FOREIGN EXCHANGE (FX) MARKETS

Review, Organization & Central Bank Intervention

FX Market: Exchange Rates

• Definition
An exchange rate is a price: The relative price of two currencies.

Example: On January 14, 2019, the price of a euro (EUR) in terms of USD was USD 1.14696 per EUR
⇒ The exchange rate, S_EUR, was 1.14696 USD/EUR.

• Remark - Exchange Rate: Just a Price
An exchange rate is just like any other price.
⇒ Price of a gallon of milk: USD 3.50 (or 3.50 USD/milk).

Think of the currency in the denominator as the good you buy/sell.
Q: What is confusing in the FX Market?

A simple price, $S_t = 1.14696$ USD/EUR.

But, a little bit different: Both, the numerator (USD) and the denominator (EUR), are easily exchanged for each other.

In the case of the price of milk, only one good (USD) can be used to buy the other. It’ll be very difficult to go to Walmart with 10 gallons of milk and get USD 35.

What makes exchange rate quotes tricky is that any of the two goods traded (USD and EUR) can be exchanged for the other. You can go to a bank with EUR 1 and get USD or with USD 1 and get EUR.

- Just a Price, but an Important One

$S_t$ plays a very important role in the economy since it influences the current account ($CA = X$ (exports) – $M$ (imports)), cross-border investments, the domestic price level, $P_d$, and real wages.

For example:
- When $S_t \uparrow$, imports become more expensive in USD ⇒ $M \downarrow$ & $P_d \uparrow$

  ⇒ Real wages ↓ (through a reduction in purchasing power).

- Also, when $S_t \uparrow$, USD-denominated goods and assets are more affordable to foreigners.

  ⇒ Foreigners buy more goods and assets in the U.S. ($X$, bonds, real estate, companies, etc.).
• **Supply & Demand in the FX Market**

Like any other price, $S_t$ is determined by supply and demand.

- On the vertical axis, we have the price, $S_t$ (=units of DC per unit of FC)
- On the horizontal axis, we have the quantity of the good we are buying, in this case, the foreign currency (say GBP).

• **Similar to Supply & Demand in other Markets**

The price of milk, $P_t$ (= Units of DC per gallon of milk).

- New technology increases milk production (Supply ↑)

• $S_t$ moves from A to B
  ⇒ Milk becomes less expensive in terms of USD.
**Effect of a Change in Supply**

Suppose that there is a craze for British goods.

\[
\begin{align*}
S_t &= 1.70 \\
S_{0}^E &= 1.60
\end{align*}
\]

Demand for GBP \(\uparrow\) to pay for more British imports (D moves up to D').
\[\Rightarrow\] The value of the GBP increases (more USD needed to buy GBP 1).

**Terminology:** We say the USD *depreciates* against the GBP (or the GBP *appreciates* against the USD).

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**The Real Exchange Rate (R_t)**

The nominal exchange rate, \(S_t\), is a *nominal* variable: The price (in DC) of one unit of FC. Economists like to distinguish between nominal and real values. After all, an increase in \(S_t\) does not necessarily mean that domestic goods are cheaper to foreigners: \(P_d\) can increase too.

To compare where things are more expensive, *the real exchange rate*, \(R_t\), is used. \(R_t\) measures the cost of foreign goods relative to domestic goods:

\[
R_t = \frac{S_t P_f}{P_d}
\]

where \(P_f\) is the price of foreign goods (in FC) and \(P_d\) is the price of domestic goods (in DC).

**Example:**

Price of Oil in Europe and U.S.: \(P_f = EUR 50; P_d = USD 60\)
\(S_t = 1.2376\) USD/EUR

\[\Rightarrow R_t = 1.2376\) USD/EUR \times \frac{EUR 50}{USD 60} = 1.03133\]
• The Real Exchange Rate ($R_t$)
$R_t$ gives a measure of competitiveness.

Example: From previous example, once translated to same currency, oil is cheaper in the U.S.: 3.13% cheaper ⇒ “U.S. more efficient.”

Terminology:
If $R_t$ increases, we say the DC depreciates in real terms ⇒ domestic goods become more competitive relative to foreign goods.

Supply & Demand in the FX Market

• Who supplies GBP in the (U.S.) FX market?
  - UK investors, investing in the U.S.
  - US exporters, exporting to the U.K.
  - UK tourism

• Who demands GBP in the (U.S.) FX market?
  - US investors, investing in the U.K.
  - US importers, importing from the U.K.
  - US tourism
• **What moves Supply & Demand?**
  – International Investing,
  – International Trade,
  – International Tourism,
  – Other factors (Central Banks needs, international transfers, etc.)

All these activities are reflected in the Balance of Payments (BOP).

• **Balance of Payments**
  At the national accounts level, we define the BOP as:
  
  \[
  \text{BOP} = \text{Current Account (CA)} + \text{Capital Account (KA)}
  \]

  \[
  \text{CA} = \text{Net Exports of goods and services (main component)} + \text{Net Investment Income} + \text{Net Transfers}
  \]

  \[
  \text{KA} = \text{Financial capital inflows} - \text{Financial capital outflows}
  \]

  The BOP = 0  \implies \text{The CA is financed by the KA.}

- We tend to think that CA is influenced by prices: \( P_d, P_f, S_t \) (or \( R_t \))
- We tend to think that KA is influenced by expected rates of returns. In the short term, interest rates \( (i_d & i_f) \) dominate.
- \( Y \) (income) influences both CA & KA.
- Factors that affect prices, expected rates of returns, & income, such as taxes, tariffs, tech, uncertainty, etc., also have an influence on the BOP.
• **Economic Variables ("Fundamentals") Affecting the BOP (S & D)**
- Interest rates ($i_{USD} - i_{FC}$)
- Inflation rates ($I_{USD} - I_{FC}$)
- Income growth rates ($y_{USD} - y_{FC}$)
- Others: tariffs, quotas, other trade barriers, expectations, taxes, tastes, expected returns in financial assets/real estate, technology, etc.

  ⇒ Changes in the fundamentals will affect $S_t$.

• **A Word about Models**
In the economy variables are interrelated. We use *models* to simplify the interactions and focus on the main impact, say money markets, goods markets. These models that focus on the equilibrium in only one market, say the goods market, are called *partial equilibrium models*.

There are also *general equilibrium models*, where we study equilibrium in all markets, say the goods market, the money market, and the BOP.

• **Remarks**
- *Interactions among variables*: In S & D graphs, we assume that only one variable changes (the *ceteris paribus* assumption). But, in economics, variables are interrelated. For example:
  
  Higher $I$ ⇒ higher $i$;
  Restrictions to trade affect $Y$ and $P$; $Y$ affects $i$, $P$ affects $I$, etc.

When we are drawing the S&D curves, we need to make assumptions about which curve moves more (the dominant one).

- *No dynamics*: In all the S&D graphs we present two situations: initial equilibrium (with $S_0$) and final equilibrium (with $S_1$).

We pay no attention to the adjustment process – i.e., how $S_t$ moves from $S_0$ to $S_1$. The adjustment process is important and it may take a while to move from $S_0$ to $S_1$. 
Example: Changes in the interest rate differential
The U.S. Fed increases interest rates \((i_{USD} \uparrow)\) ⇒ \((i_{USD} - i_{EUR})\uparrow\)

Two effects:
– European residents buy more U.S. T-bills (S of EUR ↑)
– U.S. residents buy less European T-bills (D for EUR ↓)
⇒ both Supply and Demand curves shift.

- \(S_t\) moves from A to B
  ⇒ The EUR becomes cheaper in terms of USD. We say the EUR \(\text{depreciates}\) against the USD (or the USD \(\text{appreciates}\)).

Intuition check: The U.S. Fed decreases interest rates \((i_{USD} \downarrow)\)
 ⇒ \((i_{USD} - i_{EUR})\downarrow\)
– European residents buy less U.S. T-bills  (Supply of EUR ↓)
– U.S. residents buy more European T-bills  (Demand for EUR ↑)

- \(S_t\) moves from A to B
  ⇒ The EUR becomes more expensive in terms of USD. That is, the EUR \(\text{appreciates}\) against the USD.
Example: Changes in the inflation rate differential

U.S. inflation increases \((I_{USD}) \Rightarrow (I_{USD} - I_{EUR})\uparrow\)

Foreigners want to buy less U.S. goods (Supply ↓)

Americans want to buy more European goods (Demand ↑)

\[\begin{align*}
S_0 &= 1.15 \\
S_t &= 1.20 \\
S_1 &= 1.17
\end{align*}\]

- \(S_t\) moves from A to B
  \[\Rightarrow\] The EUR becomes more expensive in terms of USD. That is, the EUR \textit{appreciates} against the USD.

