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## INTRODUCTION TO EXCHANGE RATES AND THE FOREIGN EXCHANGE MARKET

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# Defining the Exchange Rate

- Exchange rate ( $E_{\text{domestic/foreign}}$ )
  - ◆ The price of a unit of foreign currency in terms of domestic currency for immediate purchase.
  - ◆ 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 \$1.85, then  $E_{\$/\pounds} = 1.85$ .

# Be Careful...

- 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 \$1.15, then  $E_{\$/\text{€}} = 1.15$ .
    - This is known as the “American terms.” (What Americans must pay in dollars to buy European currency.)
  - ◆ If 1 euro is worth \$1.15, how much is \$1 worth?
  - ◆ Taking the inverse,  $E_{\$/\text{€}} = 1/1.15 = 0.87$ .
    - This is known as the “European terms.” (What Europeans must pay in euros to buy U.S. currency.)

# Examples of Exchange Rate Quotations

Country (currency)	Currency Symbol	EXCHANGE RATES ON JUNE 1, 2007			EXCHANGE RATES ON JUNE 1, 2006 <i>ONE YEAR PREVIOUSLY</i>		
		(1) Per \$	(2) Per £	(3) Per €	(4) Per \$	(5) Per £	(6) Per €
Canada (dollar)	C\$	1.064	2.106	1.428	1.103	2.060	1.414
Denmark (krone)	DKr	5.551	10.99	7.449	5.819	10.87	7.458
Euro (euro)	€	<b>0.745</b>	1.475	—	<b>0.780</b>	1.457	—
Japan (yen)	¥	122.0	241.5	163.8	112.4	210.0	144.1
Norway (krone)	NKr	6.038	11.95	8.101	6.079	11.36	7.792
Sweden (krona)	SKr	6.945	13.74	9.318	7.220	13.49	9.254
Switzerland (franc)	SFr	1.231	2.436	1.652	1.218	2.276	1.562
United Kingdom (pound)	£	0.505	—	0.678	0.535	—	0.686
United States (dollar)	\$	—	1.979	<b>1.342</b>	—	1.868	<b>1.282</b>

# Appreciations and Depreciations

- Definitions
  - ◆ 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.
- The value of 1 euro
  - ◆ Example: consider the exchange rate  $E_{\$/\text{€}}$ 
    - $E_{\$/\text{€},t} = \$1.06$ ,  $E_{\$/\text{€},t+1} = \$1.28$
    - A euro buys  $\Delta E_{\$/\text{€}} / E_{\$/\text{€}} = 0.22/1.06 = 21\%$  more U.S. dollars.
    - We would say the euro has appreciated by (about) 21% against the U.S. dollar.

# Appreciations and Depreciations

- Key points:
  - ◆ When the U.S. exchange rate  $E_{\$/\text{€}}$  is rising the dollar is depreciating
  - ◆ When the U.S. exchange rate  $E_{\$/\text{€}}$  is falling the dollar is appreciating
  - ◆ Also note that the % home depreciation approximately equals the % foreign appreciation
    - The exchange rates are reciprocals of each other.
    - The approximation is valid for small changes.

# Multilateral Exchange Rates

- The *bilateral* exchange rate, as seen above, shows the price at which one currency is exchanged for another.
  - ◆ In practice, it is possible for one currency to appreciate relative to one currency, while depreciating relative to another.
  - ◆ In order to understand the “average” change in the value of a currency, we need to use a multilateral exchange rate.

# Multilateral Exchange Rates

- The **nominal effective exchange rate (NEER)** is calculated as the sum of the trade shares multiplied by the exchange rate changes for each country.
  - ◆ The dollar 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 the dollar price of this basket tell us how the value of the dollar has changed “on average” against the entire basket of currencies.
  - ◆ The NEER shows these changes against all foreign currencies “on average”.

# Multilateral Exchange Rates

- Computing the NEER
  - ◆ If the home country trades with countries 1, ..., N then the fractional (%) change in NEER relative to the base year is given by finding the trade-weighted average change in each bilateral exchange rate:

$$\frac{\Delta E_{\text{effective}}}{E_{\text{effective}}} = \underbrace{\frac{\text{Trade}_1}{\text{Trade}} \frac{\Delta E_1}{E_1} + \frac{\text{Trade}_2}{\text{Trade}} \frac{\Delta E_2}{E_2} + \dots + \frac{\text{Trade}_N}{\text{Trade}} \frac{\Delta E_N}{E_N}}_{\text{trade-weighted average of bilateral nominal exchange rate changes}}$$

# *How Much Has the Dollar Fallen?*

## HEADLINES

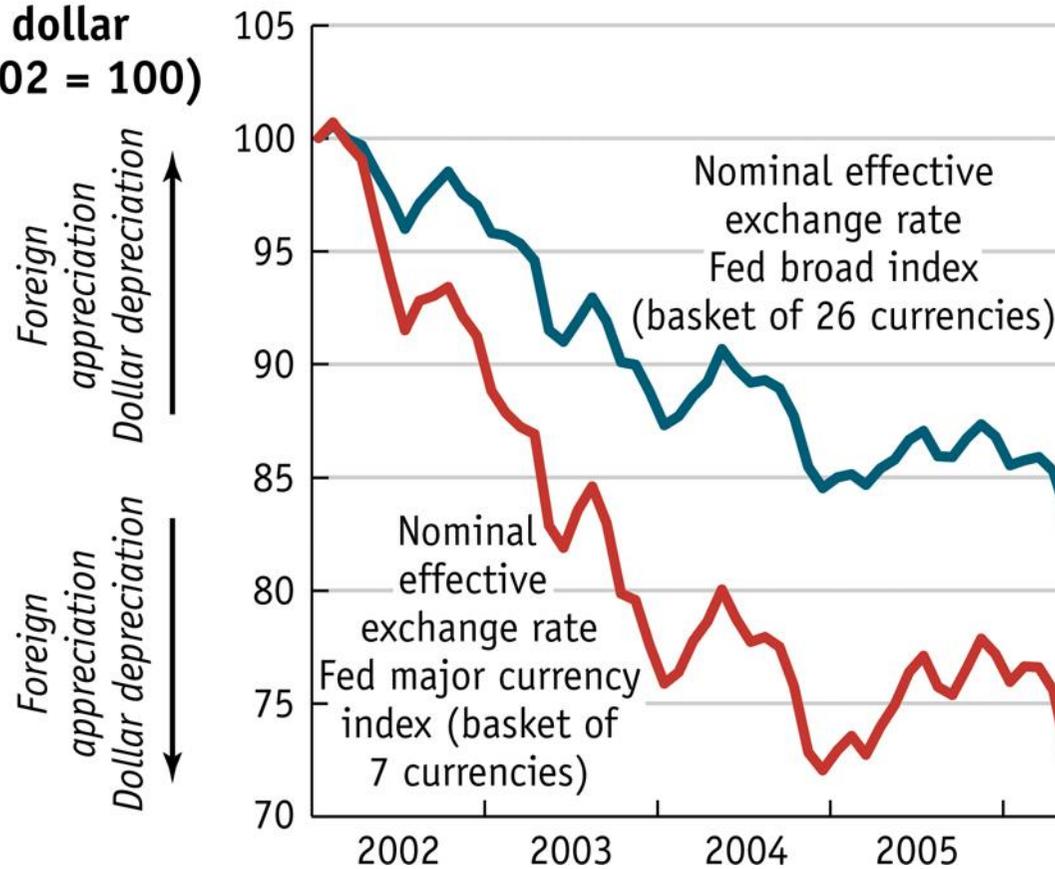
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- The U.S. dollar depreciated against some key currencies between 2002-2004.
- This depreciation was not as pronounced when measured against major U.S. trading partners.
- The major trading partners were mostly floating countries, like U.K., Japan, Canada.
- The others included countries with more fixed exchange rates, like China, India.

