Chapter 13

Introduction to Exchange Rates and the Foreign Exchange Market
Chapter 13: Outline

• 13–1 Exchange Rate Essentials
  ✷ Definitions
    ▪ Appreciations and depreciations
  ✷ Using exchange rates to compare prices
    ▪ Exchange rate changes and relative prices

• 13–2 Exchange Rates in Practice
  ✷ The policy environment
    ▪ Exchange rate regimes
    ▪ Simple abstraction: fixed versus floating regimes
    ▪ Complex reality: multiple regime types
    ▪ Case studies
Chapter 13: Outline

• **13–3 The Market for Foreign Exchange**
  - The market environment: actors and arbitrage
  - Characteristics of the forex market

• **13–4 Arbitrage and exchange rates**
  - Cross rates and vehicle currencies

• **13–5 Arbitrage and interest rates**
  - Assets and their attributes
  - Riskless Arbitrage and Covered Interest Parity
  - Risky Arbitrage and Uncovered Interest Parity
    - Allowing for risk premia

• **13–6 Conclusion**
LEARNING OBJECTIVES
13–1 Exchange Rate Essentials

• Understand definition of the exchange rate between home and foreign currencies
  • and between home and rest of world
• Understand appreciations and depreciations
• Understand how to use exchange rates to convert prices into a common currency
• Understand how changes in exchange rates affect the relative prices of goods from different countries
Definitions

- **Exchange rate** \( (E_{\text{domestic/foreign}}) \)
  - The price of a unit of foreign currency in terms of domestic currency for immediate purchase
  - To be completely accurate this measure is
    - In general, we will use the term “exchange rate” to mean the **spot bilateral nominal exchange rate** for simplicity.
    - A **nominal** rate (refers to the relative values of currencies)
    - A **spot** rate (refers to a trade at this instant)
    - A **bilateral** rate (one currency versus another)
    - There are other exchange rates which refer to real values, trades at future times, or multiple currencies.
  - The exchange rate \( E \) measures the relative price of one currency in terms of another.
    - For example: if the U.S. dollar price of 1 U.K. pound sterling (\( £1 \)) is \$1.95, then \( E_{\$/£} = 1.95 \).
Definitions

• We must always take care with units
  - For any pair of currencies, the exchange rate can be expressed two ways, where one way is the inverse of the other
  - For example: suppose the U.S. dollar price of 1 euro (€1) is $1.25, then $\frac{E}{\text{€}} = 1.25.$
    - This is known as the “American terms.” (What Americans must pay in dollars to buy European currency.)
  - If 1 euro is worth $1.25, how much is $1 worth?
  - Taking the inverse, $\frac{E}{\text{€}} = 1/1.25 = 0.80.$
    - This is known as the “European terms.” (What Europeans must pay in euros to buy U.S. currency.)
Examples: Typical Charts
American v European Terms (inverse of each other)

The US exchange rate
= The American terms
= $/€
= cost of €1 in $
= value of €1 in $

The Eurozone exchange rate
= The European terms
= €/$
= cost of $1 in €
= value of $1 in €
### Exchange Rates for 07/08/06

<table>
<thead>
<tr>
<th>Country</th>
<th>Today</th>
<th>Year ago</th>
<th>per £</th>
<th>per euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1.31</td>
<td>1.3</td>
<td>2.49</td>
<td>1.68</td>
</tr>
<tr>
<td>Britain</td>
<td>0.52</td>
<td>0.56</td>
<td>-</td>
<td>0.67</td>
</tr>
<tr>
<td>Canada</td>
<td>1.13</td>
<td>1.22</td>
<td>2.15</td>
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<tr>
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<td>5.79</td>
<td>6.04</td>
<td>11.05</td>
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</tr>
<tr>
<td>EURO-11</td>
<td>0.78</td>
<td>0.81</td>
<td>1.48</td>
<td>-</td>
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<tr>
<td>Hong Kong</td>
<td>7.77</td>
<td>7.77</td>
<td>14.83</td>
<td>10.01</td>
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<tr>
<td>Japan</td>
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<td>218.25</td>
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<td>Spain</td>
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<td>0.81</td>
<td>1.48</td>
<td>166.39</td>
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<tr>
<td>Sweden</td>
<td>7.14</td>
<td>7.56</td>
<td>13.63</td>
<td>9.19</td>
</tr>
<tr>
<td>United States</td>
<td>-</td>
<td>-</td>
<td>1.91</td>
<td>1.29</td>
</tr>
</tbody>
</table>
Appreciations and Depreciations

- If a currency starts to buy more of another currency we say it has **appreciated** against that currency.
- If a currency starts to buy less of another currency we say it has **depreciated** against that currency.