Intuition check: U.S. inflation decreases relative to European inflation \((I_{USD} - I_{EUR})\downarrow \Rightarrow S_t?\)

- European residents buy more U.S. goods (Supply of EUR ↑)
- U.S. residents buy less European goods (Demand for EUR ↓)

\[\begin{align*}
S_0 &= 1.20 \\
S_1 &= 1.17 \\
S_t &= 1.20
\end{align*}\]

\[\text{Quantity of EUR}\]

\[\Rightarrow\] The EUR \textit{depreciates} against the USD.
Example: Changes in other factors: Tariffs

- U.S. residents buy less Korean goods (Demand for KRW ↓)
- No movement on U.S. exports to Korea (Supply unchanged)

$S_t$ moves from A to B
⇒ The KRW depreciates against the USD.

Example: Change in other factors: Uncertainty
Terrorism threats increase. Switzerland is considered a safe haven.

- Foreign residents bring less CHF to the U.S. (Supply of CHF ↓)
- U.S. residents buy more CHF (Demand for CHF ↑)

$S_t$ moves from A to B
⇒ The CHF appreciates against the USD.
Example: Changes in Other Factors: Export Prices
The price of oil decreases significantly (⇒ a negative wealth shock)
- Canadian oil exports are worth less USD. (Supply of USD ↓)
- There may be a secondary effect –Canadian may be able to buy less imports. (Demand for USD may go down)

\[ S_t = 1.10 \]

\[ S_0 = 1.09 \]

\[ \text{Quantity of USD} \]

- \( S_t \) moves from A to B
  ⇒ The USD \textit{appreciates} against the CAD.

Example: Changes in Other Factors: Export Prices
Intuition check: Price of oil increases significantly (a positive wealth shock) ⇒ Canadian oil exports increase in USD value (Supply↑)
- \( S_t \) moves from A to C (\( S_t \downarrow \))
  ⇒ The CAD \textit{appreciates} against the USD.

\[ S_t = 1.08 \]

\[ S_0 = 1.09 \]

\[ \text{Quantity of USD} \]

- If the wealth effect is big and given that Canada is considered a small economy –i.e., it has no influence on international prices– (\( P_f - P_d \)) may also decrease (through non-tradable goods). Then, \( R_t = S_t \frac{P_f}{P_d} \downarrow \).
- The drop in \( R_t \) can be big, causing a big CA deficit (\textit{Dutch disease}).
**Example: The Role of Expectations**

Suppose that because of a rumor people expect the GBP to depreciate. Then, it may be optimal to sell GBP, regardless of the truth behind the rumor/expectation.

The GBP can depreciate in a hurry (think of the Keynesian beauty contest). Expectations matter.

“Professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick, not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view.”

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**• Exchange Rates Move a Lot**

The Federal Reserve constructs an index to reflect the value of the USD against a basket of currencies (TWC). The basket includes the EUR (58%), the JPY (14%), the GBP (12%), the CAD (9%), the SEK (4%), and the CHF (4%). It is quoted in TWC/USD terms.
FX Markets: Organization

Q: How is the FX market organized?
A: It is organized in two tiers:
   i. the retail tier
   ii. the wholesale tier (the "market")

Retail Tier: Where small agents buy and sell FX.

Wholesale Tier: Informal network of about 2,000 banks and currency brokerage firms that deal with each other and with large corporations.

The wholesale tier is where FX rates are determined (97% of volume). These FX rates usually reported on financial websites and newspapers.

It is an OTC market. There is no central exchange or clearinghouse.

Bloomberg FX Quotes
Wholesale Tier: Quotes from Bloomberg.

FX Market: Geographically Dispersed ⇒ Always Open
• **FX Market**: Huge daily turnover ⇒ Largest Financial Market

**Global foreign exchange turnover**

- **Characteristics of the FX market**
  - Largest of all financial markets in the world:
    - Daily volume USD 5.1 trillion (down from USD 5.4 T in 2013)
    - USD 5.1 trillion = 40 times daily volume of international CA flows.
    - = 85 times the U.S. daily GDP.
    - = 40% of total official foreign exchange reserves.
    - = 50 times daily volume on NYSE.
  - Geographically dispersed: Tokyo (6% of volume), HK (7%), Singapore (8%), Zurich (2%), London (largest market, 37%), NY (20%).
  - Open 24 hours a day, 365 days a year.
  - Organization:
    - OTC market, where brokers and dealers negotiate directly.
    - Typical transaction in USD: About 1 million ("one dollar").
    - Typical minimum trading size is 100K units (a standard “lot”).
- Currencies are noted by a three-letter code, the ISO 4217 (USD, EUR, JPY, GBP, CHF, AUD, CAD, SEK, HKD, MXN).

- USD, EUR, and JPY are the major currencies.

- USD involved in 88% of transactions (EUR 31%, JPY 22%).

- USD/EUR most traded currency pair (23% of turnover).

- Emerging market currencies: 21% of turnover (CNY 4%, MXN 2.5%).

- 58% of transactions involve a cross-border counterpart (65% in 2010).

- 5 desks in 5 countries (UK, US, Singapore, HK & Japan) intermediated 77% of trading.
**Characteristics of the FX market** (continuation)

- Very small *bid-ask* spreads for actively traded pairs, usually no more than 3 *pips*—i.e., 0.0003.

**Example**: A bid/ask quote of USD/EUR: 1.2397/1.2398 (spread: one *pip* or 0.008%). See screenshot from electronic trading platform EBS below:
• **Characteristics of the FX market** (continuation)

**Example**: A bid/ask quote of USD/GBP: 1.8218/1.8221 (spread: one pip). As a percentage (relative to the ask quote):

\[
\text{bid-ask spread (\%)} = \frac{0.0003}{1.8221} = 0.0165\%
\]

Compare this spread to the retail one (see below, from Edinburg, U.K.): 

\[
\text{bid-ask spread (\%)} = \frac{0.143}{1.396} = 10.24\%
\]

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**Characteristics of the FX market** (continuation)

**Example (continuation)**: Explanation of EBS screenshot.

Note the price available for dealing is 138.21/26, with a regular amount on the bid but only 3 mio on the offer - the best regular offer is 138.27. Note also there is an inside offer at 138.25 (circled in blue) - this is due to credit limits in place in the FX market and would not be relevant in futures.
• **Characteristics of the FX market** (continuation)

**Example (continuation):** EBS Keypad.

- **Players:** Big Corporations, Speculators, Banks, Central Banks
  ⇒ Financial institutions are involved in 93% of transactions:
    - 42% Reporting dealers ("interbank")
    - 51% Other financial institutions (hedge funds 8%)

- A large bank trades billions of dollars daily. Largest dealer bank (2016): Citi (12.9%). The top 5 include JP Morgan (8.8%), Deutsche Bank (7.9%), UBS (8.8%), BOFA/ML (6.4%).

- The interbank market gets the majority of commercial turnover.
- Banks trade on behalf of customers and for themselves.
- HFT (high frequency trading) accounts for 35% of volume (33% for institutional investors/hedge funds in 2016).
• **Dealers:**
  
  — *Market-makers* (Hold inventories to provide liquidity. Give a two-way quote: *bid* and *ask*)
  
  — *Traders* (Buy and sell on their own accounts)
  
  — *Brokers* (Finds the best price for another player)

Until recently, FX brokers did large amounts of business, facilitating interbank trading and matching anonymous counterparts for small fees.
Today, much of the trading has moved to electronic platforms like EBS (Electronic Broking System), Reuters Dealing 3000 Matching (D2), and Bloomberg Tradebook. The major trading banks (Barclays, UBS) have their own electronic platforms (single-bank trading systems). There are also multi-bank trading platforms (FXall, Currenex, Hotspot).

