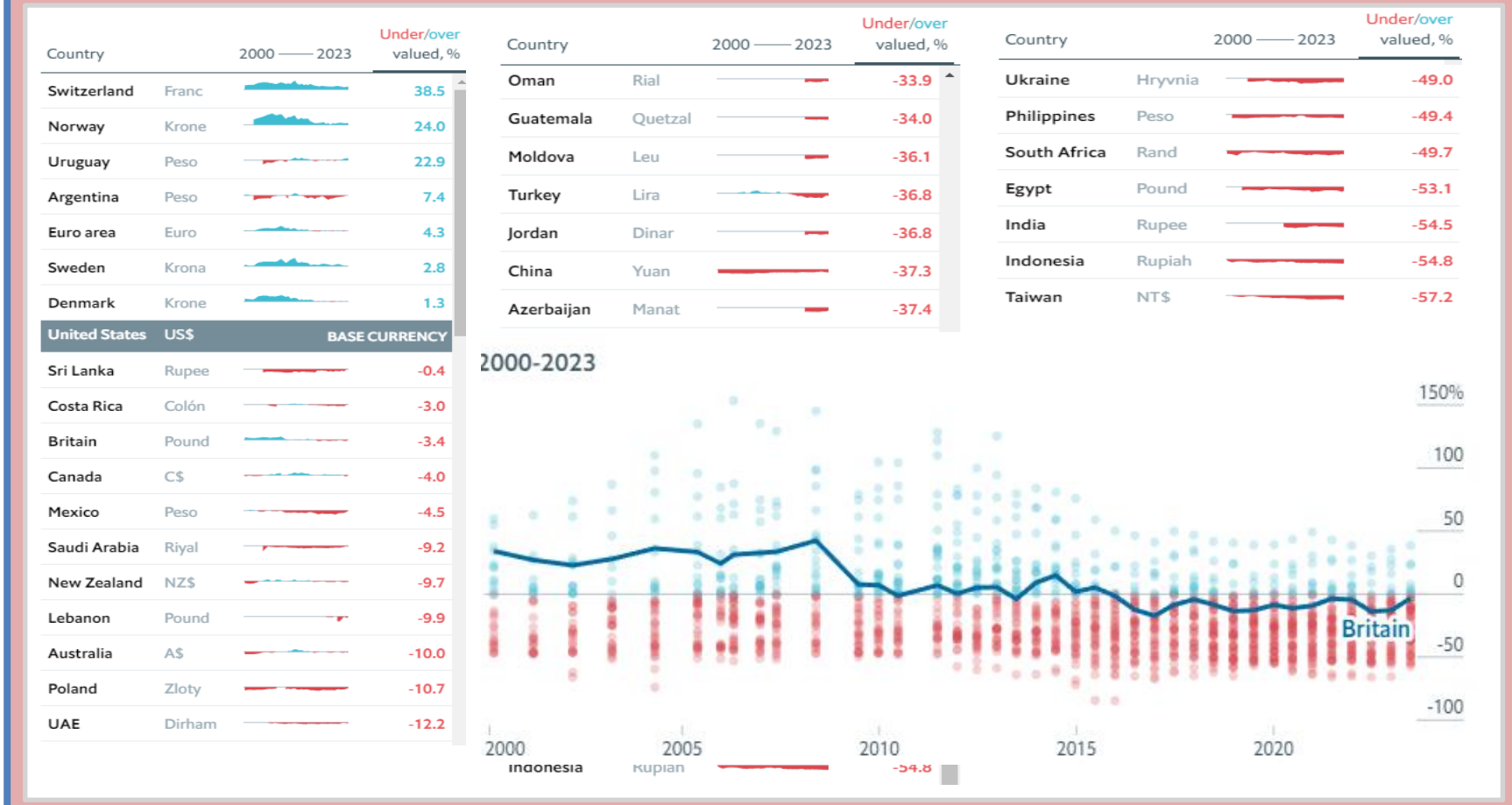


- A Big Mac costs **SFr6.70** in Switzerland and **US$5.58** in the United States. The implied exchange rate is **1.20**. The difference between this and the actual exchange rate, **0.87**, suggests the Swiss franc is **38.5% overvalued**
- A Big Mac costs **19.90 zloty** in Poland and **US$5.58** in the United States. The implied exchange rate is 3.57. The difference between this and the actual exchange rate, **3.99**, suggests the Polish zloty is **10.7% undervalued**
- A Big Mac costs **NT$75 in** Taiwan and **US$5.58** in the United States. The implied exchange rate is 13.44. The difference between this and the actual exchange rate, **31.43**, suggests the Taiwanese dollar is **57.2% undervalued**

