International Financial Management

FINA 4360 – 2022 Lecture Notes

Rauli Susmel
Bauer College of Business
Univ. of Houston

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Dept. of Finance
Bauer College of Business
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Chapter 0 – Introduction to International Finance

Many of the concepts and techniques are the same as the one used in other Finance classes (Investments, Corporate). For example, an international bond is valued using the same NPV formulas used to value a domestic bond. The CAPM also applies to Japanese or Mexican stocks.

Q: What makes international Finance different?

Two distinctive features:	Exchange Rates	⇒ FX Risk
(with associated risks)	Different National Policies	⇒ Country Risk

0.1 Topics to be Covered

• Exchange Rates, FX Markets, and Determinants of Exchange Rates. (Chapters 3, 4)
• FX Derivatives (Futures, Forwards, Options) (Chapters 5, 11)
• Government Role and Intervention in FX Markets (Chapter 6)
• Arbitrage and Equilibrium in the FX Market (Chapters 7, 8)
• Forecasting Exchange Rates (Chapter 9)
• FX Risk, FX Risk Management (Chapters 10, 11, 12)
• Direct Foreign Investment (DFI), International Diversification (Chapter 13)
• Multinational Capital Budgeting (Chapter 14)
• Country Risk and Discount Rates (Chapter 16)
• Cost of Capital for MNCs (Chapter 17)
• Long-term Financing (Bonds, Swaps) (Chapter 18)
• Short-term Financing and Borrowing (Chapters 20, 21)

0.2 Background Concepts that you should know (we'll review some of the concepts in class)

• Supply and Demand (Chapter 3, 4)
• Basic concepts of Monetary Policy (Central Bank behavior, Open Market Operations) (Chapter 6)
• Arbitrage and Equilibrium (Chapter 7, 8)
• Expected value, Variance and Covariance, Correlation Coefficient (Chapter 8, 9, 10, 11, 12, 20, 21)
• Probability Distribution (Chapters 5, 8, 9, 10, 11, 12, 20, 21)
• Regression, Testing Null Hypothesis (Chapter 8, 9, 10, 12)
• CAPM, ß (Chapter 13, 17)
• NPV, discount rates (Chapter 14, 15, 16, 18)
• Basic Bond Pricing Concept (Par, YTM, spread, bps, etc.) (Chapter 18)
• The Term Structure of interest rates (Chapter 18)

Chapter 3 - Foreign Exchange (FX) Markets

We will go over three topics:
1) Exchange Rates (definition, overview)
2) Currency Markets (organization, characteristics, players)
3) Segments of the FX Market

3.1. Exchange Rates

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

Example: The price of a Euro (EUR) in terms of USD is USD 1.115 per EUR
$\Rightarrow$ S_t = 1.115 USD/EUR. ¶

Exchange Rate: Just a Price
An exchange rate is just like any other price.
$\Rightarrow$ Price of a gallon of milk: USD 3.75 (or 3.75 USD/milk).
$\Rightarrow$ Price of a British pound (GBP): USD 1.30 (or 1.30 USD/GBP)

Think of the currency in the denominator as the currency you buy.

Both the numerator (USD) and the denominator (GBP) are easily exchanged for each other.

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

• Supply and Demand: The price of milk (P_t)

Figure 3.1: Demand and Supply in the Market for Milk

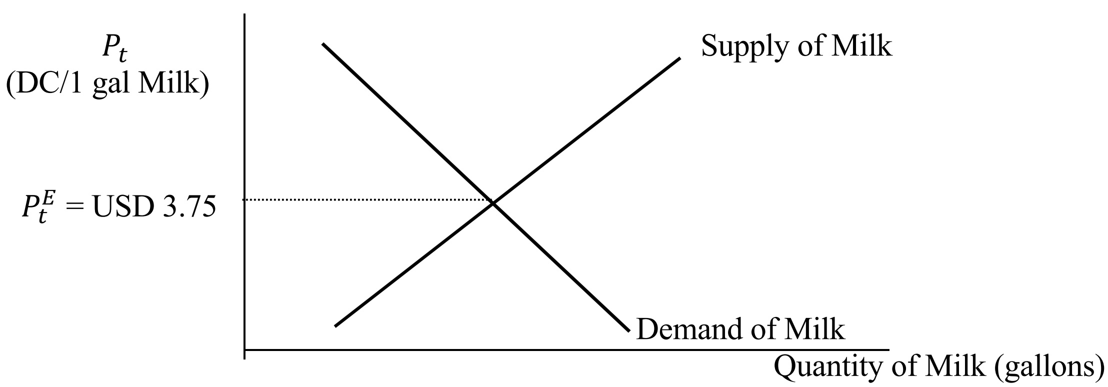


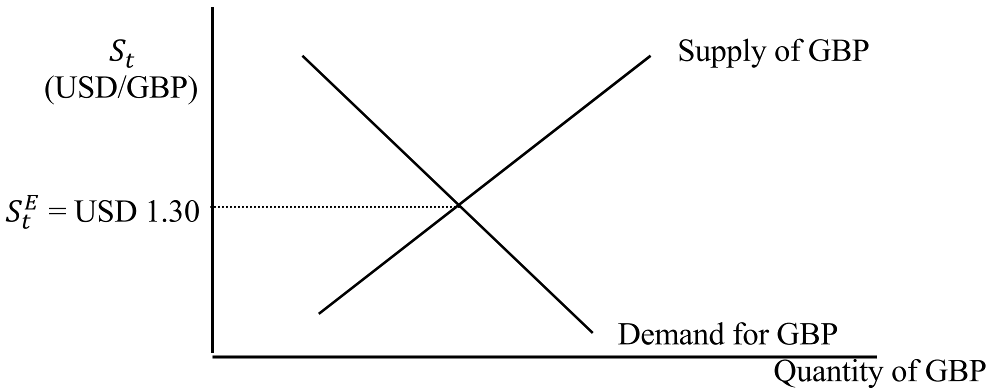
Figure 3.1 shows the determination of the equilibrium price of milk, P_t^E = USD 3.75/milk, which is determined in the Wholesale market. Interpretation of notation (P_t = 3.75 USD/milk):
1 gallon of milk = USD 3.75

Note: 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 37.50.

What makes an exchange rate tricky is that any of the two goods traded (DC and FC) 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.

• **Supply and Demand determine S_t.**

Figure 3.2: Demand and Supply in the FX Market

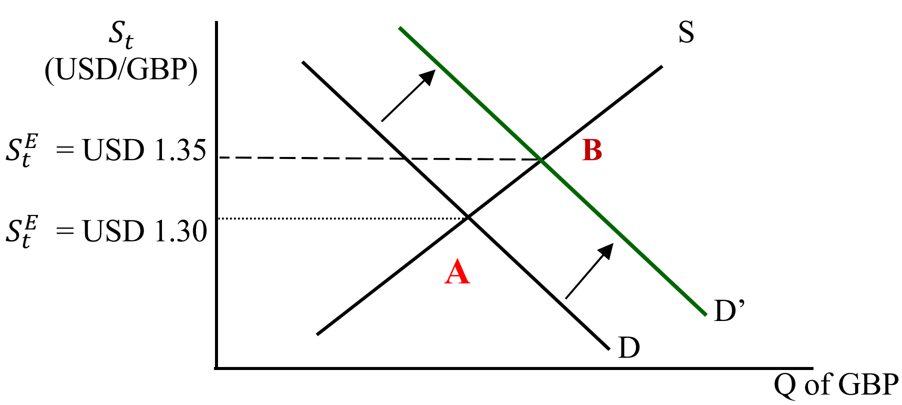


The price of one GBP is determined in the FX (wholesale) market, as shown in Figure 3.2:
GBP 1 = USD 1.30 (S_t = 1.30 USD/GBP).

Note: According to this notation, we are in the U.S. The currency in the numerator is the DC. This is the way prices are quoted in the domestic economic. DC units per good we want to buy.

Every time supply and demand move, S_t changes. For example, suppose the FX market is at point **A**, with an equilibrium exchange rate, S_t^E, equal to 1.30 USD/GBP. All of the sudden, there is a craze for British goods. Then, the demand for GBP increases to pay for the British imports (D moves up to D'). As a result, the value of the GBP increases (more USD are needed to buy GBP 1). The new equilibrium is point **B**, with S_t^E= 1.35 USD/GBP.

Figure 3.3: Movements of D & S curves in the FX Market



The GBP becomes more expensive in terms of USD. We say the GBP *appreciates* against the USD (or the USD *depreciates* against the GPB). In general, an appreciation of the foreign currency helps domestic exporters and hurts domestic importers.

Remark: Do not confuse movements of the curve (the demand curve shifts up), with movements along the curve (movement along the supply curve from A to B).

• Just a Price, but an Important One

S_t plays a very important role in the economy since it directly influences imports, exports, & cross-border investments. It has an indirect effect on other economic variables, such as the domestic price level, P_d, and real wages. For example:

- When $S_t\uparrow$, foreign imports become more expensive in USD

$\Rightarrow P_d \uparrow$ & real wages $\downarrow$ (through a reduction in purchasing power).

- When $S_t\uparrow$, USD-denominated goods and assets are more affordable to foreigners. Foreigners buy more goods and assets in the U.S. (exports, real estate, bonds, companies, etc.)

. $\Rightarrow$ Aggregate demand $\uparrow \Rightarrow Y_d \uparrow$ (though, it may take a while for this effect to occur.)

• 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: domestic prices can increase so much that domestic goods, once translated to FC, are more expensive. To easily compare where things are more expensive, the real exchange rate, R_t, is used:

$$\mathbf{R_t} = S_t\ P_f / P_d,$$

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

If $\mathbf{R_t}$ increases, we say the DC *depreciates in real terms* $\Rightarrow$ domestic goods become more competitive (cheaper) relative to foreign goods.

$\mathbf{R_t}$ gives a measure of competitiveness. It is a useful variable to explain trade patterns and GDP.

3.2. Currency Markets

Q: How is the FX market organized?

A: It is organized in two tiers:

- ◊ The *retail tier*
- ◊ The *wholesale tier* (the "FX or Forex market")

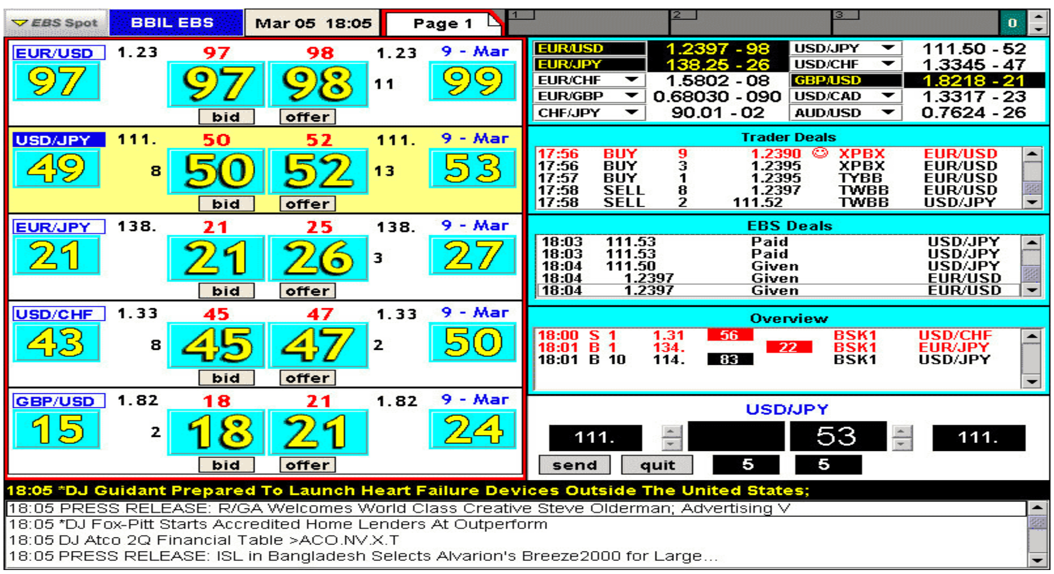
Retail Tier: Where small agents buy and sell FX.

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

• Characteristics of the FX Market

◊ Largest of all financial markets in the world.
◊ OTC market, with market makers and dealers.
◊ Geographically dispersed (NY, LA, NZ, Tokyo, HK, Singapore, Moscow, Zurich, London).
◊ **London** is the largest market (**38%** of total turnover), followed by NY (19%) & Singapore (9%).
◊ Open 24 hours a day.
◊ Typical transaction in USD is about 10 million ("ten dollars").
◊ Currencies are noted by a three-letter code, the ISO 4217 (USD, EUR, JPY, GBP, CHF, MXN)
◊ Daily volume of trading (turnover) -spot, forward and FX swap-: **USD 7.5 trillion** (2022).
Q: What is USD 7.5 trillion? 40 times the daily volume of international trade flows.
85 times the daily total U.S. GDP.
40% of total official FX reserves.
◊ USD, EUR, and JPY are the major currencies
. ◊ USD is the dominant currency: involved in 88% of transactions
◊ USD/EUR most traded currency pair (23% of turnover), followed by USD/JPY (18%)
◊ Emerging market currencies account for **18%** of turnover (CYN, HKD, KRW).
◊ 62% of transactions involve a cross-border counterpart.
◊ Very small *bid-ask* spreads for actively traded pairs, usually no more than 3 *pips* –i.e., 0.0003.
◊ Electronic trading platforms dominate; only **28%** of FX transactions are done via voice.

Example: A bid/ask quote of EUR/USD: 1.2397/1.2398 (spread: one *pip*). See screenshot from electronic trading platform EBS below:



Take the EUR/USD quote. The first number in black, **1.23**, represents the "big figure" –i.e., the first digits of the quote. The big numbers in yellow, within the green/blue squares, represent the last digits of the quote to form 1.2397-1.2398. The number in black by the ask ("*offer*") 98 (**11**) represents an irregular amount (say USD 11 million); if no number is by the bid/ask quote, then the "usual" amount is in play (say, USD 10 million, usually set by the exchange and may differ by currency). These irregular amounts have a better price quote than the regular amounts. The best regular quotes are on the sides 97 & 99. ¶

• 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: Transaction: BRL for JPY
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 situation applies for MB in Japan. ¶

Financial institutions are involved in the majority of total trading volume (93%).
- ◊ 42% interbank (between dealers).
- ◊ 51% other financial institutions (22% non-reporting dealers, 16% institutional investors, 8% hedge funds).

• Activities
- Speculation (open or "naked" positions)
- Hedging (covered positions)
- Arbitrage (establish positions to take advantage of pricing mistakes in one or more markets)
  - ◊ Types of arbitrage: Local/spatial (one good, one market)
    Triangular (two related goods, one market)
    Covered (two related markets, futures and spot transactions)

• Players and Dealers
- Players
  - ◊ Big Corporations
  - ◊ Mutual funds, Pension funds, Hedge funds, Insurance companies
  - ◊ Financial Institutions (Banks, Investment banks)
  - ◊ Big Speculators
  - ◊ Central Banks (hold, buy and sell FC)

- Dealers:
  - ◊ *Market-makers*: provide a two-way quote: bid and ask. Live off the spread.
    ⇒ Short-term and high volume. Small profits per transactions are expected.
  - ◊ *Speculators*: trade with a proprietary system. The dealer's own capital is put at risk.
    ⇒ Capital can be at risk for extended periods. Large profits are expected.
  - ◊ *Brokers*: find the best price for another player. Live off commissions.

• In the U.S., there are over 90 institutions considered active dealers in the FX market (some are market makers, others are brokers, some are all). Almost 90% of them are commercial banks. Ten institutions handled over 50% of the FX turnover in the U.S.

• The majority of the trading is done through electronic platforms. But, dealer institutions still have traditional trading rooms with traders specializing in areas: spot, forwards, options, etc. They have "back offices," where transactions are confirmed and finalized through a clearing system. Increasingly, there is also a "mid-office," where the validity of valuations/strategies is checked.

• Typical "voice-trader" (circa 1995): 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).

• Electronic Trading
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, FXConnect, Hotspot). Trades are increasingly taking place through multilateral 'electronic non-bank market makers' like XTX Markets, Virtu Financial, Citadel Securities, GTS and Jump Trading.

In 2022, electronic trading captured 60% of all FX transactions (up from 20% in 2001). This move towards electronic trading should improve costs and transparency (better price discovery).

For many years, the main electronic 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.

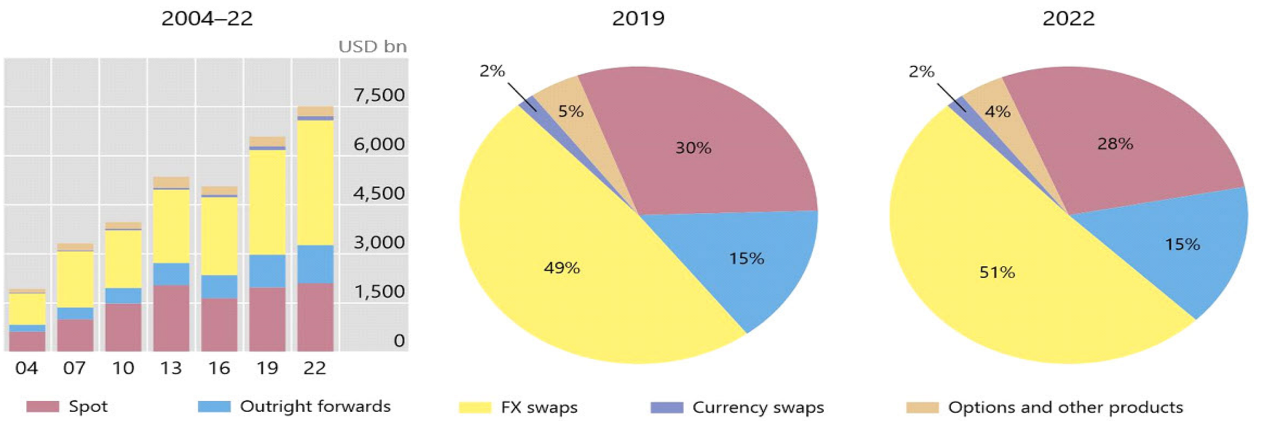
But, competition from single-bank trading systems (*internalization of flows*) is big and driving significantly down volume at both venues (traded volume at EBS went from 60% in 2011 to 19% in 2016). A big percentage of the FX trading is done through algorithmic trading. In the EBS platform, algorithm trading represents 75% of the volume.

3. Segments of the FX Market
All transactions in the FX Market are classified into different segments, see Exhibit 3.1 below. The daily turnover (USD 7.5 trillion) is divided into:
- USD 2.10 trillion in spot transactions (**28%**)
- USD 1.16 trillion in outright forwards (**15%**)
- USD 3.81 trillion in FX swaps (**51%**)
- USD 428 billion estimated gaps in options, currency swaps, etc.

Exhibit 3.1: Size of FX Market by Segments

Foreign exchange market turnover by instrument[1]

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



[1] Adjusted for local and cross-border inter-dealer double-counting, ie "net-net" basis.

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

• ***Segment 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 **28%** of total daily turnover (USD 2.1 trillion in 2022).