# How Much Has the Dollar Fallen?

## HEADLINES

Foreign currency  
baskets per  
U.S. dollar  
(Jan 2002 = 100)



## Example: Using Exchange Rates to Compare Prices in a Common Currency

- 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 the prices in different countries is to convert prices into a common currency.
  - ◆ The UK price in dollar terms is  $E_{\$/\pounds} P_{UK}$ .
    - Always check units.
    - For example, here:  $\$/\pounds$  times  $\pounds = \$$ .

## Example: Using Exchange Rates to Compare Prices in a Common Currency

- ◆ This table shows how the hypothetical cost of James Bond's next tuxedo in different locations depends on the exchange rates that prevail.
- ◆ Local prices are £2000, HK\$30000, \$4000.
- ◆ Convert to £.

Scenario		1	2	3	4
Cost of the tuxedo in local currency	London	£2,000	£2,000	£2,000	£2,000
	Hong Kong	HK\$30,000	HK\$30,000	HK\$30,000	HK\$30,000
	New York	\$4,000	\$4,000	\$4,000	\$4,000
Exchange rates	HK\$/£	15	16	14	14
	\$/£	2.0	1.9	2.1	1.9
Cost of the tuxedo in pounds	London	£2,000	£2,000	£2,000	£2,000
	Hong Kong	£2,000	£1,875	£2,143	£2,143
	New York	£2,000	£2,105	£1,905	£2,105

# Example: Using Exchange Rates to Compare Prices in a Common Currency

- Scenario 1: Indifferent between three markets
  - Hong Kong:  $\text{HK\$}30,000 / 15 \text{ HK\$ per } \text{£} = \text{£}2,000$
  - New York:  $\text{\$}4,000 / \text{\$}2 \text{ per } \text{£} = \text{£}2,000$
  
- Scenario 2: Buy tuxedo in Hong Kong
  - Hong Kong:  $\text{HK\$}30,000 / 16 \text{ HK\$ per } \text{£} = \text{£}1,875$
  - New York:  $\text{\$}4,000 / \text{\$}1.9 \text{ per } \text{£} = \text{£}2,105$
  
- Scenario 3: Buy tuxedo in New York
  - Hong Kong:  $\text{HK\$}30,000 / 14 \text{ HK\$ per } \text{£} = \text{£}2,143$
  - New York:  $\text{\$}4,000 / \text{\$}2.1 \text{ per } \text{£} = \text{£}1,905$
  
- Scenario 4: Buy tuxedo in London
  - Hong Kong:  $\text{HK\$}30,000 / 14 \text{ HK\$ per } \text{£} = \text{£}2,143$
  - New York:  $\text{\$}4,000 / \text{\$}1.9 \text{ per } \text{£} = \text{£}2,105$

# Example: Using Exchange Rates to Compare Prices in a Common Currency

- Lessons

- ◆ When comparing goods and services across countries, we can use the exchange rate to compare prices in same currency terms.
- ◆ Changes in the exchange rate affect the relative prices of goods across countries:
  - Appreciation in the home currency leads to an increase in the relative price of its exports to foreigners and a decrease in the relative price of imports from abroad.
  - A depreciation in the home currency leads to a decrease in the relative price of its exports to foreigners and an increase in the relative price of imports from abroad.

# Exchange Rate Regimes: Fixed versus Floating

- **Fixed exchange rate** (pegged exchange rate)
  - ◆ Where a country's exchange rate does not fluctuate at all (or only narrowly) against some base currency over a sustained period, usually a year or longer.
  - ◆ Government intervention in the market for foreign exchange is needed to maintain the fixed exchange rate.
- **Floating exchange rate** (flexible exchange rate)
  - ◆ A country's exchange rate typically fluctuates over time.
  - ◆ The government makes no attempt to peg the exchange rate against a base currency.
    - Appreciations and depreciations may occur from year to year, each month, even by the day or every minute.
    - The amplitude or volatility of these fluctuations may vary greatly from one floating regime to another

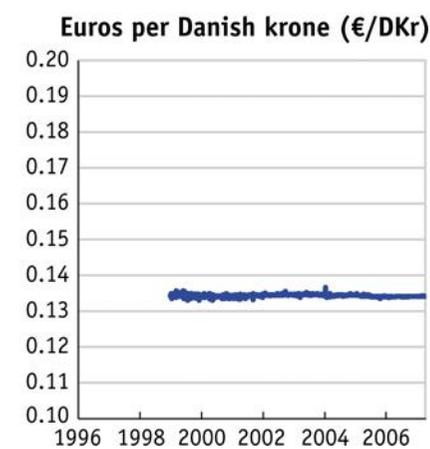
# Recent Exchange Rate Experiences Developed Countries

## APPLICATION

- Developed Countries
  - ◆ There is a great deal of short-run exchange rate volatility.
    - U.S. dollar is floating relative to the Japanese yen, British pound, and Canadian dollar (also known as the “loonie”)
    - Patterns for the euro are similar.
    - Danish krone maintains a  $\pm 2\%$  exchange rate **band** to the euro through intervention by the Danish central bank.

# Recent Exchange Rate Experiences Developed Countries

## APPLICATION



# Recent Exchange Rate Experiences Developing Countries

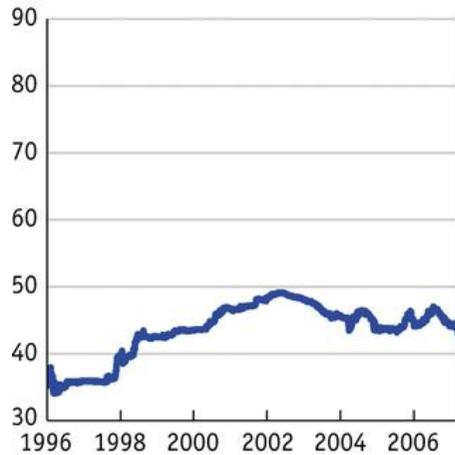
## APPLICATION

- Developing Countries
  - ◆ Exchange rates in developing countries tend to be more volatile.
  - ◆ Some countries adopted fixed exchange rate regimes, but were forced to abandon the peg after an exchange rate crisis.
  - ◆ Many have adopted variants of fixed exchange rate regimes
    - **Managed float**, designed to prevent dramatic changes in the exchange rate without committing to a strict peg.
    - **Crawl**, where the exchange rate follows a trend, rather than a strict peg.