Source: https://www.economist.com/big-mac-index

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

FIGURE 3-5 (2 of 2) The Big Mac Index (continued)



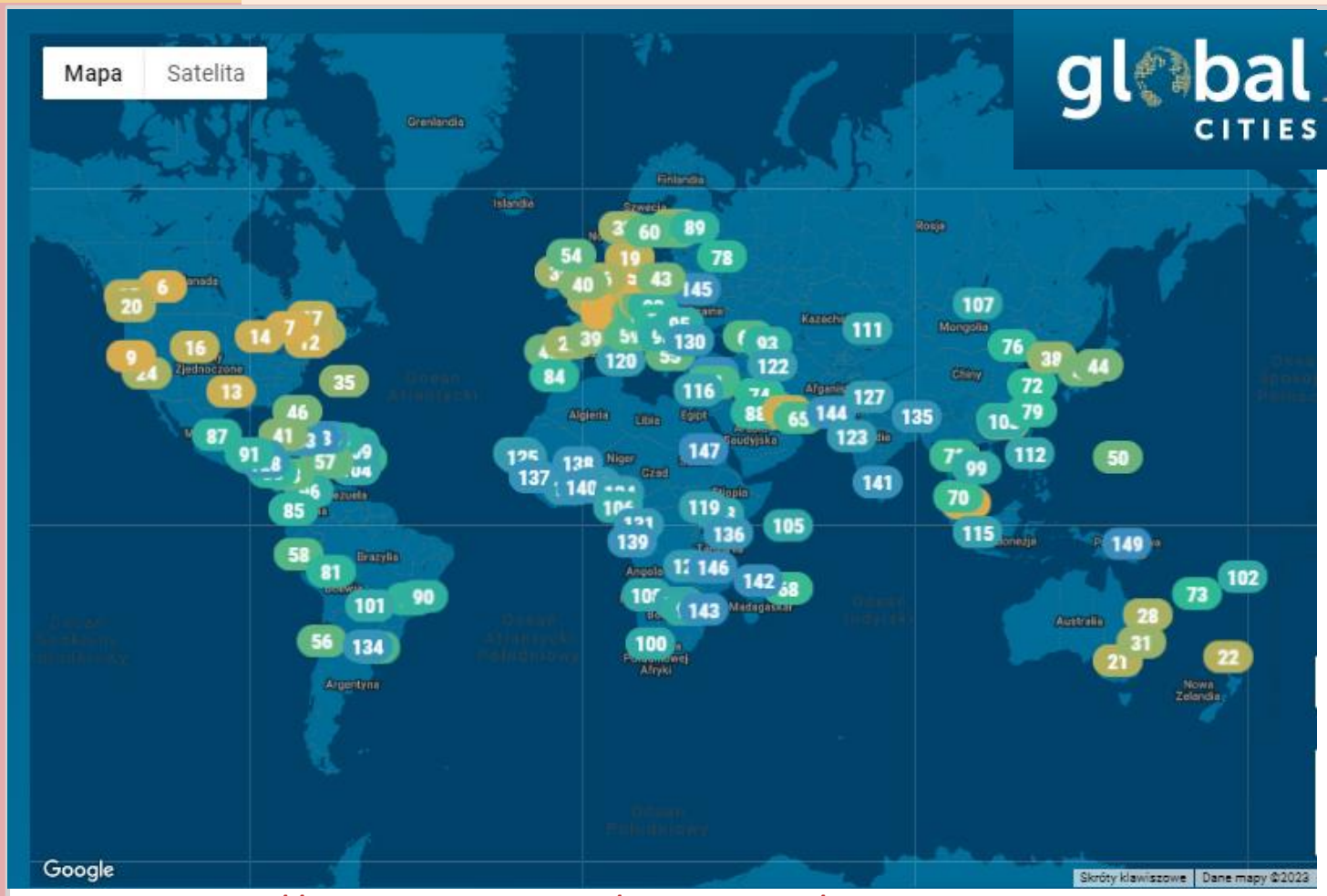
Country		2000 — 2023	Under/over valued, %
Switzerland	Franc		38.5
Norway	Krone		24.0
Uruguay	Peso		22.9
Argentina	Peso		7.4
Euro area	Euro		4.3
Sweden	Krona		2.8
Denmark	Krone		1.3
United States	US$		BASE CURRENCY
Sri Lanka	Rupee		-0.4
Costa Rica	Colón		-3.0
Britain	Pound		-3.4
Canada	C$		-4.0
Mexico	Peso		-4.5
Saudi Arabia	Riyal		-9.2
New Zealand	NZ$		-9.7
Lebanon	Pound		-9.9
Australia	A$		-10.0
Poland	Zloty		-10.7
UAE	Dirham		-12.2

