

# Week 4: Foreign Exchange (FX) Markets

## FINA3020

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# Today: Foreign Exchange (FX) Markets

- Definitions
  - Spot markets
  - Order book, bid-ask spread
  - Forward markets
  - Onshore vs offshore
  - Exchange rate regimes
- Uncovered interest parity (UIP)
- Covered interest parity (CIP)

# Foreign Exchange (FX) Definitions

FX = conversion between two different currencies, and currency = official form of money in a specific location

- Spot market = Immediate purchase/sale
- Forward market = Agreement (obligation) to purchase/sell at specified price at a future date
  - Futures are standardized forward contracts, generally traded on exchanges, while forwards are typically customized and over the counter (OTC)
- A **swap** is a contract with two legs, same quantity and different timing: spot and forward
- Options provide the right but not obligation to buy/sell at a specified price on/before a future date
- **Wholesale** market has OTC bulk transactions between institutions, majority of total volume
  - Retail market has individual investors as one counterparty
- A **broker** is an intermediary that executes trades for a fee. Many brokers are also **dealers** who buy and sell for profit with their own **inventory**.

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# What Distinguishes FX Markets

- 24 hours per day for 5 days per week (6am HKT Monday through 6am Saturday)
  - Overlapping market hours in Sydney, Tokyo, London, New York, and other exchanges in each region
- High trading volume: daily turnover of over US\$7T *per day*
- Dollar dominance: USD is counterparty of almost 90% of transaction volume
  - At least the 7 most traded currency pairs all involve the USD
- High use of derivatives: Half of total volume is swaps, and FX options have the highest volume among options

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For any currency pair, e.g. USD vs HKD *from HK's perspective*, there are two perspectives:

- Direct quotation: how many units of domestic currency to buy 1 unit of foreign currency? 7.78 HKD per USD
  - The international norm is “American terms” = direct quote from US perspective
- Indirect quotation: how many units of foreign currency to buy 1 unit of domestic currency? 0.129 USD per HKD

Why must the indirect quotation be the inverse of the direct quotation?

- Suppose to the contrary that the product were greater than 1. For example, someone is willing to sell you  $\frac{3}{4}$  GBP per USD and someone else is willing to sell you  $\frac{5}{3}$  USD per GBP. Then you would have arbitrage = risk-free profits
  - start with  $N$  GBP: buy USD to obtain  $\frac{5}{3}N$  USD, then buy GBP to obtain  $\frac{3}{4} \cdot \frac{5}{3}N = \frac{5}{4}N > N$
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Why must the indirect quotation be the inverse of the direct quotation? Locational arbitrage

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To convert the prices of foreign goods in foreign currency to domestic currency, multiply by the direct quotation (or divide by the indirect).

- Example: suppose you wish to buy a gold necklace from India priced at 90k INR. If your direct quote is 0.088 HKD per INR, then you must convert  $90k \times 0.088 = 7.9k$  HKD to purchase the necklace

The HKD **appreciates** against the USD if you need more USD to buy 1 HKD (rise in HK's indirect quotation, fall in US's direct quotation). The opposite is **depreciation**

- Example from Week 1: When the US raised interest rates from  $\approx 10\%$  to  $\approx 20\%$  in 1979-1981 to combat an oil shock, that increased demand for USD through higher demand for US bonds, resulting in USD appreciation of  $\approx 20\%$
- Example from Week 3: Due to capital outflows in response to a local banking crisis and speculative attacks on its peg to the USD, the Thai baht depreciated  $\approx 40\%$  over 1997-1998

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# Order Book and Bid-Ask Spread

An **order book** shows the amount that participants are willing to buy (bid) and sell (ask/offer) at each price on an exchange.

The **tick size** is the minimum permissible price increment.

You can read the bid-ask spread off the top of the order book.

Market-makers provide liquidity through their willingness to both buy and sell, and are compensated by trades crossing the bid-ask spread

Prices are units of HKD per USD  
(HK direct, US indirect)

Bids		Asks	
Price	Size	Price	Size
7.7990	1,000,000	7.8010	1,200,000
7.7985	750,000	7.8015	800,000
7.7980	2,000,000	7.8020	1,500,000
7.7975	1,500,000	7.8025	600,000
7.7970	900,000	7.8030	2,200,000

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Suppose a market participant comes along and wants to sell \$500k immediately. What happens?

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# Order Book Mechanics: Market Order

Suppose someone who holds HKD comes along and wants to sell \$500k immediately. The transaction occurs at price 7.799. The seller “**hit the bid**”

This is called a **market order**: immediately at the best available current price in the order book.

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Now suppose someone who holds USD comes along and wants to buy \$100k immediately. The transaction occurs at price 7.801. The buyer **“lifted the offer”**

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Now assume a large institution wants to sell \$3M immediately. What happens?

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# Order Book Mechanics: Market Order

Now assume a large institution wants to sell \$3M immediately. What happens?

The order “walks the book” and cannot be fully filled at the best bid of 7.7990. Average price is 7.9829:

$$\frac{0.5\text{M} \times 7.990 + 0.75\text{M} \times 7.985 + 1.75\text{M} \times 7.980}{3\text{M}}$$

More liquid markets have more **depth** and less **slippage** for large orders

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7.7970	900,000	7.8030	2,200,000

## Order Book Mechanics: Market Order

If nobody posts additional bids, then the order book now looks like this →

However, when someone makes a large market order, the market-makers worry that that entity has **private information**, in this case that the HKD will *strengthen* against the USD (need fewer HKD to buy 1 USD). The market-makers might adjust their quotes accordingly.