  - For example, suppose the terms are:
    \[ E_\$/\€ = 1.2000 \text{ a year ago, } E_\$/\€ = 1.2500 \text{ today} \]
    \[ E_{\€/\$} = 0.8333 \text{ a year ago, } E_{\€/\$} = 0.8000 \text{ today} \]

  - A euro buys \( \Delta E_\$/\€ / E_\$/\€ = 0.05 / 1.20 = 4.1667\% \) more dollars: the euro has appreciated by (about) 4\% against the dollar.

  - A dollar buys \( \Delta E_{\€/\$} / E_{\€/\$} = 0.0333 / 0.8333 = 4\% \) fewer euros: the dollar has depreciated by 4\% against the euro.

  - Note that the home depreciation approximately equals the foreign appreciation.
Appreciations and Depreciations

• Take care: the definition can seem counterintuitive at first glance, and therefore potentially confusing.
  ◯ The U.S. exchange rate is the price of euros in dollar terms
  ◯ $E_{$/€} = 1.2000$ a year ago, $E_{$/€} = 1.2500$ today
  ◯ The exchange rate $E$ has risen.
  ◯ A dollar is now worth less than one year ago.
• An increase in the U.S. exchange rate $E_{$/€}$ indicates a depreciation of the U.S. currency.
• A decrease in the U.S. exchange rate $E_{$/€}$ indicates an appreciation of the U.S. currency.
  ◯ In fact this makes sense. Why?
  ◯ When the (dollar) price of anything falls, the dollar is appreciating in value relative to that thing.
  ◯ Here the thing is the euro.
Examples

The US exchange rate
\[ E_{\$/\欧元} \]
= cost of €1 in $  
RISING TREND MEANS $ DEPRECIATING AGAINST €

The Eurozone exchange rate
\[ E_{\€/$} \]
= cost of $1 in €  
FALLING TREND MEANS € APPRECIATING AGAINST $
### Exchange Rates for 07/08/06

<table>
<thead>
<tr>
<th>Country</th>
<th>per $</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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**$ Appreciation**
Change in foreign currency value of $1
### Exchange Rates for 07/08/06

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<th>Country</th>
<th>per $ Today</th>
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</thead>
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<td>7.56</td>
</tr>
<tr>
<td>United States</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**$ Appreciation**

Change in foreign currency value of $1

- +1%
- -7%
- -7%
- -4%
- -4%
- No change
- +2%
- -4%
- -6%
- -
Multilateral Exchange Rates

• In the last example we saw that the U.S. dollar appreciated against some currencies and depreciated against others.
  ✷ These **bilateral exchange rates** show changes against each foreign currency in turn relative to some base year.

• Can we say “on average” how the value of the U.S. dollar changed against the rest of the world?
  ✷ Yes. A “basket” of foreign currencies is used.
  ✷ The weight of each currency in the basket (in a base year) is given by the share of that country in U.S. trade.
  ✷ Changes in dollar price of this basket tell us how value of the dollar has changed “on average” against all currencies.
  ✷ This defines the change in the **multilateral exchange rate**.
Multilateral Exchange Rates

- Example: Trade weights in the U.S. “broad” multilateral exchange rate computed by the Federal Reserve:

  - Euro area 18.80%
  - Canada 16.43%
  - China 11.35%
  - Japan 10.58%
  - Mexico 10.04%
  - U.K. 5.17%
  - Korea 3.86%
  - Taiwan 2.87%
  - Hong Kong 2.33%
  - Malaysia 2.24%
  - Singapore 2.12%

  plus 15 others (less than 2% each)
**Multilateral Exchange Rates**

- The multilateral exchange rate is referred to as the **nominal effective exchange rate** (NEER) or \( E_{\text{effective}} \).
  - Changes in NEER are measured relative to some base year.
  - If the home country trades with countries 1, \( \ldots \), \( N \) then the FRACTIONAL (%) change in NEER relative to the base year is calculated as the *trade-weighted average* change in each bilateral exchange rate:

\[
\frac{\Delta E_{\text{effective}}}{E_{\text{effective}}} = \frac{\text{Trade}_1}{\text{Trade}} \frac{\Delta E_1}{E_1} + \frac{\text{Trade}_2}{\text{Trade}} \frac{\Delta E_2}{E_2} + \ldots + \frac{\text{Trade}_N}{\text{Trade}} \frac{\Delta E_N}{E_N}
\]

trade-weighted average of bilateral nominal exchange rate changes
### Example: Multilateral Exchange Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>Nominal Effective Exchange Rate (Jan. 2002=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-2002</td>
<td>100</td>
</tr>
<tr>
<td>Jan-2003</td>
<td>95</td>
</tr>
<tr>
<td>Jan-2004</td>
<td>90</td>
</tr>
<tr>
<td>Jan-2005</td>
<td>85</td>
</tr>
<tr>
<td>Jan-2006</td>
<td>80</td>
</tr>
</tbody>
</table>