Country		2000 — 2023	Under/over valued, %
Oman	Rial		-33.9
Guatemala	Quetzal		-34.0
Moldova	Leu		-36.1
Turkey	Lira		-36.8
Jordan	Dinar		-36.8
China	Yuan		-37.3
Azerbaijan	Manat		-37.4
Indonesia	Rupiah		-54.8

Country		2000 — 2023	Under/over valued, %
Ukraine	Hryvnia		-49.0
Philippines	Peso		-49.4
South Africa	Rand		-49.7
Egypt	Pound		-53.1
India	Rupee		-54.5
Indonesia	Rupiah		-54.8
Taiwan	NT$		-57.2

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

FIGURE 3-6 (1 of 2) If you could live anywhere in the world… **WHERE WOULD IT BE?**



Source: https://www.air-inc.com/global-150/

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

Table 3-1 If you could live anywhere in the world… **WHERE WOULD IT BE?**

	Overall Attractiveness Global 150 cities index	Lifestyle Rank Global 150 cities index	Financial Rank Global 150 cities index
1	Zurich, Switzerland	Prague, Czech Republic	Manama, Bahrain
2	Geneva, Switzerland	Toronto ON, Canada	Zurich, Switzerland
3	Munich, Germany	Tokyo, Japan	George Town, Cayman Islands
4	Luxembourg	Zurich, Switzerland	Geneva, Switzerland
5	Berlin, Germany	Montreal QC, Canada	Riyadh, Saudi Arabia
6	Calgary AB, Canada	Helsinki, Finland	Macau
7	Toronto ON, Canada	Munich, Germany	Kuwait City, Kuwait
8	Singapore	Berlin, Germany	Abu Dhabi, U.A.E.
9	San Francisco CA, U.S.A.	Calgary AB, Canada	Amman, Jordan
10	Vienna, Austria	Singapore	Guatemala City, Guatemala
11	Dubai, U.A.E.	Vancouver BC, Canada	Houston TX, U.S.A.
12	New York NY, U.S.A.	Copenhagen, Denmark	Seattle WA, U.S.A.
13	Houston TX, U.S.A.	Dublin, Ireland	Dubai, U.A.E.
14	Chicago IL, U.S.A.	Geneva, Switzerland	Chicago IL, U.S.A.
15	Vancouver BC, Canada	Vienna, Austria	Luxembourg
16	Denver CO, U.S.A.	Melbourne, Australia	Denver CO, U.S.A.
17	Montreal QC, Canada	Amsterdam, Netherlands	San Francisco CA, U.S.A.
18	Prague, Czech Republic	Paris, France	Boston MA, U.S.A.
19	Copenhagen, Denmark	Seoul, Korea	Los Angeles CA, U.S.A.
20	Seattle WA, U.S.A.	Luxembourg	Doha, Qatar

1 Exchange Rates and Prices in the Long Run: Purchasing Power Parity and Goods Market Equilibrium

FIGURE 3-6 (2 of 2) If you could live anywhere in the world… **WHERE WOULD IT BE?**

Source: https://www.air-inc.com/global-150/

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

- In the long run the exchange rate is determined by the ratio of the price levels in two countries. But this prompts a question: *What determines those price levels?*
- Monetary theory supplies an answer: In the long run, price levels are determined in each country by the relative demand and supply of money.
- This section recaps the essential elements of monetary theory and shows how they fit into our theory of exchange rates in the long run.

What Is Money?

Economists think of **money** as performing three key functions in an economy:

1. Money is a *store of value* because it can be used to buy goods and services in the future. If the opportunity cost of holding money is low, we will hold money more willingly than we hold other assets.