Example: Bank of America (BOFA) buys GBP 1M in the spot market at $S_t = 1.30$ USD/GBP.
In 2 business days, BOFA will receive a GBP 1M deposit and will transfer to the counterparty USD 1.3M. ¶

Two quote systems:

◊ *Indirect quote* or "European" quote
S(indirect) = units of foreign currency that one domestic unit will buy.

◊ *Direct quote* or "American" quote.
S(direct) = units of domestic currency 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. ¶

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

Remark: In class, we will use **direct** quotations.

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. We will see this topic again in Chapter 7):
⇒ (Quote X/Z)/(Quote Y/Z) = Quote X/Y (⇒ currency Z has to cancel out!)

Example: Calculate the CHF/EUR cross rate:
S_t = 1.00 CHF/USD
S_t = 0.97 EUR/USD

$S_{\frac{CHF}{EUR},t}$ = 1.00 CHF/USD / 0.97 EUR/USD = 1.03093 CHF/EUR. ¶

Example: JPY/GBP cross rate.
S_t = 0.00833 USD/JPY = 120 JPY/USD.
S_t = 1.30 USD/GBP

$S_{\frac{JPY}{GBP},t}$ = 120 JPY/USD * 1.30 USD/GBP = 92.3077 JPY/GBP. ¶

• *Segment 2*: The Forward Market
A forward transaction is generally the same as a spot transaction:
⇒ but settlement is deferred much further into the future, at a later time T.
- T (=Maturity): 7-day, 1-, 2-, 3- and 12-month settlements. (Up to 10-year contracts.)
- Forward transactions are tailor-made.
- Forward contracts allow firms and investors to transfer risk.
- Notation. $F_{t,T}$: Forward price at time t, with a T day maturity.
- Forward transactions are classified into two classes: *outright* and *swap.*
⇒ Outright forward transaction: an uncovered speculative position in a currency (though it might be part of a currency hedge to the other side).

- The (outright) Forward Market represents **15%** of total daily turnover (USD 1.2 trillion in 2022).
- 40% of outright forwards have duration of less than 7 days.

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 $F_{t,7-day}$ = 1.305 USD/GBP to transfer the currency risk of her position.

In 7 days, BOFA will receive USD 1,305,000 and will transfer to the counterparty GBP 1M. ¶

Forward transactions are classified into two classes: *outright* and *swap.*

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

• *Segment 3:* The FX Swap

FX swap transaction (a "package trade"): The simultaneous sale (or purchase) of spot foreign exchange against a forward purchase (or sale) of approximately an equal amount of the foreign currency.

Motivation for a FX swap transaction: A position taken to reduce the exposure in a forward trade.

The FX Swap Market represents **51%** of total daily turnover (USD 3.81 trillion). The majority of FX Swaps (70%) are short-term (7 days or less).

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

Simultaneously, the U.S. trader

(1) Buys GBP 1M spot at S_t = 1.30 USD/GBP,

(2) Buys the short-term GBP 1M bond position, and

(3) Sells GBP 1M forward at $F_{t,7-day}$ = 1.305 USD/GBP.

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

Transactions (1) and (3) are classified as an FX Swap transaction. ¶

CHAPTER 3 – BRIEF ASSESMENT

1) In the USD/GBP market, draw the effect on the equilibrium S_t of the following movements of the curves:
a) The supply of GBP increases.
b) The demand for GBP decreases.

2) Calculate the CHF/JPY cross rate, using the following exchange rates:
S_t = 1.00 CHF/USD
S_t = 112 JPY/USD

3) Structure an FX swap for a U.K. trader that wants to invest in a US T- bond for a 14-day period.

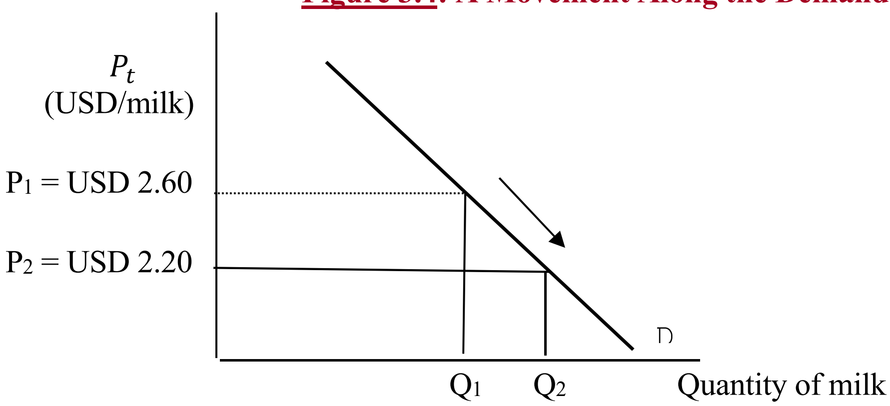
Chapter 3 - BONUS COVERAGE: A Shift vs. A Movement

In economics, a *movement* and a *shift* in relation to the supply and demand curves represent very different market events.

1. *A Movement*

A movement refers to a change along a curve. On the demand curve, a movement denotes a change in both price and quantity demanded from one point to another on the curve. The movement implies that the demand relationship remains unchanged. Therefore, a movement along the demand curve will occur when the price of the good changes and the quantity demanded changes in accordance to the original demand relationship. In other words, a movement occurs when a change in the quantity demanded is caused only by a change in price, and vice versa.

Figure 3.4: A Movement Along the Demand Curve

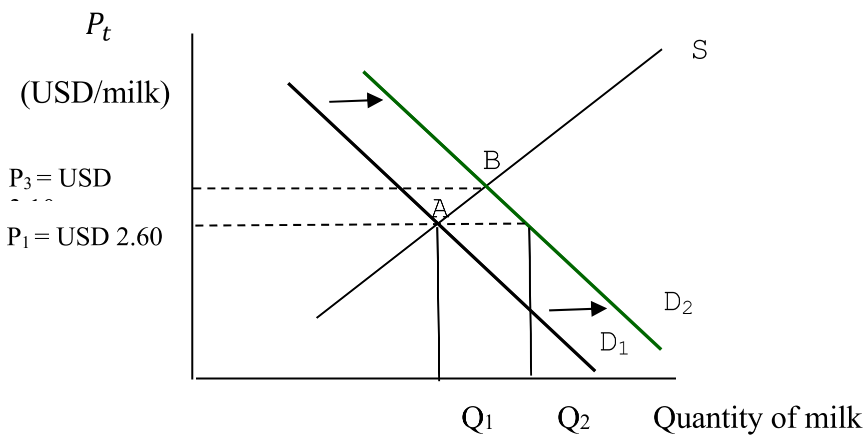


Similarly, a movement along the demand curve, a movement along the supply curve means that the supply relationship remains unchanged. Therefore, a movement along the supply curve will occur when the price of the good changes and the quantity supplied changes in accordance to the original supply relationship. In other words, a movement occurs when a change in quantity supplied is caused only by a change in price, and vice versa.

2. *A Shift*

A shift in a demand or supply curve occurs when a good's quantity demanded or supplied changes even though price remains the same. For instance, if the price for a gallon of milk was USD 2.60 and the quantity of milk demanded increased from Q1 to Q2, then there would be a shift in the demand for milk. Shifts in the demand curve imply that the original demand relationship has changed, meaning that quantity demand is affected by a factor other than price. A shift in the demand relationship would occur if, for instance, cereal for breakfast –a complimentary good- suddenly became very inexpensive. As a result of the shift in demand, the final price is USD 3.10 (new equilibrium is Point B).

Figure 3.5: A Shift in the Demand Curve

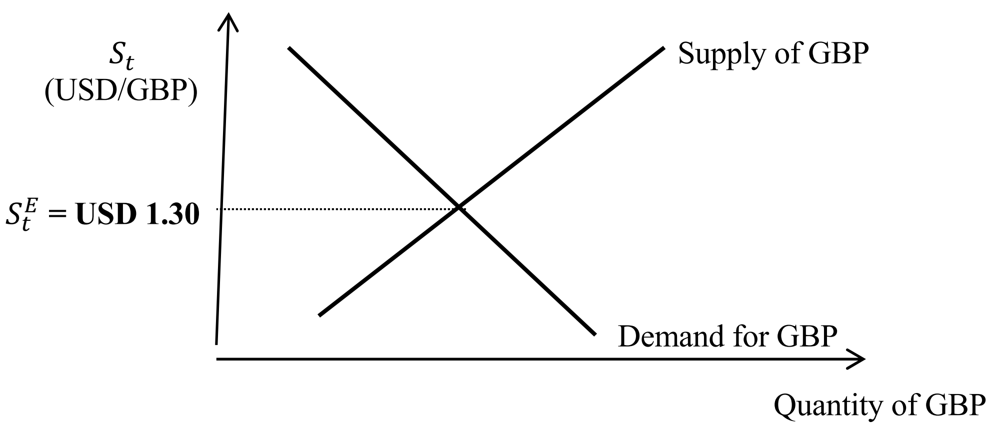


Conversely, if the price for a gallon of milk was USD 2.60 and the quantity supplied decreased from Q1 to Q2, then there would be a shift in the supply of milk. Like a shift in the demand curve, a shift in the supply curve implies that the original supply curve has changed, that is, the quantity supplied is affected by a factor other than price. A shift in the supply curve would occur if, for instance, a virus caused a significant reduction in the stock of cows; milk producers would be forced to supply less milk for the same price.

Chapter 4 – Determinants of FX Rates

Review from Chapter 3:
FX is a huge market (the biggest financial market)
- Open 24/7
- 3 segments: Spot, Forward, and FX swap (biggest)
- Supply and Demand determines S_t –always expressed as DC/FC. Figure 4.1 shows the equilibrium price in the GBP/USD Market.

Figure 4.1: Supply and Demand Determines S_t



In this class we study the economic factors that determine S & D.

• Economic Activities behind Supply & Demand

Think about the economic activities that determine the USD/GBP exchange rate.
Q: What kind of activities demand and/or supply GBP in the FX market (say, in the US market)?

◊ International Trade:	Exports to the UK (supply GBP)
	Imports from the UK (demand GBP)
◊ International Investing:	British Investors investing in the US (supply GBP)
	US Investors investing in the UK (demand GBP)
◊ International Tourism:	British tourism to the US (supply GBP)
	US tourism to the UK (demand GBP)
◊ Investment Income:	British Investors/Companies sending income back home (Dem GBP)
	U.S. Investors/Companies sending income back home (Sup GBP)

• Balance of Payments

At the national accounts level, the above activities are reflected in the Balance of Payments (BOP):
BOP = Current Account (CA) + Capital Account (KA)
CA = Net Exports of goods and services (main component) + Net Investment Income + Net Transfers
KA = Financial capital inflows – Financial capital outflows

The BOP = 0 $\Rightarrow$ The CA is financed by the KA.

• Factors Affecting the BOP

Q: Now, what economic variables ("Fundamentals") affect Supply & Demand (or the BOP)?

A: Several variables:

- Interest rates ($i_{USD} - i_{GBP}$): Affect savings and investments (KA).
- Inflation rates ($I_{USD} - I_{GBP}$): Affect trade (CA).
- Income growth rates ($y_{US} - y_{UK}$): Affect everything (both CA & KA).
- Others: Tariffs, quotas, other trade barriers, expectations, taxes, uncertainty, tastes, etc.

We will analyze the effect on S_t of a change of only one variable at a time.

• A Word about Models

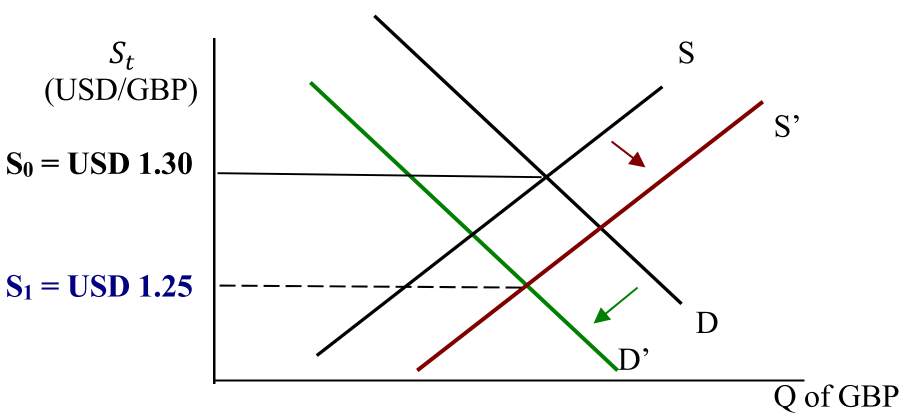
In the economy variables are interrelated, a change of one variable can have an effect on many markets. We will use a *model* to simplify the interactions and focus on the main impact, say money markets, goods markets, etc. These models that focus on the equilibrium in only one market, say the goods market, are called *partial equilibrium models.*

There are other models, *general equilibrium models*, where we study equilibrium in all markets, say the goods market, the money market, and the BOP. We will mention these models, but we will not cover them.

• Changes in Economic Variables and S_t

1. Changes in interest rates: ($i_{USD} - i_{GBP}$) ↑

Figure 4.2: Effect of a Change in the Interest Differential on S_t



Main impact of a change in relative interest rates: Capital flows (KA), think of short-term CDs.

($i_{USD} - i_{GBP}$) ↑ ⇒ US CDs are more attractive than UK CDs.

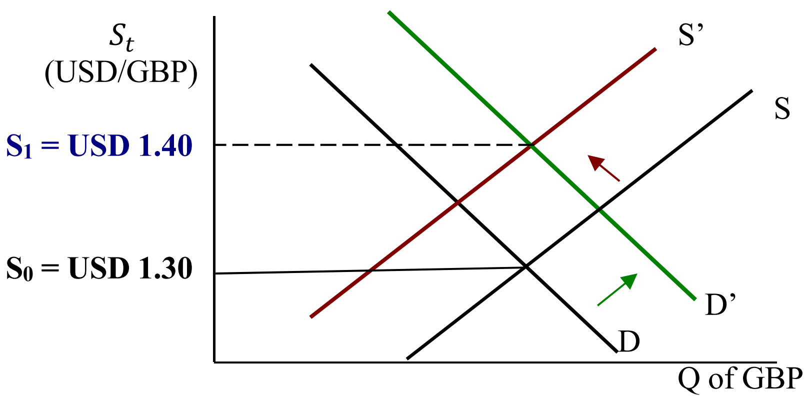
- More investments in the US from UK residents (supply moves to S')
- Less investments in the UK from US residents (demand moves to D')

As Figure 4.2 shows, the GBP depreciates against the USD (becomes less expensive in terms of USD). Or, we can also say that the USD appreciates against the GBP.

Check: $(i_{USD} - i_{GBP}) \downarrow \Rightarrow S_t \uparrow$

***2. Changes in inflation rates*:** $(I_{USD} - I_{GBP}) \uparrow$

Figure 4.3: Effect of a Change in the Inflation Rate Differential on S_t



Main impact of a change in relative inflation rates: Trade flows (CA).

$(I_{USD} - I_{GBP}) \uparrow \Rightarrow$ US goods are relatively more expensive than UK goods.
- Less purchases of US goods by UK residents –less US exports (supply moves to S').
- More purchases of UK goods by US residents –more US imports (demand moves to D').

As shown in Figure 4.3, the GBP appreciates against the USD (becomes more expensive in terms of USD). Or the USD depreciates against the GBP.

Check: $(I_{USD} - I_{GBP}) \downarrow \Rightarrow S_t \downarrow$

3. Changes in income growth rates: $(y_{US} - y_{UK}) \uparrow$. Suppose $Y_{US} \uparrow$ (& Y_{UK} remains the same).

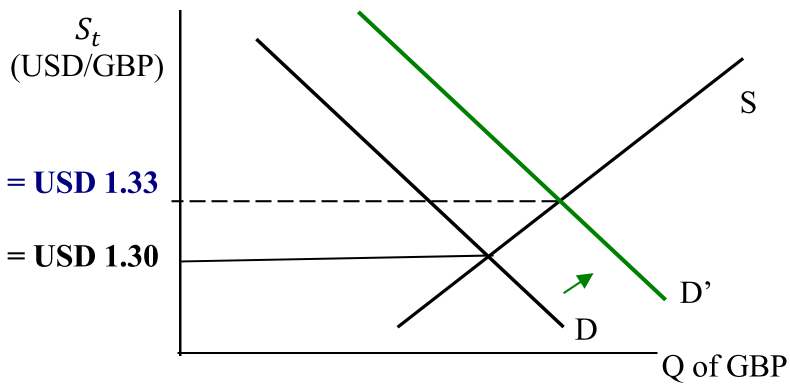
When $Y_{US} \uparrow$ we tend to increase all our demands: we demand more of everything (domestic goods, foreign goods, investments, money, etc.). The final effect on S_t depends on which variable (market) has a bigger impact on S&D.

There are two main equilibrium stories:
- ◊ Balance of Trade Approach (Approach in Madura's textbook)
- ◊ Monetary Approach (MA)

3.1 BT Approach
Under the BT approach, trade flows –i.e., exports and imports- are the main factors influencing demand and supply for FC. The CA is the main determinant of S_t. (This is the story in the textbook, standard view before the financial liberalization of the '70s.)

BT: Y_{US}↑ (& no change in Y_{UK}) ⇒ More US demand of everything, among them imports (M) from UK. The TB_{US} (=X-M) ↓. Demand for GBP increases ⇒ S_t↑ (Figure 4.4 shows these dynamics.)
(Note: We can think that under the BT approach, Y_{US}↑ has no significant effect on US interest rates.)

Figure 4.4: Effect of a Change in US Income (under BT Approach)



Note: Things are dynamic. As UK exports more, Y_{UK}↑. Then, US exports more to the UK (S also moves). The net effect on the TB_{US} will depend on imports and exports income elasticities. Strange things can happen, but, in general, we expect an increase in the TB to appreciate the domestic currency.

3.2 Monetary Approach
Under the MA, S_t is determined in equilibrium by relative money demand and money supply between the two currencies involved. Each currency is just another asset, whose yield is given by i_{DC} & i_{FC}. Thus, interest rates and income will influence demand for money and, thus, currency. Money supply will also be a relevant variable that affects the yield.

MA: Y_{US}↑ ⇒ More US demand of everything, among them domestic money (USD). Demand for US money increases ⇒ i_{USD}↑ ⇒ ($i_{USD} - i_{GBP}$)↑ (capital flows move in favor to the U.S.) ⇒ S_t↓

Remark: Financial variables, like interest rates and exchange rates, adjust very quickly to changes. It will take longer for companies to adjust trade flows, due to long-term contracts, bureaucracy, etc.

The MA is the usual story reported by the press, since exchange rates will adjust very quickly to changes in interest rates. When a country grows, in the short-run, its currency tends to appreciate.

Note: There is a variation of the MA, called the *portfolio-balance approach*, where relative demands and supplies of domestic and foreign bonds also play a role in determining S_t. For this approach to work, domestic and foreign bond have to be *imperfect substitutes* (otherwise, they will have the same price and relative demands/supplies will be irrelevant).

For example, an increase in the relative supply of domestic bonds to foreign bonds comes with an increased compensation (otherwise, no incentive to hold them) on the domestic bonds that will make the DC depreciate in the spot market (S_t↑).