- **FX Trading Quickly Moving to Electronic Trading**
  - Multi-dealer trading platforms dominate, but single-dealer platforms are growing. (FXall, Currenex, Hotspot).
  - Voice trading (“on the phone”) losing ground.
• **FX Trading Quickly Moving to Electronic Trading**

For many years, the main trading platforms were EBS and Reuters.
– EBS: main venue for EUR/USD, USD/JPY, EUR/JPY, USD/CHF and EUR/CHF. (the main bulk of the interbank spot market.)
– Reuters D2: primary venue for all other interbank currency pairs.

But, competition from single-bank trading systems (*internalization of flows*) is big and driving significantly down volume at both venues.
• **Typical Trading Day (from the early 90s):**
For a DEM trader (DEM: German Mark):
   Executed about 270 transactions a day (one every 67′′).
   Average daily volume traded USD 1.2 billion.
   For large transactions brokers were used.
   Median spread: DEM .0003 (.02% of the spot rate).

• **Speculation and Trading**
A market participant that holds an open FX position at the end of the day is classified as a *speculator*.

An FX trader will attempt to be *square* or *flat* by the end of the day. That is, a trader is square when she has no exposure (or risk) on the FX market.

*Terminology:* Squaring up is when you have an open position and you are going to close. A trader is:
– ‘squaring up’ when buying a currency to close a position (the trader sold the currency before)
– ‘going flat’ when selling a currency to close a position.
1. The Spot Market

The spot market is the exchange market for payment and delivery today. In practice, "today" means today only in the retailer tier. Usually, it means 2 business days.

The Spot Market represents 33% of total daily turnover.

Example: Bank of America (BOFA) buys GBP 1M in the spot market at $S_i = 1.60$ USD/GBP.

In 2 business days, BOFA will receive a GBP 1M deposit and will transfer to the counterparty USD 1.6M.

- Two quote systems:
  i. indirect quote or "European" quote
     \[ S(\text{indirect}) = \text{units of FC that one domestic unit will buy.} \]
  ii. direct quote or "American" quote.
     \[ S(\text{direct}) = \text{units of DC that one foreign unit will buy.} \]

Remark: indirect quotation = reciprocal of the direct quotation.

Example: A U.S. tourist wishes to buy JPY at LAX.

(A) Indirect quotation (JPY/USD).

A quote of JPY 110.34 – 111.09 means the dealer is willing to buy one USD for JPY 110.34 (bid) and sell one USD for JPY 111.09 (ask).

For each round-trip USD transaction, she makes a profit of JPY .75.

(B) Direct quotation (USD/JPY).

If the dealer at LAX uses direct quotations, the bid-ask quote will be .009002 – .009063 USD/JPY.

Calculation: 
\[ S(\text{direct})_{\text{bid}} = 1/S(\text{indirect})_{\text{ask}} = 1/111.09 = 0.009002 \text{ USD/JPY} \]
**Note:** \( S(\text{direct})_{\text{bid}} = 1 / S(\text{indirect})_{\text{ask}}, \)

\( S(\text{direct})_{\text{ask}} = 1 / S(\text{indirect})_{\text{bid}}. \)

**Remark:** In class, we will use **direct** quotations. Think of the currency in the denominator as the currency you buy. For us, it will be the foreign currency.

**Example:** Quotes:

\[ S_t = 1.03 \text{ CHF/USD} \quad \Rightarrow \text{You are in Switzerland} \]

\[ S_t = 0.70 \text{ USD/EUR} \quad \Rightarrow \text{You are in the U.S.} \]

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- **Cross-quotes**

Most currencies are quotes against the USD, so that *cross-rates* must be calculated from USD quotations. (Think of liquidity!)

Rule for cross-rates (based on triangular arbitrage), with 3 currencies: X, Y, and Z (common currency):

\[
\Rightarrow \frac{\text{Quote}(X/Z)}{\text{Quote}(Y/Z)} = \text{Quote}(X/Y)
\]

(\( \Rightarrow \text{currency Z has to cancel out!} \))

**Example:** Calculate the CHF/EUR cross rate:

\[ S_t = 1.03 \text{ CHF/USD} \]

\[ S_t = 0.70 \text{ EUR/USD} \]

\[
S_{\text{CHF/EUR}} = \frac{1.03 \text{ CHF/USD}}{0.70 \text{ EUR/USD}} = 1.47 \text{ CHF/EUR} \]

• **Settlement of FX transactions**

At the wholesale tier, no real money changes hands.

⇒ electronic transactions using the international clearing system.

Two banks involved in a FX transaction simply transfer bank deposits.

**Example:**

– Parties: Argentine Bank: Banco de Galicia (BG),
  Malayan Bank: Malayan Banking Berhard (MB).

– Transaction: BG sells BRL (Brazilian real) to MBB for JPY.

– Settlement: a transfer of two bank deposits:
  (1) BG turns over to MB a BRL deposit at a bank in Brazil,
  (2) MB turns over to BG a JPY deposit at a bank in Japan.

If BG doesn’t have a branch in Brazil, an associated bank, called a *correspondent bank*, will hold the deposit in BG’s name. Same for MB in Japan.

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2. **The Forward Market**

A forward transaction is generally the same as a spot transaction:

⇒ but settlement is deferred much further into the future.

"Further into the future": 7-day, 15-day, 1-, 2-, 3- and 12-month settlements (& up to 10 years).

Characteristics:

- Forward transactions are tailor-made.
- Forward contracts allow firms and investors to transfer risk.
- Forward transactions are classified into two classes:

**Outright & FX swap**

° The (outright) Forward Market represents 14% of total daily turnover.

⇒ Outright forward transaction: an uncovered speculative position in a currency (though it might be part of a currency hedge to the other side).

  - 40% of outright forwards have duration of less than 7 days.

° The FX Swap combines a forward transaction with a spot transaction.
Example: BOFA holds British bonds worth GBP 1,000,000. BOFA fears the GBP will lose value against the USD in 7 days. BOFA sells a 7-day GBP forward contract at $F_{t,7-day} = 1.605 \text{ USD/GBP}$ to transfer the currency risk of her position.

In 7 days, BOFA will receive USD 1,605,000 and will transfer to the counterparty GBP 1M. ¶

Terminology: FX premium

• A foreign currency is said to be a premium (discount) currency if its forward rate is higher (lower) than the spot rate.
  
  \[ F_{t,T} > S_t \text{ for a premium currency.} \]
  
  \[ F_{t,T} < S_t \text{ for a discount currency.} \]

Example: From previous examples

\[ S_t = 1.60 \text{ USD/GBP} \]
\[ F_{t,7-day} = 1.605 \text{ USD/GBP} \]

\[ F_{t,7-day} > S_t \rightarrow \text{“GBP trades at a premium in the forward market.”} \]

The premium and discount of a $F_{t,T}$ is expressed as an annualized percentage deviation from $S_t$.

The forward premium, $p$, is calculated as follows:

\[ p = \left[ \frac{(F_{t,T} - S_t)}{S_t} \right] \times \frac{360}{T}. \]

Note: $p$ could be a premium (if $p > 0$), or a discount (if $p < 0$).

Example: The 7-day USD/GBP forward premium is:

\[ p = [(1.605 - 1.60)/1.60] \times (360/7) = .1607 \text{ (or 16.07\%.)} \]

The GBP is trading at an annualized 16.07% premium for delivery in 7 days. ¶

Remark: Think of $p$ as the annualized return of selling forward the FC for $T$ days and buying the FC spot today.
3. The FX Swap

FX swap involves 2 transactions:
- A spot and a forward with opposite signs (a sale & a purchase).
- Both have approximately an equal amount of the FC.
- They should be executed together (simultaneous).

That is, an FX swap represents the simultaneous sale (or purchase) of spot foreign exchange against a forward purchase (or sale) of approximately an equal amount of the foreign currency.

Rationale of an FX Swap: A position taken to reduce the exposure in a forward trade.

- The FX Swap Market represents 47% of total daily turnover.
- The majority of FX Swaps (70%) are short-term (≥ 7 days).

Example:
A U.S. trader wants to invest in GBP bond position for a 7-day period. (Assume the U.S. trader thinks interest rates in the U.K. will go down and is worried about the GBP/USD exchange rate.)