**Graph:**
- **Foreign currency baskets per U.S. dollar**
- **Broad index** (basket of 26 currencies)
- **Major index** (basket of 7 currencies)

**Legend:**
- Foreign appreciation
- Dollar depreciation
Using exchange rates to compare prices

• Why are exchange rates useful?
• Suppose you wish to compare the prices of a good sold in two locations.
  ⊕ It sells in the UK for $P_{UK}$ expressed in £.
  ⊕ It sells in the US for $P_{US}$ expressed in $.
  ⊕ The currency units differ.
• The only meaningful way to compare prices is by converting to a common currency
  ⊕ E.g., the UK price in dollar terms is $E_{$/£} P_{UK}$.
  ⊕ Always check units. Here $$/£$ times £ = $. OK.
**Example: Retail Therapy for James Bond**

**Table 13-2**

*Using the Exchange Rate to Compare Prices in a Common Currency*  
Now pay attention 007! This table shows how the hypothetical cost of James Bond’s next tuxedo in different locations depends on the exchange rates that prevail.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of the tuxedo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in local currency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hong Kong</td>
<td>HK$30000</td>
<td>HK$30000</td>
<td>HK$30000</td>
<td>HK$30000</td>
</tr>
<tr>
<td>New York</td>
<td>$3000</td>
<td>$3000</td>
<td>$3000</td>
<td>$3000</td>
</tr>
<tr>
<td>Exchange rates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HK$/£</td>
<td>15</td>
<td>16</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>$/£</td>
<td>1.5</td>
<td>1.4</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Cost of the tuxedo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in pounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hong Kong</td>
<td>£2000</td>
<td>£1875</td>
<td>£2143</td>
<td>£2143</td>
</tr>
<tr>
<td>New York</td>
<td>£2000</td>
<td>£2143</td>
<td>£1875</td>
<td>£2143</td>
</tr>
</tbody>
</table>
Using exchange rates to compare prices

• Lessons? If the prices of a good in are fixed in home currency terms in all locations:
  - Changes in the exchange rate cause changes in prices of foreign goods expressed in the home currency
  - Changes in the exchange rate cause changes in the relative prices of goods produced in different countries
  - When the home country’s exchange rate depreciates against the foreign country, home exports become less expensive as imports to foreigners, and foreign exports look more expensive as imports to home residents
  - When the home country’s exchange rate appreciates against the foreign country, home export goods look more expensive as imports to the foreigners, and foreign export goods look cheaper as imports to home residents

• Looking ahead: Can you think why these effects might be economically important?
LEARNING OBJECTIVES
13–2 Exchange Rates in Practice

• Gain familiarity with different kinds of observed exchange rate behavior
• Understand the classification of this behavior via exchange rate regimes
• Understand a simple and coarse classification that is widely used:
  ♦ Fixed versus Floating
• Learn about some of the finer classifications and be aware of the existence of intermediate regimes
Exchange rate regimes

- Any theory of exchange rates must account for observed behavior, so we familiarize ourselves with patterns we seek to explain.
- For the purposes of classification, different patterns of behavior are grouped into categories known as exchange-rate regimes.
  - These regimes reflect policy choices made by governments, and their causes and consequences will be a major focus of our study.
- For most purposes, two general categories are sufficient:
  - **Fixed** exchange-rate regimes
  - **Floating** exchange-rate regimes
- Note
  - This is a coarse classification
  - Finer distinctions are possible (see later).
  - It is not always possible to rely on what governments announce as their exchange rate regime. It is more reliable to look at how the exchange rate actually behaves (see later).
Regimes with a **fixed exchange rate** (or pegged exchange rate) are those where a country’s exchange rate does not fluctuate at all (or only very very narrowly) against some base currency over a sustained period, usually a year or longer.

- **Note:** It is not chance when market prices remain rigidly fixed for long periods. Such an outcome is the result of government intervention, in one or both countries.

- **Questions:** How common is this type of intervention? How and why is it carried out? Our theories will have to address these features of the data.
Regimes with a **floating exchange rate** (or flexible exchange rate) are all the other cases: those where a country’s exchange rate typically fluctuates over time, and the authorities make no attempt to fix it against any other base currency. Appreciations and depreciations may occur from year to year, each month, even by the day or every minute.