⇒ If the expected future spot rate, $E_t[S_{t+T}]$, is unchanged the expected rate of appreciation (depreciation) over the future T days increases (decreases).

4. Other:

- ⋄ Quotas: Affect foreign trade and the CA.
- ⋄ Expected Rates of Return on financial assets/real estate: Affect the KA.
- ⋄ Uncertainty: Political problems, war, terrorism, etc.
- ⋄ Tastes: A sudden increase in tastes for foreign goods, say luxury goods.
- ⋄ Worker's skills/Technology: Anything that improves worker productivity/production costs.
- ⋄ Expectations: If a lot of people expect the GBP to depreciate, it is optimal to sell GBP, regardless of the truth behind the expectation. The GBP can depreciate in a hurry (think of the Keynesian beauty contest). Recall that financial assets are influenced by expectations about the future value of the asset.

• Remarks:

⋄ *Interactions among variables*: So far, we have assumed that only one variable changes (the *ceteris paribus* assumption). But, in economics, variables are interrelated. Higher inflation means a higher interest rate; restrictions to trade affect income, etc. In these situations, when we are drawing the S&D curves, we need to make assumptions about which curve moves more –that is, which effect is the dominant one.

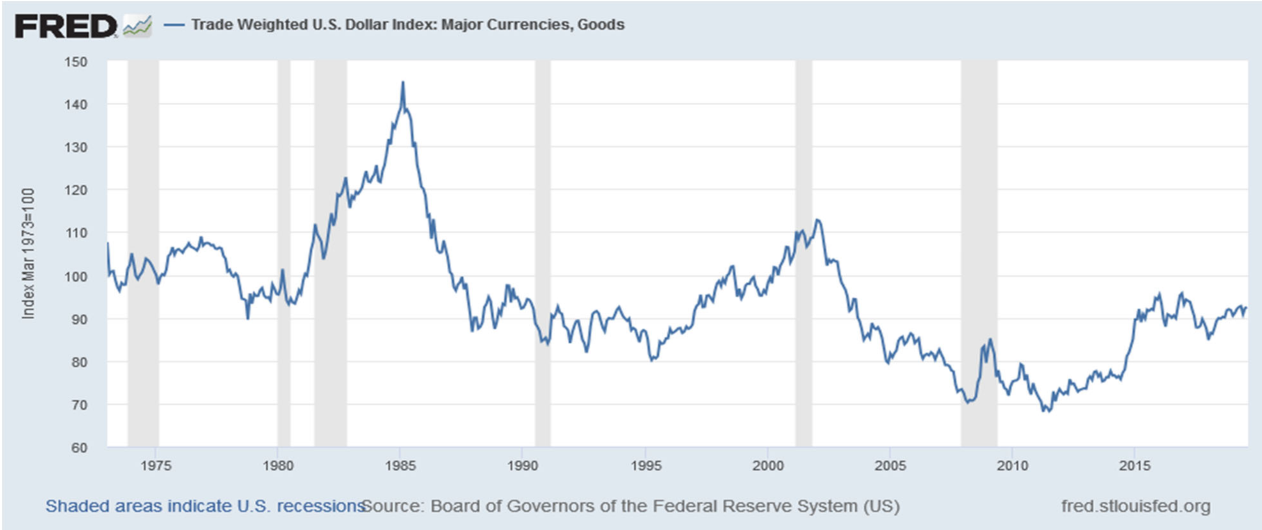
⋄ *No dynamics*: In all the S&D graphs above, we presented two situations: initial equilibrium (with $\mathbf{S_0}$) and final equilibrium (with $\mathbf{S_1}$). We have paid no attention to the adjustment process –i.e., how S_t moves from $\mathbf{S_0}$ to $\mathbf{S_1}$.

• Exchange Rates Move a Lot

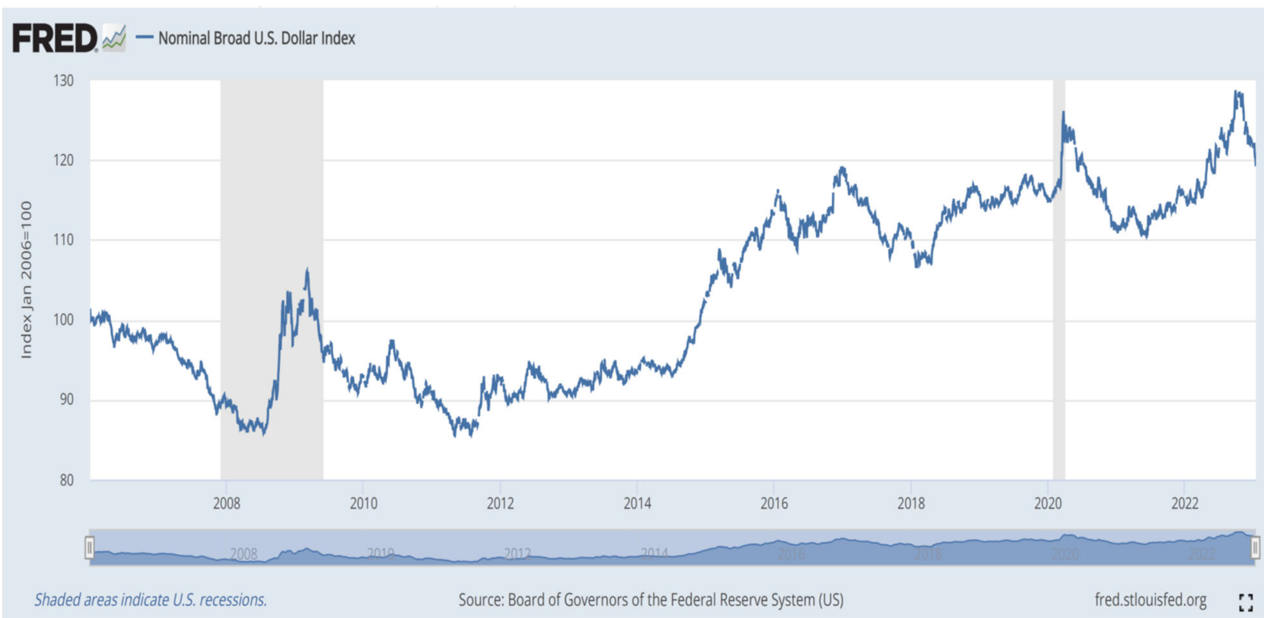
The Federal Reserve constructs an index to reflect the value of the USD against a basket of currencies (TWC). The Fed changes the basket, accordingly to trade patterns. The old basket includes the EUR (58%), the JPY (14%), the GBP (12%), the CAD (9%), the SEK (4%), and the CHF (4%). It is quoted in TWC/USD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

Exhibit 4.1 shows the performance of the USD against the TWC since 1973, just after the U.S. abandoned the fixed exchange rate system (see Chapter 6). As it can be seen, the USD moves a lot, though, in general, slowly over time.

Exhibit 4.1
The Value of the USD against the TWC, S_t (TWC/USD)



Below, we show the new basket, Nominal Broad USD Index, started in 2020. The Fed computed the new basket retroactively to 2006. It is quoted in TWC/USD terms.



CHAPTER 4 - APPENDIX: KEYNES' BEAUTY CONTEST AND INVESTORS

"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."

From the perspective of modern economics, Keynes' beauty contest is a coordination game -i.e., a game where the participants get high (low) payoff if they choose the same (a different) action. You may sell (or buy) an asset, say GBP, not because you think it is overvalued. You may sell GBP because you think the other investors think it is overvalued!

CHAPTER 4 – BRIEF ASSESMENT

1) In the MXN/USD market, draw a graph showing the effect on S_t of the following surprises:
a) Interest rates in Mexico increase (everything else remains the same).
b) The inflation rate in Mexico decreases (everything else remains the same).
c) The Mexican economy slows down (everything else remains the same). Be specific about the theoretical approach you use to answer this question.

2) Suppose a European country surprisingly votes to exit the European Union. What is the effect of this decision on the EUR/USD exchange rate. Draw a graph.

3) The U.S. government decides to increase tariffs on Mexican imports ("border-adjustment tax"). What is the effect of this new tariff on the USD/MXN exchange rate?

4) UAE's economy is very dependent on oil exports. Draw a graph showing the effect on S_t (AED/USD) of a sudden increase in the price of oil.

Chapter 5 - Currency Derivatives (FX Management Tools)

S_t changes with several variables: ($i_{USD} - i_{GBP}$), ($I_{USD} - I_{GBP}$), ($y_{US} - y_{UK}$).
Interest rates, in particular, change all the time. S_t will also change. (See Exhibit 4.1.) This introduces *exchange rate risk* (one form of price risk).

Currency Derivatives can reduce the risk in FX transactions.

1. Currency Futures/Forwards
2. Currency options
3. Money Market (Replication of IRP. Chapter 10)
4. Other hedging tools (Ch 10-12): - Pricing in DC
   - Risk-sharing
   - Matching Outflows & Inflows

In this chapter, we will present two FX Derivatives:

- Currency Futures/Forwards (agreement to buy/sell FC at a given price at time T)
- Currency Options (right to buy/sell FC at a given price during a period of time, t to T)

5.1 Currency Risk

Definition: The risk that the value of an asset/liability/financial instrument will (negatively) change due to changes in FX rates. (Financial risk applied to international finance!)

Example: ABYZ, a U.S. company, imports wine from France. ABYZ has to pay EUR 5,000,000 on January 2. Today, September 4, the exchange rate is 1.29 USD/EUR.

Situation: Payment due on January 2: **EUR 5,000,000.**
$S_{Sep\ 4}$ = **1.29 USD/EUR**.

Problem: S_t is difficult to forecast ⇒ Uncertainty.
Uncertainty ⇒ Risk.
Example: on January 2, $S_{t=Jan\ 2}$> or < **1.29 USD/EUR**.

At $S_{Sep\ 4}$, ABYZ total payment would be: **EUR 5M** * **1.29 USD/EUR** = **USD 6.45M**.

On January 2 we have two potential scenarios relative to Sep 4:
If the $S_{Jan\ 2}$↓ (USD appreciates) ⇒ ABYZ will pay less USD.
If the $S_{Jan\ 2}$↑ (USD depreciates) ⇒ ABYZ will pay more USD.

The second scenario introduces *Currency Risk.* ¶

If the value of an asset/liability does not change "a lot" when S_t moves, we will consider the asset/liability to have low currency risk. (Of course, if it does not change in value at all, it does not face currency risk.)

In finance, we relate "a lot" to the variance or volatility. For currency risk, we will look at the volatility of FX rates: ⇒ more volatile currencies, higher currency risk.

Example **(continuation)**: Consider the following situations:
(A) $S_{Jan\,2}$ can be with 50% either scenario:
(i) 1.28 USD/EUR, for a total payment: **EUR 5M** * 1.28 USD/EUR = USD 6.40M.
(ii) 1.30 USD/EUR, for a total payment: **EUR 5M** * 1.30 USD/EUR = USD 6.50M.

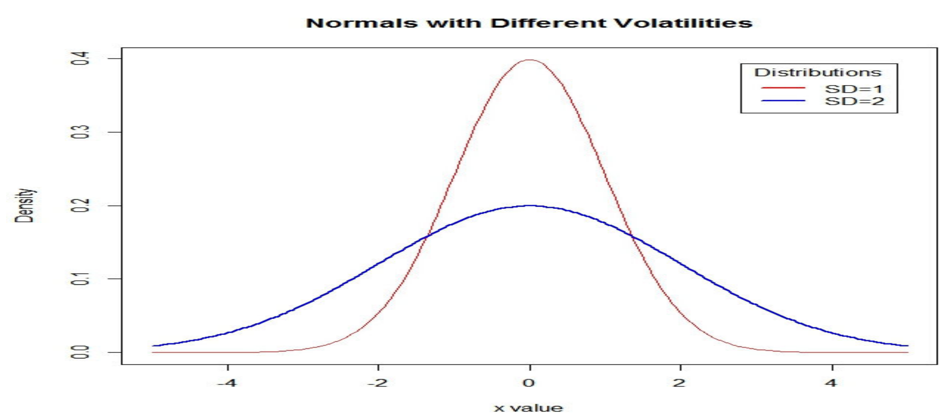
(B) $S_{Jan\,2}$ can be with 50% either scenario:
(i) 1.09 USD/EUR, for a total payment: **EUR 5M** * 1.09 USD/EUR = USD 5.45M.
(ii) 1.49 USD/EUR, for a total payment: **EUR 5M** * 1.49 USD/EUR = USD 7.45M.

Both situations have the same expected value (expected payment: **USD 6.45 M**), but different levels of risk. Situation B is riskier (more volatile) for ABYZ, since it may result in a higher payment.

Note: Under situation B, ABYZ may end up paying a lot less than in situation A. That is the usual risk/reward trade-off in finance: No pain (risk, volatility), no gain (in this case, lower payments)! ¶

Currency (financial) risk is evaluated using probability distributions. For example: the normal distribution. Two different normal distributions are plotted in Figure 5.1 with the same mean (0), but different volatilities (standard deviations, SD). The blue distribution (SD=2) would be considered riskier than the red distribution.

Figure 5.1: Normal Distributions with Different Standard Deviations



Recall that a probability distribution completely describes the behavior of a random variable. (For us: the random variable: S_t. The behavior we want to be described: the variability of S_t.)

Before making decisions regarding FX derivative instruments, a company should take into consideration the distribution (the behavior) of future S_t. In the previous example, under Situation A, ABYZ can ignore FX risk; but under Situation B, ignoring FX risk is risky!

• Brief Aside: Characteristics of the Distribution of FX Rates
Below, Table 5.1 shows the distribution of percentage changes in FX Rates, $e_{f,t}$, for selected currencies (annualized mean & SD), using 1990-2017 monthly data (336 observations).

TABLE 5.1: Descriptive Statistics for selected currencies (1990-2017) using monthly data

Currency	Mean	Standard Deviation	Skewness	Excess Kurtosis	Normal?
GBP/USD	0.0090	0.0951	0.9681	3.4004	No
CHF/USD	-0.0097	0.1101	0.2171	1.3365	No
DKK/USD	0.0118	0.1030	0.4803	1.2113	No
EUR/USD	0.0166	0.1102	0.5253	1.2145	No
INR/USD	0.0565	0.0820	3.0932	24.1434	No
JPY/USD	-0.0010	0.1056	-0.1936	1.9347	No
KRW/USD	0.0295	0.1247	1.7968	15.9320	No
THB/USD	0.0179	0.1055	2.6493	32.3567	No
SGD/USD	-0.0095	0.0563	0.5677	2.9251	No
CNYUSD*	-0.0122	0.0160	-0.4484	7.9325	No
KWD/USD	0.0024	0.0446	2.1568	74.9592	No
SAR/USD	0.0000	0.0030	3.3228	119.9623	No
CAD/USD	0.0106	0.0792	0.8378	5.7371	No
MXN/USD	0.0818	0.1359	5.0008	51.7441	No
ZAR/USD	0.08053	0.14163	0.08053	2.1010	No
EGP/USD*	0.04084	0.05303	0.04084	216.7728	No
NGN/USD*	0.1666	0.5804	15.7821	259.9828	No
AUD/USD	0.01062	0.11436	0.01062	4.3249	No
Average	**0.0349**	**0.1180**	**2.7443**	**38.4349**	**No**

Notes: * shorter sample: CNY (9/1994-12/2017), EGP (1/1995-12/2017) & NGN (1/1994-12/2017).

- On average, since 1990, the USD appreciated against international currencies at an annualized mean of 3.49%. The average annualized SD is 11.80%.
- USD against developed currencies (in blue): 0.5% annualized appreciation, with a 9.51% SD.
- *Excess Kurtosis.* It describes the fatness of the tails. Under normality, excess kurtosis equals 0. All the currencies show excess kurtosis, that is, the tails are fatter than the tails of a normal –i.e., probability of

a tail event is higher than what the normal distribution implies. The tails are very thick, reflecting higher extremes, in emerging markets.
- *Skewness*. If the distribution is symmetric (mean=median, for example, a normal), skewness is 0. Almost all the currencies show positive skewness (mean>median); that is, the fat part of the curve is on the left. Again, emerging market currencies show higher skewness.
- From the last column, which shows the results of a test of normality, the Jarque-Bera (1980) test, we can say that $e_{f,t}$ does not follow a normal distribution. Not a surprising result, given the big skewness and excess kurtosis.

The last three results are typical of financial time series.

5.2 Currency Futures or Forward Contracts

FX Forward/Futures are agreements that set, today, the price of the exchange rate at a given future date. The agreement also specifies a given quantity.

• Basic Terminology
◊ Short: Agreement to Sell.
◊ Long: Agreement to Buy.
◊ Contract size: Number of units of foreign currency in each contract.
◊ Maturity (T): Date in which the agreement has to be settled.
◊ Futures/Forward price ($F_{t,T}$): Price at which the forward transaction at maturity will be executed.

• Forwards vs Futures
◊ Forward markets: Tailor-made contracts.
Location: none (OTC traded contracts).
Reputation/collateral guarantees the contract.

◊ Futures markets: Standardized contracts (standardized duration, size, collateral).
Location: organized exchanges (CME, Euronext (LIFFE), Tokyo FX)
Clearinghouse guarantees the contract.

CME Standardized sizes: GBP 62,500, AUD 100,000, EUR 125,000, JPY 12.5M. There is a smaller sized-contract (E-micro), the size is 10% of standardized size.
CME expiration dates: Mar, June, Sep, and Dec + Three nearby months
Margin account: Amount of money you deposit with a broker to cover your possible losses involved in a futures/forward contract. Two important quantities:
- Initial Margin: Initial level of margin account.
- Maintenance Margin: Lower bound allowed for margin account.
Mechanism: If margin account goes below maintenance level, a *margin call* is issued:
⇒ Funds have to be added to restore the account to the initial level.

Example: GBP/USD CME futures
Initial margin: USD 2,800
Maintenance margin: USD 2,100

If losses do not exceed USD 700, no margin call will be issued.
If losses accumulate to USD 850, USD 850 will be added to account. ¶

Table 5.2 summarizes the main differences between the two contracts.

TABLE 5.2: Comparison of Futures and Forward Contracts

	Futures	Forward
Amount	Standardized	Negotiated
Delivery Date	Standardized	Negotiated
Counter-party	Clearinghouse	Bank
Collateral	Margin account	Negotiated
Market	Auction market	Dealer market
Costs	Brokerage and exchange fees	Bid-ask spread
Secondary market	Very liquid	Highly illiquid
Regulation	Government	Self-regulated
Location	Central exchange floor	Worldwide

• Real Life Examples of Forwards and Futures

Pizza delivery: Customer buys future pizza; pays with USD (domestic currency)
Pizza Hut sells future pizza; gets paid with USD (domestic currency)

Terms of contract:

Size: One pizza
Duration: 30' or less.
Collateral: Credit card or None.