Suppose a market-maker decides to cancel the 250k order at 7.7980, post an additional bid of \$1.5M at 7.7965, and post an additional offer of \$1M at 7.8005. How would the order book adjust?

Prices are units of HKD per USD  
(HK direct, US indirect)

Bids		Asks	
Price	Size	Price	Size
7.7980	250,000	7.8010	1,100,000
7.7975	1,500,000	7.8015	800,000
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Suppose a market-maker decides to cancel the 250k order at 7.7980, post an additional bid of \$1.5M at 7.7965, and post an additional offer of \$1M at 7.8005. How would the order book adjust?

The new orders by the market-maker are **limit orders**, instructions to sell at a specific price or better, executed at a point in the future when someone else hits the bid or lifts the offer

Prices are units of HKD per USD  
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Bids		Asks	
Price	Size	Price	Size
7.7975	1,500,000	7.8005	1,000,000
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## Order Book Mechanics: Limit Order

If market-maker X enters another bid for \$300k at 7.7975, so total depth at the best bid is \$1.8M, and there is a market order to sell \$1.2M, then market-maker X generally does not get filled at all

*Price-time priority:* The best price always has priority. Within orders at the same price, those placed earlier are filled first.

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A **pip** (“percentage in point”) is the tick size in many common currency pairs: 0.0001

- EUR-USD is the highest volume currency pair, with average spread of  $0.0004 = 4$  pips
- HKD-USD spread is usually equal to the tick size of 1 pip
- Sometimes, bid-ask spreads are reported *normalized* by the **mid** (average between best bid and best ask)
- Major EM currencies' spreads with USD are generally low when normalized. Examples:
  - BRL-USD average spread is 10 pips, equal to 0.02% of mid
  - MXN-USD average spread is 60 pips, equal to 0.03% of mid
- EM currencies' spreads with each other tend to be high. Example:
  - MXN-BRL average spread is 50 pips, equal to 0.14% of mid

Main exception is JPY, which defines pip as 0.01 because 1 USD is  $\approx 100$  JPY (lately around 150)

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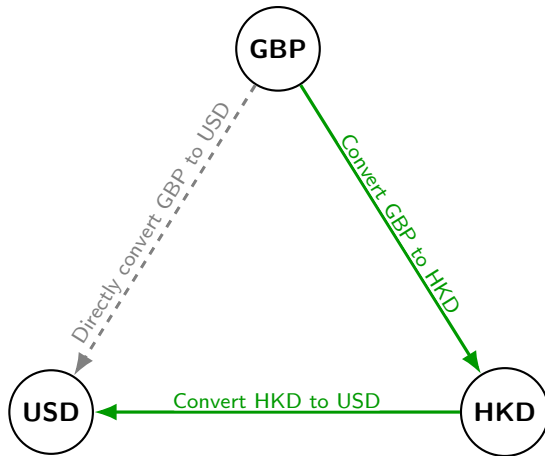
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Quotations must satisfy **triangular arbitrage**:  
If you can trade  $X$  GBP per HKD, and  $Y$  HKD per USD, then how many GBP per USD?

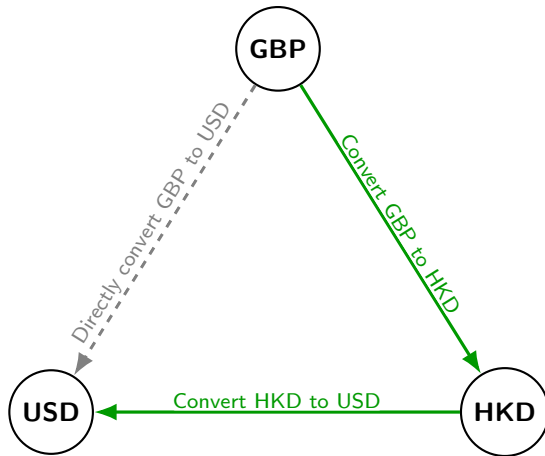
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- This identity should hold in any direction, up to the **spreads**



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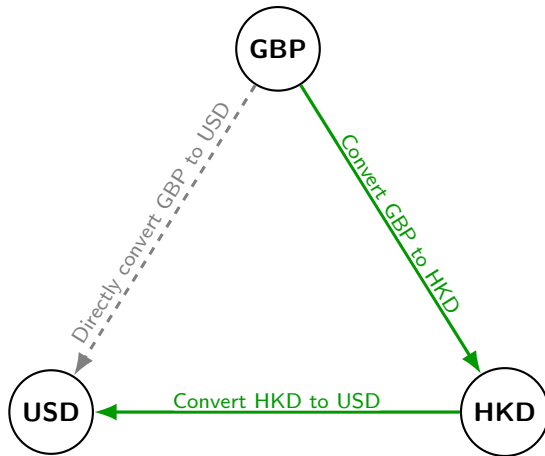




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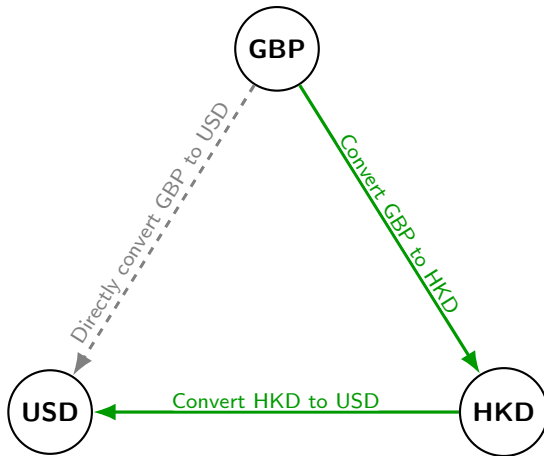


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# Why does Triangular Arbitrage Hold?