- Note: Governments are still pursuing objectives, but tight control over the exchange rate isn’t one of them.
- Questions: How common are these changes and how large? Our theories must account for a wide range of experience: the amplitude or volatility of these fluctuations may vary greatly from one floating regime to another.
Exchange rate regimes: examples 1
CAN YOU IDENTIFY FIXED AND FLOATING?

Selected developed countries
Scale x2

![Graphs showing exchange rates for various currencies over years 1996 to 2004.](Image)
Exchange rate regimes: examples 2
CAN YOU IDENTIFY FIXED AND FLOATING?

Selected developing countries
Asia
Scale x3

Latin America
Scale x10

dollarization complete by end 2000
Both fixed and floating regimes are widely in use: so we need to understand both types of regime

- Questions: how do they work? why are they chosen?

Note: Fixed category includes many countries that use a currency other than their own (e.g., eurozone and dollarized economies)

- Questions: what is going on there?
### Dollarized economies

<table>
<thead>
<tr>
<th>Economy</th>
<th>Currency</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Samoa</td>
<td>U.S. $</td>
</tr>
<tr>
<td>Andorra</td>
<td>euro</td>
</tr>
<tr>
<td>British Virgin Islands</td>
<td>U.S. $</td>
</tr>
<tr>
<td>Cocos (Keeling) Islands</td>
<td>Aus. $</td>
</tr>
<tr>
<td>Cook Islands</td>
<td>N.Z. $</td>
</tr>
<tr>
<td>Cyprus, Northern</td>
<td>Turkish lira</td>
</tr>
<tr>
<td>East Timor</td>
<td>U.S. $</td>
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<tr>
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</tr>
<tr>
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<tr>
<td>Greenland</td>
<td>Dan. krone</td>
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<td>Guam</td>
<td>U.S. $</td>
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<tr>
<td>Kiribati</td>
<td>Aus. $</td>
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</tr>
<tr>
<td>Liechtenstein</td>
<td>Swiss franc</td>
</tr>
<tr>
<td>Marshall Islands</td>
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<tr>
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<tr>
<td>Nauru</td>
<td>Aus. $</td>
</tr>
<tr>
<td>Niue</td>
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</tr>
<tr>
<td>Norfolk Island</td>
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<tr>
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<td>U.S. Virgin Islands</td>
<td>U.S. $</td>
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<tr>
<td>Vatican City</td>
<td>euro</td>
</tr>
</tbody>
</table>

Note: Only some of these are independent states. * Issues own coins.
LEARNING OBJECTIVES
13–3 The Market for Foreign Exchange

• Understand some of the basic characteristics of the forex (FX) market
  ✷ Overview of the market
  ✷ Types of contracts
    ▪ Spot and Forward
    ▪ Other Derivatives
  ✷ Private actors
  ✷ Government actors
Forex Market Characteristics

• Perhaps the biggest global market of all?
  ❖ Very large market
    ▪ $1.9 trillion ($1,900 billion) PER DAY in 2004
    ▪ Main centers account for more than 50% of transactions:
      London ($753 bn), NY ($461 bn), Tokyo ($199 bn)
  ❖ Very liquid market
    ▪ Can quickly find counterparties willing to buy/sell
    ▪ Large sales/purchases don’t much affect the market price
  ❖ Near-continuous market
    ▪ Trading is spread over almost all time zones
    ▪ Runs 24 hours a day (except on weekends)
  ❖ Not a centrally organized market or exchange
    ▪ Forex market has no exchange trading. Instead, there is over-the-counter trading (OTC), which is bilateral (between two parties).
    ▪ Default risk very low; most settlement is now nearly instantaneous.
  ❖ Nearly frictionless market (spreads= fees+commission < 0.03%)
    ▪ Usually. But not for small tourist trades! Only on big trades by banks
    ▪ Even lower on the most commonly traded currencies (<0.01%)
Key currencies

- Main currencies traded (% of transactions)
  - $ 89%
  - € 37%
  - ¥ 20%
  - £ 17%
  (note: these add up to 200%; there are 2 currencies in each trade)

- Main currency pairs traded (% of transactions)
  - $/€ 28%
  - $/¥ 17%
  - £/$ 14%
Types of contracts

- **Spot**
  - A and B agree to trade one currency for another for delivery on the spot at set price. (Continuous linked settlement since 1997.)

- **Forward**
  - A and B agree to trade currencies at set price in the future. Contract cannot be traded to third parties.

- **Swap**
  - A and B agree to trade at set price today and do reverse trade at a set price in the future. I.e. a contract that combines a spot and a forward (lower transaction costs than 2 contracts).