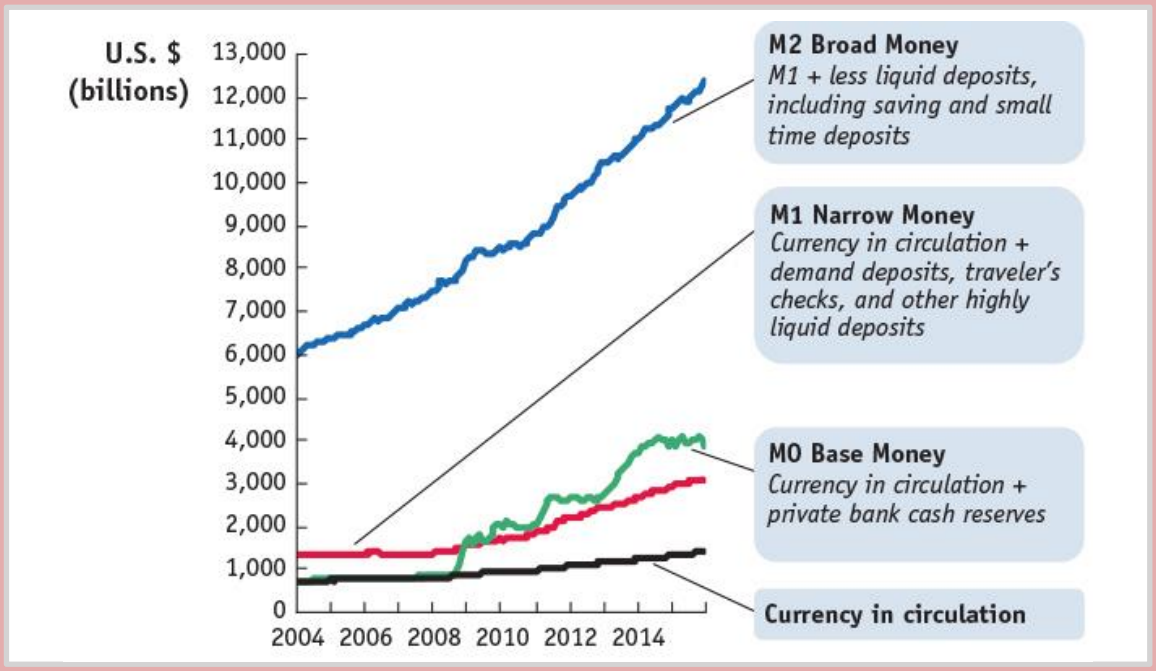
2. Money also gives us a *unit of account* in which all prices in the economy are quoted.

3. Money is a *medium of exchange* that allows us to buy and sell goods and services without the need to engage in inefficient barter.

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

The Measurement of Money

FIGURE 3-7



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 2015. 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**).

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

- All else equal, a rise in national dollar income (nominal income) will cause a proportional increase in transactions and in aggregate money demand.

The Demand for Money: A Simple Model

- Dividing the previous equation by *P,* the price level, we can derive the *demand for real money balances*:

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

- Real money balances are simply a measure of the purchasing power of the stock of money in terms of goods and services. The demand for real money balances is strictly proportional to real income.

Equilibrium in the Money Market

- The condition for equilibrium in the money market is simple to state: The demand for money M^d must equal the supply of money M, which we assume to be under the control of the central bank.
- Imposing this condition on the last two equations, we find that nominal money supply equals nominal money demand:

$$M = \overline{L}\, P\, Y$$

and, equivalently, that real money supply equals real money demand:

$$\frac{M}{P} = \overline{L}\, Y$$

A Simple Monetary Model of Prices

- Expressions for the price levels in the United States and Europe are:

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

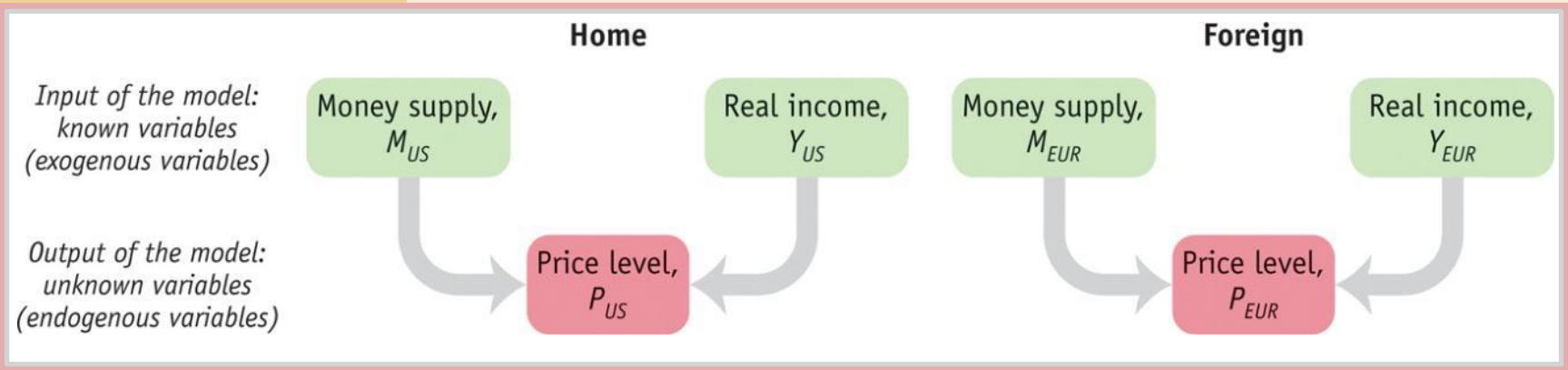
- These two equations are examples of the **fundamental equation of the monetary model of the price level**.