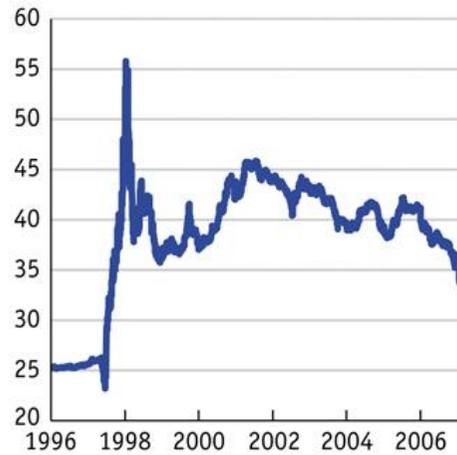
# Recent Exchange Rate Experiences Developing Countries

## APPLICATION

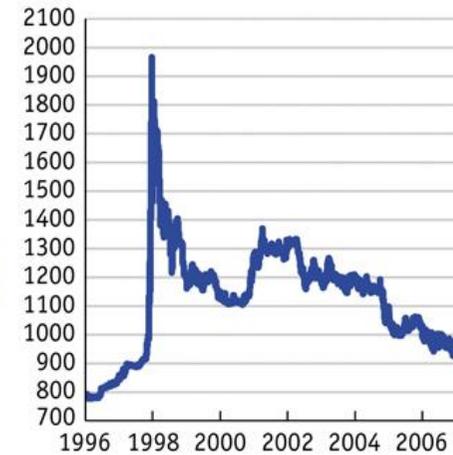
Indian rupees per \$



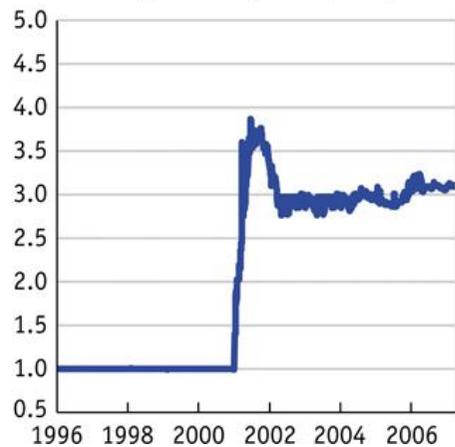
Thai baht per \$



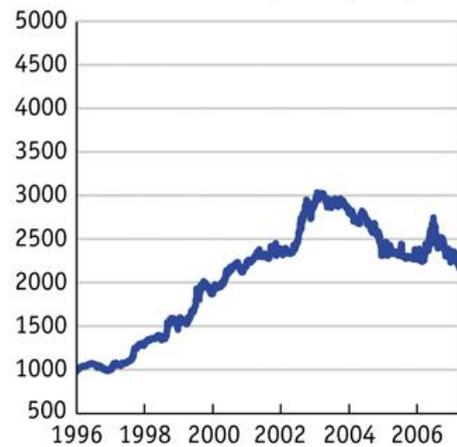
South Korean won per \$



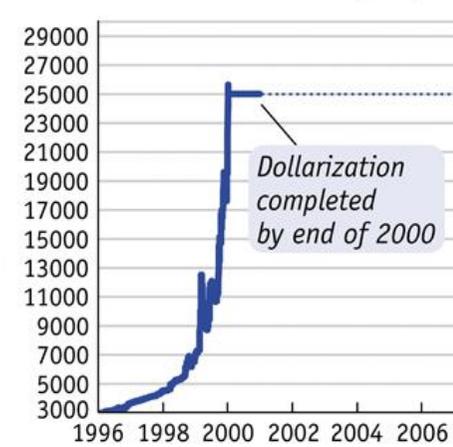
Argentine pesos per \$



Colombian pesos per \$



Ecuadorean sucres per \$



# Recent Exchange Rate Experiences

## APPLICATION

- ◆ There are official and unofficial exchange rate regimes.
  - The difference occurs because some countries that adopt one regime follow another in practice.
  - E.g., they say they float but they really peg.
- ◆ Instead of fixed and floating there is a continuum
  - **Free floating** versus **managed floating**
  - **Crawls** and **bands** allow some movement
  - No such movement in a **hard peg**; sometimes this takes the form of a **currency board**, a very hard peg with special rules (as we shall see later).
  - Some countries have **no currency of their own**.

# *Currency Unions and Dollarization*

## SIDE BAR

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- A currency may be used in more than one country in two cases:
  - ◆ **Currency union**
    - A group of countries agree to use a common currency.
    - Currency unions, such as the eurozone, often involve joint monetary policy across countries.
  - ◆ **Dollarization**
    - A country adopts an existing currency.
    - Countries that dollarize, often do so unilaterally without any influence over monetary policy.

# The Market for Foreign Exchange

- Overview
  - ◆ The foreign exchange market has no central organized market or exchange
    - Foreign exchange market has no exchange trading.
    - Over-the-counter trading (OTC) - bilaterally between two parties.
  - ◆ Large market
    - \$3.2 trillion traded per day (April 2007)
    - Main centers account for more than 50% of transactions: London, New York, and Tokyo
  - ◆ Trades spread over most time zones

# The Market for Foreign Exchange

- The Spot Contract
  - ◆ How the spot contract works:
    - A and B agree to trade one currency for another for delivery on the spot at set price.
    - The price they agree upon is known as the spot exchange rate.
  - ◆ Characteristics of the spot market
    - Default risk very low; settlement is now nearly instantaneous.
    - Most common type of trade, accounting for nearly 90% of all foreign exchange market transactions.
    - Personal transactions account for a very small share of total transactions.

# The Market for Foreign Exchange

- Transaction Costs
  - ◆ Costs associated with conducting trades in a market.
  - ◆ **Spread**
    - Difference between the “buy at” and “sell for” prices.
    - Example of a **market friction** or **transaction cost** that create a wedge between the price paid by the buyer and the price received by the seller.
    - Reflects intermediaries standing between the individual seeking to exchange currency and the centralized foreign exchange market.
    - Spreads are larger for individuals than they are for banks and corporations involved in large-volume transactions.

# The Market for Foreign Exchange

- Derivatives
  - ◆ **Derivatives** are contracts with pricing derived from the spot rate.
    - Derivatives allow investors to trade foreign exchange for delivery at different times and at different contingencies.
    - In general, derivatives allow investors to alter payoffs, affecting the risk associated with his/her collection of investments (e.g., portfolio).
      - Hedging: risk reduction
      - Speculation: risk taking.
  - ◆ Types: **forwards, swaps, futures, and options.**

# *Foreign Exchange Derivatives*

## APPLICATION

- Forwards
  - ◆ A and B agree to trade currencies at set price on the settlement date. Contract cannot be traded to third parties.
- Swaps
  - ◆ A and B agree to trade at set price today and do reverse trade at a set price in the future. Swaps combine two contracts (a spot and a forward) into one, taking advantage of lower transactions costs.

# *Foreign Exchange Derivatives*

## APPLICATION

- 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 A, 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.

# Foreign Exchange Derivatives

## APPLICATION

- Examples of how derivatives work
  - ◆ Example 1: Hedging
    - A Chief Financial Officer (CFO) of a U.S. firm expects to receive payment of €1 million in 90 days for exports to France.
    - The current spot rate is \$1.10 per euro. The Chief Executive Officer (CEO) knows that severe losses would be incurred on the deal, if the dollar strengthened (i.e., the euro weakened) to less than \$1 per euro.
    - What should the CFO do?
      - Buy €1 million in call options on \$ at rate of \$1.05 per euro
      - Insures the firm's euro receipts will sell for at least this rate.
      - The call option guarantees the firm a profit, even if the spot rate falls below \$1.05.