• Using FX Forwards and Futures

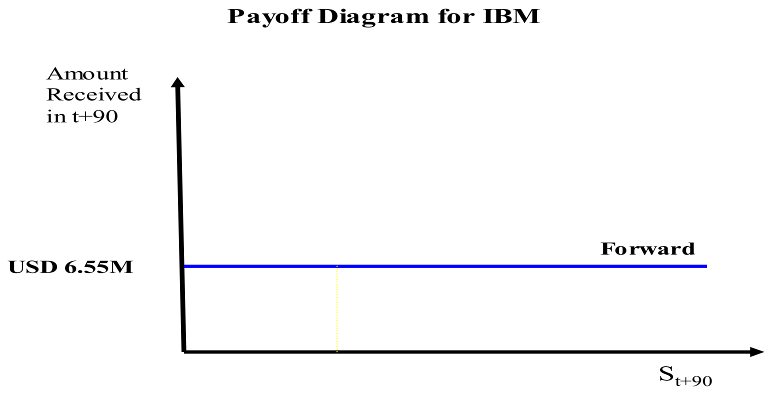
Q: Who buys/sells FX Forward and Futures Contracts?
A: Hedgers and Speculators

Example: IBM has to pay in 90 days EUR 5M to a French supplier.
Problem: IBM is concerned about a depreciation of the USD against the EUR in the near future.
Solution: IBM buys from Chase a EUR forward contract.

Size = EUR 5M
Maturity = 90 days.
$F_{t,90}$ = 1.31 USD/AUD

Note: IBM knows that, in 90 days, it will pay USD 6.55M (=EUR 5M*1.31 USD/EUR) to the supplier. As shown in Figure 5.2, there is no uncertainty whatsoever about this amount: S_{t+90} does not affect the amount to receive in 90 days. (No uncertainty, no volatility ⇒No FX risk).

Figure 5.2: CFs under an FX Futures



Hedging Note:
- Underlying position: Short EUR 5 M.
- Hedging position: Long 90 days futures for EUR 5 M. ¶

Example: A U.S. investor has GBP 1 million invested in British gilts (UK government bonds).
Problem: Uncertain about future value of USD/GBP in December.
Solution: Sell GBP Dec futures.
Situation: It is Sep 12.
Underlying position: British bonds worth GBP 1,000,000.
$F_{Sep\ 12,Dec}$ = 1.55 USD/GBP
Futures contract size: GBP 62,500.
$S_{Sep\ 12}$: 1.60 USD/GBP.
number of contracts = ?

Hedging position: The investor sells GBP 1,000,000/(62,500 GBP/contract) = 16 contracts.

Note: If the U.S. investor decides to sell her British gilts in December she will receive exactly USD 1.55M. No uncertainty whatsoever about this amount.

But, if she decides not to sell the gilts, there will be a cash flow from the difference between S_{Dec} - $F_{Dec,Dec}$. ¶

Hedging Note:
- Underlying position: Long GBP 1 M.
- Hedging position: Short futures for GBP 1 M.

From both hedging notes ⇒ Hedging is very simple: Take an opposite position!

We call the hedger with a long FX futures/forward position, the *long hedger*. Similarly, we call the hedger with a short FX futures/forward position, the *short hedger*.

5.3 Currency Options

An option is a contract that gives the holder the right to do something for a certain amount of time or at a certain date. The holder of the option buys this right at a cost: the *premium*.

In the FX market, the "right to do something" is the right to buy/sell an amount of FC at a given price.

• Options: Brief Review

- Major types of option contracts:
  ◊ C*alls* gives the holder the right to buy a certain amount of the underlying asset
  ◊ *Puts* gives the holder the right to sell a certain amount of the underlying asset.
- The complete definition of an option must specify:
  ◊ *Exercise* or *strike price* (X): price at which the right is "exercised."
  ◊ *Expiration date* (T): date when the right expires.
  ◊ *Size*: Amount of the underlying asset.
  ◊ When the option can be exercised: Anytime (American)
  At expiration (European).
- The option to buy or sell an asset has a price: the *premium* (paid upfront).
- Options are priced using variations of the Black-Scholes formula.
- Currency premiums are affected by six factors:
  i. S_t (underlying asset's market price)
  ii. X. (exercise or strike price)
  iii. T-t (time till expiration)
  iv. σ (volatility of underlying asset)
  v. i_d (domestic interest rate)
  vi. i_f (foreign interest rate)
- Moneyness. The relation between S_t**,** and the option's strike price, **X**, determines the *moneyness* of the option (if exercised today how profitable the option is for the holder). An option can be:.
  ◊ *At-the-money* (ATM) if $S_t = X$
  ◊ *In-the-money* (ITM) if $S_t > X$ (calls)
  if $S_t < X$ (puts)
  ◊ *Out-the-money* (OTM) if $S_t < X$ (calls)
  if $S_t > X$ (puts)

• Real Life Examples of Options

Insurance, layaways, tuition, movie tickets.

Example 1: An advanced purchase of a movie ticket.
I have the right to go to a movie. If I have something better to do, I do not have to go.
Size: 1 ticket.
Premium: ticket price.
Maturity: time at which the movie ends.

Example 2: College tuition and Moneyness.
Paying tuition allows a student to come to class. Unless attendance is mandatory, some students only attend when it is convenient/valuable –i.e., when, for them, the option is ITM. Usually, the class before

the exam is considered by all students ITM. On the other hand, the class after the exam is considered, for many students, OTM.

• OTC and Exchange-traded Currency Options
There are 2 markets for FX options:

(1) Interbank (OTC) market centered in London, New York, and Tokyo.
OTC options are tailor-made as to size, maturity, and exercise price.

(2) Exchange-based markets centered in Philadelphia (PHLX) or NY (ISE).
PHLX options are on spot amounts of 10,000 units for the main FC (JPY: 1M, MXN: 100K).
PHLX maturities: 1, 3, 6, and 12 months.
PHLX expiration dates: March, June, September, December, and the two nearby months.

Exercise price of an option at the PHLX or CME is stated as the price in USD cents of a unit of FC. A typical newspaper option quote is shown in Exhibit 5.1.

Exhibit 5.1: PHLX Option quote

OPTIONS
PHILADELPHIA EXCHANGE
May 15, 2013

		Calls		Puts		
		Vol.	Last	Vol.	Last	
Euro					**135.54**	(← S_t = 1.3554 USD/EUR)
10,000 Euro-cents per unit.(← Size of EUR contract)						
132	Oct	....	0.01	3	0.38	
134	Sep	3	1.74	90	0.15	
134	Oct	3	1.90	....	....	
134	Dec	2	2.17	25	1.70	(←Premium in USD cents=USD .017 per EUR)
136	Dec	8	1.85	12	2.83	
138	Oct	75	0.43	....	0.01	
142	Dec	1	0.08	1	7.81	
Australian Dollar				**95.37**		
10,000 Australian Dollars-cents per unit.						
94	Oct	....	0.01	20	0.31	
95	Sep	20	0.30	....	....	
96	Oct	30	0.42	....	0.01	

Q: Who buys options?
A: Speculators/Hedgers

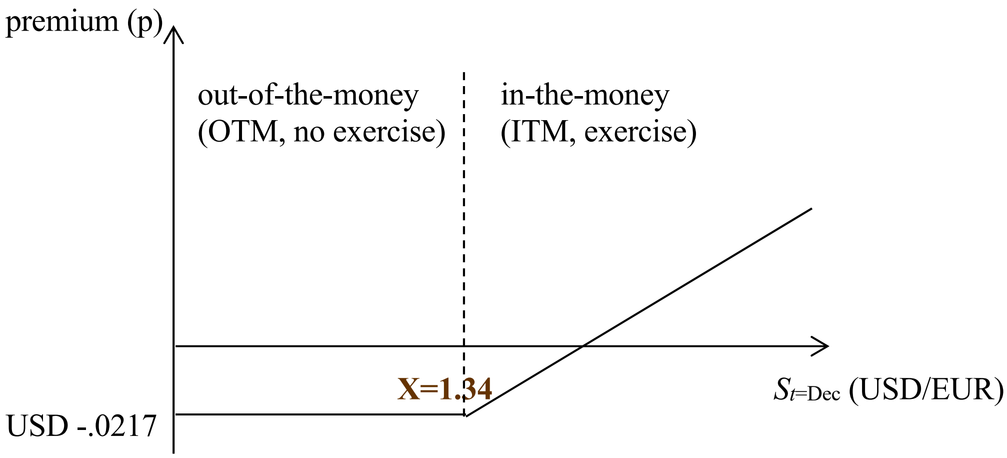
Q: Why options and not futures?
A: Options simply expire if S_t moves in a beneficial way. (But, they are not free. There is an upfront payment.)

Example: We buy a EUR Dec call with **X = 1.34 USD/EUR** and also a futures contract with $F_{t,Dec}$=1.34 USD/EUR.

If S_t > **1.34 USD/EUR**, we exercise the call and we get EUR at **USD 1.34**.
with the future contract we get EUR at **USD 1.34**.
If S_t < **1.34 USD/EUR**, we do not exercise the option and we get EUR at less than **USD 1.34**.
with the future contract we get EUR at **USD 1.34**.

Figure 5.3 shows the net cash flows in December associated with the long Dec call with **X=1.34 USD/EUR**.

Figure 5.3: Profit Diagram for a Long Call



• Hedging with Currency Options
Hedging with options is simple:

- *Situation 1*: Underlying position: Short in foreign currency.
Hedging position: Long in foreign currency calls.

- *Situation 2*: Underlying position: Long in foreign currency.
Hedging position: Long in foreign currency puts.

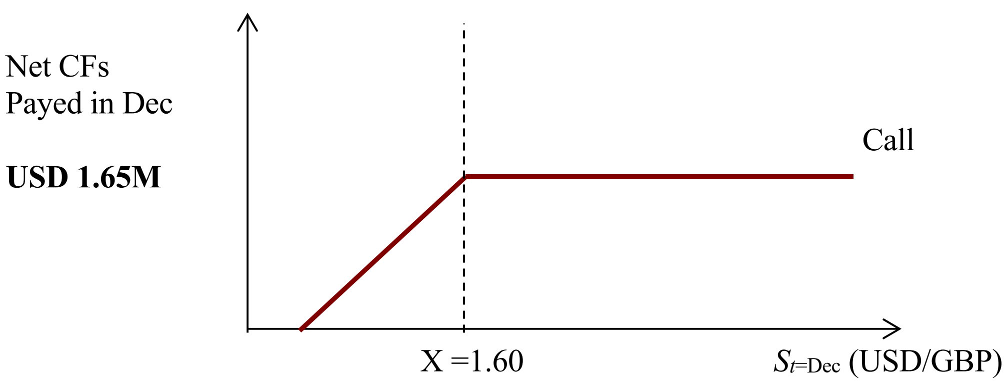
Example: *Situation 1* - A U.S. investor is considering buying U.K bonds for GBP 1M in December. She hedges using Dec call options with X = USD 1.60 (at-the-money).

Underlying position: Short GBP 1,000,000.
S_t = 1.60 USD/GBP.
Size of the PHLX contract: GBP 10,000.
X = USD 1.60
P = premium of Dec call = USD .05.

Cost of Dec calls = 1,000,000 * USD .05 = USD 50,000. (Cost of Dec call is a sunk cost.)
Number of contracts = GBP 1,000,000/ GBP 10,000 = 100 contracts.

There are 3 situations at exercise (third Wednesday of December):
1) $S_{t=\text{Dec}} < X$ (call is out-of-the-money, OTM)
Suppose that on Dec, S_{Dec} = 1.30 USD/GBP, option is not exercised.
→ If the U.S. investor decides to buy the UK bonds, she will pay USD 1.30M.
2) $S_{t=\text{Dec}} = X$ (call is at-the-money, ATM)
Suppose that on Dec, S_{Dec} = 1.60 USD/GBP, option is not exercised (technically, indifferent).
→ If the U.S. investor decides to buy the UK bonds, she will pay USD 1.60M.
3) $S_{t=\text{Dec}} > X$ (call is in-the-money, ITM)
Suppose that on Dec S_{Dec} = 1.80 USD/GBP, option is exercised.
→ If the U.S. investor decides to buy the UK bonds, she will pay USD 1.60M.

Figure 5.4: CFs under an FX Call



As shown in Figure 5.4, the maximum Net Amount to Pay is (USD 1.60M+USD .5M) = **USD 1.65M.**

Note: The U.S. investor has established a *cap*: Maximum net amount she may pay is USD 1.65M. ¶

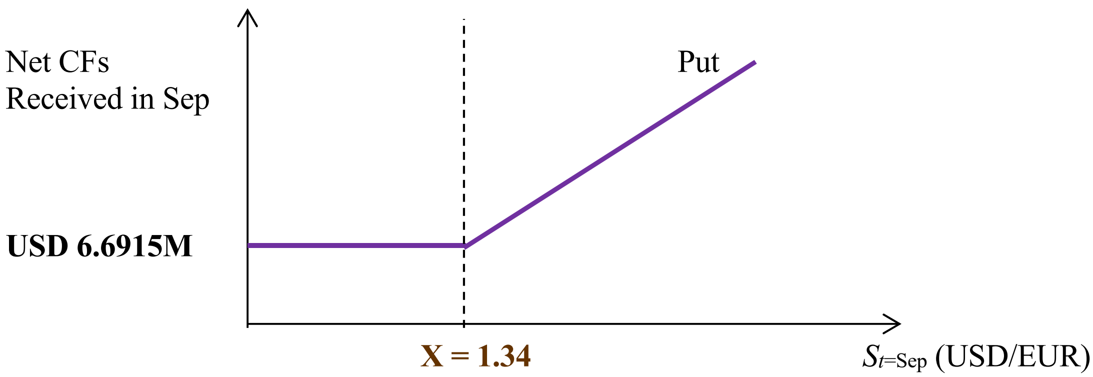
Example: *Situation 2* - IBM will receive a **EUR 5M** payment in 90 days from a French customer.
Date: September 15, 2016 (90 days from today).
Underlying Position = Short **EUR 5,000,000**.
Hedging Position = EUR Sep put options: **X = 1.34 USD/EUR** (Premium= USD 0.0217 per EUR)
S_t = 1.3554 USD/EUR.

Number of contracts = **EUR 5M**/EUR 10,000 = 500 contracts.
Cost of Sep puts = **EUR 5M** * USD .0217/EUR = USD 108,500.
Minimum amount received = **EUR 5M** * 1.34 USD/EUR = USD 6.70M (Net = **USD 6.6915M**)

If $S_{t=\text{Sep}}$ < **1.34 USD/EUR**, put is ITM:
⇒ IBM will exercise the put option. IBM will receive USD 6.70M
If $S_{t=\text{Sep}}$ > **1.34 USD/EUR**, put is OTM:
⇒ IBM will not exercise the put option. IBM will receive more than USD 6.70M.

Figure 5.5 shows the net cash flows for IBM in 90 days.

Figure 5.5: CFs under an FX Put



Minimum Net Amount to Receive: USD 6.70M - USD .1085M = **USD 6.5915M**.

Note: IBM has established a *floor*: Minimum amount IBM will receive is USD 6.70M. ¶

- **Hedging Strategies**

Hedging strategies with options can be more sophisticated:

⇒ Investors can play with several exercise prices with options only.

Example: Hedgers can choose different options for the same maturity:
- Out-of-the-money (OTM, least expensive)
- At-the-money (ATM, expensive)
- In-the-money options (ITM, most expensive). ¶

- Same trade-off of car insurance: High deductible/high floor (cheap)
  Low deductible/low floor (expensive)

Example: It is June 15, 2014.
UP = Long bond position EUR 1,000,000.
HP = EUR Dec put options: X =134 and X=136.
S_t = 1.3554 USD/EUR.

(A) OTM Sep 134 put.
Total cost = USD .0170 * 1,000,000 = USD 17,000
Floor = 1.34 USD/EUR * EUR 1,000,000 = USD 1,340,000.

(B) OTM Sep 136 put.
Total cost = USD .0283 * 1,000,000 = USD 28,300
Floor = 1.36 USD/EUR * EUR 1,000,000 = USD 1,360,000

Typical trade-off: A higher minimum (floor) amount for the UP (USD 1,360,000) is achieved by paying a higher premium (USD 28,300). ¶

CHAPTER 5 – BRIEF ASSESMENT

1. Walmart has to pay in 180 days GBP 5M to a U.K. supplier. Walmart is offered a forward contract at 1.40 USD/GBP. Draw a graph showing the GBP cash flow (in USD) in 180 days relative to S_{t+180}. Does Walmart face uncertainty regarding the amount to pay (in USD) in 180 days?

2. Fifi Bank sold a call option on GBP for USD .03 per unit. The strike price was 1.45 USD/GBP, and the spot rate at the time the option was exercised was 1.40 USD/GBP. Using the following table, fill in the net profit (or loss) per unit to Fifi Bank, based on the listed possible spot rates of the GBP on the expiration date.

Possible S_t (USD/GBP) on Expiration Date	Net Profit (Loss) per Unit if S_t Occurs
1.31	
1.36	
1.39	
1.42	
1.45	
1.49	

What is the maximum net profit and the maximum net loss per unit?

3. It is September 2017. Pez Inc., a Houston-based fishing company, has a GBP 20 million payable due in November 2017. Pez decides to use options to reduce FX risk. Available options with November maturity are:

X	Calls	Puts
1.38 USD/CAD	3.77	0.65
1.42 USD/CAD	1.08	2.88
1.45 USD/CAD	0.16	5.40,

where X represents the strike price and premiums are expressed in USD cents –i.e., 1.08 equals to USD 0.0108.
The exchange rate is 1.40 USD/GBP.

Calculate the premium cost and use a graph to describe the *net* cash flows, including premium paid, (in USD) in December 2017 for Pez Oil under the following choices:
i) in-the-money option
ii) out-of-the money option

4. Using an example, explain how a U.K. company with BRL receivables can establish a floor (in GBP).

5. Using an example, explain how a U.K. company with BRL payables can establish a cap (in GBP).

Chapter 6 - Government Influence on FX Rates

In this chapter we cover the different FX systems that are adopted by different central banks (CT) around the world.

• FX Rate Systems

There are two pure FX Rate Systems: Flexible exchange rate (free float) system
Fixed exchange rate system

One way to characterize these two systems is to look at the role of the Central Bank (CB) –i.e., the institution in charge of the domestic currency, domestic money supply and domestic interest rates.

• CB: Brief Review

A CB is a "bank." It holds:

◊ Assets: Foreign (international reserves of FC (mainly in FC bonds) + Gold + Domestic (mainly loans to domestic institutions and government securities)

◊ Liabilities: DC outstanding (backed by assets the CB owns) + Deposits of banks.

Note: Change in assets = Change in liabilities. That is, a purchase of an asset, say FC (or the unusual assets bought by CBs during the 2007-2008 financial crisis), results in an increase in the liabilities, through an increase in the domestic money supply (MS).

