Exchange rate and interest rates

Rodolfo Helg, October 2016

(adapted from Feenstra Taylor)

Defining the Exchange Rate

- Exchange rate ($E_{domestic/foreign}$)
  - 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 $E_{\$/£} = 1.85$.

Be Careful…

- For any pair of currencies, the exchange rate can be expressed in 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 $E_{\$/€} = 1.15$.
  - (A): indirect or quantity quotation (CERTO PER INCERTO): price of domestic currency in terms of foreign currency.

  (In the US 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, $E_{€/\$} = 1/1.15 = 0.87$.
  - (B): direct or price quotation (INCERTO PER CERTO): price of foreign currency in terms of domestic currency. (This is known as the "European terms." What Europeans must pay in euros to buy U.S. currency.)
- **So: A =1/B**

Examples of Exchange Rate Quotations

		EXCHANGE RATES ON JUNE 1, 2007			EXCHANGE RATES ON JUNE 1, 2006 *ONE YEAR PREVIOUSLY*		
		(1)	(2)	(3)	(4)	(5)	(6)
Country (currency)	**Currency Symbol**	**Per $**	**Per £**	**Per €**	**Per $**	**Per £**	**Per €**
Canada (dollar)	C$	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)	€	**0.745**	1.475	—	**0.780**	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	**1.342**	—	1.868	**1.282**

Or, for more recent quotation, see, for example, the FT website

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 $E_{\$/€}$
    - $E_{\$/€,t}$ = \$1.30 (22 October 2012), $E_{\$/€,t+1}$ = \$1.37 (20 October 2013)
    - A euro buys $\Delta E_{\$/€} / E_{\$/€}$ = (0.07/1.32)*100 = 5.3% more U.S. dollars.
    - We would say the euro has appreciated by (about) 5.3% against the U.S. dollar during last year.

Appreciations and Depreciations

- Key points:
  - When the exchange rate $\mathbf{E_{\$/€}}$ **is rising** the dollar is **depreciating**
  - When the. exchange rate $\mathbf{E_{\$/€}}$ **is falling** the dollar is **appreciating**

  - Also note that the % home depreciation <u>only approximately</u> equals the % foreign appreciation
    - The exchange rates are reciprocals of each other.
    - The approximation is valid for small changes (see note 4 on page 466).

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

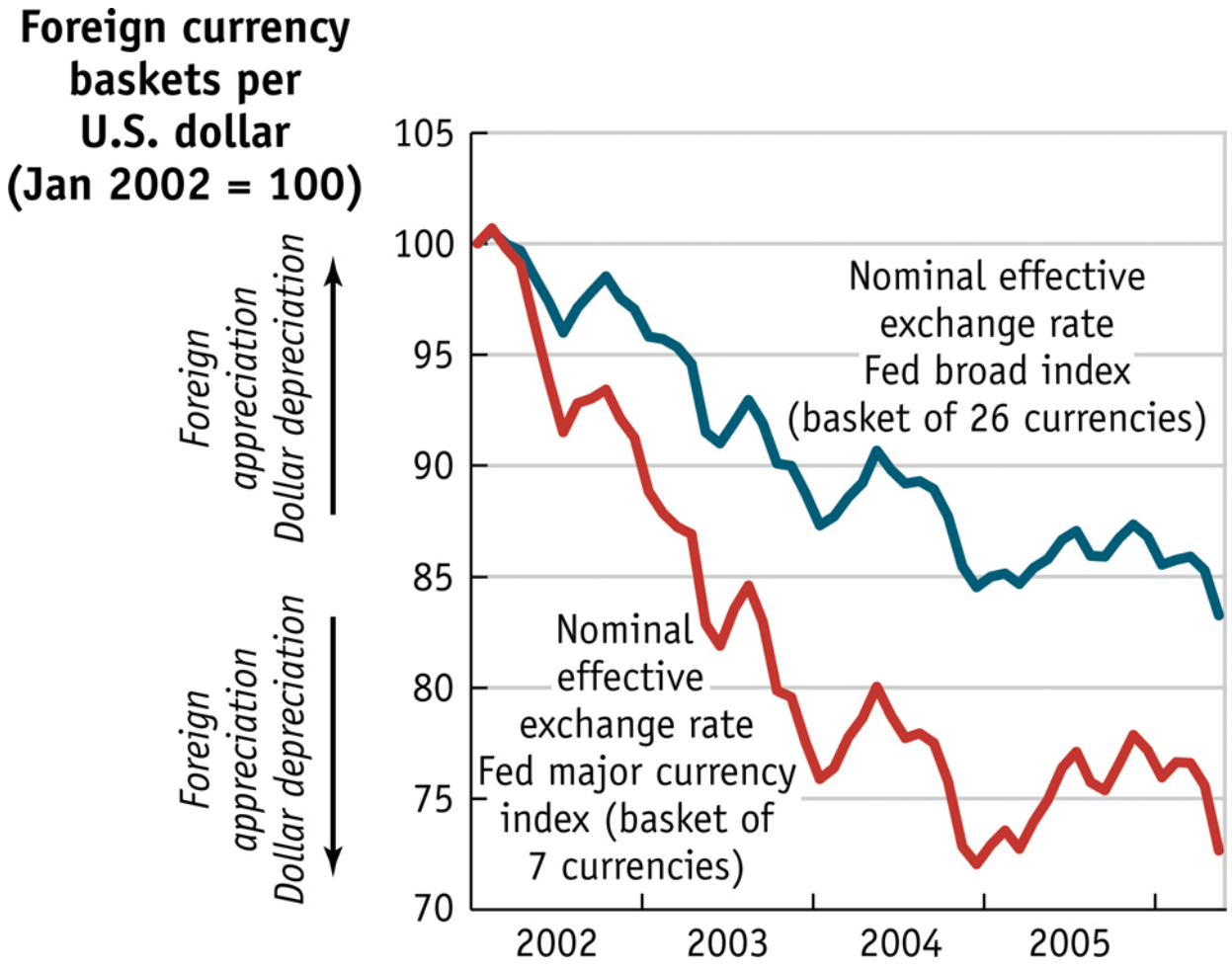
- Computing the NEER
  - If the home country trades with countries 1,…,N then the fractional (%) change in NEER relative to the base year is given by finding the trade-weighted average change in each bilateral exchange rate:

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

How Much Has the Dollar Fallen?

- 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?



EURO NEER

For a measure of the Euro Area NEER see the ECB website

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 $E_{\$/£}\ P_{UK.}$
    - Always check units.
    - For example, here: $/£ times £ = $.

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: HK$30,000/15 HK$ per £ = £2,000
  - New York: $4,000/ $2 per £ = £2,000

- Scenario 2: Buy tuxedo in Hong Kong
  - Hong Kong: HK$30,000/16 HK$ per £ = £1,875
  - New York: $4,000/ $1.9 per £ = £2,105

- Scenario 3: Buy tuxedo in New York
  - Hong Kong: HK$30,000/14 HK$ per £ = £2,143
  - New York: $4,000/ $2.1 per £ = £1,905

- Scenario 4: Buy tuxedo in London
  - Hong Kong: HK$30,000/14 HK$ per £ = £2,143
  - New York: $4,000/ $1.9 per £ = £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.

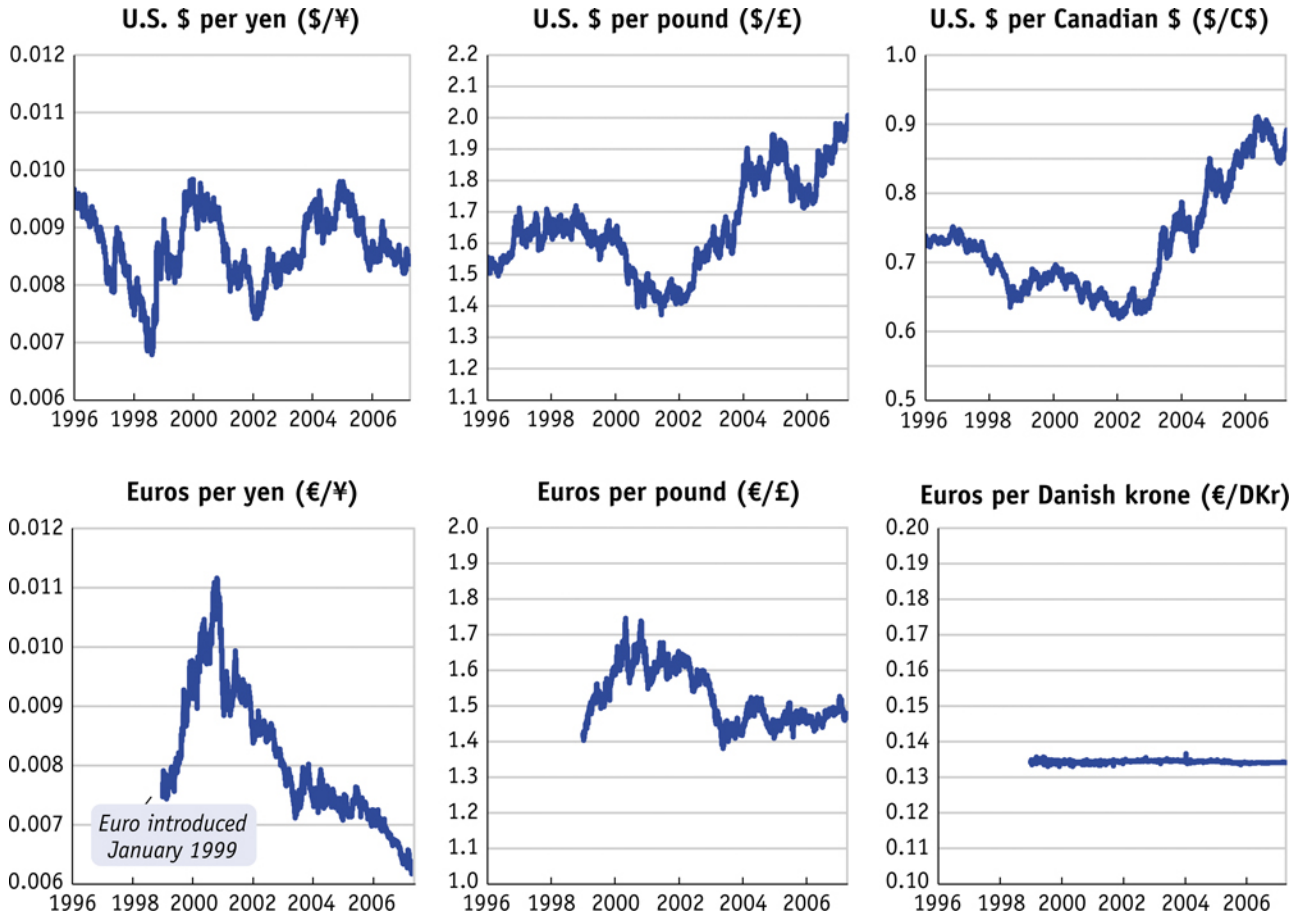
Exchange Rate Regimes: Fixed versus Floating

- **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

- 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 ±2% exchange rate **band** to the euro through intervention by the Danish central bank.