Assume that the *highest bid* for buying GBP using USD  $\frac{\text{GBP}}{\text{USD}}$  were 0.75 (size 200 USD) and the *highest bid* for buying USD using HKD  $\frac{\text{USD}}{\text{HKD}}$  were 0.128 (size 1500 HKD).

Assume the *lowest offer* to sell GBP in return for HKD  $\frac{\text{GBP}}{\text{HKD}}$  were *strictly more* than  $0.75 \cdot 0.128 = 0.096$ , say 0.100 at size 2000 HKD. If you start with 1000 HKD, then you could

- ① Buy 100 GBP using your 1000 HKD by lifting the  $\frac{\text{GBP}}{\text{HKD}}$  offer
- ② Sell 100 GBP to receive  $\frac{100}{0.75} = 133.33$  USD by hitting the  $\frac{\text{GBP}}{\text{USD}}$  bid
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This is **arbitrage** because it is risk-free if you can do these transactions “at the same time” and they clear simultaneously, and you have profited 1041.64 HKD now minus 1000 HKD originally = 41.64 HKD of arbitrage profit

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- ① Buy 75 GBP using 750 HKD by lifting the  $\frac{\text{GBP}}{\text{HKD}}$  offer
- ② Sell 75 GBP to receive  $\frac{75}{0.75} = 100$  USD by hitting the  $\frac{\text{GBP}}{\text{USD}}$  bid
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This is stilll arbitrage, but now the arbitrage profit is smaller:  $781.25\text{HKD} - 750\text{HKD} = 31.25\text{HKD}$

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- ③ Sell 100 USD to receive  $\frac{100}{0.128} = 781.25$  HKD by hitting the  $\frac{\text{USD}}{\text{HKD}}$  bid

## Arbitrage Size

- *highest bid* for buying GBP using USD  $\frac{\text{GBP}}{\text{USD}}$  were 0.75 (size 100 USD)
- *highest bid* for buying USD using HKD  $\frac{\text{USD}}{\text{HKD}}$  were 0.128 (size 1500 HKD)
- *lowest offer* to sell GBP in return for HKD  $\frac{\text{GBP}}{\text{HKD}}$  were 0.100 (size 2000 HKD)

How did we know which size to begin with? Start with the case of unlimited size of existing bids/offers given your initial cash (1000 HKD) and see which leg is **binding**:

- ① Buy 100 GBP using your 1000 HKD by lifting the  $\frac{\text{GBP}}{\text{HKD}}$  offer
- ② Sell 100 GBP to receive  $\frac{100}{0.75} = 133.33$  USD by hitting the  $\frac{\text{GBP}}{\text{USD}}$  bid
- ③ Sell 133.33 USD to receive  $\frac{133.33}{0.128} = 1041.64$  HKD by hitting the  $\frac{\text{USD}}{\text{HKD}}$  bid

Then decrease the size through **backwards induction** with the binding leg:

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Assume the *lowest offer* to sell GBP in return for HKD  $\frac{\text{GBP}}{\text{HKD}}$  were *strictly more* than  $0.75 \cdot 0.128 = 0.096$ , say 0.100 at size 1000 HKD. *Even if you still begin with 1000 HKD, you should not trade it all because you are constrained by the bid size for  $\frac{\text{USD}}{\text{HKD}}$ . Instead:*

- ① Buy 76.8 GBP using 768 HKD by lifting the  $\frac{\text{GBP}}{\text{HKD}}$  offer
- ② Sell 76.8 GBP to receive  $\frac{76.8}{0.75} = 102.4$  USD by hitting the  $\frac{\text{GBP}}{\text{USD}}$  bid
- ③ Sell 102.4 USD to receive  $\frac{102.4}{0.128} = 800$  HKD by hitting the  $\frac{\text{USD}}{\text{HKD}}$  bid

*This is stilll arbitrage, but now the arbitrage profit is smaller:  $800\text{HKD} - 768\text{HKD} = 32\text{HKD}$*

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If you start with 90 GBP, then you could

- ① Sell 90 GBP to receive 1000 HKD by hitting the  $\frac{\text{GBP}}{\text{HKD}}$  bid
- ② Buy  $128 = 0.128 \cdot 1000$  USD using your 1000 HKD by lifting the  $\frac{\text{USD}}{\text{HKD}}$  offer
- ③ Buy  $96 = 0.75 \cdot 128$  GBP using your 128 USD by lifting the  $\frac{\text{GBP}}{\text{USD}}$  offer

Your arbitrage profit is  $96 \text{ GBP} - 90 \text{ GBP} = 6 \text{ GBP}$ .

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What if you started with 1000 HKD, as in the original case? You do the steps in a different order:

- ① Previous Step 2: Buy  $128 = 0.128 \cdot 1000$  USD using your 1000 HKD by lifting the  $\frac{\text{USD}}{\text{HKD}}$  offer
- ② Previous Step 3: Buy  $96 = 0.75 \cdot 128$  GBP using your 128 USD by lifting the  $\frac{\text{GBP}}{\text{USD}}$  offer
- ③ Adjusted Previous Step 1: Sell 96 GBP to receive 1066.67 HKD by hitting the  $\frac{\text{GBP}}{\text{HKD}}$  bid

Your arbitrage profit is  $1066.67 \text{ HKD} - 1000 \text{ HKD} = 66.67 \text{ HKD}$ .