- **Futures**
  - A and B agree to trade currencies at set price in the future. Either side of contract can be traded to third parties C, D, E,... (on exchanges). Parties left holding contract must deliver.

- **Options**
  - A grants to B option to buy (call) or sell (put) currencies from/to at set price in the future. B may or may not execute the option, but if B opts to execute the contract then A must deliver.
Example 1: Hedging via derivatives

- As Chief Financial Officer of a U.S. firm you expect to receive payment of €1 million in 90 days for exports to France. The current spot rate is $1.10 per euro. Your Chief Executive Officer knows that severe losses would be incurred on the deal if the dollar weakened to less than $1 per euro. You advise that the firm buy €1 million in call options on dollars at a rate of $1.05 per euro, ensuring that the firm’s euro receipts will sell for at least this rate. This locks in profit even if the spot rate falls below $1.05. This is hedging.
Example 2: Speculation via derivatives

- The market currently prices one-year euro futures at $1.20, but you think the dollar will weaken to $1.32 in the next 12 months. If you wish to make a bet, you would buy these futures and if you are proved right you will realize a 10% profit. Any level above $1.20 will generate a profit. If the dollar is at or below $1.20 a year from now, however, your investment in futures will be a total loss. This is speculation.
Major contracts

- Major type of contract: spot
  - Total involving spots: $1600 bn day
    - Spot (outright): $600 bn/day
    - Spot (combined with forward=swap): $1000 bn/day
  - Others: $400 bn/day
    - Forwards (outright): $200 bn/day
    - Options: $200 bn/day

- We focus on spot and forward contracts
  - Key question: How are these contracts priced?
Example: Spot and forward quotes (daily from the *Financial Times*)

Data available at www.ft.com/marketsdata

<table>
<thead>
<tr>
<th>Spot</th>
<th>Forwards (1, 3, 12 mo.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aug 7</strong></td>
<td><strong>One month</strong></td>
</tr>
<tr>
<td><strong>European currencies</strong></td>
<td><strong>Rate</strong></td>
</tr>
<tr>
<td>Czech Rep. (Koruna)</td>
<td>21.9163</td>
</tr>
<tr>
<td>Denmark (DKr)</td>
<td>5.7911</td>
</tr>
<tr>
<td>Hungary (Forint)</td>
<td>210.161</td>
</tr>
<tr>
<td>Norway (Nkr)</td>
<td>6.1223</td>
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<tr>
<td>Poland (Zloty)</td>
<td>3.0202</td>
</tr>
<tr>
<td>Russia (Rouble)</td>
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</tr>
<tr>
<td>Slovakia (Koruna)</td>
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</tr>
<tr>
<td>Slovenia (Tolar)</td>
<td>186.066</td>
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<tr>
<td>Sweden (SKr)</td>
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<tr>
<td>Switzerland (SFr)</td>
<td>1.2182</td>
</tr>
<tr>
<td>Turkey (Lira)</td>
<td>1.479</td>
</tr>
<tr>
<td>UK (0.5236)* (£)</td>
<td>1.9108</td>
</tr>
<tr>
<td>Euro (0.7777)*</td>
<td>1.2866</td>
</tr>
</tbody>
</table>

Foreign terms, except * = American terms (traditional)
Example: \$ per euro, spot and forward
Private actors

- **Commercial banks**
  - The key players are forex traders, most of whom work for big commercial banks.
  - They engage in **interbank trading** (all electronic) between bank accounts in different currencies.
  - Major trading banks (% of volume) are Deutsche 17%, UBS 12.5%, Citi 7.5%, HSBC 6.4%, Barclays 5.9%.
  - This top 5 = 50% of the market.
  - The top 10 = 75% of the market.

- **Other players**
  - Other players are avoiding bank middlemen and fees and set up their own forex trading operations if their forex business is big enough.
  - Major corporations (e.g., multinationals)
  - Nonbank financial firms (e.g., mutual funds)
Governments may also get involved in forex market

1. Government may control or regulate forex market
   - Government does not want an unfettered forex market
   - May impose *capital controls* to limit trading
   - In extremis they may try to shut down the forex market

2. Government may intervene by buying and selling domestic currency in the forex market
   - Government is willing to let the market operate but wishes to influence the market price, that is to exercise some control over the exchange rate.
   - Usually this *intervention* is handled by the monetary authority, which in most cases is the *central bank*. 
The most common example is intervention by the central bank to maintain a **fixed exchange rate**. To achieve this goal the authorities must stand ready to buy or sell domestic currency at fixed rate E in exchange for the anchor or base currency.