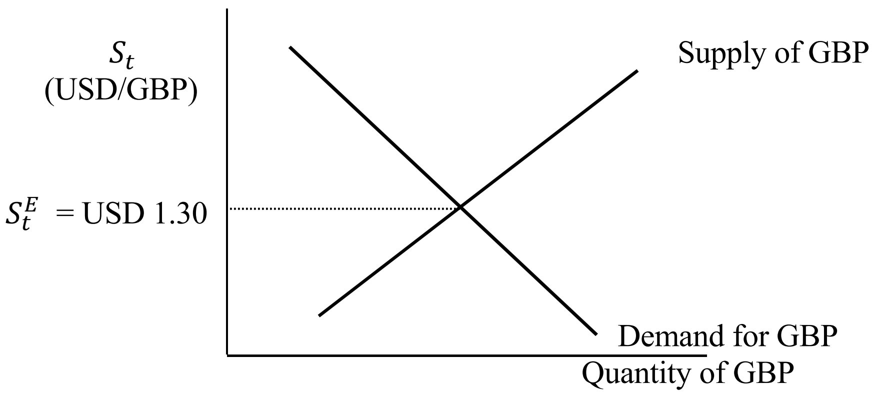
Originally, central banks were created as *lenders of last resort* ("bank of banks") and as supervisor of banks. This is the banking aspect of a central bank. But, today, central bank have other responsibilities: use monetary policy to keep an eye on inflation (low) and the economy (full employment). This is the policy side of a modern central bank. Many times, both targets are conflicting targets (say, higher S_t promotes exports & economic growth, but increases I_d).

Around the world, CBs have different names: U.S. Federal Reserve System ("The Fed"), European Central Bank (ECB), Central Bank of UAE, Central Reserve Bank of Peru, Bank of Mexico, Swiss National Bank, Monetary Authority of Singapore, etc.

6.1. Flexible Exchange Rate System (free float)

In a *flexible FX rate system* the CB allows S_t to adjust to equate the supply and demand for foreign currency, as shown below in Figure 6.1:

Figure 6.1: Free Float - CB allows Supply and Demand to determine S_t



All the variables mentioned in Chapter 4 will affect S_t. In particular, international capital inflows (outflows) will decrease (increase) S_t. Whatever S_t^E is, the CB is fine with it.

• **Features of a Flexible FX System**

- S_t reflects economic activity, through S & D for FC.
- The exchange rate is subject to volatility.
- Money supply is exogenous $\Rightarrow$ The CB can have an independent monetary policy.
- Under certain assumptions (IS-LM model, perfect capital mobility) fiscal policy does not work.
- External shocks (say, oil shocks or sudden outflows of capital) can be quickly absorbed by changes in S_t^E $\Rightarrow$ Quick(er) adjustments to shocks/disequilibrium.

With respect to the last point, Milton Friedman, Nobel Prize Winner, (1953) argued that under flexible exchange rates *"changes in S_t occur rapidly, automatically, and continuously and so tend to produce corrective movements before tensions can accumulate and a crisis develop."*

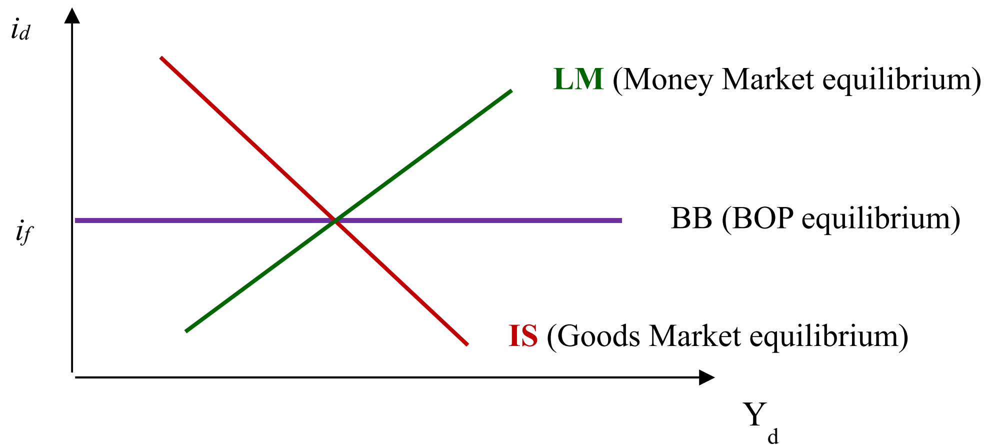
• **Brief Aside: The Mundell-Fleming Model = IS-LM + Perfect Capital Mobility**
Open macroeconomic model combining:
(1) Aggregate demand (IS and LM curves, representing equilibrium in goods and money markets)
(2) Aggregate supply (production function and labor market)
(3) BOP (= CA + KA)

The assumptions behind the Mundell-Fleming Model:
- 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) ↑ .
Figure 6.2 shows the typical equilibrium IS-LM curves + BB (BOP equilibrium, $i_d = i_f$):

Figure 6.2: Equilibrium under Mundell-Fleming model - IS-LM + BB



• Why does monetary policy work (more government spending, MS ↑)?

MS ↑ ⇒ **LM ↓** ⇒ i_d ↓ ⇒ Foreign Capital outflows ⇒ S_t ↑
⇒ CA ↑ **(IS ↑)** ⇒ Y_d ↑

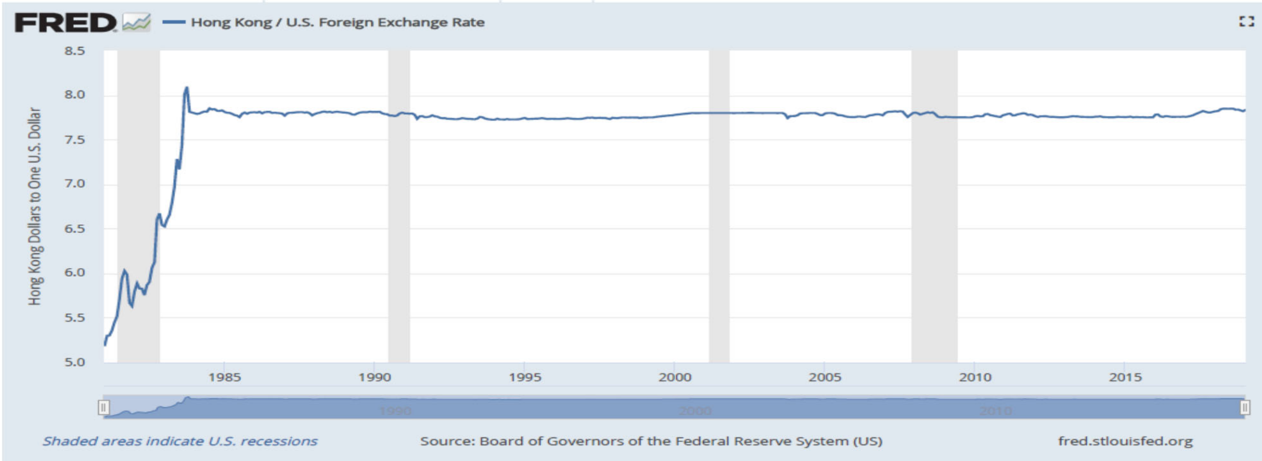
• Why doesn't fiscal policy work (more government spending, G ↑)?

G ↑ ⇒ **IS ↑** ⇒ i_d ↑ ⇒ Foreign Capital inflows ⇒ S_t ↓
⇒ CA ↓ ⇒ **IS ↓** (back to original position)

6.2. Fixed Exchange Rate System

In a *fixed FX rate system,* the CB is ready to buy and sell unlimited amounts of foreign currency at a fixed price, say S*= 3 DC/FC. Sometimes, the CB pegs the value of the DC to a *basket of currencies*, say S*= 1.273 DC/FC_{Basket}, where FC_{Basket} is the price of a basket of exchange rates, usually trade-weighted.

Example: Hong Kong has a fixed exchange rate (a peg) system since October 17, 1983. The exchange rate is S_t=7.8052 HKD/USD.



Note: The HKD is not fixed against all currencies, only against the USD. When the USD moves, the HKD moves. From 2010 to 2015, the USD moved widely against the EUR, taking the HKD for a ride, going from 11.50 HKD/EUR (April 24, 2011) to 9.15 HKD/EUR (January 8, 2015). ¶

In order to support the fixed parity S*, a CB needs enough FC reserves to make the system viable. At least, a CB needs to have enough reserves to purchase the total currency circulating in the public plus required bank's reserves at the CB –i.e., *high-powered monetary base*– at the fixed exchange rate, S*. When a CB holds this amount, it holds 100% FC reserves.

Having enough reserves may be a problem for CBs. 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*.

A solution to the potential lack of FC reserves is to 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.

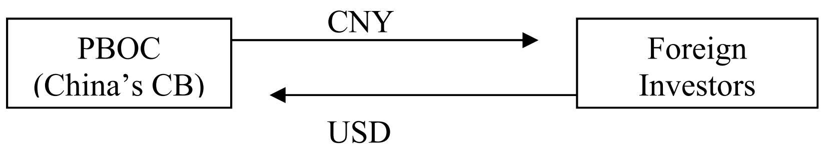
Every time somebody buys FC from the CB, the domestic money supply decreases. Every time somebody sells FC to the CB, the domestic money supply increases. Thus, the domestic money supply is endogenous. Thus, international capital flows will affect the domestic money supply.

A CB gives up the control of the MS under a fixed system.

Example: International capital inflows
For most of the past 30 years, China has maintained a fixed FX rate system and received vast amounts of capital inflows. Under this situation, the People's Bank of China (PBOC, China's CB) exchanges yuans (CNY) for FC, say USD. Exhibit 6.1 displays the currency exchange between the PBOC and foreign investors in China:

Exhibit 6.1: Effect of Capital Inflows under a Fixed FX System

Capital Inflows



That is, international capital inflows increase not only the PBOC's international reserves of FC, but also China's money supply.

Note: The PBOC may not like this increase in the money supply (along with lower interest rates and inflationary pressures) and may take some counteraction to nullify or mitigate the increase in China's money supply. A CB counteraction is called *sterilization.* For example, the PBOC can increase the bank's reserve-requirement ratio. ¶

• **Terminology**: Devaluation/Revaluation
A *devaluation* (*revaluation*) occurs when the price of FC under a fixed FX rate regime is increased (decreased) by the CB. (Remember: depreciation/appreciation occurs in a flexible FX rate system.)

Example: During the previous decade, China's yuan (CNY) was fixed at S_t = 8.27 per USD. On July 21, 2005, it was revalued to S_t = 8.11 CNY/USD, following the removal of the peg to the USD. ¶

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

• **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 ±0.5. The CLP/USD was adjusted according to the previous month's inflation minus an estimate of U.S. inflation (around 2% annually). ¶

• **Black Market**
In some countries, the exchange rate is fixed by the government, say at S*. But, it is *not* a fixed exchange rate system. The government sells FC at the official rate *only* for some transactions, for example, "favored" imports. For all non-official transactions, a *free market* -or in some cases, a *black market*- is created. Obviously, S* is set below the equilibrium S_t^E.

Example: In early June 2023, Argentina had 10 (ten!) loosely recognized exchange rates. The three more relevant are the official ("white") rate was 240.50 ARS/USD; the tourist rate, for credit card transactions abroad (official + fees + extra taxes) 505.377 ARS/USD and the black market rate ("blue") was 480 ARS/USD. (There is also a "Dollar Qatar," "Dollar Netflix," "Dollar for Savings," "Dollar for Burse Transactions," etc.)

If Argentina were to have a true fixed exchange rate system, an equilibrium exchange rate can be easily found: Monetary Base (in ARS)/CB Reserves (in USD). For April 2023,

$S_{fixed=2023}$ (fixed equilibrium) = ARS 5366598.00 /USD 28,261 = 189.89 ARS/USD. ¶

• **Features of a Fixed FX Rate System**

◊ Money supply is endogenous (a CB does not have an *independent* monetary policy!).
◊ Exchange rate has no/low volatility; actually, S_t inherits the volatility of the FC the CB fixes the DC against. (No or low volatility: Good for trade, investments and inflation control.)
◊ Under certain assumptions (IS-LM model, perfect capital mobility), fiscal policy works.
◊ If a CB does not have enough reserves, *credibility* is crucial.
◊ Since S_t is fixed, external shocks have to be absorbed through prices (including wages).

Note: The last point tends to be the Achilles heel of the fixed FX rate system. Since prices tend to be rigid (especially, wages), adjustments to shocks and/or imbalances tend to be slower, and, usually, have contractionary effects.

• **Mundell-Fleming Model in a Fixed FX Rate Economy**

Why dose fiscal policy work (more government spending, G ↑)?

G ↑ ⇒ **IS ↑** ⇒ i_d ↑ ⇒ Foreign Capital inflows ⇒ MS ↑
⇒ **LM ↓** expansion of MS amplifies effect on Y_d
(fiscal + monetary effects!)

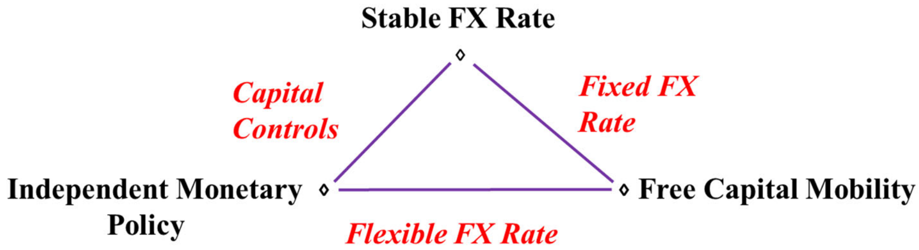
• **Trilemma** (due to Robert Mundell (1962), Nobel Prize Winner)

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

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

A country that attempts to have these three policies at the same time is said to have an *inconsistent* fixed exchange rate system. Only two of the three are possible, as illustrated in Figure 6.2. This policy trilemma is also called "*the impossible trinity*."

Figure 6.2: The Impossible Trinity



Typical Trilemma problems

Situation 1: Under a fixed exchange rate regime, the local government substantially increases the domestic money supply (MS_d) to finance deficit spending or to mitigate an external shock: Higher MS_d $\Rightarrow i_d \downarrow \Rightarrow (i_d - i_f) \downarrow \Rightarrow$ Capital will leave the country (international capital outflows) $\Rightarrow$ CB's FC reserves $\downarrow$. In a free float, $S_t \uparrow$ (>S*).

Situation 2: Under a fixed exchange rate regime, 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!): International interest rates increase $\Rightarrow i_f \uparrow \Rightarrow (i_d - i_f) \downarrow \Rightarrow$ International capital outflows $\Rightarrow$ CB's FC reserves $\downarrow$.

In both situations, in a free float, $S_t\uparrow$ (>S*). But, the exchange rate is fixed at S*: Now, in DC terms things are undervalued relative to rest of the world.

Note: If we think of the free float S_t as the "true equilibrium" (or "shadow") exchange rate, the divergence between S_t and the fixed S* signals a potential profit opportunity for speculators.

• Currency crisis

When faced with an increasing gap between the shadow S_t and S*, speculators realize that if the CB abandons the fixed FX rate system, a sizable profit can be made from buying FC at S* (usually, by borrowing DC to buy FC).

Q: Why would a CB stop supporting S*? Because it is running out of FC reserves. Then, when a CB does not have enough reserves and/or loses credibility, speculators (and everybody else!) run to exchange DC for FC at the fixed exchange rate, S*. This is called a "*currency run*" or "*speculative attack*." Unless some measures are taken to stop the run, the CB soon runs out of FC (currency crisis).

Usual solution: In general, domestic residents and governments do not like devaluations of the DC, since it increases inflation, decreases real wages, and has contractionary effects on the real economy. Governments often try to make it difficult to buy FC, imposing a set of restrictions on FC transactions. Typical measures: import bans, new capital outflows regulations and travel restrictions. These measures are, at best, temporary solutions. They create a black market, with an increasing gap between the shadow S_t and S*.

Definite solution to a currency crisis*:* Float the currency.

Example of the "usual" solution: In January 2016, the Nigerian President, Muhammadu Buhari, rejected a devaluation of the naira (NGN). During the previous months, the Central Bank of Nigeria (CBN) restricted the supply of USD, banned the import of a long list of goods, from shovels and rice to toothpicks. In January 2016, the official exchange rate was 199 NGN/USD, while the black market rate was around 300 NGN/USD.

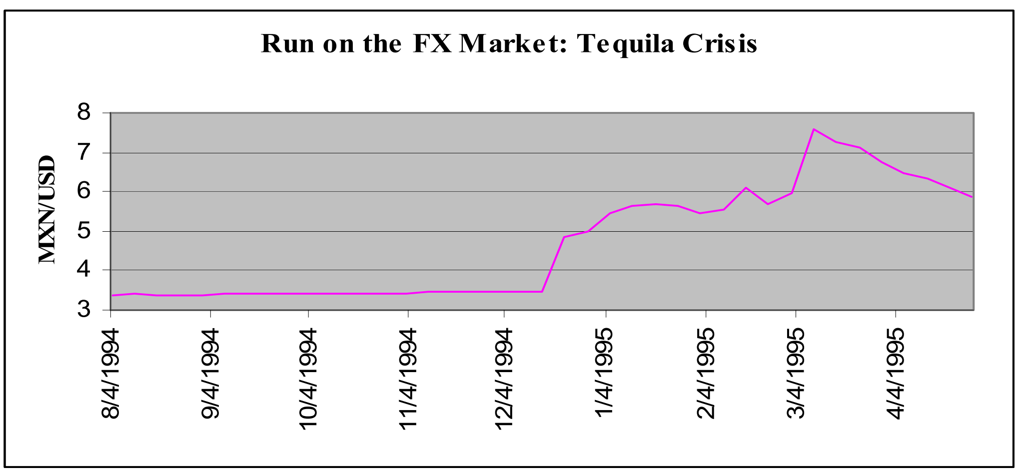
Finally, in June 2016, the CBN decided to float the currency, which quickly depreciated to 285 NGN/USD. ¶

Currency crises are not uncommon. Laeven and Valencia (2012) report 218 currency crisis during the period 1970-2011. They are often related to an "*inconsistent*" fixed exchange rate system. In these cases, the credibility of a CB monetary policy weakens and the likelihood of a speculative attack increases. Understanding what may trigger a currency crisis can be very profitable!

Predictors of a currency crisis ("*early warning signals*"): Low FC reserves, low real exchange rate (DC overvalued, often due to high domestic inflation), high government deficits, weak financial system, high short-term debt, asset/real estate bubbles financed by easy credit, etc.

Examples of currency crises: India '91, U.K. '92 (Black Wednesday), Mexico '94 (Tequila crisis), Thailand/Malaysia '97 (Rice crisis), Russia '98 (vodka crisis), Argentina '01 (Tango crisis), Iceland '08, Nigeria '16, Turkey '18. Exhibit 6.2 shows the MXN/USD before and after the Tequila crisis (mid-Dec '94).

Exhibit 6.2: USD/MXN and the Tequila Crisis



Mexican USD reserves went from USD 18 billion in October 1994 to USD 5 billion in December 1994, when the decision to abandon the fixed exchange rate against the USD was made.

Overall, Mexico spent USD 25B in FC reserves and borrowed USD 25B (from the U.S. Fed) to defend the peso's USD peg. ¶

On average, a currency crisis is followed by a 30% drop of the value of DC. In many cases there is a temporary higher drop (say, 50%), before reverting to a value closer to the average. When a crisis is very serious, a 75% or higher drop is possible (Indonesia '97, Argentina '01).