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## Forward Price

In FX, **forward** and **futures** contracts are agreements to purchase for a specified **forward price**  $F_{t,T}$  at a specified future time  $T$

Annualized forward premium between the time  $t$  spot market and expiry  $T$  forward/future is

$$\text{prem}_{t,T} \equiv \frac{F_{t,T} - S_t}{S_t} \times \frac{\text{days in year}}{\text{days until } T}.$$

Historical norm was to use 360 days per year = 12 months per year  $\times$  30 days per month

Assume the  $\frac{\text{GBP}}{\text{USD}}$  spot rate is 0.75 and the 1-year  $\frac{\text{GBP}}{\text{USD}}$  forward rate is 0.78. Then,

$$\text{prem}_{t,T} = \frac{0.78 - 0.75}{0.75} = 0.04 = 4\%$$

Will you profit by buying GBP today, then selling GBP for USD in 1 year?

# Covered Interest Rate Parity

Generally not. The FX forward premium generally reflects changes in economic & financial conditions summarized by **interest rates**.

Choices from a US investor's perspective beginning with  $N$  USD:

- ① Hold USD, invest in USD deposit rate, obtain  $(1 + i_{\text{USD}}) \times N$
- ② Exchange USD for GBP spot, invest in GBP deposit rate, and agree to exchange GBP for USD in 1 year:

$$S_{\text{GBP},0}^{\text{USD}} \times (1 + i_{\text{GBP}}) \times F_{\text{USD},0,1}^{\text{GBP}} \times N.$$

Remember that  $S_{\text{GBP},0}^{\text{USD}} = \frac{1}{S_{\text{USD},0}^{\text{GBP}}}$ .

**Covered Interest Rate Parity (CIP):**

$$1 + i_{\text{USD}} = \frac{F_{\text{USD},0,1}^{\text{GBP}}}{S_{\text{USD},0}^{\text{GBP}}} \times (1 + i_{\text{GBP}})$$

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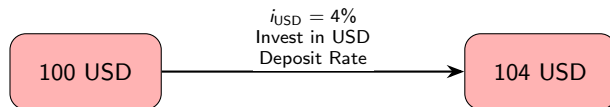
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# Covered Interest Arbitrage

If CIP did not hold, there would be Covered Interest Arbitrage (CIA).

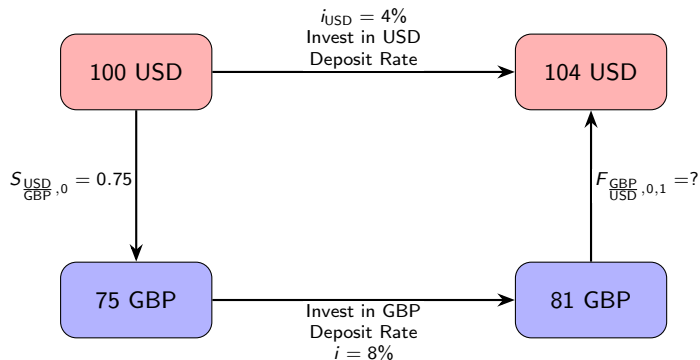
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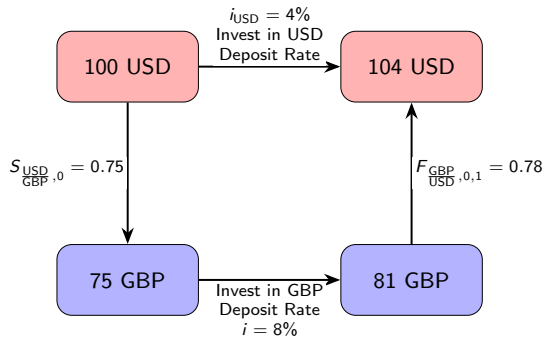
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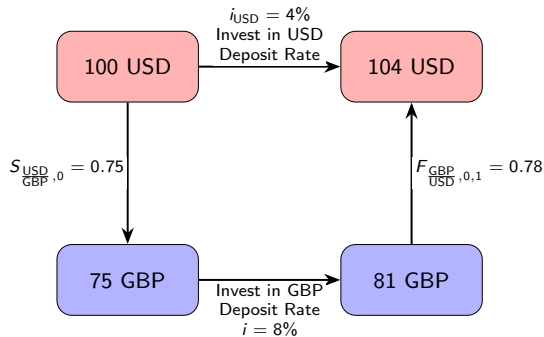
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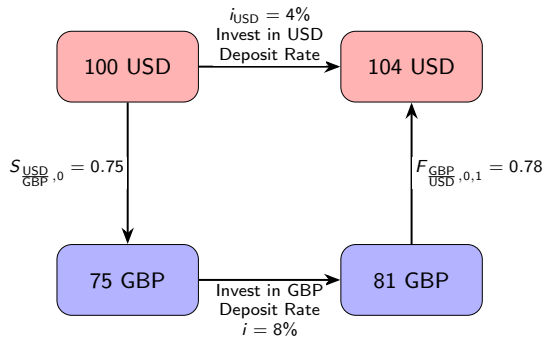
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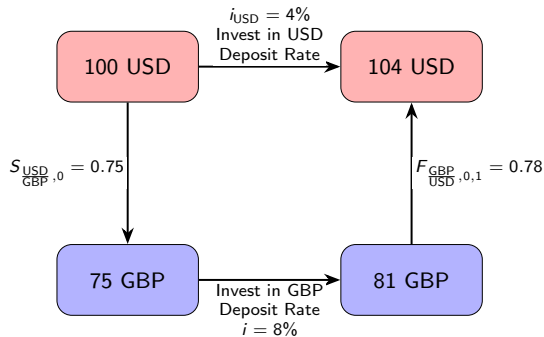
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## CIP deviation through FX swap prices