Recent Exchange Rate Experiences
Developed Countries



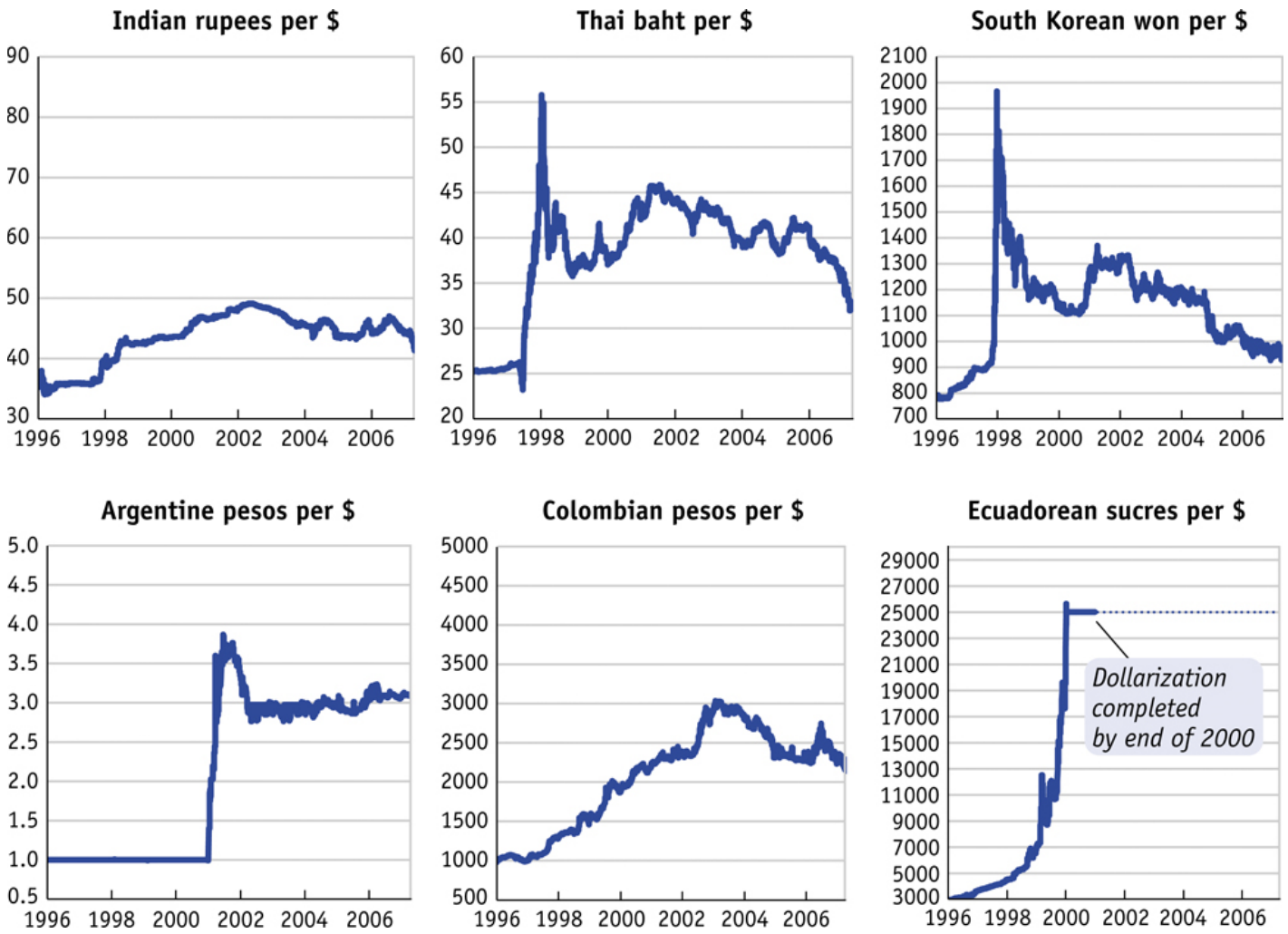
U.S. dollar

EURO

Recent Exchange Rate Experiences Developing Countries

- 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 intermediate exchange rate regimes
    - **Managed float (or dirty float)**, designed to prevent dramatic changes in the exchange rate without committing to a strict peg.
    - **Crawling peg**, where the exchange rate follows a trend or **crawling bands**, if some volatility around the trend is allowed.

Recent Exchange Rate Experiences Developing Countries



Recent Exchange Rate Experiences

- 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**.

Exchange Rate Regimes

Table 1. Shares of Classifications Using the 1998 and 2009 Systems, as of April 30, 2008

	1998 de facto system		2009 de facto system	
Hard pegs		**23**		**23**
	Arrangement with no separate legal tender	10	Exchange arrangement with no separate legal tender	10
	Currency board arrangement	13	Currency board arrangement	13
Soft pegs		**81**		**78**
	Conventional fixed peg	68	Conventional pegged arrangement	45
			Stabilized arrangement	22
of which: Intermediate pegs		**13**		**11**
	Pegged exchange rate within horizontal bands	3	Pegged exchange rate within horizontal bands	3
	Crawling peg	8	Crawling peg	5
	Crawling band	2	Crawl-like arrangement	3
Floating arrangements		**84**		**75**
	Managed floating	44	Floating	39
	Independently floating	40	Free floating	36
Other managed arrangements (residual)		**n.a.**		**12**
Total		**188**		**188**

Source: Staff calculations. Information for end-April 2009 will be published in the 2009 Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER), forthcoming.

See also
[IMF website]

Currency Unions and Dollarization

- 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, 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
    - $ 5.1 trillion traded per day in April 2016 (down from 5,4 in April 2013 and up from $3.2 trillion in April 2007 and 4 trillion in 2010 - +35%) (see BIS website)
    - Main centers account for more than 70% of transactions: London (41% in 2013), New York (19%), Singapore (5.7%), Tokyo (5.6%), Hong Kong (4.1%), Zurich (3.2%), Paris (2.8%), Sidney (2.7%).
    - Trades spread over most time zones

The Market for Foreign Exchange

Geographical distribution of global foreign exchange market turnover

Net-gross basis, daily averages in April, (billions of US dollars and percentages)

Source: BIS, Triennial Central Bank Survey, 2013

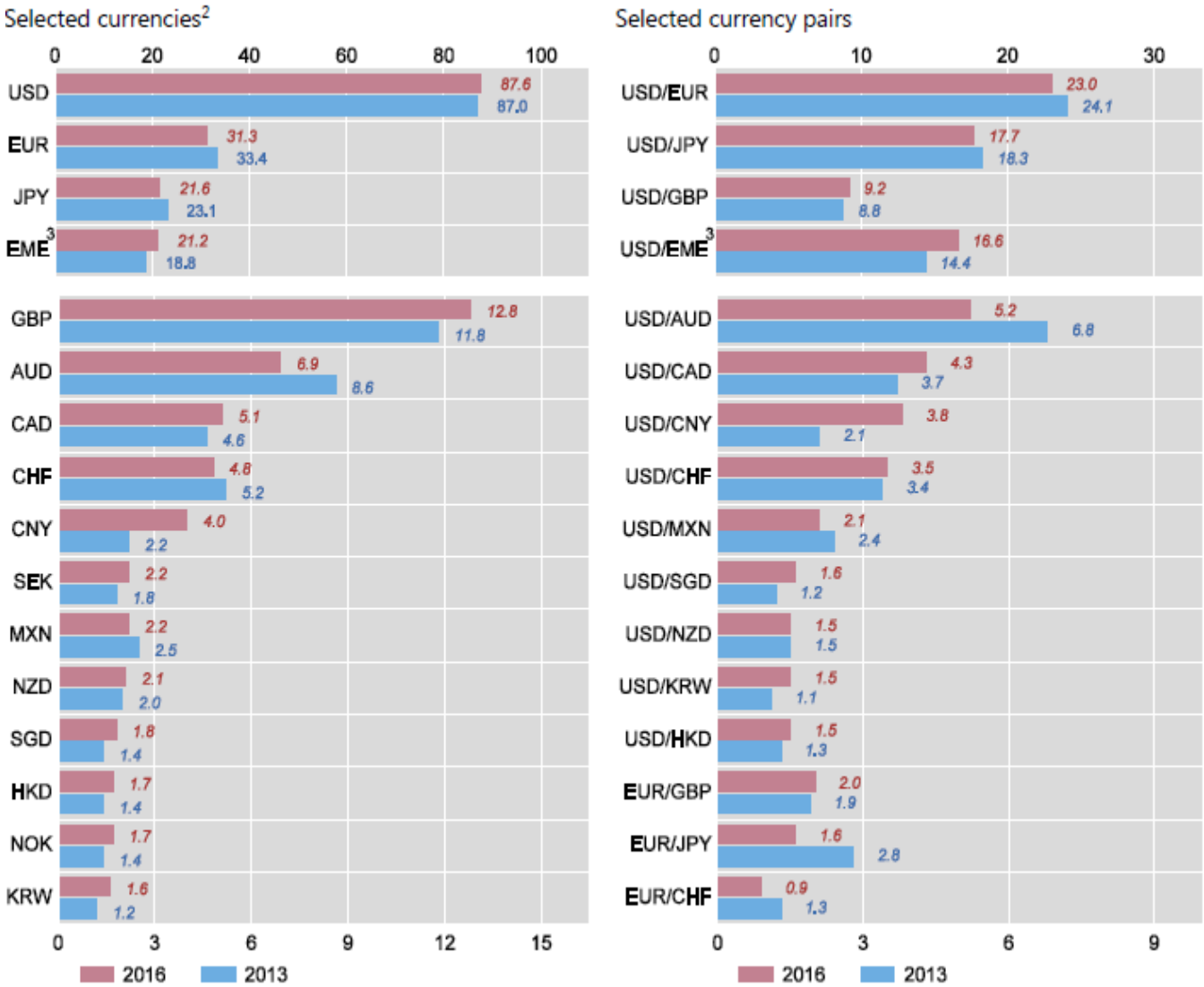
Country	1998		2013	
	Amount	%	Amount	%
United Kingdom	685	32,6	2'726	40,9
United States	383	18,3	1'263	18,9
Singapore	145	6,9	383	5,7
Japan	146	7,0	374	5,6
Hong Kong SAR	80	3,8	275	4,1
Switzerland	92	4,4	216	3,2
France	77	3,7	190	2,8
Australia	48	2,3	182	2,7
Netherlands	43	2,0	112	1,7
Germany	100	4,7	111	1,7
Denmark	28	1,3	103	1,5
Canada	38	1,8	65	1,0
Russia	7	0,3	61	0,9
Luxembourg	23	1,1	51	0,8
Korea	4	0,2	48	0,7
China	0	0,0	44	0,7
Sweden	16	0,8	44	0,7
Spain	20	1,0	43	0,6
Mexico	9	0,4	32	0,5
India	2	0,1	31	0,5
Turkey	...	...	27	0,4
Chinese Taipei	5	0,2	26	0,4
Italy	29	1,4	24	0,4
Belgium	27	1,3	22	0,3
Norway	9	0,4	21	0,3
South Africa	9	0,4	21	0,3
Austria	12	0,6	17	0,3
Brazil	5	0,2	17	0,3
Finland	4	0,2	15	0,2
Thailand	3	0,1	13	0,2
Chile	1	0,1	12	0,2
New Zealand	7	0,3	12	0,2
Ireland	11	0,5	11	0,2
Malaysia	1	0,1	11	0,2