Simultaneously, the U.S. trader
1. Buys GBP 1M spot at $S_t = 1.60$ USD/GBP,
2. Buys the short-term GBP 1M bond position, and
3. Sells GBP 1M forward at $F_{t,7-day} = 1.605$ USD/GBP.

Selling GBP 1M forward protects against an appreciation of the USD.

Return of FX Swap = $(1.605 - 1.60)/1.60 = 0.003125 \approx 0.3\%$ in 7 days
⇒ Annualized ≈ $0.003125 \times 360/7 = 0.1607 \approx p$.

The FX swap market is the segment of the FX market with the highest daily volume.
Q: How is the daily volume distributed among the segments?
This USD 5.1 trillion in global FX market turnover is broken down as:

- USD 1.7 trillion in spot transactions (33%)
- USD 714 billion in outright forwards (14%)
- USD 2.4 trillion in FX swaps (47%)
- USD 255 billion estimated gaps in options, currency swaps, etc

Exchange Rate Systems

• Pure FX Rate Systems
Defined by the role of the Central Bank (CB):
-- Free Float or Flexible
-- Fixed

• CB: Brief Review
A CB is a "bank." It holds:
* Assets: Foreign (FC Reserves FC bonds)) + Gold + Domestic (mainly loans to domestic institutions and government securities)
* Liabilities: DC outstanding (backed by assets the CB owns) + Deposits of banks.

Remark: Change in assets = Change in liabilities
⇒ A purchase of an asset or FC results in an increase in the liabilities, through an increase in the MS.
**CB: Brief Review – Asset Purchases = Change in Liabilities**

**Example:** During the 2008-09 Financial Crisis, the U.S. Fed launched the Quantitative Monetary Easing (QE) program. Under QE a CB prints DC to buy assets like government & corporate bonds and then inject cash into the economy.

Under QE, the Fed bought bond (increasing assets) and paid with USD (increasing liabilities and MS):

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Fed  Bonds  USD  Banks
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When QE finished, in Oct 2014, the Fed had bought USD 4.5 trillion worth of Treasuries, Mortgage-back securities, and Bank debt.

As a result, it kept U.S. interest rates at record low levels, keeping interest rates near zero for more than 6 years (with the expectation of stimulating spending).

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**CB: Brief Review – Asset Purchases = Change in Liabilities**

**Example:** U.S. Fed QE program: QE1 (09-10), QE2 (11) & QE3 (12-13)

**Note:** Japan has been on a QE situation since 2001! Bank of England, Swiss National Bank and ECB also had their QE programs.
• CB: Brief Review – Balance Sheet

**Table II.1**
U.S. Federal Reserve Balance Sheet (December 2017)

<table>
<thead>
<tr>
<th>Liabilities</th>
<th>Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Reserve Notes 1,569.1</td>
<td>U.S. Treasuries 2,454.2</td>
</tr>
<tr>
<td>Reverse Repurchase Agreements 386.8</td>
<td>Mortgage Backed Securities 1,764.9</td>
</tr>
<tr>
<td>Deposits 2,445.1</td>
<td>Gold 11.0</td>
</tr>
<tr>
<td>Other liabilities 6.3</td>
<td>SDR 5.2</td>
</tr>
<tr>
<td><strong>Total 4,407.3</strong></td>
<td>FC Denominated Assets 21.2</td>
</tr>
<tr>
<td>Central Bank Liquidity Swaps 12.0</td>
<td>Other assets 180.2</td>
</tr>
<tr>
<td>Capital Account 41.4</td>
<td></td>
</tr>
<tr>
<td>Capital paid in 31.4</td>
<td></td>
</tr>
<tr>
<td>Surplus 10.0</td>
<td></td>
</tr>
<tr>
<td><strong>Total 4,448.7</strong></td>
<td></td>
</tr>
</tbody>
</table>

• Capital Account
Capital Account = Total Assets – Total Liabilities = USD 41.4 B
Surplus: Retained earnings not paid to the US Treasury (USD 10 B).

• CB: Brief Review – Roles

• Historical roles of a CB:
  – Lender of last resort ("Bank of banks")
  – Supervisor of financial institutions.

This is the banking side of a CB.

• But, a CB is also the Monetary Authority: It controls the domestic money supply (MS), with the responsibility over
  – Inflation \( i_d \) low
  – Economic GDP \( Y_d \) close to full employment.

This is the economic policy side of a modern CB (today, the main role).

• Targets are conflicting: CBs set \( i_d \), balancing \( I_d \) and \( Y_d \).
• **CB: Brief Review – Monetary Policy**

  - Textbook (Monetary Economics) example:
    Fed lowers the Fed rate \( \Rightarrow \) other interest rates in the economy fall \( (i_d \downarrow) \)
      \( \Rightarrow \) Lower \( i_d \) stimulate spending (aggregate demand, \( AG, \uparrow \)).
      \( \Rightarrow \) Businesses respond, increasing production (aggregate supply \( \uparrow \))
      \( \Rightarrow \) Economic growth up (\( Y \uparrow \))

  Now, if the increase in AG is big enough it can push up \( P_d \) (\& \( I_d \uparrow \)).

  - In general, all the above effects take time: 1-3 years.

  Some estimates point that a 1% decrease in a CB rate, increases \( Y_d \) by 0.5% - 0.75% over 2 years & \( I_d \) by .25% over 2-3 years.

  Aside Note: What is the effect on \( S_i \)? On average, a 1% surprise increase in \( i_d \) increases \( S_i \) by 1.5% almost immediately.

---

• **CB: Brief Review – Transmission of Monetary Policy**

  - The transmission of monetary policy has many channels: Saving & Investments; Spending (CF); Asset Prices & Wealth; and FX Rate.

  ![Figure 2: Channels of the Transmission of Monetary Policy](source: RBA)

  FX Channel (estimates from Australia): A 10% depreciation increases \( X \)-volumes by 3%, while reducing \( M \)-volumes by 4% within 2 years.
• CB: Brief Review – Policy Rules
• CBs balance $I_d$ and $Y_d$, following a policy rule:
  $$i_d = f(I_d, Y_d - Y_{\text{Full Employment}})$$

In practice, CBs tend to follow a Taylor rule:
  $$i_d = \omega + \lambda I_d + \theta Y_{\text{gap}}$$

$\omega = r^* + \gamma (-I_d^*) = 2\% + .5 \times (-2\%) = 1\%$
$\gamma = 0.5$
$\lambda = 1 + \gamma = 1.5$
$\theta = 0.5$
$r^* = \text{real interest rate} = 2\%$
$I_d^* = \text{CB’s target } I_d = 2\%$
$Y_{\text{gap}} = Y_d - Y_{\text{Full Employment}}$

**Note:** According to the Taylor rule, $i_d$ is low now (2018 Q2): It should be 4.20\%, but it is 2\% (& also low 2002-2005, pre-financial crisis).

• CB: Brief Review – Policy Rules
Below, we show the prescribed by the Taylor rule and the actual Fed rates. According to the Taylor rule, $i_d$ is low now (2018 Q2): It should be 4.20\%, but it is 2\% (& also low 2002-2005, pre-financial crisis).
• CB: Brief Review – Policy Rules

Taylor rule variations: Gradual adjustments, reflecting the practice of gradual, small adjustments in interest rates. This modified Taylor rule is:

\[ i_{dt} = \rho i_{dt-1} + (1 - \rho) [r^*_t + I_{dt} + \gamma (I_{dt} - I_{dt}^*) + \theta Y_{gap_t}] \]

where \( \rho \) is the smoothing parameter (\( \rho = 0 \), original Taylor rule).

• Modified Taylor rule (\( \rho = 0.5 \)) has a better fit. Prescribed Fed rate \( \approx 3\% \).

• CB: Brief Review - Names

Around the world, CBs have different names: U.S. Federal Reserve System (“The Fed”), European Central Bank (ECB), Bank of Mexico (“Banxico”), Central Bank of UAE, Central Reserve Bank of Peru, Swiss National Bank, Monetary Authority of Singapore, etc.
• CB: Brief Review - Open Market Operations

CBs have several monetary policy instruments. The most important:

- Open market operation (OMO)
- Bank reserve requirement
- Interest rate policy

OMOs are the main policy tool. Through an OMO, a CB puts money in and takes money out of the banking system, by buying/selling government securities (say, U.S. Treasury bills):

- MS Increase: CB buys securities from banks, paying with DC.