- FX swap: Contract to exchange currencies at spot rate  $S$  USD per foreign currency and reverse the exchange at a predetermined forward rate  $F$  on a future date
  - Implicit return  $F - S$  compared to domestic borrowing  $\left( \frac{1+i_{\text{USD}}}{1+i_{\text{Foreign}}} - 1 \right) \times S$ . By CIP, these should be identical!
- A non-zero basis reflects differences in funding costs or other financial market frictions
- Negative basis  $\implies$  higher borrowing costs in foreign currency than CIP would imply
- Cross-currency bases summarize global FX liquidity conditions
- Since the 2008 financial crisis, persistent deviations from CIP (large cross-currency bases) have become common
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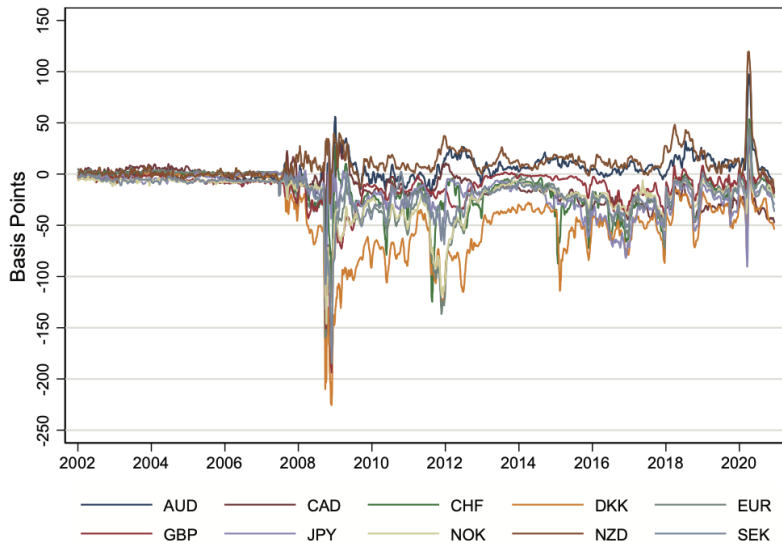
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# CIP in Reality

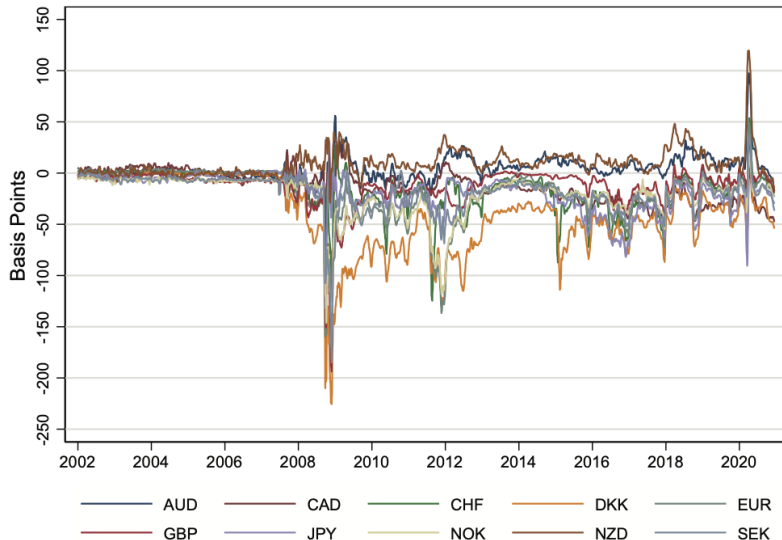


CIP deviations were mostly tiny before the 2007 crisis, but now there are large apparent CIP profits

Reason 1: Financial regulations that prevent intermediaries from providing USD funding and doing arbitrage through the forward price

Source: Cerutti, Obstfeld, Zhou (2021)

# CIP in Reality



Reason 2: Increased counterparty risk in the wholesale market to fulfill forwards, lower FX liquidity

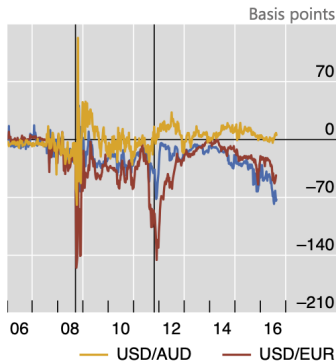
Underlying intuition: Convenience yield is the non-monetary benefit of holding an asset. USD convenience yield as “safe haven” increased during the crisis and has remained high.