# Foreign Exchange Derivatives

## APPLICATION

- Examples of how derivatives work
  - ◆ Example 2: Speculation
    - One-year euro futures are currently priced at \$1.20.
    - You expect the dollar will depreciate to \$1.32 in the next 12 months.
    - What should you do? Buy these futures
      - If you are proved right you will earn 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.

# The Market for Foreign Exchange

- Private Actors
  - ◆ Commercial banks
    - The key players are foreign exchange 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)
    - The top 5 banks account for 50% of the market.
    - The top 10 banks account for 75% of the market.
  - Bank deposits are the most important influence in the foreign exchange market.

# The Market for Foreign Exchange

- Private Actors
  - ◆ Other players
    - Major corporations (e.g., multinationals)
    - Nonbank financial firms (e.g., mutual funds)
  - ◆ By trading directly in the foreign exchange market, other players avoid paying fees and commissions charged by commercial banks.
    - The volume of transactions needs to be large enough to make in-house currency trading worthwhile.

# The Market for Foreign Exchange

- Government Intervention
  - ◆ Governments may try to control or regulate the foreign exchange market. The government may:
    - Impose **capital controls** to limit trading.
    - Establish an **official market** for foreign exchange at government-set rates.
      - This usually leads to the creation of a **black market** (illegal transactions at rates that differ from the official ones).
      - Try to shut down the foreign exchange market through outlawing trading.
  - ◆ Most often, government takes less drastic measures, relying on intervention to control foreign exchange prices. This is usually the responsibility of the central bank.

# Arbitrage and Spot Exchange Rates

- Overview
  - ◆ An important goal of players in the forex market is to exploit arbitrage opportunities.
    - Arbitrage refers to a trading strategy that exploits price differences.
    - The purest form of arbitrage involves no risk and no capital.
      - The opportunity to make a riskless profit through trading.
  - ◆ Market **equilibrium**
    - **No-arbitrage condition** = no riskless profit opportunities

# Arbitrage and Spot Exchange Rates

- Arbitrage with Two Currencies

- ◆ Example

- Take advantage of differences in price of dollars quoted in New York and London:

$$E_{\text{£}/\$}^{\text{NY}} = \text{£}0.50 \text{ per dollar}$$

$$E_{\text{£}/\$}^{\text{London}} = \text{£}0.55 \text{ per dollar}$$

- A NY trader can make a riskless profit by selling \$1 in London for 55p, using the proceeds to buy  $55/50 = \$1.10$  dollars in NY.
      - An instant 10% riskless profit!

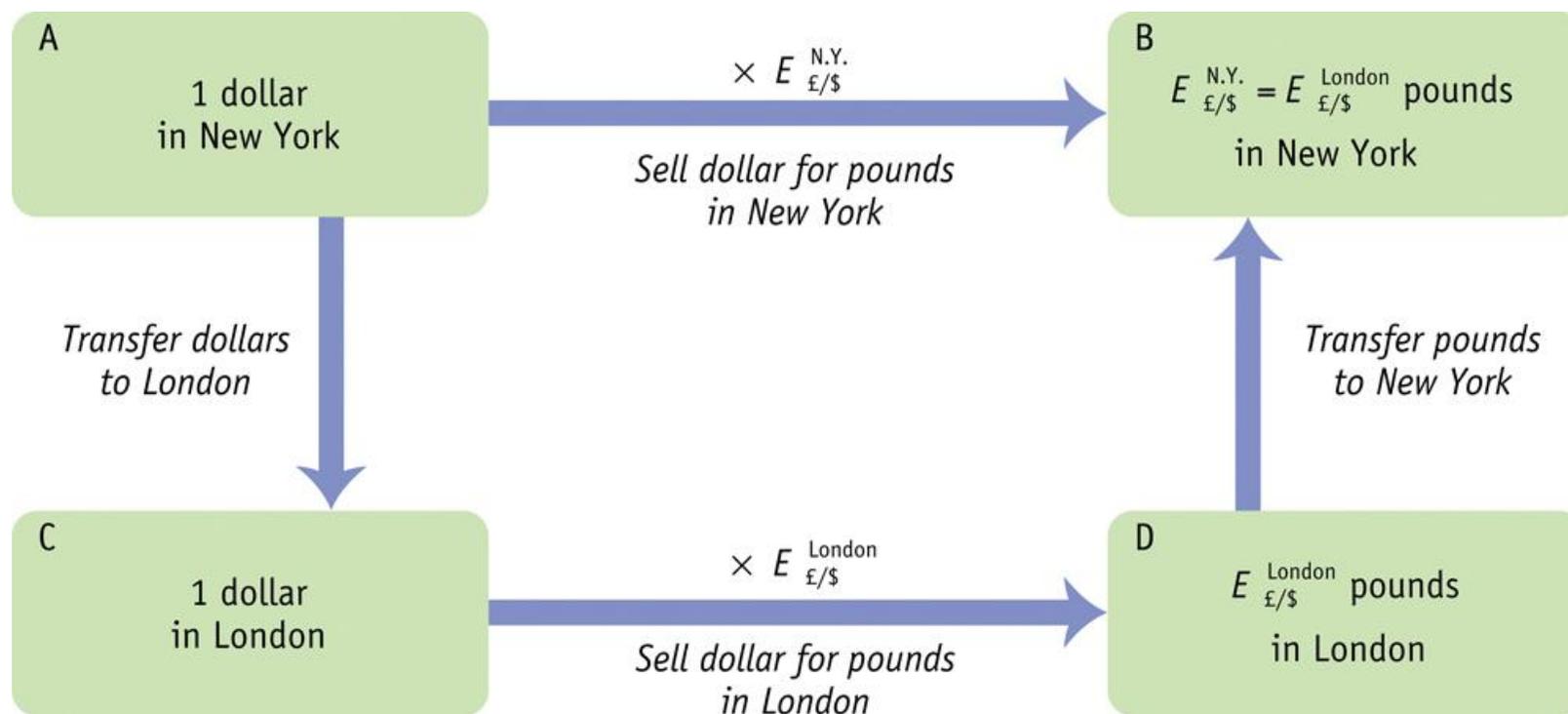
# Arbitrage and Spot Exchange Rates

- Arbitrage with Two Currencies
  - ◆ Example:
    - Market adjustment of the £/\$ exchange rate
      - As investors take advantage of this arbitrage opportunity, the demand for dollars in NY rises, causing an increase in the exchange rate (£ price of \$ rises).
      - Similarly, the supply of dollars in London rises, causing a decrease in the exchange rate (£ price of \$ falls).
      - This process continues until the exchange rates in London and New York converge to the same level.
    - Differences mean that there are riskless profits lying around
    - In today's markets, equalization occurs very, very quickly indeed!
    - Miniscule spreads may remain (less than 0.1%), due to transaction costs.