The Market for Foreign Exchange

The most traded currencies

Foreign exchange market turnover by currency and currency pairs

Net-net basis,[1] daily averages in April, in per cent — Graph 1



[1] Adjusted for local and cross-border inter-dealer double-counting. [2] As two currencies are involved in each transaction, the sum of shares in individual currencies will total 200%. [3] Emerging market currencies.

Source: BIS Triennial Central Bank Survey. For additional data by currency and currency pairs, see Tables 2 and 3 on pages 10 and 11.

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.

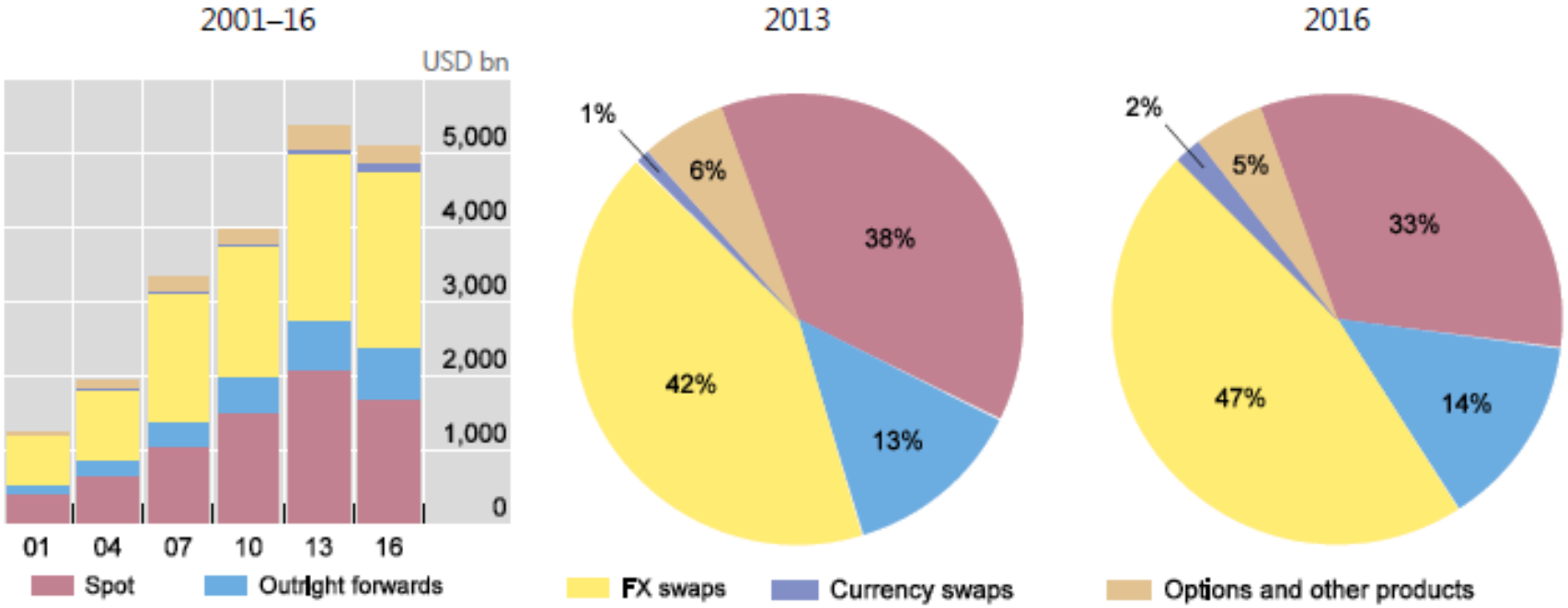
The Market for Foreign Exchange

- 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**.

The Market for Foreign Exchange

Foreign exchange market turnover by instrument

Net-net basis,[1] daily averages in April — Graph 2



[1] Adjusted for local and cross-border inter-dealer double-counting.

Source: BIS Triennial Central Bank Survey. For additional data by instrument, see Table 1 on page 9.

Foreign Exchange Derivatives

- 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

- 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

- 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

- 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) (2008)
      - The top 5 banks account for 50% of the market.
      - The top 10 banks account for 75% of the market.
    - They trade currencies not just for their clients, but also on their own account in search for profit

    - 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 regulation
  - 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
    - Assume forex trading commissions are negligible. Take advantage of differences in price of dollars quoted in New York and London:

$$E_{£/\$}^{NY} = £0.50 \text{ per dollar}$$
$$E_{£/\$}^{London} = £0.55 \text{ per dollar}$$

    - 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!

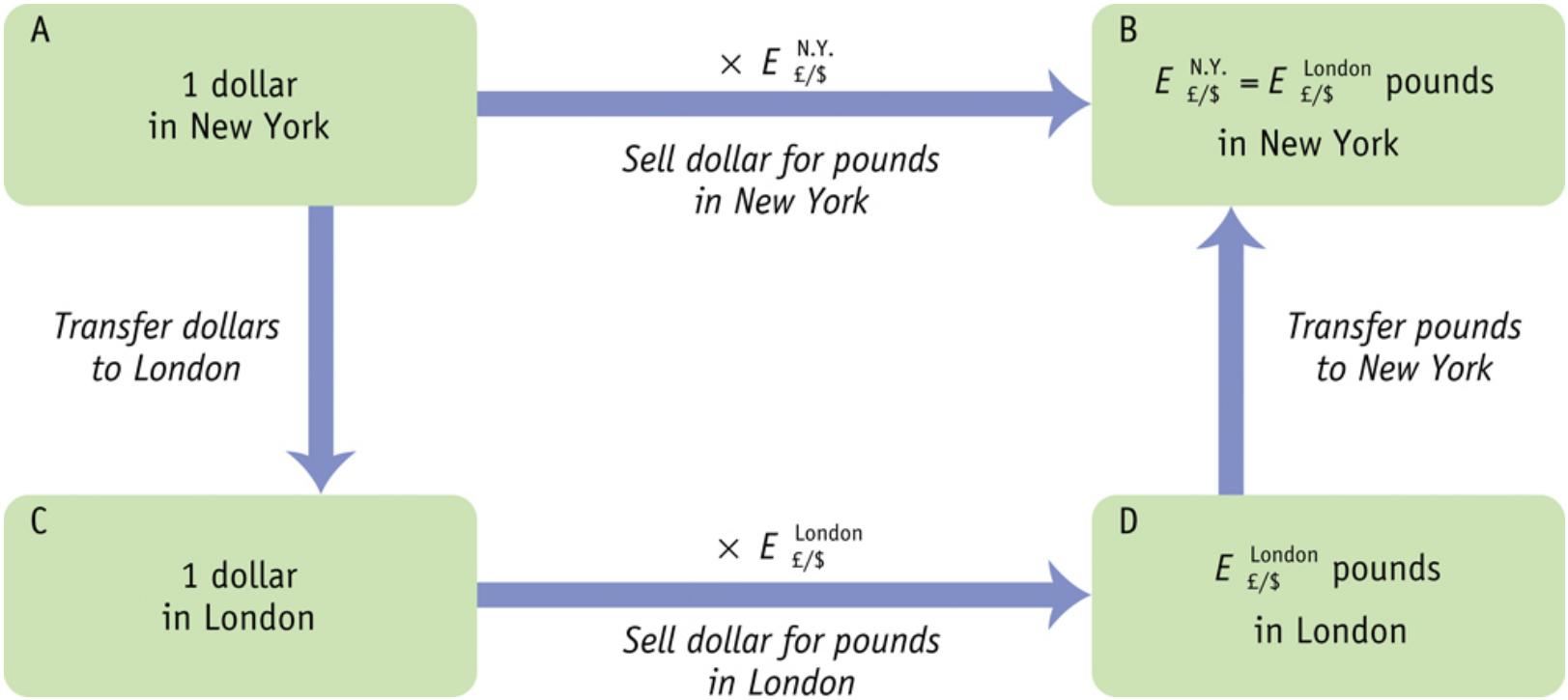
Arbitrage and Spot Exchange Rates

- Arbitrage with Two Currencies
  - Example (continued):
    - 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