• Twin Ds

In general, a currency crisis is a product of serious macro-economic problems. These macro-economic problems often lead to liquidity problems for the government and, in these situations, sovereign defaults –a government decides not to pay its debt, usually bond debt- are not rare. Sovereign defaults may also trigger a large devaluations. These are the "*Twin Ds*": *Default* and *Devaluation*.

Reinhart (2002) reports that over the period 1970-1999 the probability of a devaluation, once a country had a default event, is 84%; while without a default the probability of a devaluation is only 17%. A default is usually followed by a large devaluation: in a 6-year window around a default event, the change in value of the domestic currency is 45% compared to no default events.

Using more data, Na, Schmitt-Grohe, Uribe and Yue (2017) estimate the probability of devaluation conditioned on a default event is lower: 48%.

Na et al. (2017) suggest that large devaluations around default events are needed to realign real wages to avoid widespread unemployment. In their simulations, if a country does not devalue its currency unemployment increases by 20%.

• Fixed FX Rate Regime in Emerging Markets: Importing good behavior

A fixed FX rate is considered transparent and a simple anchor for monetary policy. Countries with weak institutions, usually less developed/emerging markets, can "import" monetary credibility by anchoring to a currency with a credible central bank, say the Fed or the ECB.

Another advantage for emerging markets: A fixed FX regime tends to reduce transaction costs and FX risk. In countries with less developed financial sectors, economic agents may not have the financial tools to hedge long-term currency risks. A fixed FX regime will help in this regard.

• Fixed or Floating?

Both regimes have pros and cons. There is no clear winner. Regime choices should reflect the individual characteristics of an economy. However, we do observe that large economies with sound monetary and fiscal policies and good institutions (say, an independent CB) prefer a flexible FX rate regime. This is fine: a flexible FX rate regime tends to insulate better a country from external shocks and/or imbalances.

On the other hand, we also observe that small or less developed countries with a history of poor institutions and/or credibility problems have relied on fixed FX rate regimes to fix problems. Some of these countries have had consistent monetary policies since the adoption of the fixed FX rate, and the fixed FX rate regime has served them well. For this reason, they have been reluctant to change the FX rate regime.

As Timothy Adams, Treasury Under Secretary for International Affairs, said in 2006, regarding the choice of FX rate regime: *"In particular, there is no substitute for sound fiscal and monetary policies and resilient institutions."*

The International Monetary Fund (IMF) classifies the different currency arrangements of its members. In 2017, the IMF classified 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, see below, is acceptable).

6.3. Mixed FX System

In practice, the exchange rate system in many countries is a mixture: *managed* floating (also called, *dirty floating*):

> A CB allows the FX Market to determine S_t. But, from time to time, the CB takes some actions with the intention to influence S_t. These actions are called *Central Bank intervention* in the FX Market. For example, the central bank buys or sells foreign currency to change S_t.

This is the usual FX rate system in developed countries.

• Central Bank Intervention

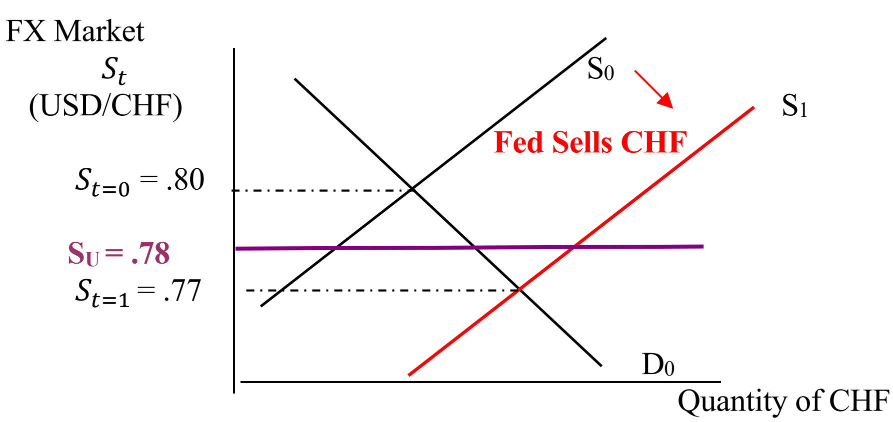
CBs have economic models to determine what they believe is an equilibrium FX rate, S_t^E. Using these models, a CB determines a range for S_t (a *trading band)* ⇒ S_t should move between $S_{t,L}$ and $S_{t,U}$.

If S_t is within the range ($\mathbf{S_{t,L}} < S_t < \mathbf{S_{t,U}}$), CB does nothing (free float system!)
If S_t is above $S_{t,U}$ ($S_t > \mathbf{S_{t,U}}$), CB determines FC is overvalued (or "too" expensive) ⇒ CB intervention
If S_t is under $S_{t,L}$ ($S_t < \mathbf{S_{t.L}}$), CB determines FC is undervalued (or "too" cheap) ⇒ CB intervention

Summary: CB Intervention
"Appreciating" FC ($S_t > \mathbf{S_{t,U}}$) ⇒ CB sells FC.
"Depreciating" FC ($S_t < \mathbf{S_{t,L}}$) ⇒ CB buys FC.

Example: The Fed (U.S. CB) considers the CHF overvalued or $S_t > \mathbf{S_{t,U}}$.
⇒ The Fed intervenes in the FX market to stop the appreciation of the CHF against the USD, as shown below in Figure 6.3:

Figure 6.3: Central Bank Intervention in the FX Market

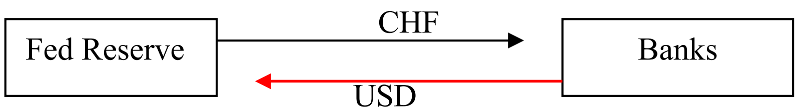


The Fed determined **S_U=.78 USD/CHF.**

Now, demand for CHF has increased –suppose Swiss interest rates are up. New S_t = .80 USD/CHF. The Fed determines the S_t = .80 USD/CHF is too high (CHF too expensive) since $S_t > S_{t,U}$.
Fed FX intervention ⇒ Sell CHF

Exhibit 6.3: CB Intervention in the FX Market – Effect on Money Supply

FX Int



As shown in Exhibit 6.4, the Fed's FC reserves (CHF) and the U.S. Money supply are decreased.

Note: The arrows above are a simplification of three transactions. Technically speaking, the Fed sells Swiss government securities (in CHF) to a Swiss commercial bank, which pays the Fed through a deposit in a U.S. commercial bank. Then, the Fed debits the reserves of the U.S. commercial bank. ¶

In general, CB FX intervention is justified by arguing that the CB has better information (CB knows the true model for S_t) to determine S_t^E –i.e., the equilibrium value for S_t. If this is not the case, the CB may be setting a "*wrong rate*," which can have side effects.

• **CB FX Intervention Issues**:
1. Implicit notion of "overvaluation/undervaluation" in FX market. The *wrong rate* problem.
⇒ Q: Do CB have "superior" information –i.e., do they know better than the FX Mkt?
A: Not clear consensus in the academic literature: Sometimes CBs lose millions, sometimes CBs make millions. However, there is some evidence that shows that CB purchases of FC tend to be associated with subsequent FC appreciation. This evidence is taken to support the *leaning-against-the wind* behavior by CBs.
2. CB can generate FX instability:
⇒ Uncertainty over CB actions increases FX volatility and risk (what a CB dislikes!)
Academic studies tend to find that CB intervention does increase FX volatility.
3. Potential conflict with other countries:
⇒ When a CB intervenes in the FX market to depreciate the DC to boost domestic exports, trading partners will be affected. This type of FX intervention is called *beggar-they-neighbor* devaluation. Popular in the 1930s.

Despite these issues and the academic sentiment that FX intervention is not worth it, central banks do intervene in FX markets. In a 1999 BIS survey of CBs, the percentage of business days on which CB report intervening from 0.5% to 40% percent, with a 4.5% median.

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.

• CB Intervention: Details

According to a 1999 BIS survey, CB interventions transactions almost always (95%) are conducted at least partially in spot markets. Some CBs also use the forward market, perhaps in conjunction with the spot market to create a swap transaction.

During FX intervention, CBs tend to deal with major domestic and, less often, foreign banks.

Some countries have large FX reserves, which can be used to influence the value of exchange rates. For example, by the end of 2014, China and Japan had the largest FX reserves in the world, USD 3.9 trillion and USD 1.2 trillion, respectively. Saudi Arabia was in third place with USD 0.74 trillion (& the U.S. was in 13th place with USD 0.13 trillion.)

But, large FX reserves are not necessary in many markets. In emerging markets, CBs have a huge potential "firepower," since the ratio of official reserves to average daily turnover is very high. On average, official reserves were 15 times the size of daily turnover in emerging market currencies, compared with less than half in smaller industrial countries.

When a CB has firepower, sometimes just a rumor or the verbal threat of CB FX intervention can bring the FX market in line with the CB's desired valuation. This type of verbal intervention is referred as *jawboning*. It is cheap and, sometimes, effective.

Example: Jawboning at work

On September 6, 2011, the Swiss National Bank (SNB) announced a "minimum" exchange rate of 1.20 CHF/EUR, saying that the SNB would buy "unlimited quantities of foreign currency." The CHF fell from 1.11 CHF/EUR to 1.20 CHF/EUR almost immediately. ¶

The actual size of a CB FX intervention depends on the reaction of the FX market. In general, if the CB finds the initial response to be positive, the size of the intervention will be cut. Neely (2001) found, in a sample of 24 countries, that in 39% of cases it took just a few minutes to observe the desired effect –but, in 49% it took a few days or more!

On average, during 2002-2004, the size of an FX intervention –as a percentage of average daily FX market turnover– was in the interval 5% to 12%.

Most central banks intervene secretly, releasing actual intervention data with a lag, if at all. Some authorities, like the SNB, always publicize interventions at the time they occur.

6.3.1 CB Intervention: Sterilized and Non-Sterilized

FX Intervention affects Money Markets $\Rightarrow$ Money supply is affected (& also interest rates).

A CB might not like to change interest rates in the domestic economy, especially increasing interest rates if the economy is in a recession or decreasing interest rates if the economy is doing well.

The counter actions taken by the CB to neutralize/mitigate the effect of CB FX intervention in domestic Money Market are called *sterilization*. If the CB coordinates FX Intervention with a counteraction to mitigate the effects on domestic Money Markets, the intervention is called *sterilized.* If, on the other hand, the CB allows the FX Intervention to affect domestic Money Markets, the intervention is called *non-sterilized.*

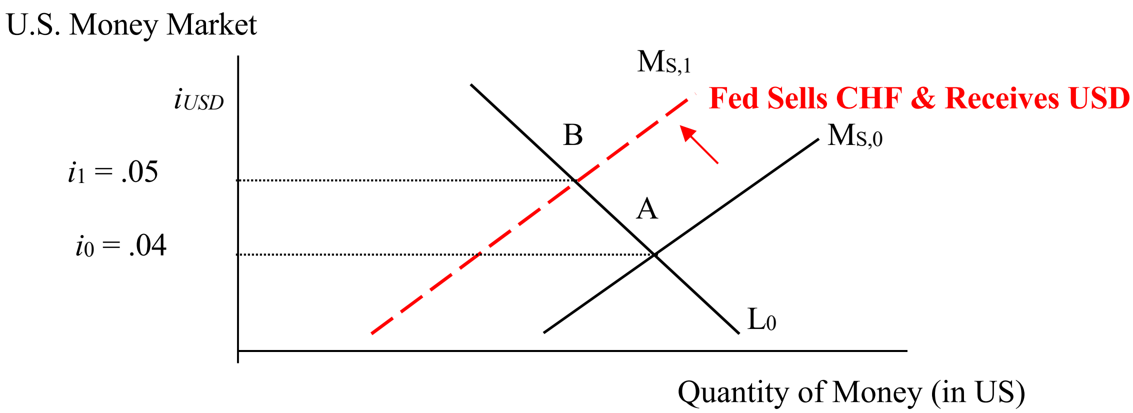
Usual sterilization tools: Open Market Operation (OMO), bank reserve-requirement ratios.

Example (continuation): The Fed considers the CHF overvalued :

Fed FX intervention $\Rightarrow$ Fed Sells CHF & Receives USD

As shown in Figure 6.4 and Exhibit 6.4, the effect of the Fed's intervention is a decrease in the U.S. money supply, increasing interest rates from 4% to 5%.

Figure 6.4: CB Intervention in the FX Market - Effect on Money Markets



Fed's unwanted effect from FX Intervention (Fed sells CHF): $M_S \downarrow \Rightarrow$ interest rates (i_{USD}) $\uparrow$

Sterilization: The Fed uses an OMO to counteract the effect of FX intervention in Money Markets.

$\Rightarrow$ OMO: Fed buys T-Bills to increase M_S (*sterilized intervention*), as shown in Exhibit 6.3.

Exhibit 6.4: OMO to Sterilize Effect of CB Intervention on FX Market

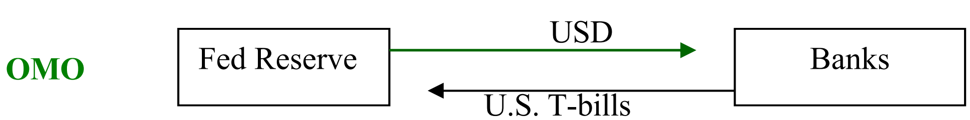


Figure 6.5 shows the sterilizing effect on the U.S. Money Supply of the OMO.

Figure 6.5: CB Sterilized Intervention – No Effect on Money Markets

U.S. Money Market

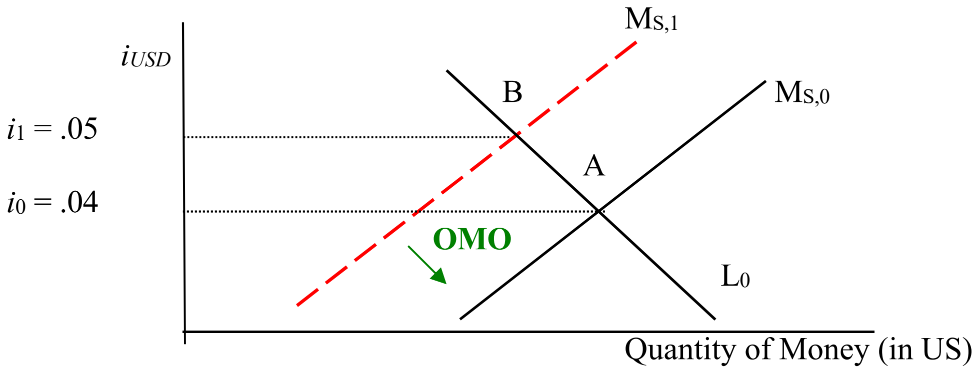
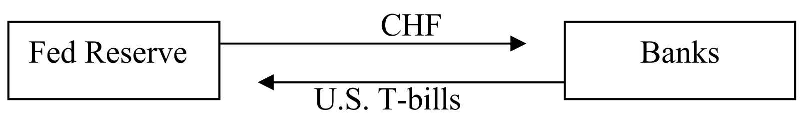


Exhibit 6.5 shows the net effect of a well-executed sterilized intervention.

Exhibit 6.5: Net effect: OMO + Fed FX Intervention



Note: Instead of using an OMO, the Fed can decrease the bank reserve-requirement ratio. This will also increase the U.S. money supply. ¶

• Sterilized Interventions: Side Effects

Although sterilized intervention does not change the domestic MS, it does change the composition of the Fed's (and, in equilibrium, the public's) mix of domestic and foreign 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. In general, for major currencies, this effect is very small. But for minor currencies, the balance sheet effect can be substantial.

Another side effect may materialize if the CB can successfully maintain for a while S_t artificially high/low and, then, keep money markets out of sync with the FX Market. For example, suppose a CB keeps sterilizing to keep S_t low (DC overvalued). Then, the CB is forcing the economy, as whole, to subsidize the import sector (and domestic consumption) and leaving its domestic producers in a tough competitive situation.

For a short time, the side effects can be tolerated; for a long time, they can lead to resource allocation problems.

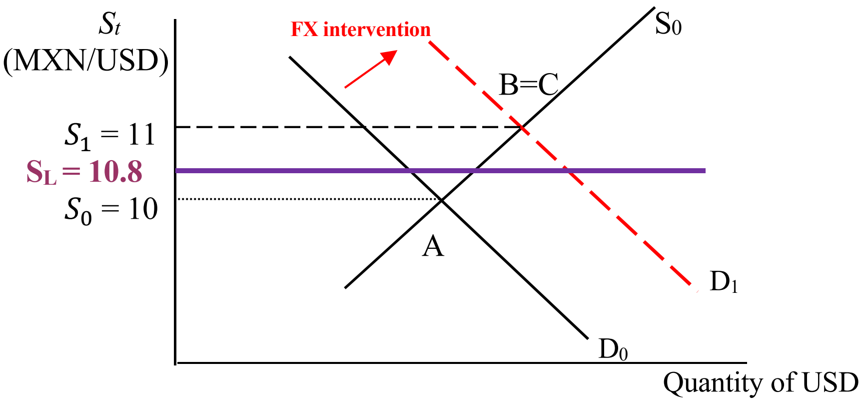
In addition, banks may not like the situation of having to hold large amounts of government bills (T-bills) and/or having high reserve-requirement ratios. Both situations will reduce bank's profits.

Example: The Banco de México (Banxico, México's CB) considers the USD undervalued, say $S_t <$ **S_L**, with **S_L=10.8 MXN/USD**

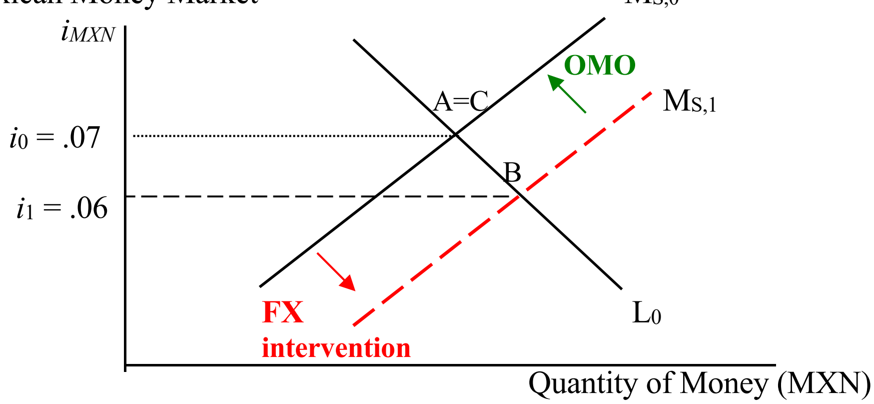
⇒ Banxico decides to intervene, but does not want to affect local interest rates. Thus, it uses an OMO (CETES: Mexican T-bills).