Source: Cerutti, Obstfeld, Zhou (2021)

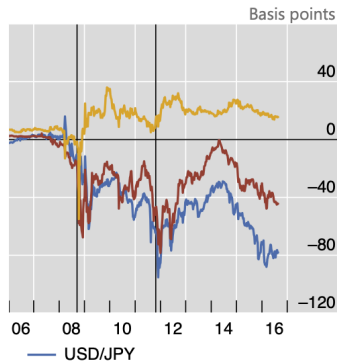
# CIP in Reality

Borrowing USD *synthetically* through FX swaps has become relatively expensive

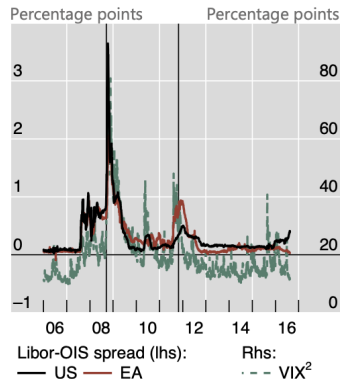
Three-month basis



Three-year basis



Libor-OIS spreads and the VIX



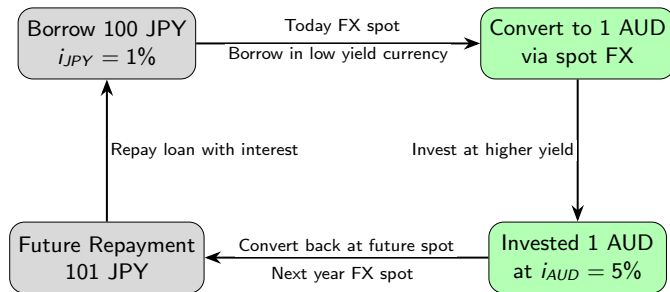
<sup>1</sup> The vertical lines indicate 15 September 2008 (Lehman Brothers file for Chapter 11 bankruptcy protection) and 26 October 2011 (euro area authorities agree on debt relief for Greece, leveraging of the European Financial Stability Facility and the recapitalisation of banks). <sup>2</sup> Chicago Board Options Exchange S&P 500 implied volatility index; standard deviation, in percentage points per annum.



# Carry Trade

Borrowing in a currency with a low interest rate and investing in a currency with a higher interest rate to earn the differential.

- Carry trade generally refers to unhedged spot transactions, requiring accurate FX forecasts to consistently earn profits
- In addition to typical FX risk, there is liquidity risk: sudden market shifts can force costly unwinding

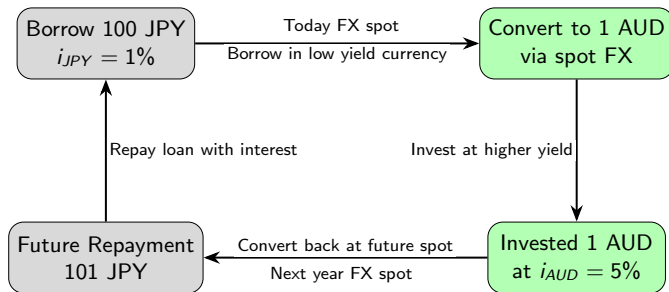


In this example, as long as next year's spot rate is at least 96.2 JPY per AUD, you profit, but this is **not** risk-free so it is not arbitrage

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# Uncovered Interest Parity (UIP)

UIP links interest rate differentials to expected currency depreciation

- General statement:

$$1 + i_H = \frac{\mathbb{E}_t(S_{t+\tau})}{S_t} \times (1 + i_F)$$

- Rearranged:

$$\mathbb{E}_t \left[ \frac{S_{t+\tau} - S_t}{S_t} \right] \approx i_H - i_F$$

- Interpretation: if home interest rates are higher, market expects home currency to depreciate

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How UIP differs from covered interest parity

- CIP condition (arbitrage-based):

$$1 + i_H = \frac{F_{t,T}}{S_t} \times (1 + i_F)$$

- CIP uses the forward rate  $F_{t,T}$ , UIP uses the expected future spot  $\mathbb{E}_t(S_{t+T})$
- Key point:
  - CIP is enforced by arbitrage across spot and forward markets
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## Does UIP hold in practice?

- At short horizons, UIP is often rejected: exchange rate changes do not line up with rate differentials
- Possible reasons
  - Risk premia in uncovered positions
  - Rare-event bias (peso problem)
  - Interaction between policy rates and exchange rates
- At longer horizons (5–20 years), evidence more supportive, but firms generally hedge on shorter horizons, motivating the focus on CIP over UIP

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# Why Discuss UIP Despite Poor Fit

- UIP embeds expectations, so is central to open-economy macro-financial models outside the scope of this course
- Its breakdown implies that exchange rate risk premia are important
- If UIP held, FX intervention could not shift  $S_t$  without moving rates
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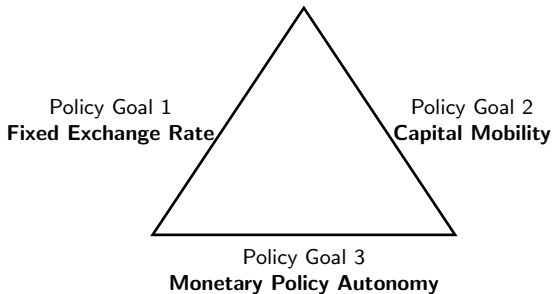
# Review of Exchange Rate Regimes