# Arbitrage and Spot Exchange Rates

- Arbitrage with Two Currencies

- ◆ Example



# Arbitrage and Spot Exchange Rates

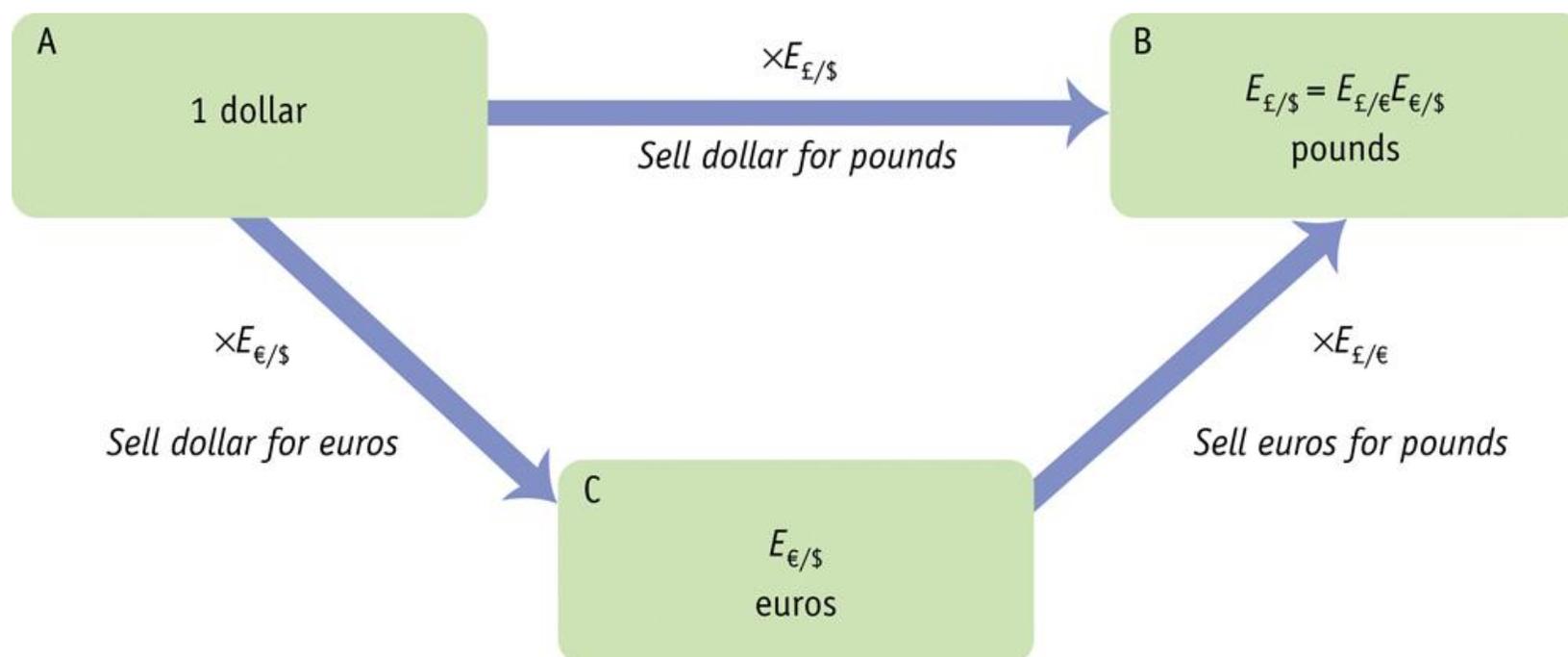
- Arbitrage with Three Currencies
  - ♦ The **cross rate** allows us to compare exchange rates defined in terms of different currencies.
    - For example, consider the bilateral exchange rate  $E_{\$/\text{€}}$ .
    - This can be expressed in terms of  $E_{\text{€}/\$}$  and  $E_{\text{€}/\text{£}}$ :

$$\underbrace{E_{\text{£}/\$}}_{\text{Direct exchange rate}} = E_{\text{£}/\text{€}} E_{\text{€}/\$} = \frac{E_{\text{£}/\text{€}}}{\underbrace{E_{\$/\text{€}}}_{\text{Cross rate}}}$$

- The fact that any two currencies must have equal prices in two different locations implies the same for a triangular trade involving three currencies.

# Arbitrage and Spot Exchange Rates

- Arbitrage with Three Currencies



# Arbitrage and Spot Exchange Rates

- Cross Rates and Vehicle Currencies
  - ◆ The vast majority of currency pairs are exchanged through a third currency.
    - This is because some foreign exchange transactions are relatively rare, making it more difficult to exchange currency directly.
  - ◆ When a third currency is used in these types of transactions, it is known as a vehicle currency.
    - As of April 2007, the most common vehicle currency was the U.S. dollar – used in 86% of all foreign exchange transactions.
    - The euro, Japanese yen, and British pound are also used as vehicle currencies.

# Arbitrage and Interest Rates

- Overview of the two kinds of arbitrage
  - ♦ Exchange rate risk refers to changes in the value of an asset due to a change in the exchange rate.
- Riskless arbitrage
  - ♦ Investor covers the risk of the exchange rate changing in the future by using a forward contract.
  - ♦ No exchange rate risk because there is no chance the exchange rate on the contract will change.
  - ♦ No-arbitrage condition is known as **covered interest parity (CIP)**.
- Risky arbitrage
  - ♦ Investor does not cover the risk and invests according to the current and expected future exchange rate.
  - ♦ Since the future spot exchange rate is not known, there is exchange rate risk – the investor is not covered against this risk
  - ♦ No-arbitrage condition is known as **uncovered interest parity (UIP)**.

# Riskless Arbitrage: Covered Interest Parity

- **Forward Exchange Rate**
  - ◆ The price of forward contracts.
  - ◆ Forward contracts allow investors holding deposits in foreign currencies to be certain about the future value of these deposits (measured in home currency).
  - ◆ No exchange rate risk in the future.
- Riskless arbitrage implies that the rate of return on identical investments in two different locations will generate the same rate of return.