Fed $\rightarrow$ U.S. T-bills $\rightarrow$ Banks $\rightarrow$ U.S. MS↑

- MS Decrease: CB sells securities to banks, receiving DC.

1. Flexible Exchange Rate System (Free Float)

In a flexible exchange rate system the CB allows the exchange rate to adjust to equate the supply and demand for foreign currency.

\[ S_e = \text{USD} 1.60 \]

All the variables mentioned before \((i_d - i_f ; I_d - I_f, \text{etc.})\) will affect \(S_e\). In particular, international capital flows will change \(S_e\).

Whatever \(S_e\) is, the CB is fine with it.
**Features of a Free Float**

- $S_t$ reflects economic activity, through S & D for FC.
- $S_t$ is subject to volatility (there is FX risk!).
- Money supply is exogenous. Thus, the CB has an independent monetary policy.
- Under certain assumptions (IS-LM model, perfect capital mobility), fiscal policy does not work. But, monetary policy works.
- External shocks (say, oil shocks or sudden outflows of capital) can be quickly be absorbed by changes in $S_t^E$.

Milton Friedman, Nobel Prize Winner, (1953) argued that under a free float “changes in $S_t$ occur rapidly, automatically, and continuously and so tend to produce corrective movements before tensions can accumulate and a crisis develop.”

**Terminology**

A currency **depreciates** (appreciates) when, under a free float, it becomes less (more) expensive in terms of foreign currency.

---

**Aside: Mundell-Fleming Model = IS-LM + Perfect Capital Mobility**

Open macroeconomic model combining:

1. Aggregate demand (IS and LM curves, representing equilibrium in goods and money markets)
2. Aggregate supply (production function and labor market)
3. BOP (= CA + KA)

**Mundell-Fleming Model - Assumptions**

- Exchange rate regime: Flexible (Fixed, in the next section)
- Perfect capital mobility.
- Under utilized resources & no supply constraints –i.e., Keynesian world
- The Marshall-Lerner condition is satisfied –i.e., $S_t \uparrow \downarrow \Rightarrow CA \uparrow \downarrow$
- The price level, $P_d$, is fixed (in particular, no FX rate pass-through)
- No currency substitution (say, dollarization).
- Exchange rate expectations are static and/or there is no risk premium.
- $P_f$, $Y_f$, & $i_f$ are given –i.e., not influenced at all by domestic changes.
**Mundell-Fleming Model in a Free Float Economy**

Monetary Policy: Increase in the Money Supply (MS↑) ⇒ **LM** (curve) ↓
Fiscal Policy: More government spending (G↑) ⇒ **IS** (curve) ↑.

Typical equilibrium IS-LM curves + BB (BOP equilibrium, i_d = i_f):

- Why does monetary policy work (expand money supply, MS ↑)?
  \[ \text{MS} \uparrow \Rightarrow \text{LM} \downarrow \Rightarrow i_d \downarrow \Rightarrow \text{Foreign Capital outflows} \Rightarrow S_t \uparrow \]
  \[ \Rightarrow \text{CA} \uparrow (\text{IS} \uparrow) \Rightarrow Y_d \uparrow \]

- Why doesn’t fiscal policy work (more government spending, G ↑)?
  \[ \text{G} \uparrow \Rightarrow \text{IS} \uparrow \Rightarrow i_d \uparrow \Rightarrow \text{Foreign Capital inflows} \Rightarrow S_t \downarrow \]
  \[ \Rightarrow \text{CA} \downarrow \Rightarrow \text{IS} \downarrow (\text{back to original position}) \]

2. **Fixed Exchange Rate System**

In a **fixed exchange rate system** the Central Bank is ready to buy and sell *unlimited* amounts of domestic currency at set **fixed** price, say \( S^* \).

**Example**: Hong Kong has a fixed exchange rate (a *peg*) system since October 17, 1983. The exchange rate is \( S^* = 7.8052 \text{ HKD/USD} \).
**Example (continuation):**

Remark: The HKD is not fixed against all FCs, only against the USD:

USD moves against EUR $\Rightarrow$ HKD moves against EUR.

From 2010 to 2015, the USD moved widely against the EUR, the HKD also moved: From 11.50 HKD/EUR (Apr 24, 2011) to 9.15 HKD/EUR (Jan 8, 2015).

- Close to 50 countries follow a conventional fixed system. Africa has most of them: 19 countries. Fourteen of them using the CFA franc (pegged to the EUR), and three pegged to the South African Rand (ZAR) as part of a Common Monetary Area.

<table>
<thead>
<tr>
<th>In order to support the fixed parity $S^*$, a CB needs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) enough DC to buy “unlimited” amounts of FC.</td>
</tr>
<tr>
<td>(b) enough reserves (FC) to buy “unlimited” amounts of DC.</td>
</tr>
</tbody>
</table>

Two observations:

1. The second element, (b), is the one that causes problems to CB. A CB credibility plays a big role. If there is not enough FC reserves and the demand for FC cannot be met, the CB has a problem: A currency crisis.

**Note:** Element (b) can be addressed by placing enough FC reserves to buy the DC MS (keep 100% reserves) outside the reach of a CB/government. This arrangement is called Currency Board.

Small Caribbean countries (Grenada, Saint Lucia, Dominica, etc.) have a fixed exchange rate system (pegged to the USD) with a currency board.

2. Every time somebody buys (sells) FC from (to) the CB, the domestic MS decreases (increases) $\Rightarrow$ A CB does not control the MS.
• MS is *endogenous* to the FC demand/supply. Thus, international capital flows affect the domestic MS. Difficult to do monetary policy!

**Example:** International capital inflows to China:

![Diagram showing capital inflows to China](image)

**Note:** The People’s Bank of China (PBOC, China’s CB) may not like an increase in the MS (along with lower \(i_{\text{CNY}}\) & inflationary pressures) and take some counteraction to mitigate the increase in MS.

• A CB gives up the control of the MS under a fixed system. The only hope for independent monetary policy is to use indirect tools – usually, capital controls and/or change banking required reserve ratios (RRR).

A CB counteraction taken to mitigate the effect of some variable (say, capital inflows) on the domestic MS is called *sterilization*.

**Example:** For most of the past 30 years, China has maintained a fixed FX system and received huge capital inflows. To sterilize the PBOC has changed RRR 42 times, currently stands at 20% (twice as in U.S.).

**Accumulation of foreign exchange reserve in China – 2000 to 2012**
(taken from Chung, Hwang, & Wang, 2014):

![Graph showing accumulation of foreign exchange reserve](image)
Change of required reserve ratio in China (taken from Chung, Hwang, & Wang, 2014):

Note: The PBOC is attempting to sterilize the international capital flows and have some control over China’s MS. Another solution to control MS: capital controls.

Fixed FX System: Variations
Some CBs have a fixed exchange rate system, but $S_t$ is not really fixed:
- “Target zone system,” where the exchange rate is kept within a band (the target zone).
- “Crawling peg system,” where the fixed exchange rate is regularly adjusted, usually to keep up with domestic inflation.

Example: On July 21, 2005, the People's Bank of China (China’s CB) announced that the CNY would be pegged to a basket of foreign currencies, rather than being only tied to the USD.

The CNY would trade within a narrow 0.3% band against the basket of currencies. The basket is dominated by the USD, EUR, JPY and KOW.

The Central Bank of Chile, in 1983 (adjusted in 1984), adopted a crawling peg with a fluctuation band of $\pm 0.5\%$. The CLP/USD was adjusted according to the previous month’s inflation minus an estimate of U.S. inflation (around 2% annually).
**Example**: Giving up Monetary Policy

Since 1982, Denmark adopted a target zone system, pegging against the DEM and, in 1999, to the EUR. Following the ERM II, \( S_t \) is fixed at \( S^* = 7.46038 \) DEK/EUR, but it may fluctuate by ± 2.25%.

When the ECB changes its monetary policy interest rates, Danmarks Nationalbank typically responds by making similar changes.