- Note an important asymmetry.
- If private actors want to sell forex to the bank in exchange for domestic currency at E no problem: the bank can print more domestic currency.
- If private actors want to sell domestic currency to the bank in exchange for forex at E, there is a problem: the bank can’t print more forex.
- Hence the bank must hold *some* quantity of **foreign exchange reserves** as a buffer.
LEARNING OBJECTIVES
13–4 Arbitrage and Exchange Rates

• Understand the (near) equalization of exchange rates in different locations.
• Understand cross rates and vehicle currencies and why they are used for most forex transactions that do not involve two major currencies.
Arbitrage: Summary

- A major goal of players in the forex market is to exploit arbitrage opportunities. Examples are:
  - Riskless arbitrage
    - The opportunity to make a riskless profit through trading
    - Such opportunities do not go unexploited!
  - Risky arbitrage
    - The opportunity to make trades in which make a profit “on average”—i.e., an expected profit (but with some risk)
    - These opportunities might be avoided by “risk averse” traders.
    - But “risk neutral” traders would not be deterred and would exploit these opportunities too.
- We look at two kinds of arbitrage
  - Exchange rate arbitrage (this section)
  - Interest rate arbitrage (next section)
  - Same principles apply throughout (and in next chapter too)
**Exchange rate arbitrage**

**Figure 13-7**

**Arbitrage and Spot Rates** Arbitrage ensures that the trade of currencies in New York along the path AB occurs at the same exchange rate as via London along path ACDB. Hence, at B the pounds received must be the same on both paths, and \( E_{\text{N.Y.}}^{\text{£/$}} = E_{\text{London}}^{\text{£/$}} \)

A

1 dollar in New York

transfer dollars to London

1 dollar in London

\[ \times E_{\text{N.Y.}}^{\text{£/$}} \]

sell dollar for pounds in New York

\[ \times E_{\text{London}}^{\text{£/$}} \]

sell dollar for pounds in London

B

\[ E_{\text{N.Y.}}^{\text{£/$}} = E_{\text{London}}^{\text{£/$}} \]

pounds in New York

transfer pounds to New York

C

D

\[ E_{\text{London}}^{\text{£/$}} \]

pounds in London
Exchange rate arbitrage

Figure 13-8

**Arbitrage and Cross Rates** Triangular arbitrage ensures that the direct trade of currencies along the path AB occurs at the same exchange rate as via a third currency along path ACB. Hence, at B the euros received must be the same on both paths, and

\[ E_{\ell/\$} = E_{\ell/\varepsilon} E_{\varepsilon/\$} \]

**Diagram:**

- **A:**
  - 1 dollar
  - \( \times E_{\ell/\$} \) sell dollar for pounds
  - \( \times E_{\varepsilon/\$} \) sell dollar for euros

- **B:**
  - \( E_{\ell/\$} = E_{\ell/\varepsilon} E_{\varepsilon/\$} \) pounds

- **C:**
  - \( E_{\varepsilon/\$} \) euros
  - \( \times E_{\ell/\varepsilon} \) sell euros for pounds
Exchange rate arbitrage

• Market equilibrium
  ♦ “No arbitrage condition” = no profit opportunities

• Lessons
  ▪ Note: We can treat forex market as having essentially zero transaction costs
  ♦ All currencies must trade at the same price in all locations.
    ▪ Example: E$_$/£ rate must be same in NY and London
    ▪ If not: riskless profit!
  ♦ Direct trade must be at same price as trade via a third currency.
    ▪ Example: E$_$/£ must equal E$_$/€ x E€/£
Vehicle currencies

- A rough count: there exist 162 distinct currencies
- This implies 13,041 currency pairs
- Number of actively traded currency pairs is far smaller than this. (A few hundred.)
- Why?
- Most currency pairs are traded via a third currency (called the vehicle currency)
  - Main vehicle currencies are $, €, ¥, £
  - Explains why these occur in so many transactions
  - Cross rates are needed to work out the implied rate.
- Example: SA rand – US dollar – Mex peso
  - SA rand – Mex peso direct would be too small a market and too illiquid, leading to high transaction costs.
  - But both currencies trade heavily with the US $.
  - Lower transaction costs via US $, even if you pay twice.
LEARNING OBJECTIVES
13–5 Arbitrage and Interest Rates

• Understand riskless interest arbitrage using the spot and forward contract.
  ❖ There is “forward cover” of exchange rate risk.
  ❖ Understand the implied no arbitrage condition: covered interest parity (CIP).