Original Situation:	Point A (S_0= 10 USD/MXN and i_0 = 7%)
Banxico intervention in FX market (Buy USD/Sell MXN)	Point B (S_1 = 11 USD/MXN and i_1 = 6%)
Sterilization intervention (OMO: Buy MXN/Sell CETES)	Point C (S_1 = 11 USD/MXN and i_0 = 7%)

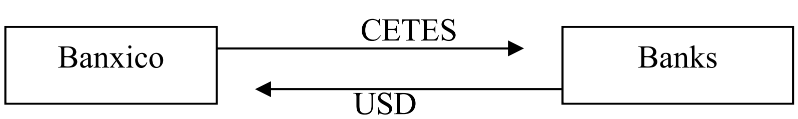
FX Market



Mexican Money Market



Net effect: OMO + BOM Intervention



Banxico will invest the USD in U.S. T-bills, which have a lower effective yield than the CETES (now, with even a greater yield: 7%!) creating a negative balance sheet effect (if sterilization works the change in S_t is zero).

Note: If Banxico keeps sterilizing for a long time, keeping $S_t > S_t^E$, Mexico subsidizes its export sector (and protects its domestic sector from foreign competition). In addition, for the given S_t, Mexican interest rates will be higher, affecting consumption and investments. ¶

• Sterilized Interventions: Durable Effects on S_t

There are two main channels through which sterilization can have a more durable effect on S_t: (1) the *portfolio balance channel* and (2) the *signaling channel*.

(1) *Portfolio balance channel*: Suppose the BOM intervenes to support the USD. Then, banks buy CETES and sell USD, which used to be held in T-bills. Then, the relative supply of domestic to foreign bonds increases. If domestic and foreign bonds are *imperfect substitutes*, then, their relative prices would change in favor of the foreign bonds, increasing S_t.

(2) *Signaling channel*: Agents perceive a CB intervention as signaling a CB's intentions, regarding its future monetary policy.

• 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 the 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.

CHAPTER 6 – BRIEF ASSESMENT

1. Compare the effect of capital outflows in S_t and the FX Central Bank reserves under a floating exchange rate system and a fixed exchange rate system.

2. Brunei has fixed its currency, the Brunei dollar (BND), to the Singapore dollar (SGD), fixing the parity at 1. During the recent past, oil prices have decrease substantially. Brunei's economy is heavily dependent on oil.
(a) Describe the pressures the BND faces due to the increase in oil prices? What does the CB of Brunei have to do in order to support the fixed FX exchange rate? Do the FX reserves increase or decrease in the BND?
(b) What is the impact on Brunei's domestic money supply and interest rates?
(c) How can the CB neutralize (sterilize) the effect of low oil prices on Brunei's money supply?

3. Before a national election, many governments engage in expansionary policies to stimulate the economy. Suppose that one of these countries has a fixed exchange rate system. Describe how an expansionary monetary policy can generate a currency crisis. If a government decides to keep the fixed exchange rate system and the expansionary monetary policy, what measures can the government take to delay a currency run?

4. The Banco Central de Chile (BCC) considers the USD overvalued. BCC decides to intervene, but does not want to affect local interest rates. Using graphs, describe the effect of central bank intervention on the CLP/USD exchange rate, on CLP interest rates and on Chilean money supply. (CLP: Chilean peso.)

CHAPTER 6 - BONUS COVERAGE: CENTRAL BANKS

A CB is a "bank." It holds assets (foreign exchange, gold, and other financial assets) and liabilities (mainly the currency outstanding, backed by assets the CB owns). A CB may "create" new money, usually backed by the full faith and credit of the government.

CBs generally earn money by issuing currency notes and "selling" them to the public for interest-bearing assets, such as government bonds. Since currency usually pays no interest, the difference in interest generates income. In most CB systems –for example, in the U.S. and in Europe-, this income is remitted to the government.

Although a CB generally holds government debt, in some countries the outstanding amount of government debt is smaller than the amount the CB may wish to hold. In many countries, CBs hold significant amounts of assets denominated in foreign currency, rather than assets in their own national currency, particularly when the national currency is fixed to other currencies.

Any central bank purchase (sale) of assets automatically results in an increase (decrease) in the domestic money supply.

Table Appendix 6
U.S. Federal Reserve Balance Sheet (December 2017)

Consolidated U.S. Fed Balance Sheet (in USD billions)			
Liabilities		***Assets***	
Federal Reserve Notes	1,569.1	U.S. Treasuries	2,454.2
Reverse Repurchase Agreements	386.8	Mortgage Backed Securities	1,764.9
Deposits	2,445.1	Gold	11.0
Other liabilities	6.3	SDR	5.2
Total	***4,407.3***	Foreign Currency Denominated Assets	21.2
		Central Bank Liquidity Swaps	12.0
Capital Account	*41.4*	Other assets	180.2
Capital paid in	31.4	***Total***	***4,448.7***
Surplus	10.0		

The difference between the Assets and Liabilities represents the Capital Account (USD 41.4 billion) –i.e., the earnings of the U.S. Fed. In the Capital Account, the surplus represents the retained earnings not paid to the Department of Treasury (USD 10 billion).

Originally, central banks were created as *lenders of last resort* ("bank of banks") and as supervisor of banks. This is the banking aspect of a central bank. But, later central bank were given other responsibilities: keep an eye on inflation (low) and the economy (full employment). Many times, these are conflicting targets. For example, in a recession, a lower S_t promotes exports and, thus, economic growth, but, a lower exchange rate increases the prices of imports and, thus, inflation.

• Policy instruments

A CB has two main targets: keep inflation low and the economy close to full employment. To achieve these goals, CBs have several monetary policy instruments. The most important ones are:

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

• OMO (Open Market Operations)

Through OMO, a CB puts money in and takes money out of the banking system. This is done through the sale and purchase of government securities. Each time it buys securities, exchanging money for the security, it raises the money supply. Conversely, selling of securities lowers the money supply. Buying of securities thus amounts to printing new money while lowering supply of the specific security.

The main OMOs are:

- ◊ Temporary lending/borrowing of money for collateral securities ("Reverse Operations" or "repurchase operations", otherwise known as the "*repo*" market). These operations are carried out on a regular basis, where fixed maturity loans are auctioned off.
- ◊ Buying or selling government securities ("direct operations") on ad-hoc basis.
- ◊ Foreign exchange operations such as FX swaps.

All of these interventions can also influence the FX market and, thus, S_t. For example the People's Bank of China 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.

• Interest Rate Policy

CBs attempt to 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*:

$$i_d = \omega + \lambda\, I_d + \theta\, Y\_gap$$

using the following parameters:

$\omega = r^* + \gamma\,(-I_d^*) = 2\% + .5 * (-2\%) = 1\%$

$\gamma = 0.5$

$\lambda = 1 + \gamma = 1.5$

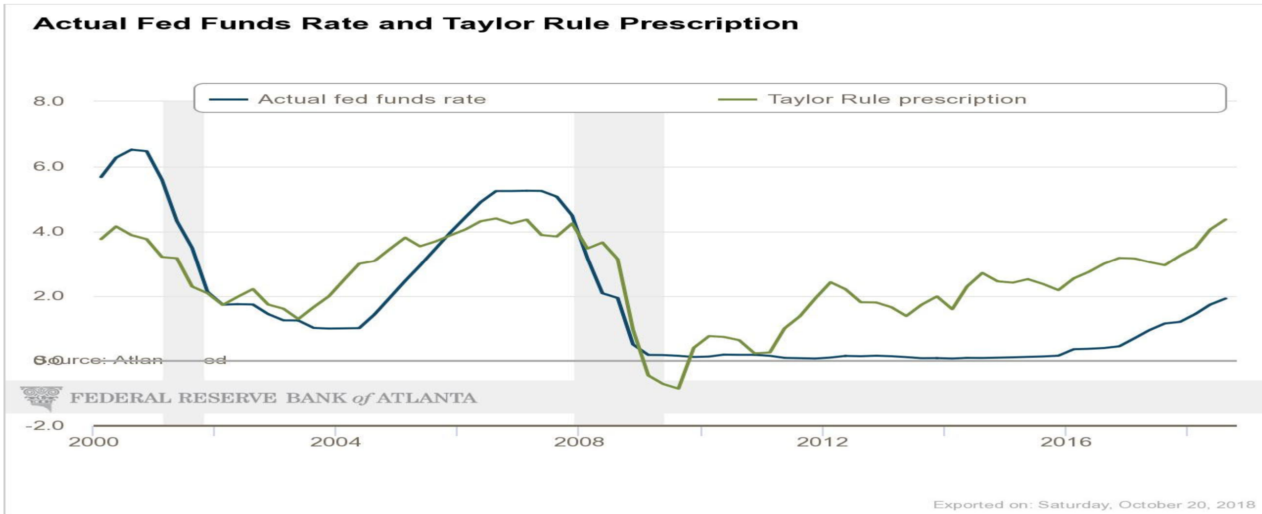
$\theta = 0.5$

r^* = real interest rate = 2%

I_d^* = CB's target I_d = 2%

$Y\_gap = Y_d - Y_{\text{Full Employment}}$

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%.)


Actual Fed Funds Rate and Taylor Rule Prescription
Actual fed funds rate
Taylor Rule prescription
8.0
6.0
4.0
2.0
0.0
-2.0
2000
2004
2008
2012
2016
Source: Atlan ed
FEDERAL RESERVE BANK of ATLANTA
Exported on: Saturday, October 20, 2018

Chapter 7 - Arbitrage in FX Markets

In Chapter 6, we went over the effect of government on S_t

- ◊ FX rate regimes: Fixed, free float & mixed.
- ◊ CB sterilized (no effect on domestic Money Markets) and non-sterilized interventions.

In this lecture we will study the effect of arbitrage on S_t

Arbitrage
Definition: It involves *no risk* and *no capital of your own*. It is an activity that takes advantages of pricing mistakes in financial instruments in one or more markets. That is, arbitrage involves
(1) Pricing mistake
(2) No own capital
(3) No Risk

Note: The definition we used presents the ideal view of (riskless) arbitrage. "Arbitrage," in the real world, involves some risk (the lower, the closer to the pure definition of arbitrage). We will call this arbitrage *pseudo arbitrage*.

There are 3 types of arbitrage:
(1) Local (sets uniform rates across banks)
(2) Triangular (sets cross rates)
(3) Covered (sets forward rates)

7.1. Local Arbitrage (One good, one market)

It sets the price of one good in one market. Law of one price: the same good should trade for the same price in the same market.

Example: Suppose two banks have the following bid-ask FX quotes:

	Bank A		**Bank B**	
USD/GBP	1.50	1.51	1.53	1.55

Taking both quotes together, **Bank A** sells the GBP too low relative to **Bank B**'s prices. (Or, conversely, **Bank B** buys the GBP too high relative to **Bank A**'s prices). This is the pricing mistake!

Sketch of Local Arbitrage strategy:
(1) Borrow USD 1.51 (<= No own capital!)
(2) Buy a GBP from **Bank A** (at ask price $S^{A}_{t,ask}$ = USD 1.51)
(3) Sell GBP to **Bank B** (at bid price $S^{B}_{t,bid}$ = USD 1.53)
(4) Return USD 1.51 and make a π = USD .02 profit (1.31% per USD 1.51 borrowed)

Local Arbitrage Notes:
◊ All steps should be done simultaneously. Otherwise, there is risk! (Prices might change).
◊ **Bank A** and **Bank B** will notice a *book imbalance:*

- **Bank A**: all activity at the ask side (buy GBP orders –i.e., "GBP undervalued at $S_{t,ask}^{A}$")
- **Bank B**: all activity at the bid side (sell GBP orders –i.e., "GBP overvalued at $S_{t,bid}^{B}$").

Both banks will notice the imbalance and they will adjust the quotes. For example, **Bank A** will increase $S_{t,ask}^{A}$ and **Bank B** will reduce $S_{t,bid}^{B}$, say to 1.530 USD/GBP and 1.525 USD/GBP, respectively. ¶

7.2. Triangular Arbitrage (Two related goods, one market)

Triangular arbitrage is a process where two related goods set a third price. In the FX Market, triangular arbitrage sets FX cross rates. Cross rates are exchange rates that do not involve the USD. Most currencies are quoted against the USD. Thus, cross-rates are calculated from USD quotations –i.e., the most liquid quotes.

The cross-rates are calculated in such a way that arbitrageurs cannot take advantage of the quoted prices. Otherwise, triangular arbitrage strategies would be possible.

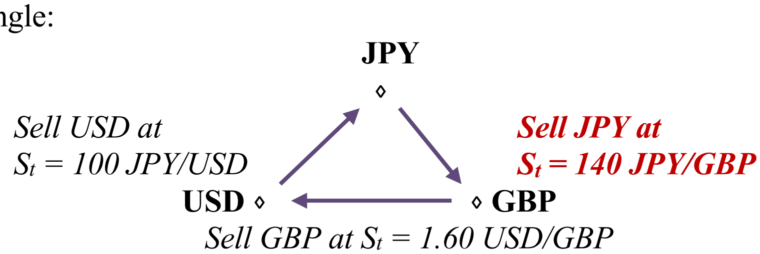
Example: Suppose Bank One gives the following quotes:
$S_{JPY/USD,t}$ = 100 JPY/USD
$S_{USD/GBP,t}$ = 1.60 USD/GBP
$S_{JPY/GBP,t}$ = 140 JPY/GBP
Take the first two quotes. Then, the implied (no-arbitrage) JPY/GBP quote should be:

$$S^{I}_{JPY/GBP,t} = S_{JPY/USD,t} * S_{USD/GBP,t} = 160 \text{ JPY/GBP} > S_{JPY/GBP,t}$$

⇒ At $S_{JPY/GBP,t}$ = 140 JPY/GBP, Bank One *undervalues the GBP* against the JPY (with respect to the first two quotes). This is the pricing mistake!

Sketch of Triangular Arbitrage (Key: Buy undervalued GPB with the overvalued JPY):
(1) Borrow USD 1
(2) Sell USD/Buy JPY at $S_{JPY/USD,t}$ = 100 JPY/USD –i,e, sell the USD for JPY 100.
(3) Sell JPY/Buy GBP at $S_{JPY/GBP,t}$ = 140 JPY/GBP –i.e., sell JPY 100 for GBP 0.7143
(4) Sell GBP/Buy USD at $S_{USD/GBP,t}$ = 1.60 USD/GBP –i.e., sell the GPB 0.7143 for USD 1.1429
(5) Return loan, keep profits: π: USD 0.1429 (14.29% per USD borrowed).

The triangle:



Note: Bank One will notice a book imbalance (all the activity involves selling USD for JPY, selling JPY for GBP, selling GBP for USD.) and will adjust quotes. Say:

$S_{JPY/USD,t} \downarrow$	(say, $S_{JPY/USD,t}$ = 93 JPY/USD).
$S_{USD/GBP,t} \downarrow$	(say, $S_{USD/GBP,t}$ = 1.56 USD/GBP).
$S_{JPY/GBP,t} \uparrow$	(say, $S_{JPY/GBP,t}$ = 145 JPY/GBP).

There is convergence between $S^{I}_{JPY/GBP,t}$ & $S_{JPY/GBP,t}$:

$S^{I}_{JPY/GBP,t}\downarrow$ (= $S_{JPY/USD,t}\downarrow$ * $S_{USD/GBP,t}\downarrow$) $\Leftrightarrow$ $S_{JPY/GBP,t}\uparrow$ ¶

Again, all the steps in the triangular arbitrage strategy should be done at the same time. Otherwise, there will be risk and what we are doing should be considered pseudo-arbitrage.

It does not matter which currency you borrow (USD, GBP, JPY) in step (1). As long as the strategy involves the step **Sell JPY/Buy GBP** (following the direction of the arrows in the triangle above!), you should get the same profit as a %.

7.3. Covered Interest Arbitrage (Four instruments -two goods per market-, two markets)

Open the third section of the WSJ: Brazilian bonds yield 10% and Japanese bonds 1%.

Q: Why wouldn't capital flow to Brazil from Japan?
A: FX risk: Once JPY are exchanged for BRL (Brazilian reals), there is no guarantee that the BRL will not depreciate against the JPY. The only way to avoid this FX risk is to be covered with a forward FX contract.

Intuition: Suppose we have the following data:
i_{JPY} = 1% for 1 year (T=1 year)
i_{BRL} = 10% for 1 year (T=1 year)
S_t = .025 BRL/JPY

We construct the following strategy, called *carry trade*, to "profit" from the interest rate differential:
Today, at time t=0, we do the following (1)-(3) transactions:

(1) Borrow JPY 1,000 at 1% for 1 year. (At T=1 year, we will need to repay JPY 1,010.)
(2) Convert to BRL at S_t = .025 BRL/JPY. Get BRL 25.
(3) Deposit BRL 25 at 10% for 1 year. (At T=1 year, we will receive BRL 27.50.)

Now, we *wait* 1 year. At time T=1 year, we do the final step:

(4) Exchange BRL 27.50 for JPY at S_{t+T}.

Problem with this carry trade: Today, we do not know $S_{t+T=1\text{-}year}$. Note:
- If S_{t+T} = .022 BRL/JPY, we will receive JPY 1250, for a profit of JPY 240.
- If S_{t+T} = .025 BRL/JPY, we will receive JPY 1100, for a profit of JPY 90.
- If S_{t+T} = .027 BRL/JPY, we will receive JPY 1019, for a profit of JPY 9.
- If S_{t+T} = .030 BRL/JPY, we will receive JPY 916, for a profit of JPY -74.

$\Rightarrow$ We are facing *FX risk*. That is, (1)-(4) is not an arbitrage strategy.

Now, at time t=0, we can use the FX forward market to insure a certain exchange rate for the JPY/BRL. Suppose we get a quote of $F_{t,1-yr}$ = .026 JPY/BRL. At time t=0, we re-do step (4):

(4') Sell BRL forward at .026 JPY/BRL. (We will receive JPY 1058, for a sure profit of JPY 48.)

$\Rightarrow$ We are facing no FX risk. That is, **(1) - (4')** is an arbitrage strategy (*covered arbitrage*).

Now, instead of borrowing JPY 1,000, we will try to borrow JPY 1 billion (and make a JPY 48M profit) or more. Obviously, no bank will offer a .026 JPY/BRL forward contract!

7.3.1 Interest Rate Parity Theorem

Q: How do banks price FX forward contracts?
A: In such a way that arbitrageurs cannot take advantage of their quotes.

To price a forward contract, banks consider covered arbitrage strategies.

Review of Notation:
i_d = domestic nominal T days interest rate.
i_f = foreign nominal T days interest rate.
S_t = time t spot rate (direct quote, for example USD/GBP).
$F_{t,T}$ = forward rate for delivery at date T, at time t.
Note: In developed markets (like the USA), a*ll* interest rates are quoted on annualized basis. We will use annualized interest rates (The textbook is completely mistaken when it quotes periodic rates!!)

Now, consider the following (*covered*) strategy:

(1) At time 0, we borrow from a foreign bank 1 unit of a foreign currency (FC) for T days.
⇒ At time=T, We pay the foreign bank $(1 + i_f * T/360)$ units of the FC.

(2) At time 0, we exchange FC 1 at S_t ⇒ for 1 unit of FC we get S_t.

(3) We deposit S_t in a domestic bank for T days.
⇒ At time T, we receive $S_t * (1 + i_d * T/360)$ (in DC).