1 and 2 are hard pegs; 4 is also called soft peg; 5 and 6 are floating

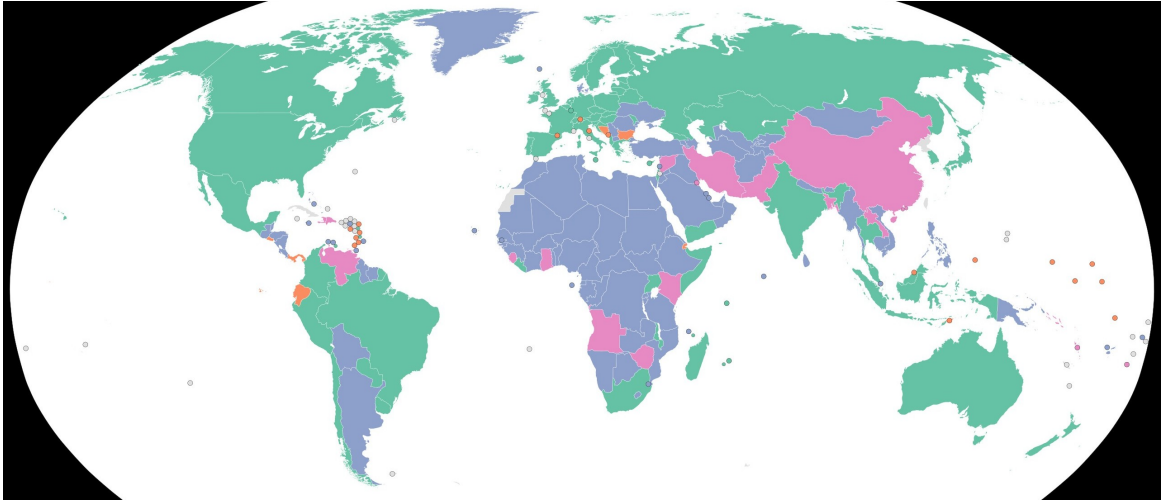
- ① Currency union: Agreement between govts to share the same currency
- ② Currency board: Monetary authority must maintain a fixed exchange rate with full convertibility and legally binding long-term commitment
- ③ Conventional peg: Fixed exchange rate with expectation that the monetary authority will maintain the peg
- ④ Crawling peg: Fixed exchange rate in short-run, periodic adjustments, meant to avoid large sudden appreciation/depreciation
- ⑤ Managed float: Exchange rate allowed to fluctuate, but monetary authority regularly intervenes
- ⑥ Free float: Exchange rate determined by market forces with minimal intervention

## Reminder: Mundell-Fleming Trilemma

The closer a country's currency is to a hard peg, the lower its monetary policy independence (or the stricter the capital controls)



# Global Exchange Rate Regimes (2023 IMF Report)

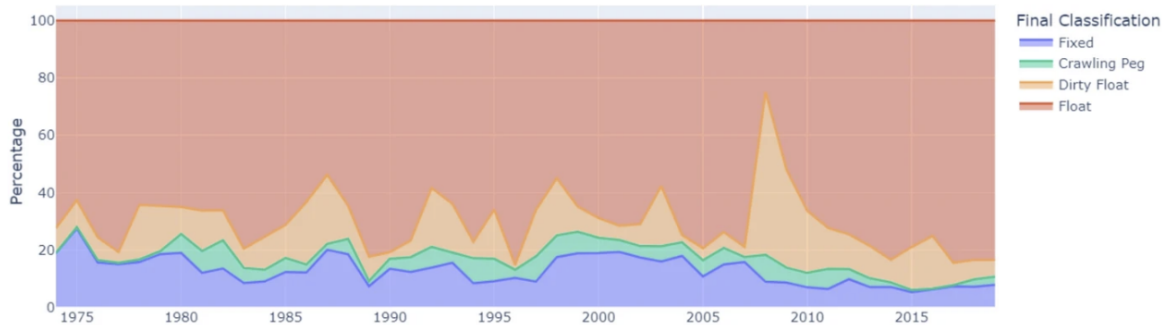


Source: Wikipedia, based on the 2023 IMF Annual Report on Exchange Arrangements and Exchange Restrictions. Green is floating. Blue is conventional or crawling peg. Orange is currency union or currency board. Pink is mostly managed float, with greater intervention than in green.



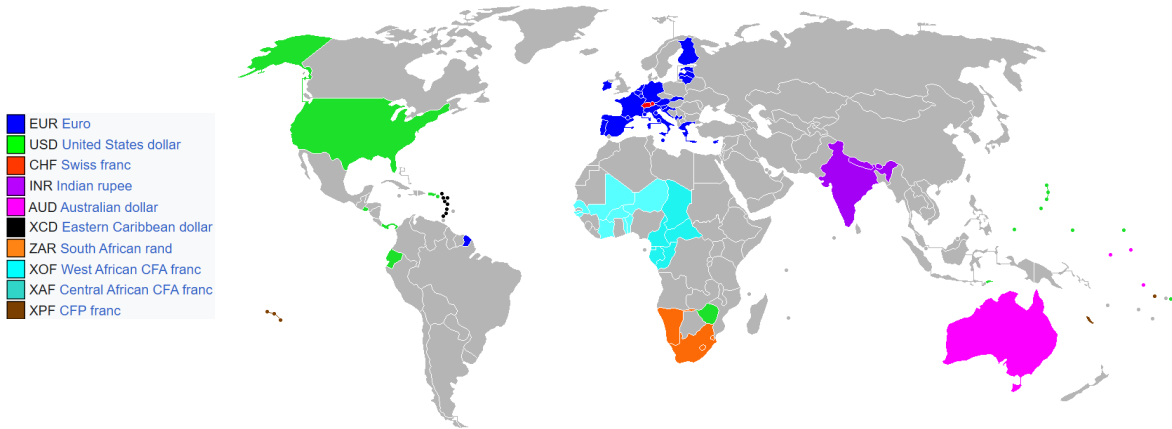
# Post-BWS Exchange Rate Classification

While half of the world's countries use fixed exchange rates, most of the world's GDP comes from countries with [relatively] free floating exchange rates:



Source: Levy-Yeyati & Sturzenegger (2024)

# Currency Union



Source: Wikipedia via the IMF. XCD is pegged to the USD. The CFP and both CFA currencies are pegged to the Euro. El Salvador, Ecuador, and Zimbabwe *dollarized* after economic crises. While Zimbabwe officially has its own currency again (ZWG), most transactions use USD due to two decades of hyperinflation.