• Understand risky interest arbitrage using only spot contracts.
  ❖ There is no “forward cover” of exchange rate risk.
  ❖ Understand the implied no arbitrage condition: uncovered interest parity (UIP).

• Understand a useful approximation to UIP

• Understand how these relationships change when contracts are subject to risk premia
Interest arbitrage

• Example: Money market bank deposits in the eurozone are paying interest of 6% for one year, but in the US only 4% for one year. You have $100 to invest. Suppose the exchange rate is $1 per €.
  ♦ Should you move all your cash to a euro money market account for one year?
Interest arbitrage

• Example: Money market bank deposits in the eurozone are paying interest of 6% for one year, but in the US only 4% for one year. You have $100 to invest. Suppose the exchange rate is $1 per €.
  ◦ Should you move all your cash to a euro money market account for one year?
• It depends…. In one year you’d have $104 or €106.
• What if the dollar–euro exchange rate changes?
  ◦ Return on investing in euro is risky
  ◦ To estimate your return you have to guess what the exchange rate $E_{\$/€}$ will be in one year’s time.
  ◦ This is a case of risky arbitrage—risk is uncovered
• On the other hand
  ◦ We know you could avoid the risk by purchasing a one year forward contract to repatriate your pounds.
  ◦ This is a case of riskless arbitrage—risk is covered
**Interest arbitrage: riskless**

**Figure 13-9**

**Arbitrage and Covered Interest Parity** Under CIP, returns to holding dollar deposits accruing interest going along the path AB, must equal the returns from investing in euros going along the path ACDB with risk removed by use of the forward contract. Hence, at B, the riskless payoff must be the same on both paths, and \( (1 + i_d) = \frac{F_{S/E}}{E_{S/E}}(1 + i_e) \).

- **A**
  - 1 dollar today
  - \( \times (1 + i_d) \)
  - earn interest on dollar deposit

- **B**
  - \( (1 + i_d) = \frac{F_{S/E}}{E_{S/E}}(1 + i_e) \)
  - dollars in one year

- **C**
  - \( \frac{1}{E_{S/E}} \)
  - euros today
  - \( \times (1 + i_e) \)
  - earn interest on euro deposit

- **D**
  - \( \frac{1}{E_{S/E}}(1 + i_e) \)
  - euros in one year

- **E**
  - \( \times F_{S/E} \)
  - sell euros and buy dollars forward, one year ahead
Covered interest parity

- CIP
  - No arbitrage condition
  - For the market to be in equilibrium the riskless returns must be equal when expressed in a common currency

\[
(1 + i_d) = (1 + i_e) \frac{F_{\$/\€}}{E_{$/\€}}
\]

- Gross dollar return on dollar deposits
- Gross dollar return on euro deposits
Solving for the forward rate F

- Knowing the spot exchange rate $E$ and the interest rates $i$ for each currency, we can solve for the forward rate $F$.

$$F_{\$/\€} = E_{\$/\€} \frac{1 + i_\$}{1 + i_\€}$$

- This is exactly how the market prices the forward contract. (±some small transaction costs)
  - Begs the question: what determines $E$? and each $i$?
  - This leads us to next look at risky arbitrage....
  - After some evidence on CIP
Evidence on CIP

\[
\begin{align*}
\text{profit} &= \left(1 + i_{\text{GER}}\right) \frac{E_{\text{UK} / \text{GER}}}{E_{\text{UK} / \text{GER}}} - \left(1 + i_{\text{UK}}\right) \\
&= \text{principal and interest from investing in German deposits measured in pounds} - \text{principal and interest from investing in U.K. deposits measured in pounds}
\end{align*}
\]

Return on German deposits minus return on UK deposits (in £)

- 1979: U.K. capital controls abolished
- 1981: German capital controls abolished
**Interest arbitrage: risky**

**Figure 13-11**

**Arbitrage and Uncovered Interest Parity** Under UIP, returns to holding dollar deposits accruing interest going along the path AB, must equal the expected returns from investing in euros going along the risky path ACDB. Hence, at B, the expected payoff must be the same on both paths, and 

\[(1 + i_s) = \frac{E^e_{S/e}}{E_{S/e}} (1 + i_e).\]
Uncovered interest parity

- UIP
  - No arbitrage condition for expected returns
  - States that the expected returns must be equal when expressed in a common currency
  - Assumes risk neutrality

\[
\left(1 + i_\$\right) = \left(1 + i_\€\right) \frac{E^e_\$/\€}{E^e_$/\€}
\]

- (gross U.S. deposit dollar return) = (gross euro deposit (expected) dollar return)
Knowing the expected exchange rate $E^e$ and the interest rates $i$ for each currency, we can solve for the spot rate $E$.