---

**Features of Fixed System**
- Money supply is endogenous \( \Rightarrow \) No independent monetary policy!
- Exchange rate has no/low volatility. (Good for trade, investments.)
- If CB does not have enough FC reserves, credibility is crucial.
- Since \( S_t \) is fixed, external shocks have to be absorbed through prices, which tend to be rigid. (Slower adjustments to shocks/imbalances.)
- Under certain assumptions (Mundell-Fleming), fiscal policy works.

**Mundell-Fleming Model in a Fixed FX Rate Economy**
- Why does fiscal policy work (more government spending, \( G \uparrow \))? 
  \( G \uparrow \Rightarrow IS \uparrow \Rightarrow i_d \uparrow \Rightarrow \text{Foreign Capital inflows} \Rightarrow MS \uparrow \Rightarrow LM \downarrow \text{expansion of money supply amplifies effect on } Y_d \)
  (fiscal + monetary effects!)
**Trilemma** – due to Robert Mundell (1962), Nobel Prize Winner.

It is impossible for a country to have at the same time:

- A fixed (stable) FX regime.
- Free international capital mobility – i.e., no capital controls.
- An autonomous (independent) monetary policy.

A country can have two, but not the three:

A “consistent” inconsistent monetary policy leads to currency crisis.

**Typical Trilemma problem: Example 1**

- Under a fixed system, the local government substantially increases the domestic money supply ($MS_d$) to finance deficit spending or to mitigate an external shock:

  $$MS_d \uparrow \Rightarrow i_d \downarrow \Rightarrow (i_d - i_f) \downarrow \Rightarrow \text{International capital outflows} \Rightarrow \text{CB’s FC reserves} \downarrow.$$

- Notice that under a free float,

  $$MS_d \uparrow \Rightarrow i_d \downarrow \Rightarrow (i_d - i_f) \downarrow \Rightarrow \text{International capital outflows} \Rightarrow S_t \uparrow (> S^*).$$

  That’s the adjustment.

- But, under a fixed system, $S^*$ does not change. This is a problem!
Typical Trilemma problem: Example 2
• Under a fixed system, international interest rates increase (say, $i_{USD} \uparrow$), but, the CB, to avoid its negative effect on GDP, does not match this increase (and, thus, attempts an independent monetary policy!).

$$i_t \uparrow \Rightarrow (i_d - i_t) \downarrow \Rightarrow \text{International capital outflows}$$

$$\Rightarrow \text{CB’s FC reserves} \downarrow.$$

• Again, under a free float:

$$i_t \uparrow \Rightarrow (i_d - i_t) \downarrow \Rightarrow \text{International capital outflows}$$

$$\Rightarrow S_t \uparrow (> S^*).$$

• Remark from Examples: Under both situations, under a free float, $S_t \uparrow (> S^*)$. We have a problem since $S_t = S^*$: Now, in DC terms, things are undervalued relative to rest of the world.

$$\Rightarrow \text{The Real exchange rate, } R_t = S_t \frac{P_f}{P_d} \downarrow.$$

Typical Trilemma problems
• In both situations, under a free float, $S_t \uparrow (> S^*)$.

Note: If we think of the free float $S_t$ as the “true equilibrium” (or “shadow”) FX rate, $(S_t - S^*)$ signals a potential profit for speculators. Eventually, if inconsistency continues, a speculative attack on the FC reserves occurs.

CB Dilemma: To Defend or Not To Defend? A CB considers the costs and benefits of defending the fixed parity, $S^*$.

• Usually, CBs defend $S^*$: They sell FC reserves, borrow FC, substantially raise $i_d$, or impose capital controls. These actions may be costly and/or may cause (or make worse) a recession.

Definite solution to a currency crisis: Float the currency (abandon $S^*$).
Currency Crisis

- When a CB abandons \( S^* \) because it is running out of FC reserves and/or the costs of defending \( S^* \) are too high, a devaluation/depreciation occurs. Speculators can gain from this movement!

- Speculators ask: Will the CB be able to defend the parity \( S^* \)? Will the government bear the costs of defending it?

- Currency Run: Domestic residents run to banks to exchange DC for FC, before the devaluation occurs (or banks run out of FC!).

- Terminology
  A devaluation (revaluation) occurs when the price of foreign currencies under a fixed exchange rate regime is increased (decreased) by the CB.

Note: The possibility of a currency crisis creates a risk under the Fixed FX system: devaluation risk. The magnitude of this risk depends on the CB credibility – i.e., very credible CB, devaluation risk near zero.

Currency Crisis: The “Tequila crisis” – Mexico Dec ‘94

Mexico had a crawling peg to the USD, but due to presidential elections, \( M_{S_d} \uparrow \). FC reserves went from USD 18B in October 1994 to USD 5B in December 1994, when the decision to abandon the fixed system.

Overall, Mexico spent USD 25B in FC reserves to defend the peso and also borrowed USD 25B (bailout funds from the U.S. Fed).
U.K. was part of the ERM, with the GBP tied, implicitly, to the DEM at \(S_\text{t}=2.95 \text{DEM}/\text{GBP}\), with \(\pm 6\%\) band. But, when \(i_{\text{DEM}}\uparrow\) to contain the high spending due to German reunification, the BOE did not follow.

Overall, UK spent GBP 30B in FC reserves (and lost GBP 3.3B).

**Currency Crisis: “Black Wednesday” – U.K. Sep 16 ‘92**

<table>
<thead>
<tr>
<th>Date</th>
<th>USD/GBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Aug-92</td>
<td>1.4</td>
</tr>
<tr>
<td>10-Aug-92</td>
<td>1.5</td>
</tr>
<tr>
<td>17-Aug-92</td>
<td>1.6</td>
</tr>
<tr>
<td>24-Aug-92</td>
<td>1.7</td>
</tr>
<tr>
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<td>1.8</td>
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<td>1.9</td>
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<td>2.4</td>
</tr>
<tr>
<td>19-Oct-92</td>
<td>2.5</td>
</tr>
<tr>
<td>26-Oct-92</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Currency Crisis: Devaluations

- On average, a currency crisis is followed by a 30% devaluation of the DC. In many cases there is a temporary higher drop of value (say, 50%), before reverting to a value closer to the average.

A very serious crisis: 75% or higher drop (Indonesia ‘97, Argentina ’01).

**Examples:** India ’91, UK ’92 (Black Wednesday), Mexico ’94 (Tequila), Thailand ’97 (Rice), Russia ’98 (Vodka), Brazil ’99 (Caipirinha), Argentina ’01 (Tango), Uruguay ’03, Iceland ’08, Nigeria ’16.

- Practical problem in academic work: Not clear definition in practice.
  - (a) \(X\%\) drop in value of DC. (captures “successful” attacks)
  - (b) \(Y\%\) drop in FC reserves. (captures “unsuccessful” attacks)
  - (c) \(Z\) Standard Deviations of a weighted average of (i) & (ii)
Currency Crisis: Not Rare
Currency crisis are not rare. Figure below shows 208 successful currency crises –defined as a 30% depreciation of DC that is also, at least, a 10% increase from previous year. (Period: 1975 – 2008.)

Currency Crisis: Devaluations are not a new phenomenon.
The first well-documented devaluation is The Kipper und Wipperzeit (1619 – 1623), when the Holy Roman Empire states in their efforts to finance the Thirty Years’ War (1618 – 48) debased its coins.
– Kipper: Coin clipping
– Wipperzeit: See-saw (an allusion to the counterbalance scales used to weigh species coin).

Two forms of debasement actually fueled the crisis:
(1) Reduce the value of silver coins by clipping shavings from them;
(2) Re-mint coins by melting the old coins and mixing them with inferior metals.
Currency Crisis: Predictors (“Early warning signals”)

Predictors of a currency crisis: Low FX reserves, high government deficits, low real exchange rate (DC overvalued, often due to high domestic inflation), weak financial system, high short-term debt, etc.

Many traders use an index to predict a currency crisis. A new one is the “Damocles Index,” used by Nomura. (Nomura claims 67% of past 54 EM currency crisis were predicted 12 months in advanced.)

Devaluations Are Unpopular

- Economic Reasons:
  - Pass-through to import prices (Domestic prices increase) ⇒ Inflation
  - Real wages decrease
  - Contractionary impact on the economy, especially in EM: 3% average loss of GDP after 7 years!