- In the long run, we assume prices are flexible and will adjust to put the money market in equilibrium.

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

A Simple Monetary Model of Prices

FIGURE 3-8



Building Block: The Monetary Theory of the Price Level According to the Long-Run Monetary Model In these models, the money supply and real income are treated as known exogenous variables (in the green boxes). The models use these variables to predict the unknown endogenous variables (in the red boxes), which are the price levels in each country.

A Simple Monetary Model of the Exchange Rate

Plugging the expression for the price level in the monetary model to Equation (3-1), we can use absolute PPP to solve for the exchange rate:

$$\underbrace{E_{\$/€}}_{\text{Exchange Rate}} = \underbrace{\frac{P_{US}}{P_{EUR}}}_{\text{Ratio of price levels}} = \frac{\left(\frac{M_{US}}{\bar{L}_{US}Y_{US}}\right)}{\left(\frac{M_{EUR}}{\bar{L}_{EUR}Y_{EUR}}\right)} = \underbrace{\frac{(M_{US}/M_{EUR})}{(\bar{L}_{US}Y_{US}/\ \bar{L}_{EUR}Y_{EUR})}}_{\text{Relative nominal money supplies divided by relative real money demands}} \qquad (3\text{-}4)$$

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

Money Growth, Inflation, and Depreciation

The implications of the fundamental equation of the monetary approach to exchange rates are intuitive.

- Suppose the U.S. money supply increases, all else equal. The right-hand side increases (the U.S. nominal money supply increases relative to Europe), causing the exchange rate to increase (the U.S. dollar depreciates against the euro).

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

Money Growth, Inflation, and Depreciation

The implications of the fundamental equation of the monetary approach to exchange rates are intuitive.

- Now suppose the U.S. real income level increases, all else equal. Then the right-hand side decreases (the U.S. real money demand increases relative to Europe), causing the exchange rate to decrease (the U.S. dollar appreciates against the euro).

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

Money Growth, Inflation, and Depreciation

The U.S. money supply is M_{US}, and its growth rate is μ_{US}:

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

The growth rate of real income in the U.S. is g_{US}:

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

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}. Thus, we know that:

$$\pi_{US,t} = \mu_{US,t} - g_{US,t} \qquad (3\text{-}5)$$

The rate of change of the European price level is the inflation rate π_{EUR}, and is calculated similarly:

$$\pi_{EUR,t} = \mu_{EUR,t} - g_{EUR,t} \qquad (3\text{-}6)$$

When money growth is higher than income growth, we have "more money chasing fewer goods" and this leads to inflation.

Money Growth, Inflation, and Depreciation

Combining (3-4) and (3-5), we can now solve for the inflation differential in terms of monetary fundamentals and compute the rate of depreciation of the exchange rate:

$$\underbrace{\frac{\Delta E_{\$/€,t}}{E_{\$/€,t}}}_{\text{Rate of depreciation of the nominal exchange rate}} = \underbrace{\pi_{\text{US,t}} - \pi_{\text{EUR,t}}}_{\text{Inflation differential}} = \left(\mu_{\text{US,t}} - g_{\text{US,t}}\right) - \left(\mu_{\text{EUR,t}} - g_{\text{EUR,t}}\right) \qquad (3\text{-}7)$$

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

Money Growth, Inflation, and Depreciation

The intuition behind Equation (3-6) is as follows:

- If the United States runs a looser monetary policy in the long run, measured by a faster money growth rate, the dollar will depreciate more rapidly, all else equal.

- If the U.S. economy grows faster in the long run, the dollar will appreciate more rapidly, all else equal.

Thank You for your attention!