$$E_{\$/\€} = E^e_{\$/\€} \frac{1 + i_{\€}}{1 + i_{\$}}$$

- Begs the question: what determines $E^e$? and each $i$?
- This leads us to next look at theories of long run exchange rates (next chapter)....
- After some evidence on UIP
Pricing spot and forward contracts

The unknowns

- Interest rates $i_\$, i_€$
- UIP
- Expected exchange rate $E^e$

Spot contract

- CIP
- Spot exchange rate $E_{\$,€}$

Derivative

- Forward exchange rate $F_{\$,€}$
Evidence on UIP

- CIP: \( (1 + i_s) = (1 + i_e) \frac{F_{$/\€}}{E_{$/\€}} \)

- UIP: \( (1 + i_s) = (1 + i_e) \frac{E^e_{$/\€}}{E_{$/\€}} \)

- CIP+UIP imply: \( F_{$/\€} = E^e_{$/\€} \)

- Intuitive. If \( F \) did not equal \( E^e \) one party to the forward contract would be better off waiting for the more favorable expected exchange rate \( E^e \) to materialize.

- Requires that \( F \) and \( E^e \) are equal relative to spot rate:
  \[
  \frac{F_{$/\€}}{E_{$/\€}} - 1 = \frac{E^e_{$/\€}}{E_{$/\€}} - 1
  \]
  forward premium      expected rate of depreciation
Evidence on UIP

45 degree line: relationship predicted by UIP & CIP

Expected Rate of Depreciation (%) vs. Forward Premium (%)
Useful approximations

- **UIP (gross returns)**

\[
(1 + i_\$) = (1 + i_\€) \frac{E_{\$/\€}^e}{E_{\$/\€}}
\]

- **UIP approximation (net returns)**

\[
i_\$ = i_\€ + \frac{\Delta E_{\$/\€}^e}{E_{\$/\€}}
\]

- interest rate on dollar deposits
- interest rate on euro deposits
- expected rate of depreciation of the dollar
- expected dollar return on euro deposits
Allowing for risk

- What if one of the countries has a very unattractive currency from a risk perspective?
  - Exchange risk (e.g., foreign currency’s real value may be volatile compared to home currency)
  - Counterparty risk (e.g., risk of bank failure, capital controls, default on the foreign side)
  - Can be a major factor in emerging markets
- Solution: add a risk premium (RP) term

\[
i_{\text{\$}} + \left[ \text{default risk premium} \right] + \left[ \text{exchange rate risk premium} \right] = \begin{matrix} i_{\text{\euro}} + \frac{\Delta E_{\$/\euro}}{E_{\$/\euro}} \end{matrix}
\]

- Begs the question: where does the RP come from?
Chapter 13: Summary

1. The exchange rate in a country is the (nominal, spot-market) price of a unit of foreign currency expressed in terms of the domestic currency.
2. When the exchange rate rises: foreign currency costs more, so the home currency is said to have depreciated; if foreign currency buys (x%) more domestic currency, the foreign currency is said to have appreciated (by x%).
3. When the exchange rate falls: foreign currency costs less, so the home currency is said to have appreciated; if foreign currency buys (x%) less domestic currency, the foreign currency is said to have depreciated (by x%).
4. The exchange rate is used to convert the prices of goods and assets into a common currency for purposes of commensurate comparisons.
• 5. Exchange rates may be stable over time or they may fluctuate. History supplies examples of the former (fixed exchange rate regimes) and the latter (floating exchange rate regimes) as well as a number of intermediate regime types.

• 6. Some countries suffer exchange-rate crises, where the exchange rate experiences a sudden and large depreciation. These events are often associated with broader economic and political turmoil, especially in developing countries, and deserve special attention.

• 7. Some countries may forego a national currency to form a currency union with other nations (e.g., the euro) or they may unilaterally adopt the currency of another country (“dollarization”).

• 8. Looking across all countries today, fixed and floating rate regimes are about equally common, so we must understand both types of regime.
Chapter 13: Summary

- 9. The forex market is dominated by spot transactions, but many other derivative contracts exist, such as forwards, swaps, futures, and options.
- 10. The main actors in the market are private investors and (frequently) the government authorities, represented usually by the central bank.
- 11. One key to understanding the forex market is arbitrage. Spot exchange rates move closely in line in different forex market centers because transaction costs are low.
- 12. Interest arbitrage leads investors to compare the return to assets in different currencies. This type of arbitrage leads to the covered interest parity (CIP) condition and the uncovered interest parity (UIP) conditions. These conditions characterize a no-arbitrage equilibrium in the forward and spot markets.