The contraction is usually associated with balance sheet effects – i.e., a mismatch between currency of denomination of debt (mainly, in FC) and income (mainly, in DC) – in corporate and government sectors.
**Devaluations Are Unpopular**

- Politicians are run out of office.
  - Cooper (1971) finds that heads of state lose their jobs twice as often within 1 year of devaluation:
    - 30% as compared to 14% in a non-devaluation control group.
  - Frankel (2005), updated sample 1971 – 2003 and measured exit 6 months after devaluation:
    - 23% (=43/109) as compared to 12% in the control group.

**Twin Ds**

- A currency crisis is usually a product of serious macro-economic problems: Sovereign defaults – a government decides not to pay its bonds – and/or banking crisis are not rare during these times.

In general, sovereign defaults are accompanied by large devaluations. These are the “Twin Ds”: Default and Devaluation.

- Reinhart (2002), looking at the period 1970 – 1999:
  - $\text{Prob}[\text{Devaluation}|\text{Default}] = 84\%$
  - $\text{Prob}[\text{Devaluation}|\text{No Default}] = 17\%$

Na et al. (2017) expand sample to 2013: 84% is too high.
- $\text{Prob}[\text{Devaluation}|\text{Default}] = 50\%$

Laevan and Valencia (2012), using their own definitions of a currency crisis, find a similar probability: 56% (=37/66).
**Twin Ds**

- Laeven and Valencia (2012) also report the following diagram with the Twin Ds and the *Twin Crisis* (simultaneous banking & currency crises).

![Diagram of Twin Crises and Twin Ds](image)

**Twin Ds**

- Default is usually followed by a large devaluation: 45% in a 6-year window around a default event.

![Graph of Excess Devaluation Around Default](image)

Na et al. (2017) suggest that these large devaluations are needed to realign prices (real wages) to avoid unemployment shock. In their model if no devaluation occurs (think Greece), unemployment is up by 20%.
### 3. Managed Float
In practice, the exchange rate system is a mixture: managed floating. In general, we see a free float, but sometimes the CB intervenes to buy and sell FC with the intent of changing the market determined $S_t$.

### 4. Dual Systems
In some markets, $S_t$ is fixed by the government. But, the government sells FC at the official $S_t$ only for some transactions. For all the other transactions, a *black market* is created.

**Example:** Until 2002, Iran had three officially recognized exchange rates. In 2002; the rates were:
1) The “official” rate of 1,750 IRR/USD, for oil, gas and essential imports; the “export” rate of 3,000 IRR/USD;
2) The variable Tehran Stock Exchange rate of 7,863 IRR/USD, used by some exporters.
3) For all other transactions, the rate was 8,615 IRR/USD.

### Range of Exchange Rate Regimes
Ranked in terms of (decreasing) flexibility for the CB:
- Free Float or Flexible
- Managed “Dirty” Float
- Crawling Peg
- Fixed
- Currency Board (Fixed + 100% FC reserves)
- Adopting a FC as legal tender. When the U.S. currency is adopted, it’s called “dollarization” (Panama, British Virgin Islands, El Salvador, Ecuador, Zimbabwe).

- In 2017, the IMF classifies 54% of currencies as “anchored” (fixed FX rate), another 20% as “stabilized” (with an anchor, but allowed to vary in some way), and 26% as “floating” (occasional CB Intervention OK).
Exchange Rate Regimes: Fixed or Flexible?

<table>
<thead>
<tr>
<th>Feature</th>
<th>Fixed</th>
<th>Flexible</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cons</td>
<td>Pros</td>
</tr>
<tr>
<td>Adjustment to imbalances</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>External shocks</td>
<td>Vulnerable</td>
<td>Less vulnerable</td>
</tr>
<tr>
<td>Support Sₗ</td>
<td>May need to raise iₓ (or cause recession)</td>
<td>No need to do anything</td>
</tr>
<tr>
<td>Monetary policy</td>
<td>Ineffective</td>
<td>Effective</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>FX Volatility</td>
<td>Stable Sₗ (good for trade &amp; investments)</td>
</tr>
<tr>
<td>Iₓ: Control/Reduce</td>
<td>Good (with credibility)</td>
</tr>
<tr>
<td>Fiscal policy</td>
<td>Effective</td>
</tr>
</tbody>
</table>

Exchange Rate Regimes: Fixed or Flexible?

- Both regimes have pros and cons: No clear winner.
- Regime choices should reflect individual characteristics of an economy.

- We observe:
  - Large economies with sound economic policies, good institutions (say, an independent CB) and high credibility prefer a flexible regime.
  - Developed economies with bad economic policies, bad institutions and low credibility rely on a fixed regime.

- Aside Q: If a CB decides to fix, which currency should be the anchor? Stable trade & investments advantage suggests fixing against the currency of a large trading partner:
  - In Latin America, the USD is a good choice.
  - In Andorra (between Spain and France), the EUR should be the anchor.
**Central Bank FX Intervention**

- **Definition**
  FX Intervention occurs when CBs buy and sell FC with the *intent* to change $S_t$ to a different $S_t^E$.

- CBs have economic models to determine what they believe is an equilibrium $S_t^E$. Using these models, CB determines a range for $S_t$
  \[ S_t \text{ should} \text{ move} \text{ between} S_t^L \text{ and} S_t^U. \]

If $S_t$ is within the range ($S_t^L < S_t < S_t^U$), CB does nothing (Free float!)
If $S_t > S_t^U$, CB determines FC is overvalued \(\Rightarrow\) CB intervention
If $S_t < S_t^L$, CB determines FC is undervalued \(\Rightarrow\) CB intervention

\[ S_t > S_t^U: \text{Appreciating FC} \quad \Rightarrow \quad \text{CB sells FC.} \]
\[ S_t < S_t^L: \text{Depreciating FC} \quad \Rightarrow \quad \text{CB buys FC.} \]

---

**Situation**: Suppose the US Fed follows the value of the CHF.

If $A$ is within the range ($S_t^L < S_t < S_t^U$), Fed does nothing (*Free float*)
If $S_t > S_t^U$, Fed determines FC is overvalued \(\Rightarrow\) **Fed sells CHF**
If $S_t < S_t^L$, Fed determines FC is undervalued \(\Rightarrow\) **Fed buys CHF**

\(\Rightarrow\) The Fed acts like an FX speculator.
Example 1: The USD depreciates against the CHF (A to A'). Now, at $S_t = .93$ USD/CHF, the Fed determines CHF too expensive: $S_t > S_t^U$

$\Rightarrow$ CB intervention: Fed sells CHF

![Diagram showing Fed selling CHF to bring $S_t$ under $S_t^U$]

$\Rightarrow$ Fed sells CHF to bring $S_t$ under $S_t^U$ (A' to C).

FX Intervention

The Fed sells CHF and receives ("buys") USD.

- CB FX intervention affects money supply:
  - When the CB sells (buys) FC $\Rightarrow$ Money supply decreases (increases)
  (This is the Fixed Regime characteristic of the managed float.)

Example 1 (continuation): Fed intervenes to halt appreciation of CHF.

![Diagram showing Fed selling CHF and reducing money supply]

Process: Fed sells CHF $\Rightarrow M_S \downarrow \Rightarrow$ interest rates ($i_{USD}$) $\uparrow$
**Example 2:** The Banco de Mexico (Banxico, Mexico’s CB) considers the USD too inexpensive (Undervalued: $S_t < S^L_t$, at A).

⇒ CB intervenes: **Banxico buys USD**

$S_t$ (MXN/USD)

$S_t = 21$

$S^L_t$

$S_0 = 20$

Quantity of USD

⇒ Banxico buys USD to bring $S_t$ over $S^L_t$ (A to C).

**FX Intervention**

Banxico buys USD and pays with MXN ⇒ $M_S \uparrow$ ⇒ $i_{MXN} \downarrow$

**CB General Policy Objective for FX Intervention:** Stabilization

*Lean against the Wind:*
- CB sells FC when it is appreciating
- CB buys FC when it is depreciating.

**CB Intervention: Issues**

(1) Implicit notion of "overvaluation/undervaluation" in FX market.