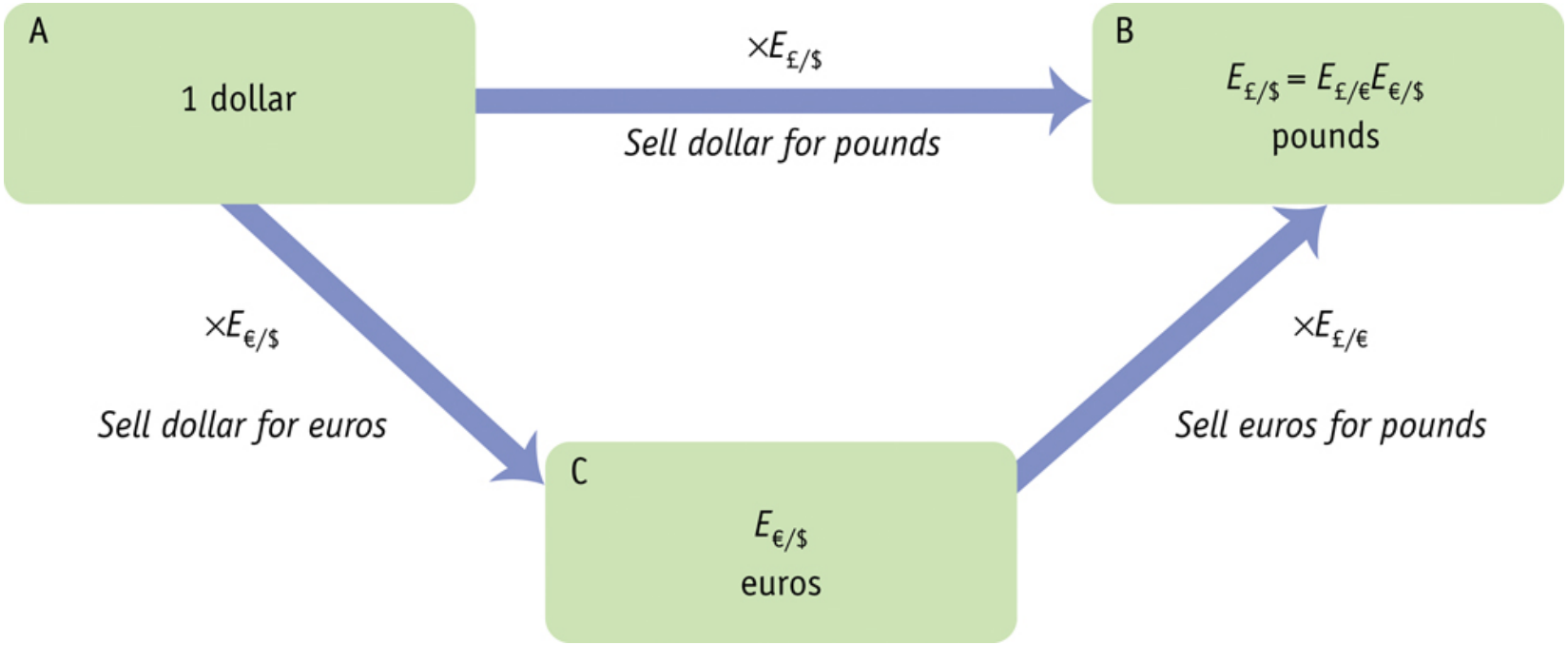
- Arbitrage with **Three Currencies**
  - The **cross rate** allows us to compare exchange rates defined in terms of different currencies (given N currencies – including numeraire – there will be N(N -1)/2 cross-rates).
    - For example, consider the bilateral exchange rate $E_{£/\$}$.
    - This can be expressed in terms of $E_{€/\$}$ and $E_{£/€}$:

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

    - 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 2010, the most common vehicle currency was the U.S. dollar – used in 84.9% of all foreign exchange transactions (declining from 89.9 in 2001).
    - The euro (39,1%, up from 37,9 in 2001), 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 an unexpected change in the exchange rate.
- <u>Riskless arbitrage</u>
  - 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).
- <u>Risky arbitrage</u>
  - 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 know, 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

- <u>Example</u>: Being a US resident citizen, consider investing $1 in a bank deposit in two places: New York and Paris.
  - 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 $(1+i_{€})$ rate of return in euros in the account in Paris.
  - Not comparable! Different currencies!
  - We must calculate the dollar return in Europe:
    - Today, one U.S. dollar buys $1/ E_{\$/€}$ euros.
    - In one year, you will have $(1+i_{€})/E_{\$/€}$ euros.
    - You do not know the $E_{\$/€}$ 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 $(1+i_{€})F_{\$/€}/E_{\$/€}$ U.S. dollars.
  - Riskless arbitrage implies these two strategies will yield the same rate of return <u>in dollars</u>.

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:

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

- The CIP equation is used to exactly price forward contracts (if we know interest rates and E then we can solve for F)

CIP

- A useful aproximation is the following:

$lg(1+i_{\$}) = lg(1+i_{€}) + lg[(F_{\$/€} / E_{\$/€}) - 1 + 1]$

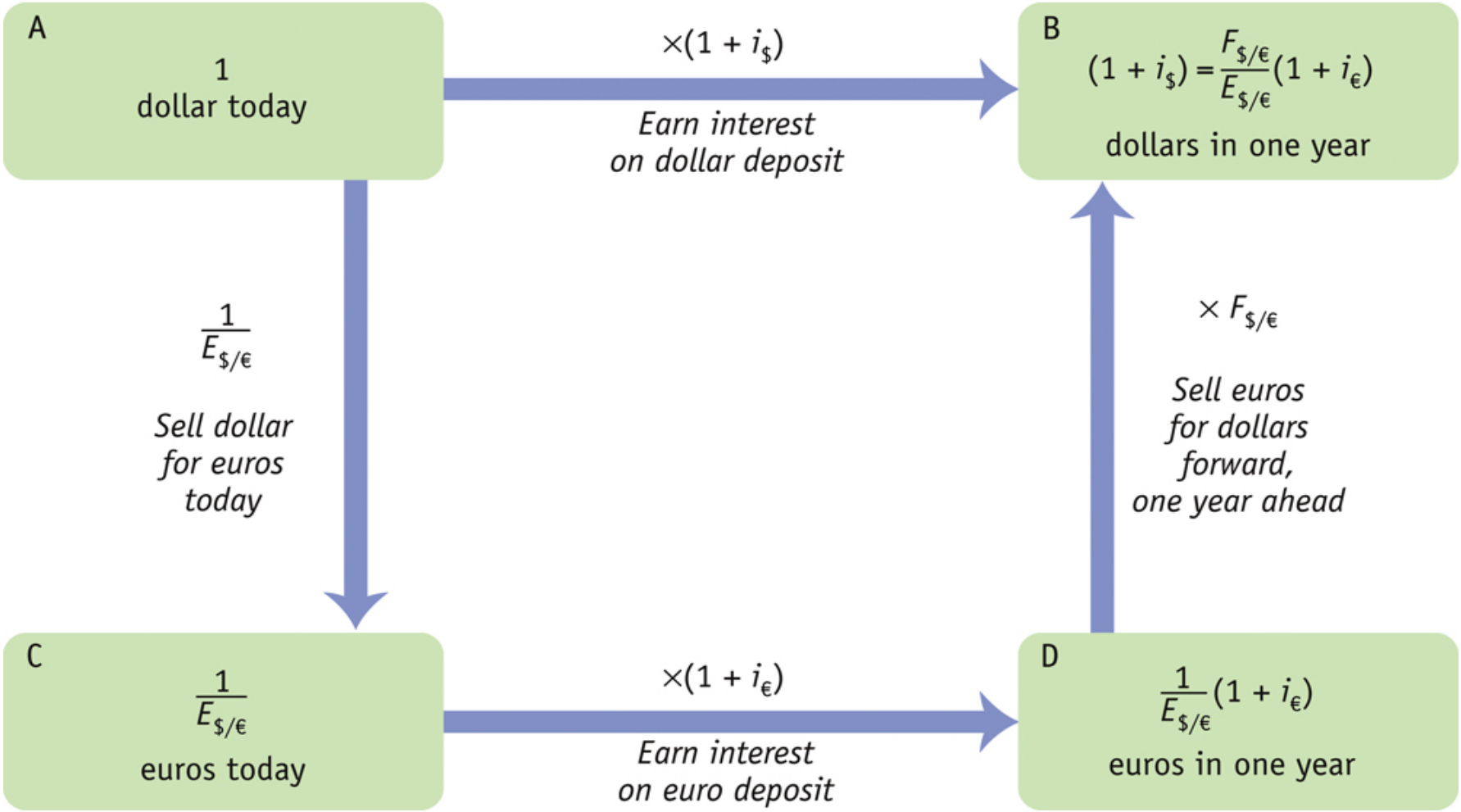
define fp = forward premium = $(F_{\$/€} / E_{\$/€}) - 1$