# Riskless Arbitrage: Covered Interest Parity

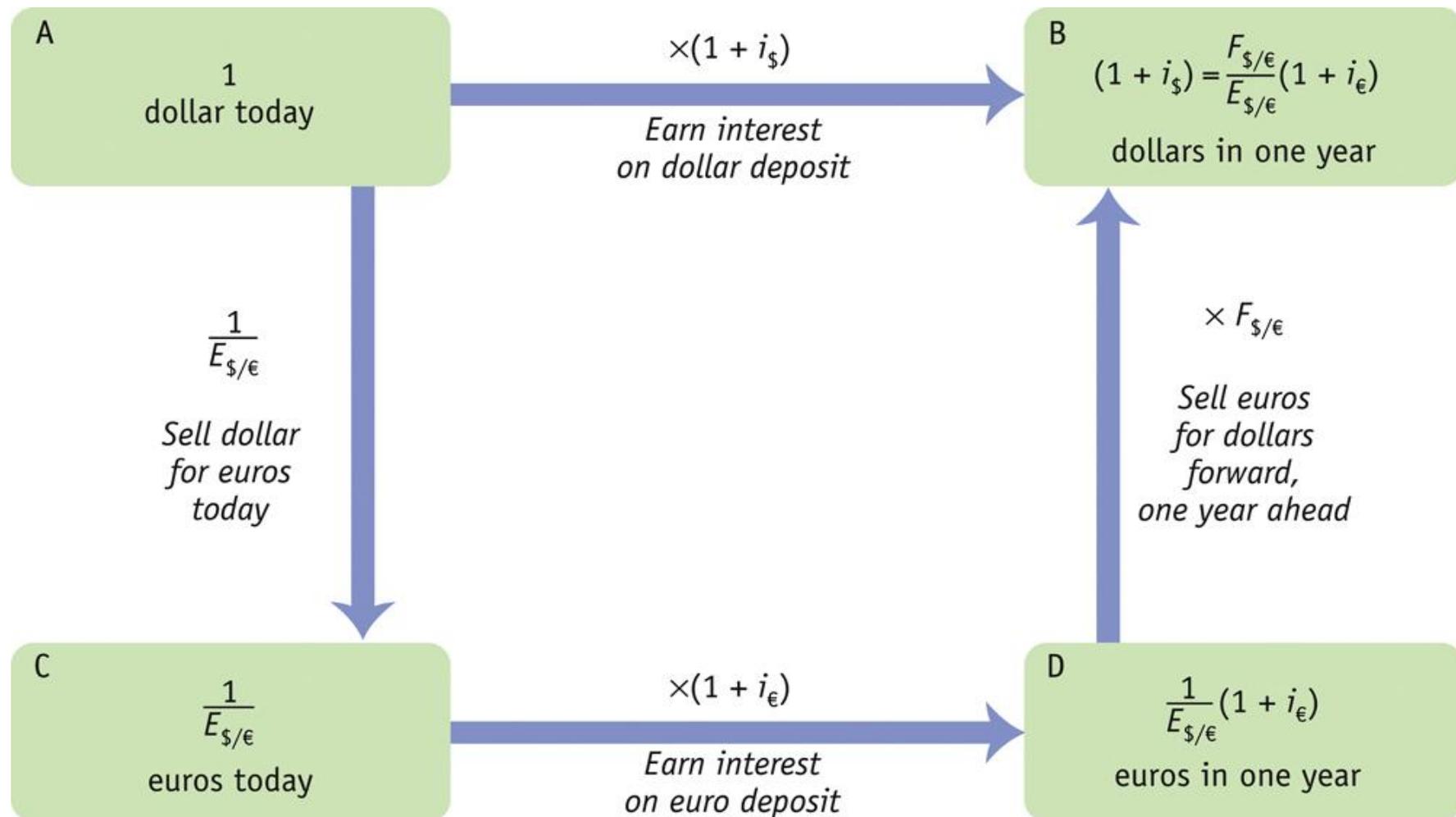
- Example: Consider investing \$1 in a bank deposit in two places: New York and Europe.
  - In one year, you will earn a  $(1+i_{\$})$  rate of return in dollars in the account in New York.
  - In one year, you will earn a  $(1+i_{\text{€}})$  rate of return in euros in the account in Europe.
- ♦ Not comparable! Different currencies!
- ♦ We must calculate the dollar return in Europe:
  - Today, one U.S. dollar buys  $1/E_{\$/\text{€}}$  euros.
  - In one year, you will have  $(1+i_{\text{€}})/E_{\$/\text{€}}$  euros.
  - You do not know the  $E_{\$/\text{€}}$  spot exchange rate that will prevail in one year when you convert your euros back into U.S. dollars
  - You may choose to employ a forward contract to cover this risk.
  - In this case, your rate of return on the European deposit would be  $(1+i_{\text{€}})F_{\$/\text{€}}/E_{\$/\text{€}}$  U.S. dollars.
- ♦ Riskless arbitrage implies these two strategies will yield the same rate of return in dollars.

# Riskless Arbitrage: Covered Interest Parity

- **Covered Interest Parity (CIP) condition**
  - ◆ No arbitrage condition
  - ◆ For the market to be in equilibrium the riskless returns must be equal when expressed in a common currency:

$$\underbrace{(1 + i_{\$})}_{\text{gross dollar return on dollar deposits}} = \underbrace{(1 + i_{\text{€}})}_{\text{gross dollar return on euro deposits}} \frac{F_{\$/\text{€}}}{E_{\$/\text{€}}}$$

# Riskless Arbitrage: Covered Interest Parity



# Riskless Arbitrage: Covered Interest Parity

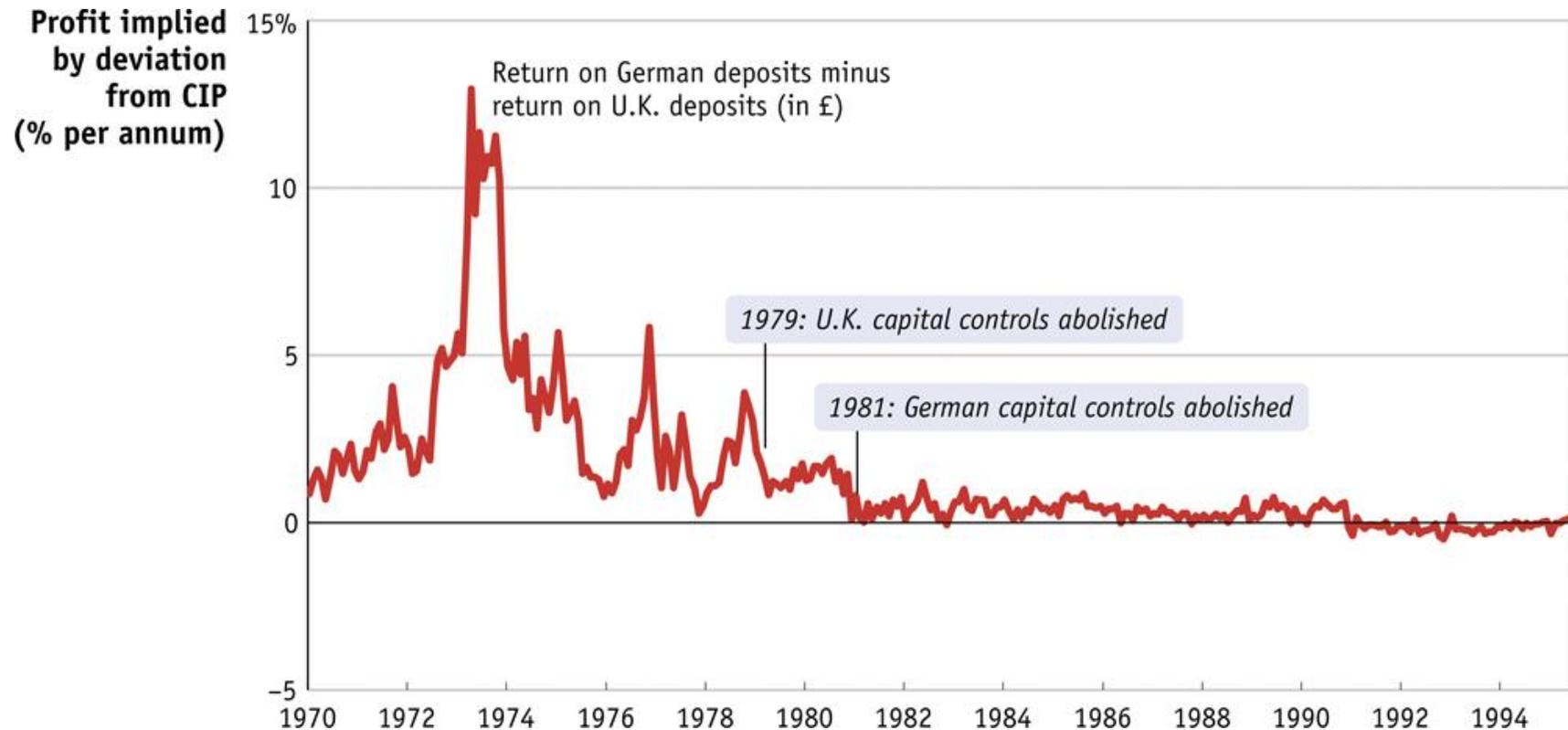
- ◆ Arbitrage profit?
  - Considers the German deutschmark (GER) relative to the British pound (UK), 1970-1994.
  - Determine whether foreign exchange traders could earn a profit through establishing forward and spot contracts
  - The profit from this type of arrangement is:

$$\text{Profit} = \underbrace{(1 + i_{GER}) \frac{F_{UK/GER}}{E_{UK/GER}}}_{\text{Pound return on German deposits}} - \underbrace{(1 + i_{UK})}_{\text{Pound return on U.K. deposits}}$$