⇒ Q: Do CBs have "superior" information?

A: Mixed evidence: Some CBs have big losses; others profits.

(2) CB generates FX stability.

⇒ Uncertainty over CB actions increase FX volatility & risk.

Precisely, what a CB dislikes.

⇒ Q: But, do CBs succeed to reduce FX volatility? Not clear.

(3) Potential conflict with other countries. When a CB intervenes in the FX market ($S_t \uparrow$) to boost exports, trading partners will be affected.

⇒ *beggar-they-neighbor* devaluation. Popular in the 1930s.
**CB Intervention: Details**

- CBs tend to deal with major domestic banks, but will also transact with major foreign banks.

- **Size of intervention.** The final size depends on the initial FX market reaction. If the initial FX market reaction goes according to the CB direction, then the CB may decide to cut short the intervention.

- **How often do CBs intervene?** In a 1999 BIS survey of CBs, the percentage of business days on which CBs report intervening from 0.5% to 40% percent, with a 4.5% median.

- **Disclosure of intervention?** Most CBs intervene secretly, releasing actual intervention data with a lag, if at all. Some authorities, like the Swiss National Bank, always publicize interventions at the time they occur. Why secrecy? Poor credibility, bad fundamentals.

**Other CB Interventions in the FX Market**

- CBs can buy foreign assets, instead of FC. For example, the PBOC and the Bank of Japan have on occasion bought several hundred billions of U.S. Treasuries, in order to stop the decline of the USD against the CNY and the JPY, respectively.

- CBs can use the forward market, instead of the spot market. In a 1999 BIS survey, 52% of CBs admitted to “sometimes using the forward market.” CBs can also use other derivatives, for example, FX options.

- Sometimes, CBs do not directly buy and sell FC. Instead, CBs can achieve a change in $S_f$ by affecting demand and supply of FC, through increases in transaction taxes, capital controls, banking regulations, etc.

For example, Spain, Ireland, and Portugal introduced capital controls-including mandatory deposits against the holding of foreign currencies-during the ERM crises of 1992-93.
• **Other CB Interventions in the FX Market**

CB intervention can be *concerted*: Several CBs agree a currency is under/over valued and decide to jointly intervene in the FX market. For example, in September 1985, the G7 decided to stop the appreciation of the USD, by buying the other G7 currencies and selling the USD.

But, the most popular form of intervention is just “talk of under/overvaluation,” by government officials, usually referred as *jawboning*. It is simpler and cheaper (if it works) than any other FX intervention. Here, the credibility of CBs plays a big role.

• **CB Intervention: Data**

Despite these issues and the academic sentiment that FX intervention is not worth it, CB do intervene in FX markets.

The largest player by far is Japan. For example, between April 1991 and December 2000, the Bank of Japan bought USD on 168 occasions for a cumulative amount of USD 304 billion and sold USD on 33 occasions for a cumulative amount of USD 38 billion.

Japanese interventions dwarf all other countries' official intervention in the foreign exchange market; for example, it exceeds U.S. intervention over the same period by a factor of more than 30.
**Sterilization**
CB actions taken to neutralize the effects of intervention in Money Markets. That is, the change in domestic interest rates.

Back to **Example 1**: Fed sells CHF (move from \( A' \) to \( C \)): \( M_S \downarrow \) & \( i_{USD} \uparrow \).

• Suppose the Fed does not want a higher \( i_{USD} \).
• CB tools to change MS: Open Market Operation (OMO), bank’s RRR.

**Sterilization in the U.S. with OMO**
- When the Fed buys T-bills, exchanging USD for T-bills \( \Rightarrow \) US MS \( \uparrow \)
- When the Fed sells T-bills, exchanging USD for T-bills \( \Rightarrow \) US MS \( \downarrow \)

**Example 1 (continuation)**: Back to previous example. The Fed uses an OMO: Fed buys T-Bills to increase MS.

This CB intervention will be classified as *sterilized intervention*. 
**CB Intervention + Sterilization**: Cash flows exchange:

- **FX Intervention**
  - Fed Reserve → Banks
  - CHF → USD

- **OMO**
  - Fed Reserve → Banks
  - USD

- **Sterilized Intervention**
  - Fed Reserve → Banks
  - CHF → U.S. T-bills
  - U.S. T-bills

**Net effect**: OMO + Fed Intervention

**Sterilized Interventions: Side Effects**

- Sterilization changes the composition of the Fed’s (and, in equilibrium, the public’s) mix of DC & FC assets. This creates a *balance sheet effect*.

Depending on the rates of return of the assets involved, this effect can be positive or negative for the CB: If CHF T-bills pay 2% and U.S. T-bills pay 1%, the previous change in the Fed’s mix has a negative effect.

- Suppose the CB can keep for a while $S_t$ artificially high/low and money markets out of sync with the FX Market.

**Example**: a CB keeps $S_t$ low (DC overvalued) to keep $I_d$ low. Then, the CB forces the economy to subsidize the import sector (& domestic consumption) and leaves domestic producers in a tough situation. For a short time, the side effects can be tolerated; for a long time, they can lead to a *resource allocation problem*. 
• **Sterilized Interventions: Side Effects**

• Banks do not like holding large amounts of government bond and/or having high reserve-requirement ratios
  \[ \Rightarrow \text{A squeeze in bank’s profits.} \]

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**Example 2 (continuation):** At A, Banxico considers the USD *undervalued* \((S_t < S_L)\), with:

\[
S_0 = 20 \text{ MXN/USD} \quad \& \quad S_L = 20.6 \text{ MXN/USD}
\]

Banxico decides to intervene, but does not want to affect \(i_{MXN}\).

Original Situation: \(S_0 = 20 \text{ USD/MXN} \quad \& \quad i_0 = 7\%\)

**Banxico FX intervention** (Buy USD): \(S_1 = 31 \text{ USD/MXN} \quad \& \quad i_1 = 6\%\)
**OMO:** Buy MXN - Sell CETES: \( S_1 = 21 \text{ USD/MXN} & i_0 = 7\% \)

Mexican Money Market

![Graph showing the money market with OMO, Mexican pesos (MS), and interest rates (i_{MXN})](image)

- \( i_0 = 0.07 \)
- \( i_1 = 0.06 \)
- \( M_{S,0} \)
- \( M_{S,1} \)
- \( M_d \)
- Banxico buys USD
- Banxico sells CETES

**Process:**

1. **Banxico buys USD** → \( M_S \uparrow \) → interest rates \( (i_{MXN}) \downarrow \)
2. **Banxico sells CETES** → \( M_S \downarrow \) → interest rates \( (i_{MXN}) \uparrow \)

**Net Effect: (1) + (2)** → \( M_S \) (\& \( i_{MXN} \)) unaffected!

**Net Effect: (1) + (2)** → \( M_S \) (\& \( i_{MXN} \)) unaffected!

**Sterilized Intervention**

- Banxico
- CETES
- Banks
- USD

Banxico will invest the USD in U.S. T-bills, which have a lower effective yield than the CETES (now, paying 7\%)

⇒ Negative balance sheet effect (if sterilization works the change in \( S_1 \) is zero).
• Sterilized Interventions: Do They Work?

In the short-run, sterilizations tend to work, affecting $S_t$ in the direction the CB wanted. But the evidence regarding lasting effects on $S_t$ is mixed and it tends to be on the negative side, especially for major currencies.

Sustaining sterilizations can be costly, due to the balance sheet effects. In Banxico example, CETES yield 7%, while US T-bills have a substantial lower yield. Over time, these costs can be difficult to bear.

Mohanty and Turner (2005) report that, between 2000 and 2004, the CBs of Korea, the Czech Republic, and Israel issued currency-stabilizing bonds of values equivalent to 300%, 200% and, 150% of their respective reserve money for the purpose of sterilization operations.

⇒ Interest payments, when domestic interest rates go up, render sterilization operations too costly to last.

FX Curiosty: Zimbabwe’s $50 Billion Dollar Note (January, 2009)

Because of its huge inflation, Zimbabwe’s Central Bank, which is rapidly running out of paper, introduced the ZWD 50 billion dollar note. The new note is equivalent to about USD 1.25.

What will ZWD 50 billion buy you? Two loaves of bread and no change.