$lg(1+i_{\$}) - lg(1+i_{€}) = lg[fp + 1]$

remember: $lg(x+1) \approx x$ for x small

$$i_{\$} - i_{€} \approx fp \qquad \text{CIP}$$

Riskless Arbitrage: Covered Interest Parity



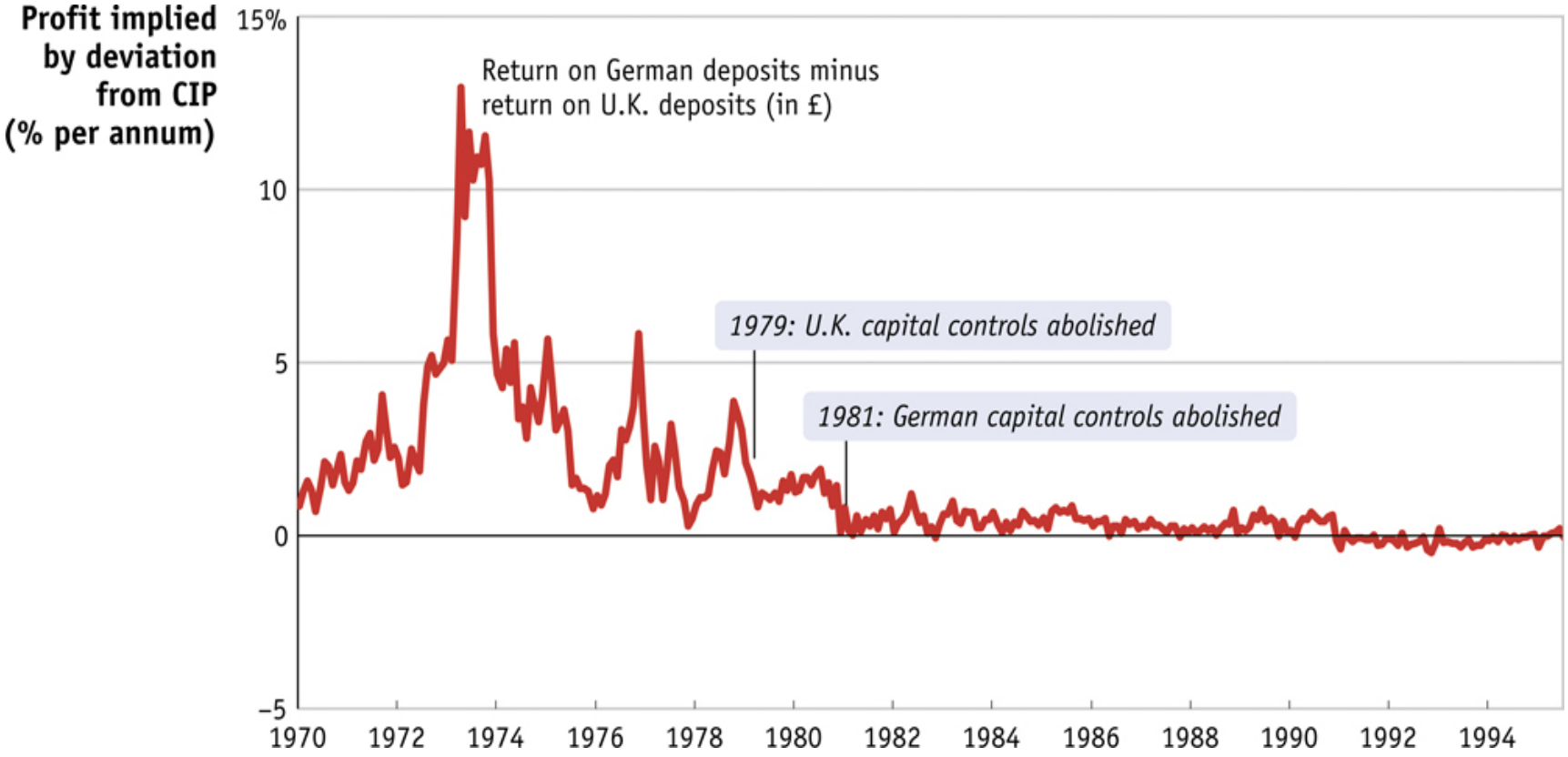
Riskless Arbitrage: Covered Interest Parity

- 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

- Arbitrage profit: German DM and British £



Evidence on Covered Interest Parity

- 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):

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

Assets and their Attributes

- 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

- 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.

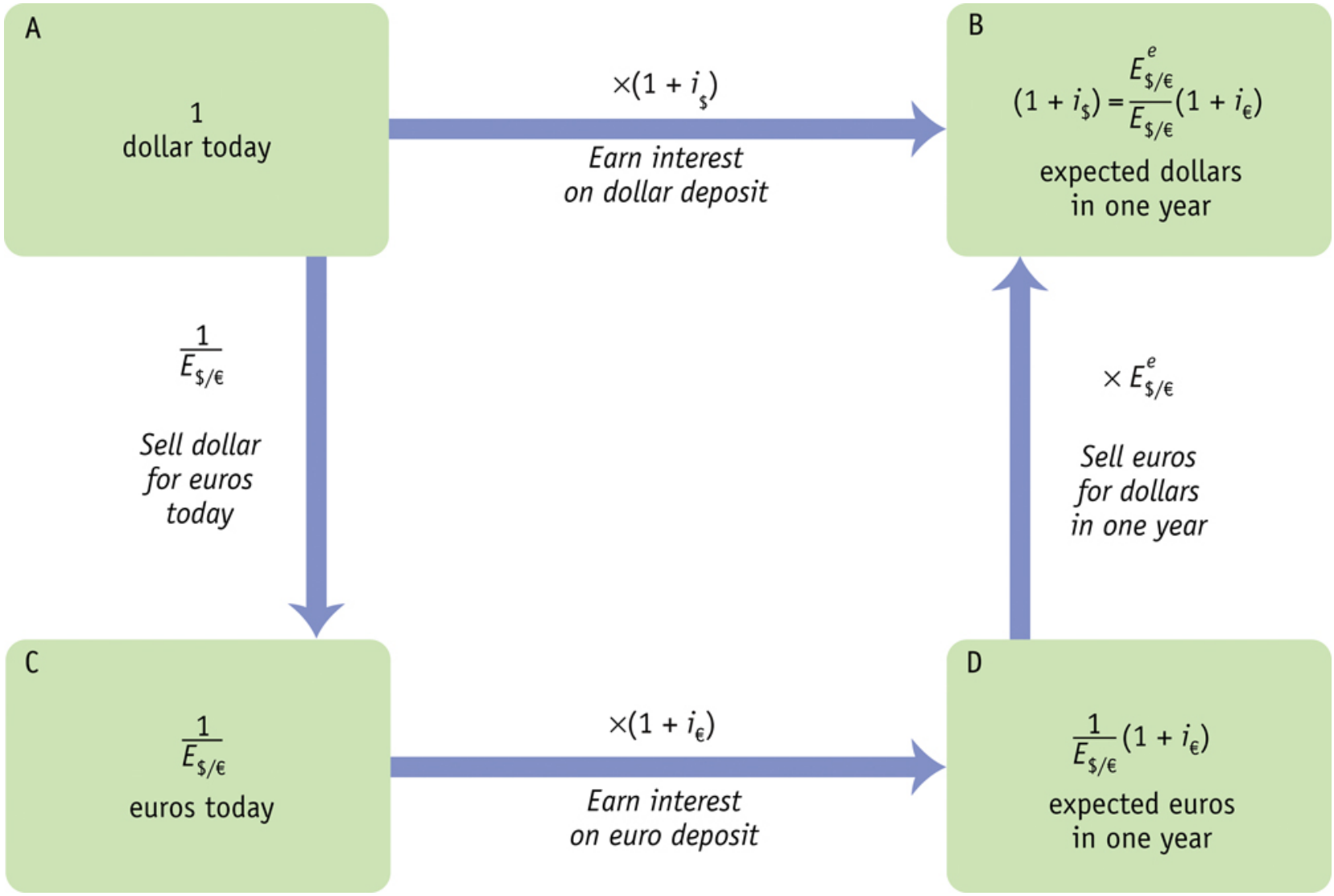
Risky Arbitrage: Uncovered Interest Parity

- 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 $E^e_{\$/€}$, and makes decisions based on this forecast.
- 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

- 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 $(1+i_{€})$ 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 $1/ E_{\$/€}$ euros.
    - In one year, you will have $(1+i_{€})/E_{\$/€}$ euros.
    - You do not know the $E_{\$/€}$ 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 $E^{e}_{\$/€}$.
    - In this case, your rate of return on the European deposit would be $(1+i_{€})$ $E^{e}_{\$/€}/E_{\$/€}$ U.S. dollars.
    - There is *exchange rate risk* because the future spot exchange rate $E^{e}_{\$/€}$ 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

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

- 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.

UIP: A Useful Approximation

- As for CIP, we can approximate UIP as:

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

- or: $i_{\$} - i_{€} \approx (\Delta E^{e}/E)$

UIP tells us how expected exchange rate <u>changes</u> are related to interest rate differentials. For example, if the US interest rate is higher than the Japanese interest rate, then we should expect a depreciation of the dollar.

It explains why investors don't place all their funds in countries offering high interest rates (Iceland example).