# Currency Union

Benefits of using a common currency with a major economy:

- Firms: lower hedging costs, easier financial planning with reduced exchange rate uncertainty
- Investors: lower currency risk incentivizes more portfolio investment, as well as financial deepening (ease of issuing bonds and equity; these assets become more liquid)
- Households: convenience for travel and purchasing power, potentially cheaper remittances

Canonical example is the Eurozone. The European Central Bank (ECB) sets monetary policy, but each country controls its own fiscal policy with its own sovereign bonds

Main downside is the lack of independent monetary policy, and the infeasibility of FX intervention to stabilize the real exchange rate (RER)

- Even though the local nominal exchange rate is fixed (e.g. to the USD or EUR), local price levels can diverge, so the RER still fluctuates
- Without the ability to devalue ER or lower interest rates, domestic recessions can last longer and lead to higher unemployment
- Without a fiscal union, “periphery” countries cannot easily boost aggregate demand: cannot print money, cannot cheaply issue debt because bond spreads widen vs “core”
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Widespread in former colonies in the 20th century; today, the HKD is the most prominent example

- Several island countries have currency boards against the USD; many British colonies once had currency boards against the GBP
- Effectively identical to currency union, but preserves national identity and domestic financial institutions
- Unlike a conventional peg, the central bank is obligated to
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# Conventional Peg

- Without the legally binding structure of a currency board, and its mandate of ample reserves, a conventional peg may be more vulnerable to self-fulfilling attacks
  - Last week, we saw the THB in 1997 as an example of a peg that failed
  - Otherwise, conventional pegs have mostly the same benefits and drawbacks as currency unions and currency boards
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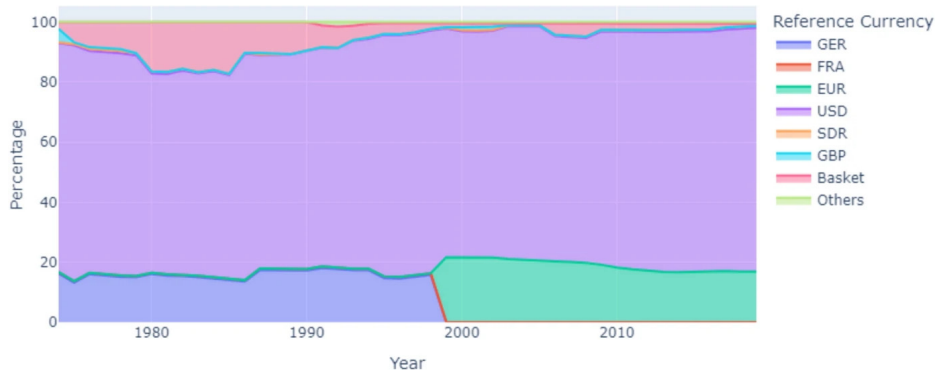
- Without the legally binding structure of a currency board, and its mandate of ample reserves, a conventional peg may be more vulnerable to self-fulfilling attacks
  - Last week, we saw the THB in 1997 as an example of a peg that failed
  - Otherwise, conventional pegs have mostly the same benefits and drawbacks as currency unions and currency boards
- Several Arab countries (e.g. Saudi Arabia, UAE, Qatar) peg to USD
  - Global crude oil trade is usually priced and settled in USD, so a USD peg may be reasonable for oil exporters to avoid hedging costs from currency mismatch between revenue and expenditure
- Many former French colonies use a currency (XOF, XAF, XPF) pegged to EUR, originally to the franc before the Eurozone
- Even since the end of the Bretton Woods System, some currencies that are now floating were pegged at some point in the past
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A similar category is “stabilized arrangement,” most prominently VND, varying within an infrequently adjusted narrow range

# Peg Reference Currency



GDP-weighted  
reference currency  
among countries  
with currency pegs

Source: Levy-Yeyati & Sturzenegger (2024)

These are various terms for currencies whose values are not pegged to any major currency, yet whose central bank regularly intervenes, whether to guide the currency in one direction (often steady depreciation) or to reduce volatility

Here are stated reasons from several central banks:

- Reserve Bank of India: reduce FX volatility, since India imports many commodities like crude oil, and wishes to avoid amplifying price shocks that pass through to uncertain inflation
- People's Bank of China: small daily adjustments against a reference basket of currencies for price stability and trade competitiveness
- Central Bank of Brazil: rules based interventions to ensure sufficient FX liquidity for firms
  - FX liquidity matters directly for trade, as well as indirectly through foreign currency debt rollover

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- comparative advantage shaping trade flows
- financial regulation (e.g. capital controls), foreign investment incentives, and other policies shaping financial flows,

to understand **why**, **when**, and **how** they intervene in FX markets, affecting

- firms' hedging costs and strategies
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