# Evidence on Covered Interest Parity

## APPLICATION

- Arbitrage profit: German DM and British £



# Evidence on Covered Interest Parity

## APPLICATION

- Are there arbitrage profits?
  - ♦ We observe that once capital controls were removed, arbitrage profits disappeared.
    - In financial systems that have become liberalized, riskless arbitrage opportunities have disappeared.
    - CIP holds, except for tiny spreads.
    - The CIP equation is used to exactly price forward contracts (if we know interest rates and E then we can solve for F):

$$\underbrace{(1 + i_{\$})}_{\text{gross dollar return on dollar deposits}} = \underbrace{(1 + i_{\text{€}})}_{\text{gross dollar return on euro deposits}} \frac{F_{\$/\text{€}}}{E_{\$/\text{€}}}$$

# *Assets and their Attributes*

## SIDE BAR

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- Investors' demand for assets depends on
  - ◆ Rate of return
    - The total net increase in wealth resulting from holding the asset for a specified period of time.
    - Investors prefer assets with higher returns.
  - ◆ Risk
    - Volatility (or uncertainty) about an asset's rate of return.
    - Investors prefer assets with lower risk.
  - ◆ Liquidity
    - The ease and speed with which the asset can be liquidated or sold (for cash).
    - Investors prefer assets with higher liquidity.

# *Assets and their Attributes*

## SIDE BAR

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- Important observations
  - ◆ Investors are willing to trade off among these attributes.
    - For example, one may be willing to accept higher risk and lower liquidity if the asset's rate of return is higher.
  - ◆ Expectations matter
    - Most assets do not have a fixed, guaranteed rate of return.
    - Similarly, not all assets have fixed levels of risk and liquidity.
    - The expected rate of return is the forecast of the rate of return.

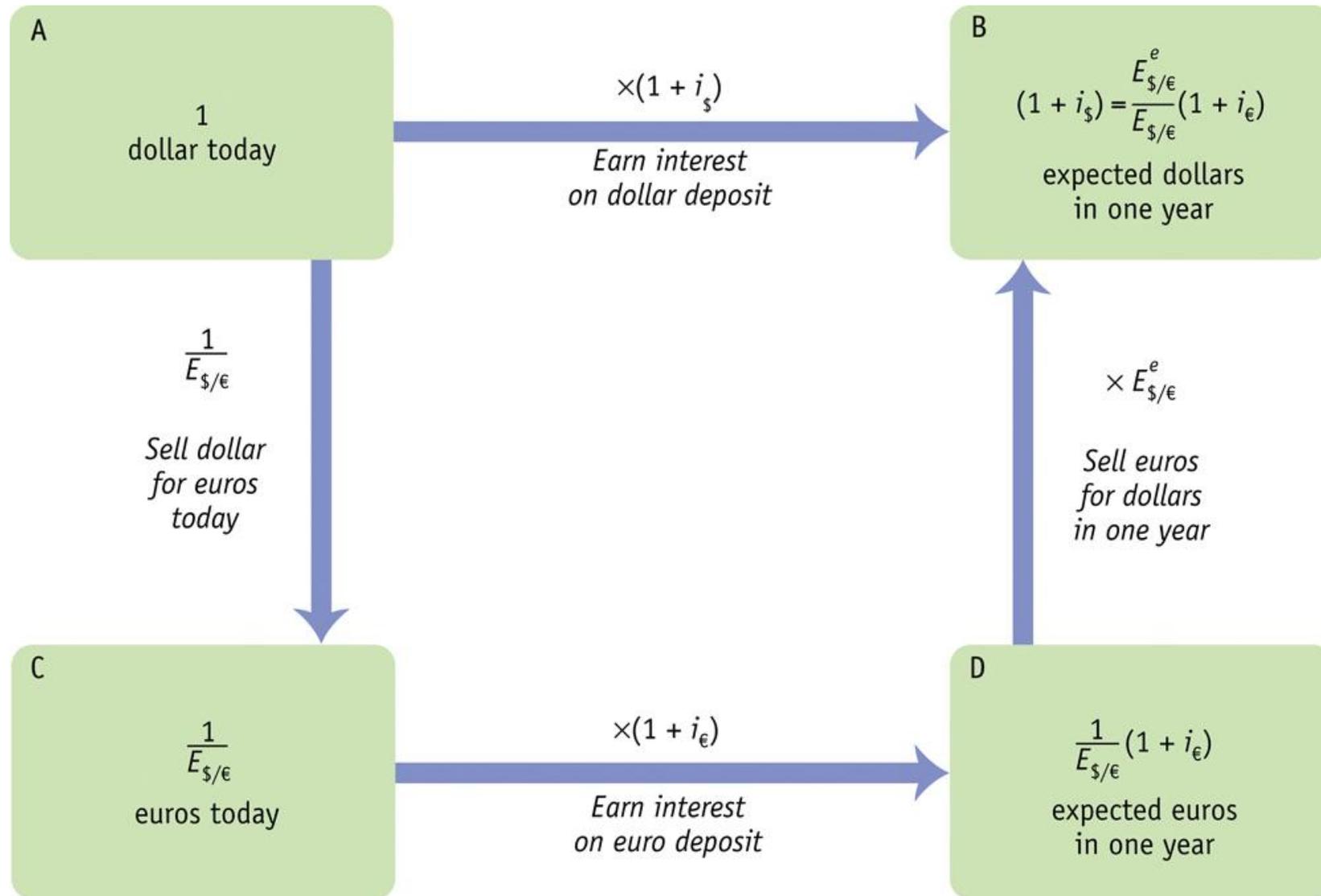
# Risky Arbitrage: Uncovered Interest Parity

- The investor does not use a forward contract to cover against exchange rate risk.
  - ◆ In this case, when the investor deposits U.S. dollars in Europe, he/she faces exchange rate risk.
- The investor makes a forecast of the expected exchange rate  $E^e_{\$/\text{€}}$ , and makes decisions based on this forecast.

# Risky Arbitrage: Uncovered Interest Parity

- Example: Consider investing \$1 in a bank deposit in two places: New York and Europe.
  - In one year, you will earn a  $(1+i_{\$})$  rate of return in dollars in the account in New York.
  - In one year, you will earn a  $(1+i_{\text{€}})$  rate of return in euros in the account in Europe.
- ♦ Again we must calculate the dollar return in Europe:
  - Today, one U.S. dollar buys  $1/E_{\$/\text{€}}$  euros.
  - In one year, you will have  $(1+i_{\text{€}})/E_{\$/\text{€}}$  euros.
  - You do not know the  $E_{\$/\text{€}}$  spot exchange rate that will prevail in one year when you convert your euros back into U.S. dollars
  - This time you take the risk, and make some forecast of the expected exchange rate in one year's time  $E^e_{\$/\text{€}}$ .
  - In this case, your rate of return on the European deposit would be  $(1+i_{\text{€}})E^e_{\$/\text{€}}/E_{\$/\text{€}}$  U.S. dollars.
  - There is *exchange rate risk* because the future spot exchange rate  $E^e_{\$/\text{€}}$  is not known when the investments are made.