Risky Arbitrage: Uncovered Interest Parity

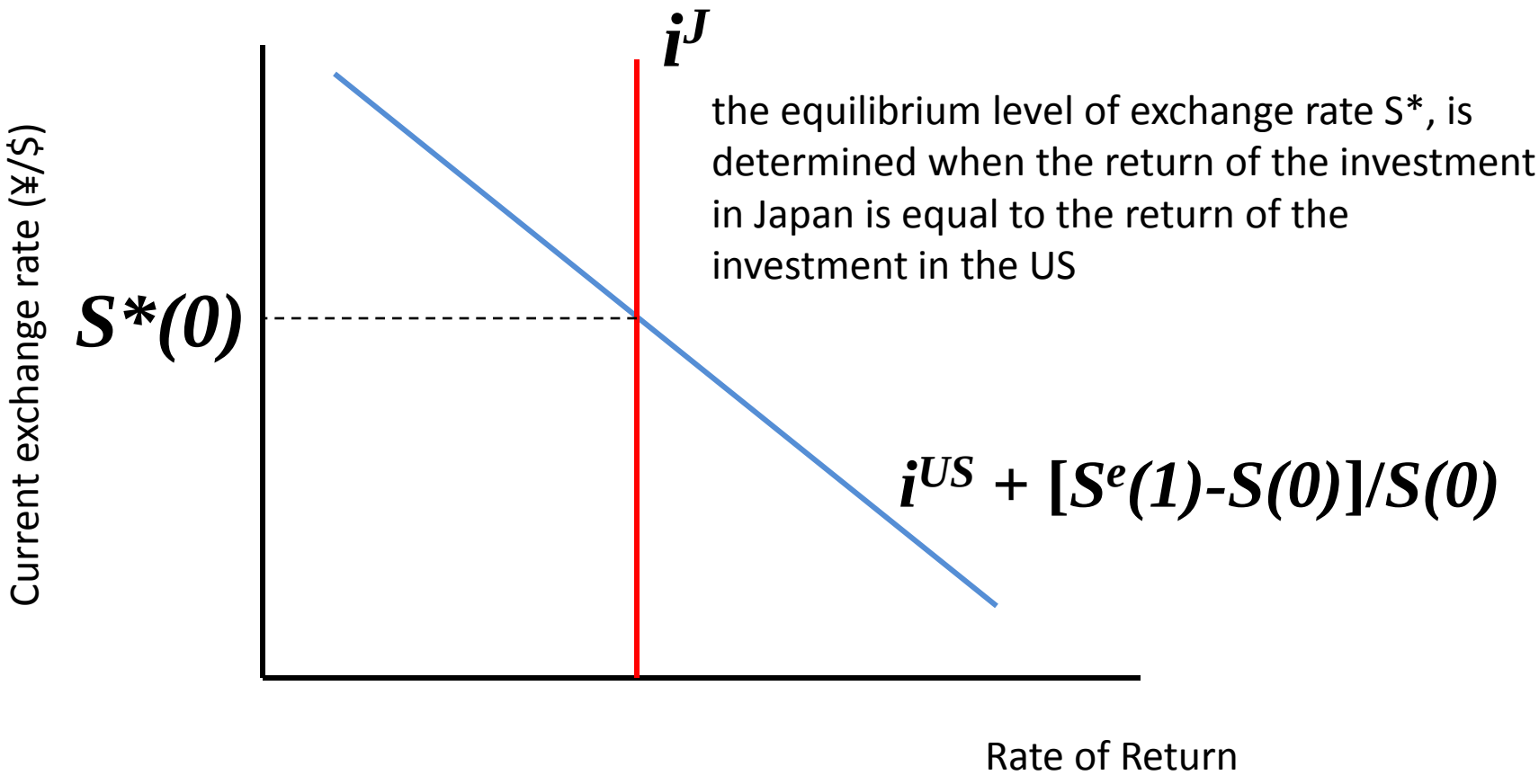
- **Uncovered Interest Parity (UIP)**
  - Knowing the expected exchange rate and the interest rates for each currency, we can solve for the spot exchange rate:

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

  - UIP might be used also as a theory of what determines the <u>level</u> of the spot rate.

UIP and the Exchange Rate

(note change in notation: the symbol for exchange rate now is S)



UIP and the Exchange Rate

(note change in notation: the symbol for exchange rate now is S)

In the graph the return on dollar account curve uses the approximate form:

$$Ret \approx i^{US} + [S^e(1) - S(0)]/S(0)$$

However using the correct definition, it easier to understand the nature of the curve:

$$Ret = (1 + i^{US}) [S^e(1)/S(0)]$$

One can easily obtain the inverse for S(0) as:

$$S(0) = (1 + i^{US}) [S^e(1)/Ret]$$

and taking logs:

$$lgS(0) = [lg(1 + i^{US}) + lg S^e(1)] - lgRet$$

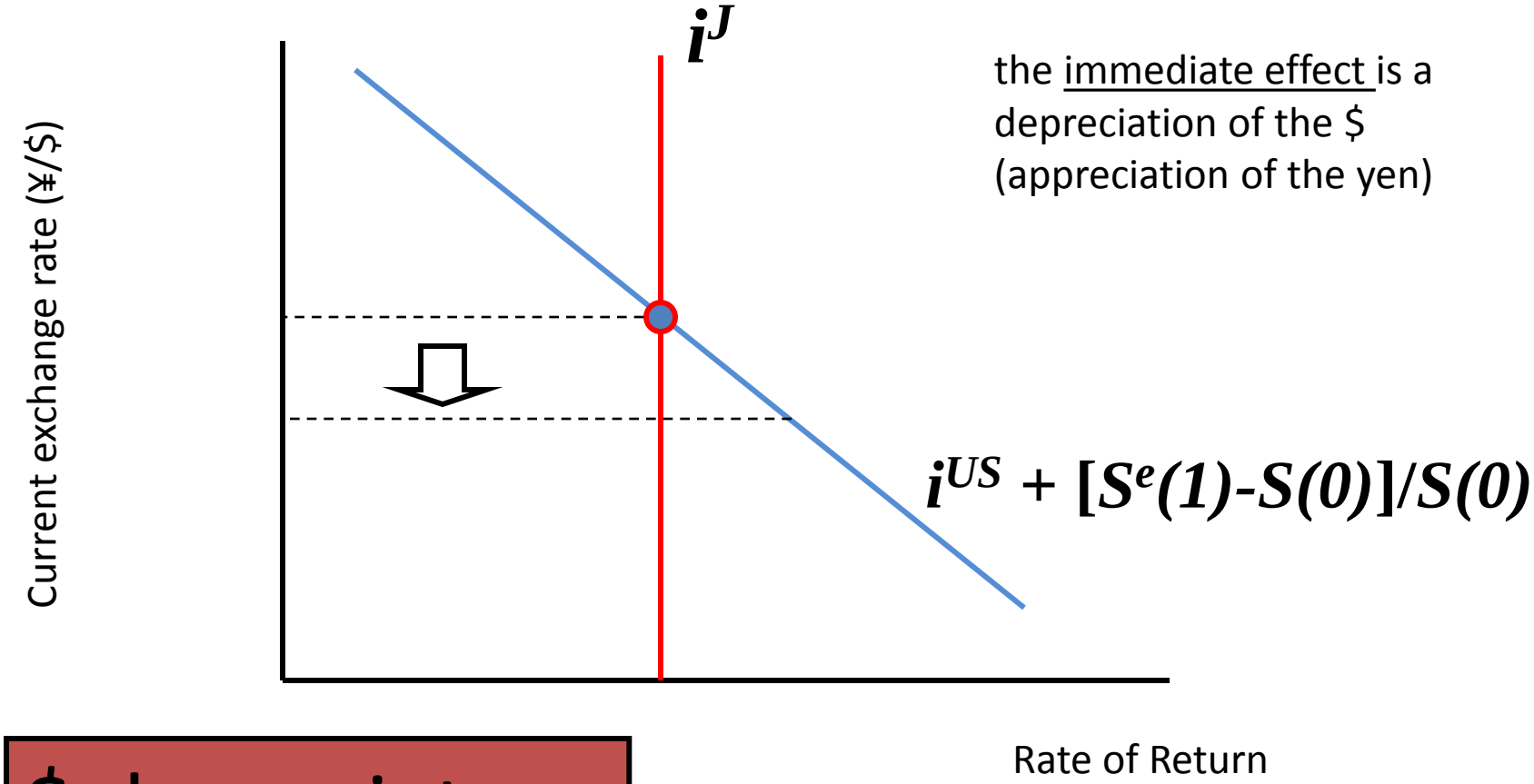
Role of Expectations (unanticipated events): future exchange rate

- We have seen that, for a given interest rate differential, S(0) is determined by $S^e(1)$. What determines $S^e(1)$? We can use the UIP for the next period to determine it:

$$i^{J\,e} = i^{US\,e} + [S^e(2) - S^e(1)]/S^e(1)$$

- And what determines $S^e(2)$? Again we can use UIP in the same way. We can keep performing this trick for many periods. At a certain point we will write the current exchange rate S(0) as a function of an expected long run exchange rate $S^e(LR)$ and all future interest rates.
- To determine $S^e(LR)$ we can use PPP.

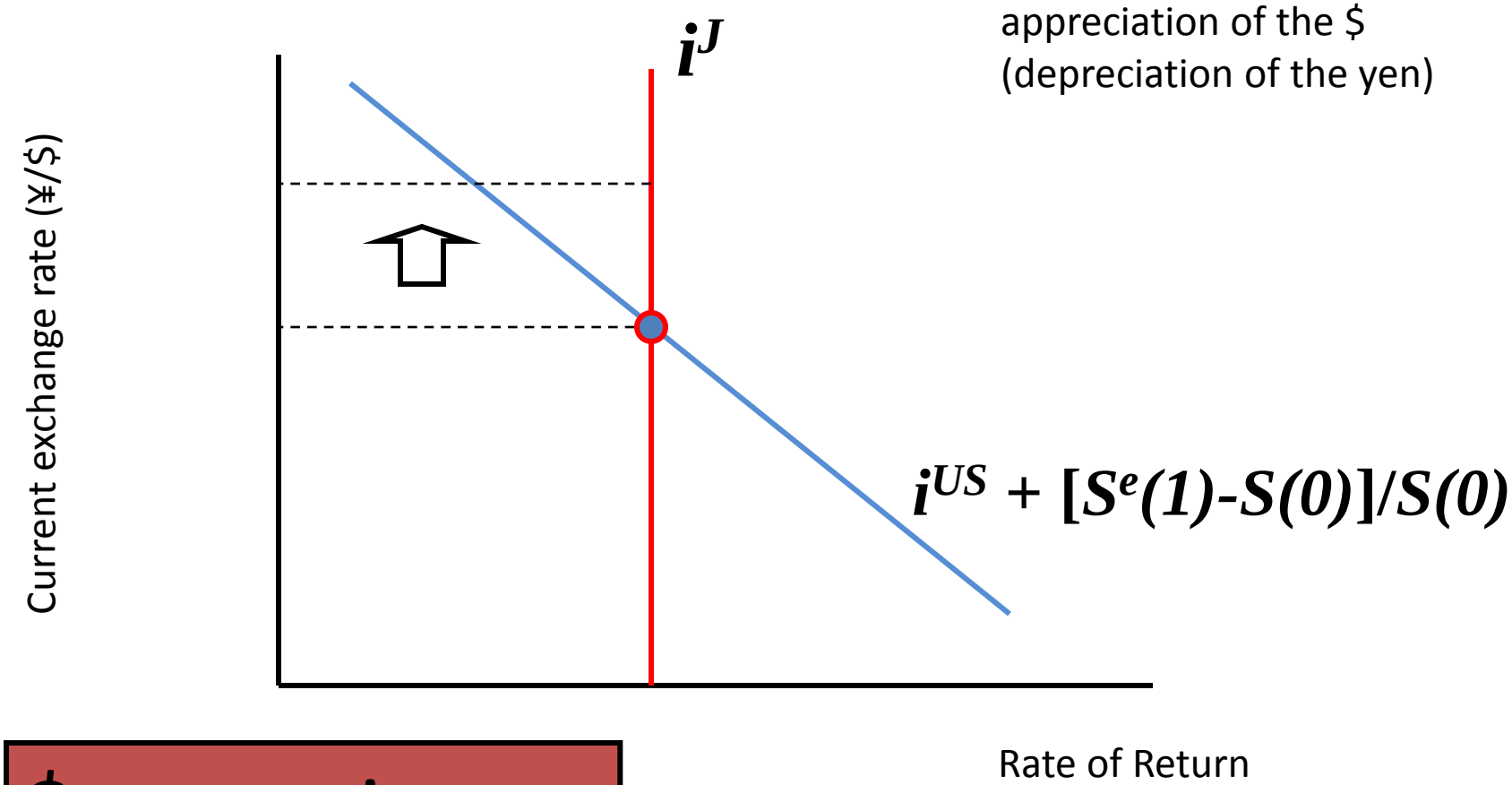
UIP and the Exchange Rate: exogenous increase in Japanese interest rates