# Risky Arbitrage: Uncovered Interest Parity



# Risky Arbitrage: Uncovered Interest Parity

- **Uncovered Interest Parity (UIP)**

- ◆ No arbitrage condition for *expected returns*
- ◆ States that the expected returns must be equal when expressed in a common currency

$$\underbrace{(1 + i_{\$})}_{\text{gross U.S. deposit dollar return}} = \underbrace{(1 + i_{\text{€}}) \frac{E_{\$/\text{€}}^e}{E_{\$/\text{€}}}}_{\text{gross euro deposit (expected) dollar return}}$$

- We assume risk neutrality; e.g. that a risk neutral US investor does not care that the left hand side is certain, while the right hand side is risky.

# Risky Arbitrage: Uncovered Interest Parity

- **Uncovered Interest Parity (UIP)**
  - ◆ Knowing the expected exchange rate and the interest rates for each currency, we can solve for the spot exchange rate:

$$E_{\$/\epsilon} = E_{\$/\epsilon}^e \frac{1 + i_{\epsilon}}{1 + i_{\$}}$$

# Evidence on Uncovered Interest Parity

## APPLICATION

- Interest parity conditions

- ♦ CIP:  $(1 + i_{\$}) = (1 + i_{\text{€}}) \frac{F_{\$/\text{€}}}{E_{\$/\text{€}}}$

- ♦ UIP:  $(1 + i_{\$}) = (1 + i_{\text{€}}) \frac{E_{\$/\text{€}}^e}{E_{\$/\text{€}}}$

- ♦ Thus CIP plus UIP imply:

$$F_{\$/\text{€}} = E_{\$/\text{€}}^e$$

- Intuition: If  $F$  did not equal  $E^e$  one party to the forward contract would be better off waiting for the more favorable  $E^e$  to materialize (if the investors are risk neutral).

# Evidence on Uncovered Interest Parity

## APPLICATION

- An important testable implication:

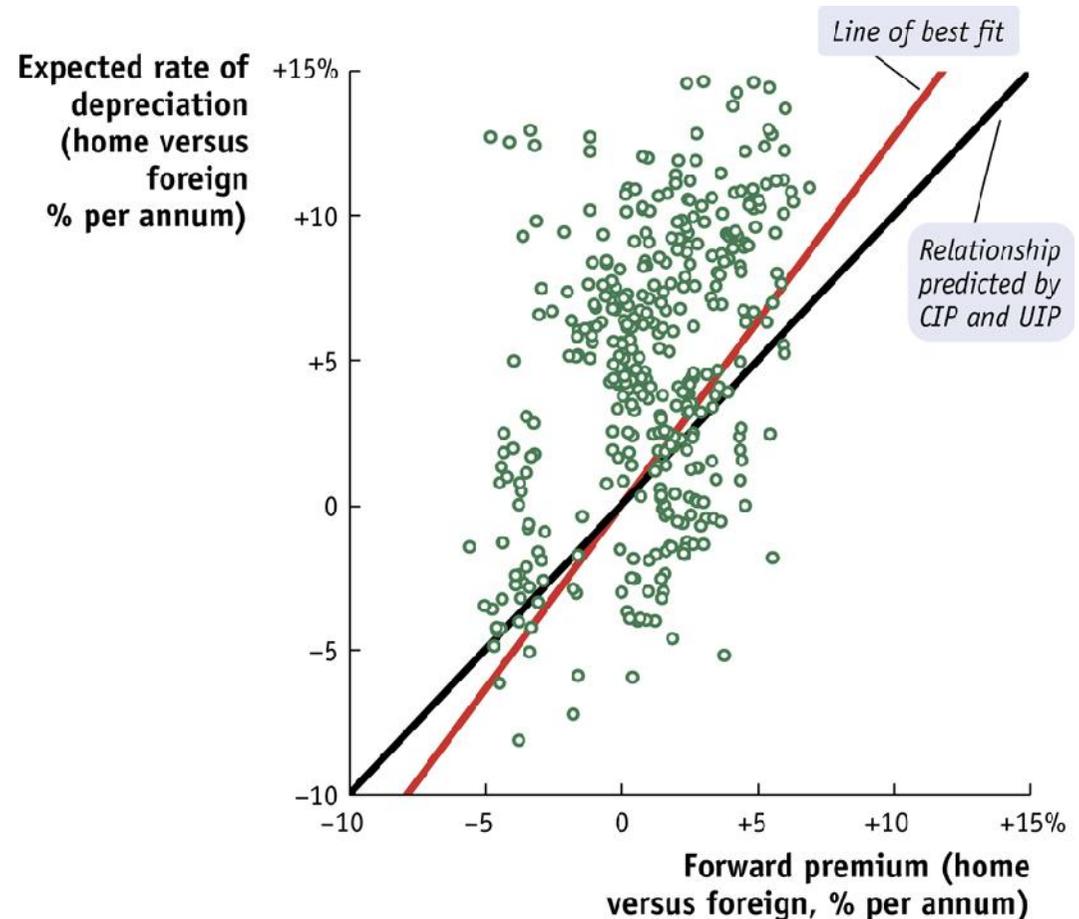
$$\underbrace{\frac{F_{\$/\epsilon}}{E_{\$/\epsilon}} - 1}_{\text{Forward premium}} = \underbrace{\frac{E_{\$/\epsilon}^e}{E_{\$/\epsilon}} - 1}_{\text{Expected rate of depreciation}}$$

- ♦ Left-hand side is the **forward premium** (+ or –)
- ♦ Says how much more/less investors are willing to pay for the forward versus the spot.
- ♦ Right-hand side is **expected rate of depreciation** (+ or –)
- ♦ In order to estimate the right-hand side, researchers have used surveys of foreign exchange traders.
- ♦ Test: plot right hand side versus left hand side...

# Evidence on Uncovered Interest Parity

## APPLICATION

- Plot RHS versus LHS:
  - ♦ UIP+CIP predicts 45 degree line.
  - ♦ Surveys tend to find a positive slope, close to 1.
  - ♦ But there is a lot of noise: traders have widely differing beliefs.
  - ♦ UIP finds some support in these data.



# UIP: A Useful Approximation

- Intuition

- ◆ Reward, or net return on one dollar deposit

- In dollar-denominated deposit = interest on dollar deposits
    - In euro-denominated deposit = interest on euro deposits + gain/loss associated with euro appreciation/depreciation

UIP approximation:

$$\underbrace{i_{\$}}_{\substack{\text{Interest rate on} \\ \text{dollar deposits} \\ = \\ \text{Dollar rate of} \\ \text{return on dollar} \\ \text{deposits}}} = \underbrace{i_e}_{\substack{\text{Interest rate on} \\ \text{euro deposits}}} + \underbrace{\frac{\Delta E_{\$/e}^e}{E_{\$/e}}}_{\substack{\text{Expected rate of} \\ \text{depreciation of the} \\ \text{dollar}}}$$

Expected dollar rate of return on euro deposits

# Arbitrage and Interest Rates

- Summary—how spot and forward rates are determined by UIP & CIP.