$ depreciates

UIP and the Exchange Rate: exogenous increase in US interest rates

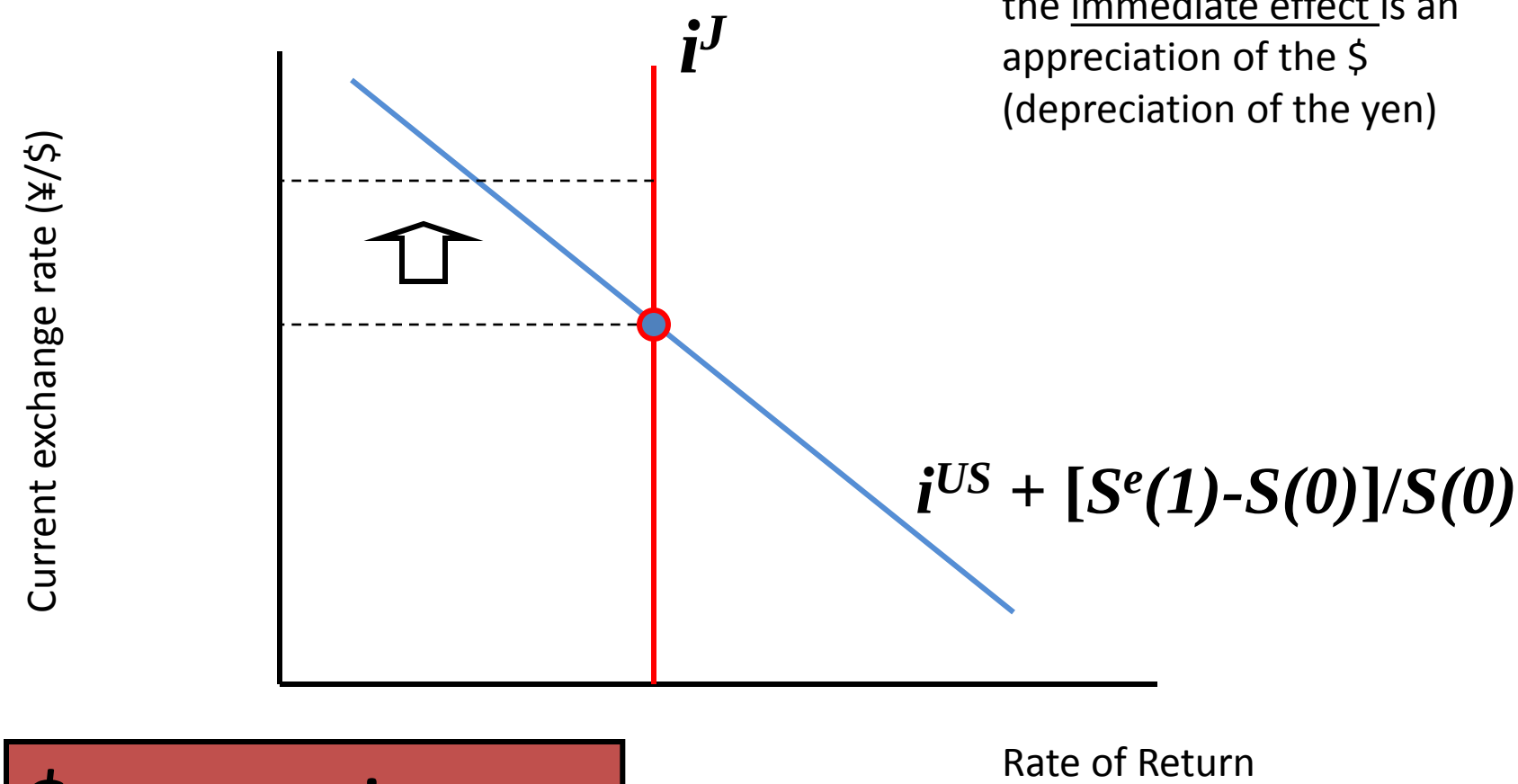
the immediate effect is an appreciation of the $ (depreciation of the yen)



$ appreciates

UIP and the Exchange Rate: revision upwards of expectations on future dollar strength

the immediate effect is an appreciation of the $ (depreciation of the yen)



$ appreciates

UIP and the Exchange Rate

- Assume expectations of future rates are fixed
- Spot market depreciation of dollar caused by:
  - Rise in Japanese interest rates
  - Fall in US interest rates
  - Expectation of future dollar depreciation
- Spot market appreciation of the dollar caused by:
  - Fall in Japanese interest rates
  - Increase in US interest rates
  - Expectation of future Yen depreciation

Role of Expectations (unanticipated events): interest rate

- Assume i^{US} = 4%, i^{J} = 1% and $S^{e}(1)$= 100. From UIP we obtain that approx. S(0)=103. Assume also that markets expect that today the FED will raise i^{US} to 6%.

  As a consequence the US $ appreciate to 105.

  However, the FED surprises the market and raises i^{US} only to 5%.

  This implies a depreciation of the US$ to 104.

A currency can depreciate while interest rates rise

Role of Expectations (unanticipated events): future exchange rate

- We have seen that, for a given interest rate differential, S(0) is determined by $S^e(1)$. What determines $S^e(1)$? We can use the UIP for the next period to determine it:

$$i^{J\,e} = i^{US\,e} + [S^e(2)-S^e(1)]/S^e(1)$$

- And what determines $S^e(2)$? Again we can use UIP in the same way. We can keep performing this trick for many periods. At a certain point we will write the current exchange rate S(0) as a function of an expected long run exchange rate $S^e(LR)$ and all future interest rates.
- To determine $S^e(LR)$ we can use PPP.

Role of Expectations (unanticipated events):

- Suppose <u>temporary increase</u> in US interest rate:

This doesn't affect long run inflation, so S^e(LR) doesn't change. Also future interest rates are most probably unaffected.

So the dollar appreciates by the amount of interest rate increase

- Suppose a <u>permanent increase</u> in US interest rate:

This should lower long run inflation so S^e(LR) will increase (appreciation).

Moreover, the whole future path of US interest rates is now expected to be higher. According to UIP, the dollar has to depreciate by more over the coming years.

Finally, to provide room for this depreciation, the dollar has to appreciate immediately.

Evidence on Uncovered Interest Parity

- <u>Interest parity conditions</u>
  - CIP:

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

  - UIP:

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

  - Thus CIP plus UIP imply:

$$F_{\$/€} = E^{e}_{\$/€}$$

- 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

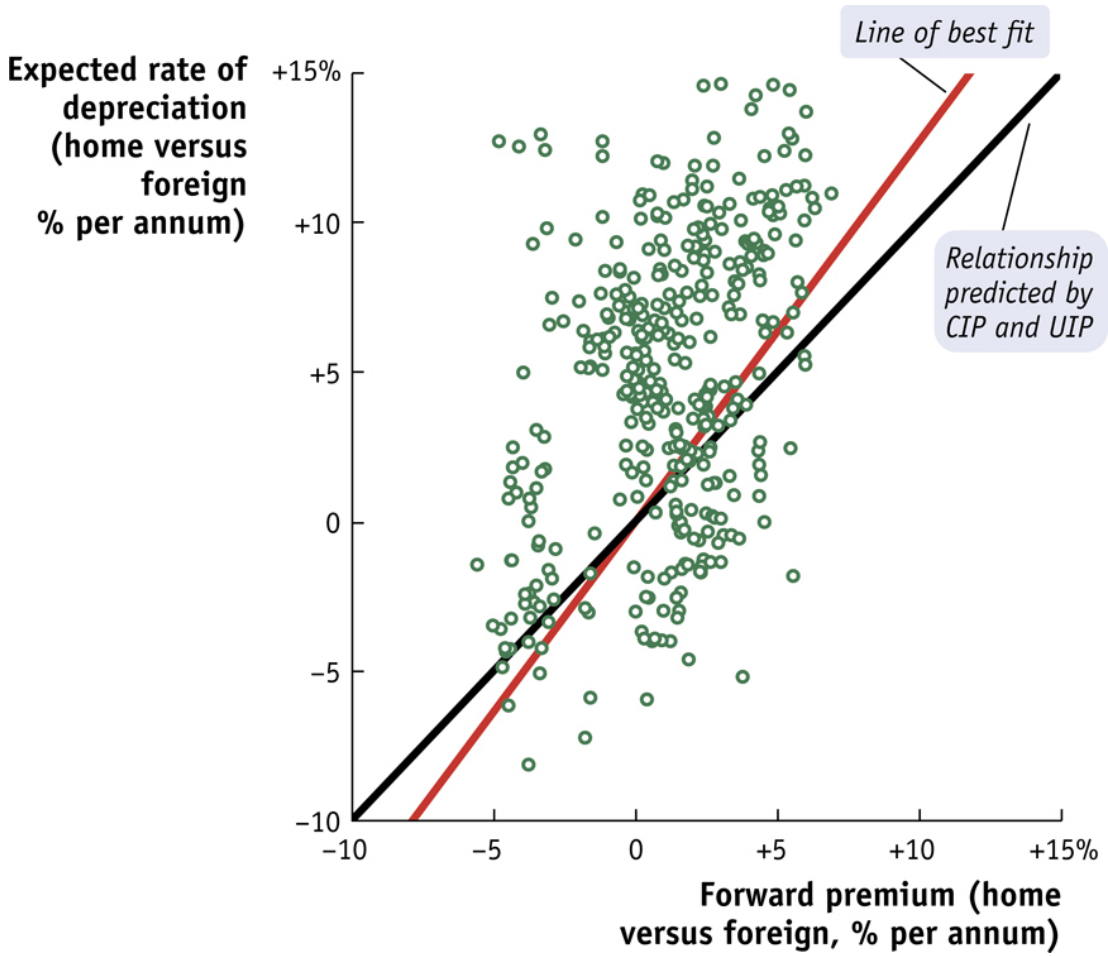
- An important testable implication:

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

  - Left-hand side is the **forward premium** (+ or –)
  - Says how much more/less investors are willing to pay for the forward versus the spot. Easy to measure.
  - Right-hand side is **expected rate of depreciation** (+ or –). It is unobservable. 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…

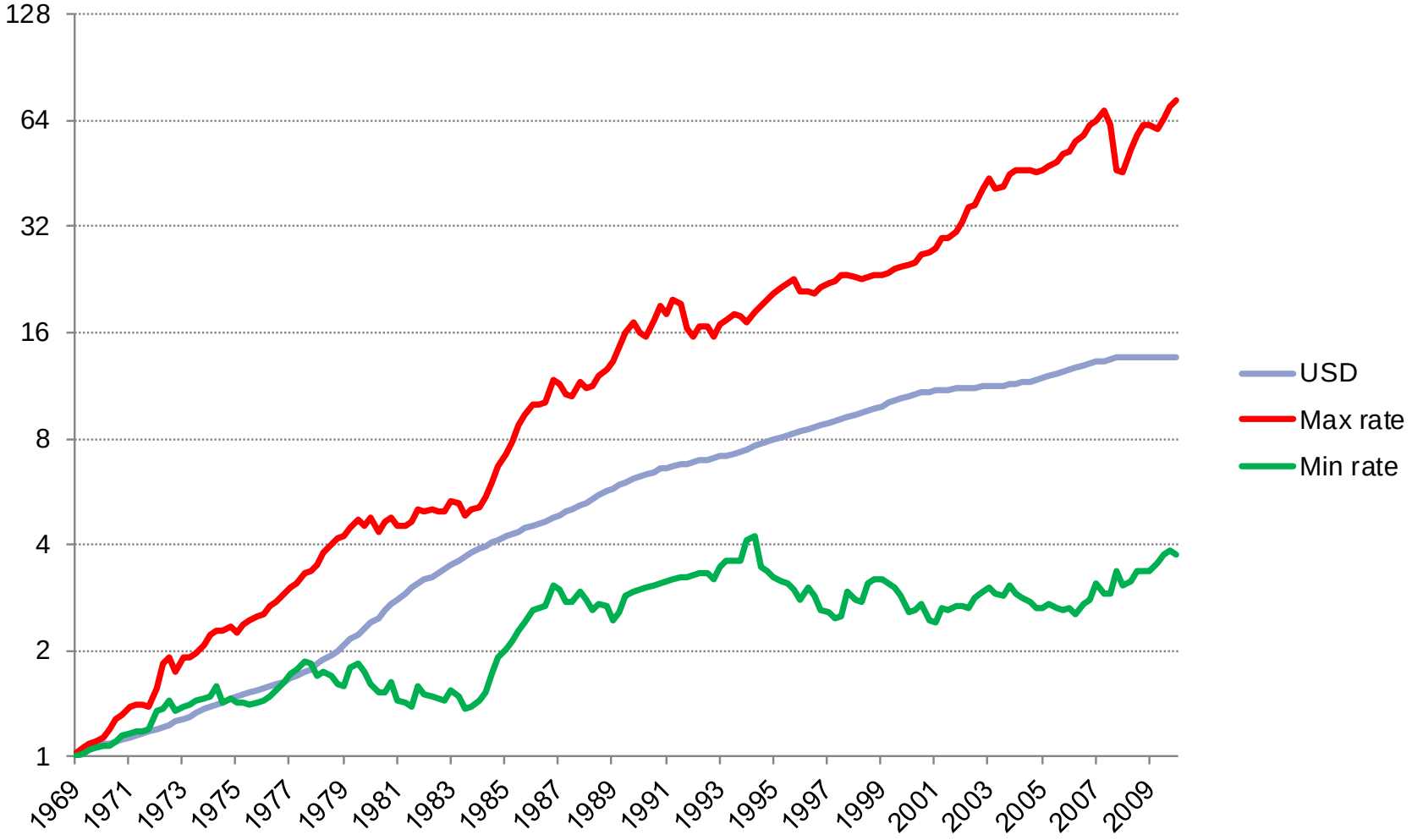
Evidence on Uncovered Interest Parity

- 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, but other evidences point against UIP. For example the profitability of Carry Trade

UIP and carry trade: on average investing in high-interest rate currencies gives higher return than normal

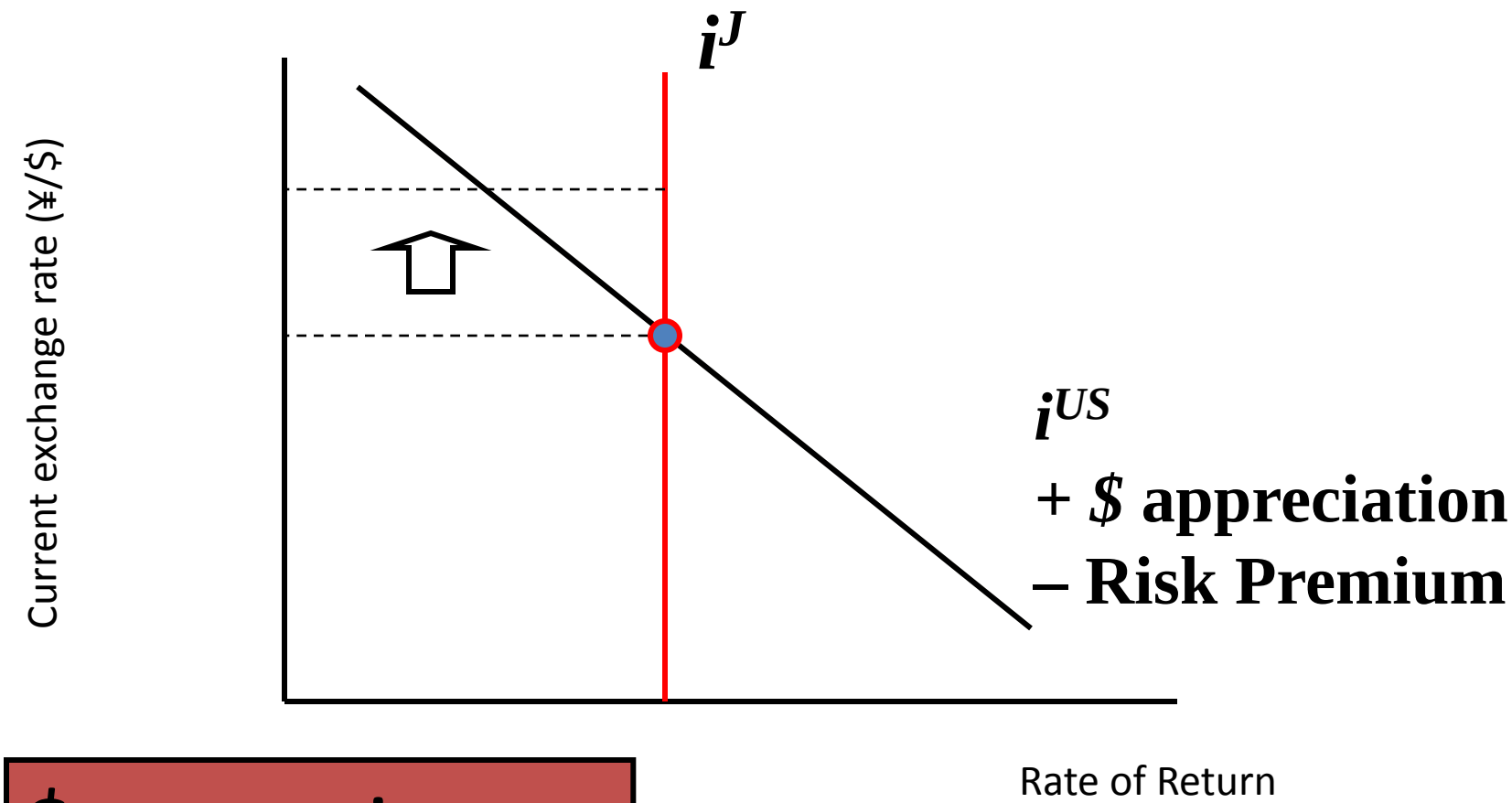


UIP and Risk Averse Investors

- UIP predictions are often violated by the data.
- So far, we've neglected risk
- Risk averse investors require risk premium to hold risky assets

US interest Rate + Expected Dollar Appreciation = Japanese Interest Rate + Risk Premium

UIP and risk aversion: Decrease in risk premium



$ appreciates

Difficulties with UIP

- The introduction of risk premium into UIP doesn’t improve much the ability of this no-arbitrage condition to explain nominal exchange rate volatility