(4) At time 0, we buy a T days forward contract to exchange domestic currency (DC) for FC at a $F_{t,T}$.
⇒ At time T, we exchange the DC $S_t * (1 + i_d * T/360)$ for FC, using $F_{t,T}$.
⇒ We get $S_t * (1 + i_d * T/360)/F_{t,T}$ units of FC.

If we do **(1)** - **(4)** simultaneously, this strategy faces No Risk. In equilibrium, no risk = no profits! This strategy will not be profitable if, at time T, what we receive in FC is less or equal to what we have to pay in FC. That is, arbitrage will ensure that

$$S_t\,(1 + i_d * T/360)/\,F_{t,T} = (1 + i_f * T/360). \qquad \text{(This is a No Arbitrage Condition!)}$$

Solving for $F_{t,T}$, we obtain the following expression:

$$F_{t,T} = S_t * \frac{(1+i_d*\frac{T}{360})}{(1+i_f*\frac{T}{360})} \qquad \text{(\textit{Interest Rate Parity Theorem} or \textit{IRPT})}$$

The IRP theory, also called *covered IRPT*, as presented above was first clearly exposed by John Maynard Keynes (1923).

It is common to use the following linear IRPT approximation:

$$F_{t,T} \approx S_t * [1 + (i_d - i_f) * \frac{T}{360}]$$

This linear approximation is quite accurate for small i_d & i_f (say, less than 10%).

Notes:

- Steps **(2)** and **(4)** simultaneously done produce a FX swap transaction! In this case, we buy the FC forward at $F_{t,T}$ and go sell the FC at S_t. We can think of ($F_{t,T}$- S_t) as a profit from the FX swap.
- We get the same IRPT equation if we start the covered strategy by **(1)** borrowing DC at i_d; **(2)** exchanging DC for FC at S_t; **(3)** depositing the FC at i_f; and **(4)** selling the FC forward at $F_{t,T}$.

Example: IRPT at work.
Data:
S_t = 106 JPY/USD.
$i_{d=JPY}$ = .034.
$i_{f=USD}$ = .050.
$F_{t,T=1-yr}$ = ?
Using the IRPT formula:

$$F^{IRP}_{t,1-yr} = 106 \text{ JPY/USD} * * \frac{(1+.034)}{(1+.05)} = \textbf{104.384 JPY/USD}.$$

Using the linear approximation:

$$F^{IRP}_{t,1-yr} = 106 \text{ JPY/USD} * (1 - .016) = 104.304 \text{ JPY/USD}.$$

⇒ The approximation error is less than 0.08%.

Note: If a bank sets $F^{A}_{t,1-yr}$ = 104.384 JPY/USD arbitrageurs cannot profit from the bank's quotes. ¶

Arbitrageurs can profit from any violation of IRPT.

Example 1: Violation of IRPT 1 - Undervaluation of forward FC (=USD, in this example).
Suppose IRPT is violated. Bank A offers: $\boldsymbol{F^{A}_{t,1-yr}}$ **= 100 JPY/USD**.

⇒ $\boldsymbol{F^{A}_{t,1-yr}}$**= 100 JPY/USD** < $\boldsymbol{F^{IRP}_{t,1-yr}}$ **= 104.384 JPY/USD** (a pricing mistake!): Bank A undervalues the forward USD against the JPY.

⇒ Take advantage of Bank A's undervaluation: **Buy USD forward** at $F^{A}_{t,1-yr}$.

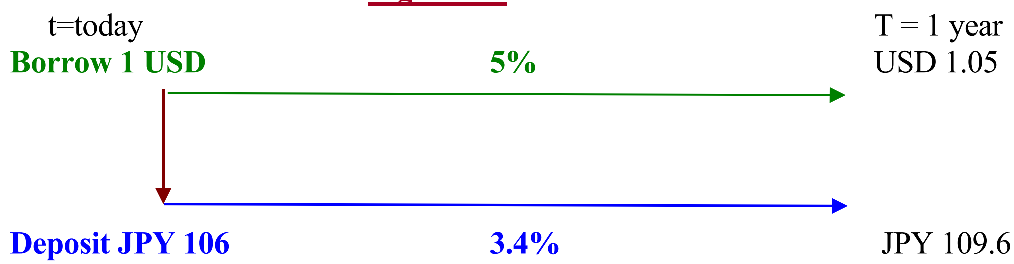
Sketch of a covered arbitrage strategy, summarized in Figure 7.1:

(1) Borrow USD 1 from a U.S. bank for one year at 5%.
(2) Convert USD to JPY at S_t = 106 JPY/USD
(3) Deposit the JPY in a Japanese bank at 3.4%.
(4) Cover. **Buy USD forward/Sell forward JPY** at $F^{A}_{t,1-yr}$ = 100 JPY/USD

Cash flows at time T=1 year,
(i) We get: JPY 106 * (1 + .034)/(100 JPY/USD) = USD 1.096
(ii) We pay: USD 1 * (1 + .05) = USD 1.05
Profit = Π = USD 1.096 – USD 1.05 = USD .046 (or 4.6% per USD borrowed)

After one year, the U.S. investor realizes a risk-free profit of USD. 046 per USD borrowed.

Figure 7.1: IRPT At Work



Note: Bank A will observe a lot of buying USD forward at $F^{A}_{t,1-yr}$ = 100 JPY/USD. Bank A will quickly increase the quote until it converges to $F_{t,1-yr}$ = 104.38 JPY/USD. ¶

Example 2: Violation of IRPT 2 - Overvaluation of forward FC (=USD).
Now, suppose Bank X offers: $F^{X}_{t,1-yr}$ **= 110 JPY/USD**.
Then, $F^{X}_{t,1-yr} > F^{IRP}_{t,1-yr}$ (pricing mistake!) ⇒ The forward USD is overvalued against the JPY.
⇒ Take advantage of Bank X's overvaluation: **Sell USD forward**.

Sketch of a covered arbitrage strategy (shown in Graph 7.1):
(1) Borrow JPY 1 from for one year at 3.4%.
(2) Convert JPY to USD at S_t = 106 JPY/USD
(3) Deposit the USD at 5% for one year
(4) Cover. **Sell USD forward/Buy forward JPY** at $F^{X}_{t,1-yr}$ = 110 JPY/USD.

Cash flows at T=1 year:
(i) We get: USD 1/106 * (1 + .05) * (110 JPY/USD) = JPY 1.0896
(ii) We pay: JPY 1 * (1 + .034) = JPY 1.034
Π = JPY1.0896 – JPY 1.034 = JPY .0556 (or 5.56% per JPY borrowed)

Note: Arbitrage will ensure that Bank X's quote quickly converges to $F_{t,1-yr}$= 104.38 JPY/USD. ¶

7.3.2 IRPT: Assumptions

Behind the covered arbitrage strategy -steps (1) to (4)-, we have implicitly assumed:
(1) Funding is available. Step (1) can be executed.
(2) Free capital mobility. No barriers to international capital flow –i.e., step (2) and, later, step (4) can be implemented.
(3) No default/country risk. Steps (3) and (4) are safe.
(4) Absence of significant frictions. Typical examples: transaction costs & taxes. Small transactions costs are OK, as long as they do not impede arbitrage.

We are also implicitly assuming that the forward contract for the desired maturity T is available. This may not be true. In general, the forward market is liquid for short maturities (up to 1 year). For many currencies, say from emerging market, the forward market may be liquid for much shorter maturities (up to 30 days).

7.3.3 IRPT and the Forward Premium

Recall the definition of forward premium, *p*:

$$p = \frac{F_{t,T} - S_t}{S_t} * \frac{360}{T}$$

Consider linearized IRPT. After some algebra, and letting T=360, we get:

$$p = \frac{F_{t,T} - S_t}{S_t} * \frac{360}{T} \approx (i_d - i_f).$$

p measures the annualized return from a long (short) position in the FX spot market and a short (long) position in the FX forward market. That is, it measures the return from an FX Swap transaction. We say if:

$p>0 \Rightarrow$ premium currency ("*the FC trades at a premium against the DC for delivery in T days*")

$p<0 \Rightarrow$ discount currency ("*the FC trades at a discount*")

Equilibrium: *p* exactly compensates $(i_d - i_f)$ → No arbitrage opportunities
→ No capital flows (because of pricing mistakes).

In Figure 7.2, the equilibrium points are along the 45º IRPT Line. Any pair (i_d -i_f, *p*) far from the IRPT Line represents an arbitrage opportunity.

Example: Violations of IRPT and Capital Flows

B - Go back to **Example 1**

$p = [(F_{t,T} - S_t)/ S_t] * 360/T = [(100 – 106)/106] * 360/360 = - 0.0566 \Rightarrow$ USD trades at a discount.

$p = - 0.0566 < (i_d - i_f) = - 0.016 \Rightarrow$ Arbitrage possible (pricing mistake!) ⇒ capital flows!

Check Steps (1)-(3) in Example 1: Foreign (U.S.) capital flows to Japan (capital inflows to Japan).

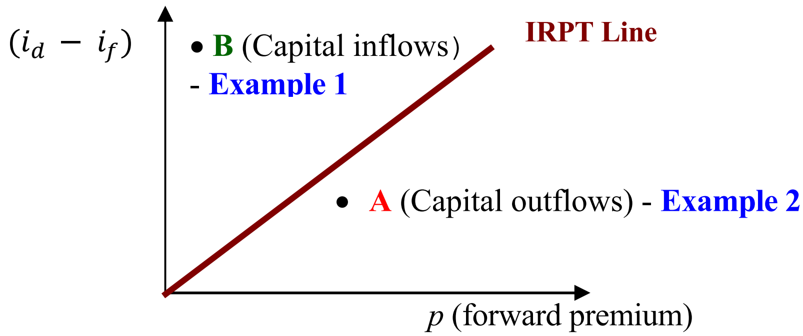
A - Go back to **Example 2**

$p = [(F_{t,T} - S_t)/ S_t] * 360/T = [(110 – 106)/106] * 360/360 = 0.0377 \Rightarrow$ USD trades at a premium.

$p = 0.0377 > (i_d - i_f) = - 0.016 \Rightarrow$ Arbitrage possible (pricing mistake!) ⇒ capital flows!

Check Steps (1)-(3) in Example 2: Domestic (Japanese) capital flows to USA (capital outflows). ¶

Figure 7.2: IRPT Line



Consider a point under the IRPT line, say **A** (like in **Example 2**): $p > (i_d - i_f)$ (or $p + i_f > i_d$) → a long spot/short forward position has a higher yield than borrowing abroad at i_f and investing at home at i_d ⇒ Arbitrage is possible! (There is a pricing mistake).

Covered Arbitrage Strategy:

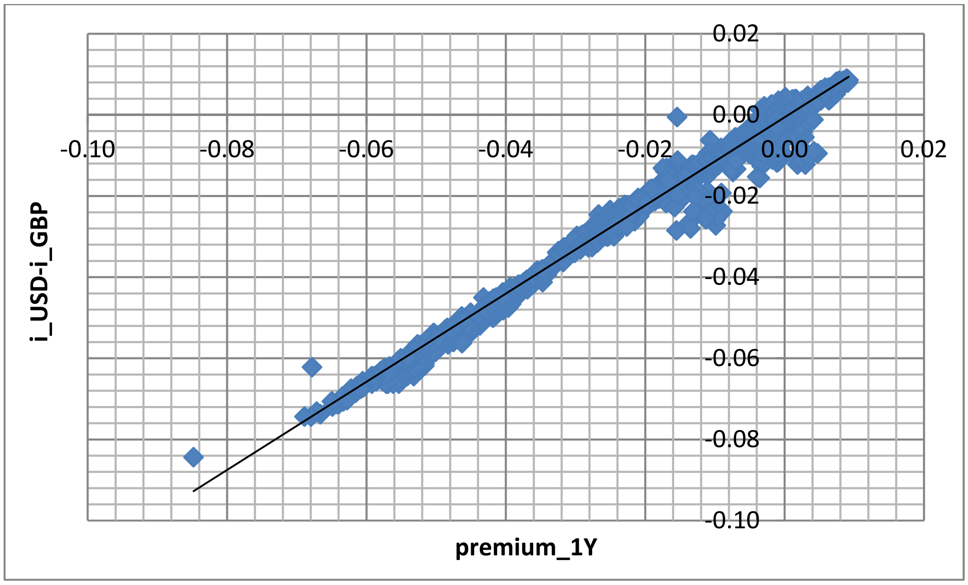
(1) Borrow DC at i_d for T days
(2) Convert DC to FC (the long position in FC)
(3) Deposit FC at i_f for T days
(4) Sell forward FC at $F_{t,T}$ (the short forward position)

That is, today, at a point like **A**, domestic capital fly to the foreign country: What an investor pays in domestic interest rate, i_d, is more than compensated by the high forward premium, p, and the foreign interest rate, i_f.

• IRPT: Evidence

Starting from Frenkel and Levich (1975), there is a lot of evidence that supports IRPT. For example, Figure 7.3 plots the daily interest rate differential against the annualized forward premium. They plot very much along the 45° line. Moreover, the correlation coefficient between these two series is 0.995, highly correlated series!

Figure 7.3: IRPT Line – USD/GBP (daily, 1990-2015)



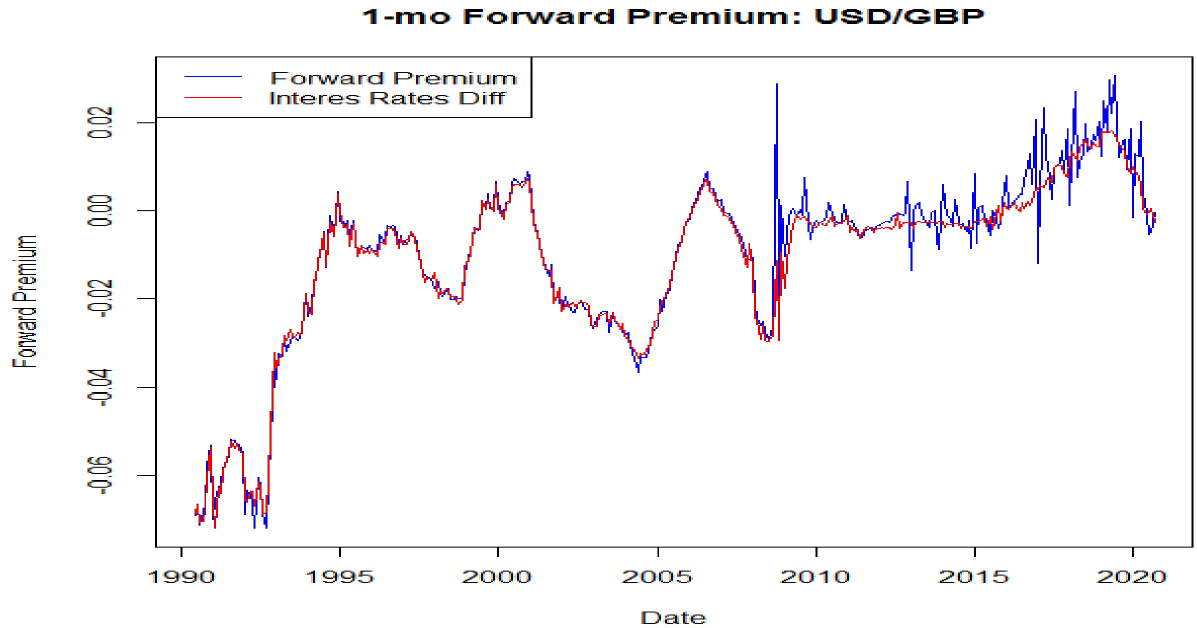
Using intra-daily data (10' intervals), Taylor (1989) also find strong support for IRPT. At the tick-by-tick data, Akram, Rice and Sarno (2008, 2009) show that there are short-lived (from 30 seconds up to 4 minutes) departures from IRP, with a potential profit range of 0.0002-0.0006 per unit. The short-lived nature and small profit range point out to a fairly efficient market, with the data close to the IRPT line.

There are situations, however, where we observe significant and more persistent deviations from the IRPT line. These situations are usually attributed to monetary policy, credit risk, funding conditions, risk aversion of investors, lack of capital mobility, default risk, country risk, and market microstructure effects.

For example, during the 2008-2009 financial crisis there were several violations of IRPT (in Graph 7.2, the point well over the line (-.0154,-.0005) is from May 2009). These violations are attributed to funding constraints –i.e., difficulties to do step (1): borrow. See Baba and Parker (2009) and Griffoli and Ranaldo (2011).

After the financial crisis, the behavior of the forward premium and interest differentials has changed. As seen in Figure 7.4, there was an almost perfect fit until 2008. Since 2008-2009, IRPT the fit is not that good. One explanation, the interest rates used are no longer "risk-free."

Figure 7.4: IRPT – Forward Premium & Interest Rate Differential (1990-2022)



Chapter 7 - Appendix – Taylor Series

Definition: Taylor Series

Suppose f is an infinitely often differentiable function on a set $\boldsymbol{D}$ and $c \in \boldsymbol{D}$. Then, the series

$$T_f(x, c) = \Sigma_n \, [f^{(n)}(c)/n!] \, (x - c)^n$$

is called the (formal) *Taylor series* of f centered at, or around, c.

Note: If c=0, the series is also called *MacLaurin Series.*

Taylor Series Theorem

Suppose $f \in C^{n+1}([a, b])$ -i.e., f is $(n+1)$-times continuously differentiable on $[a, b]$. Then, for $c \in [a,b]$ we have:

$$f(x) = T(x,c) + R = \frac{f(c)}{0!}(x-c)^0 \; + \; \frac{f^{/}(c)}{1!}(x-c)^1 \; + \frac{f^{//}(c)}{2!}(x-c)^2 \; + \ldots + \; \frac{f^{(n)}(x_0)}{n!}(x-x_0)^n + R$$

where $R_{n+1}(x) = \dfrac{1}{n!}\int f^{(n+1)}(p)(x-p)^n dp$

In particular, the $T_f(x, c)$ for an infinitely often differentiable function f converges to f iff the remainder $R_{(n+1)}(x)$ →converges to 0 as $n \to \infty$.

Example: 1st-order Taylor series expansion, around c=0, of $f(x) = \log(1+xd)$, where d is a constant

$f(x) = \log(1+x\, d)$ $\qquad\qquad$ $f'(x_0=0) = 0$

$f'(x) = d/(1+x\, d)$ $\qquad\qquad$ $f'(x_0=1) = d$

⇒ 1st-order Taylor's series formula (n=1):

$\log(1+x\,d) \approx T(x; c) = 0 + d\,(x-0) = x\,d$ $\Rightarrow$ if d=1, then $\log(1+x) \approx x$

Application: IRP Approximation

We start with IRP: $F_{t,T} = S_t * \frac{(1+ i_d * \frac{T}{360})}{(1+ i_f * \frac{T}{360})}$

Now, take logs: $\log(F_{t,T}) = \log(S_t) + \log(1 + i_d * \frac{T}{360}) - \log(1 + i_f * \frac{T}{360})$

After simple algebra: $\log(F_{t,T}) - \log(S_t) = \log(1 + i_d * \frac{T}{360}) - \log(1 + i_f * \frac{T}{360})$

Recall that log changes can approximate percentage changes: $\log(F_{t,T}) - \log(S_t) \approx \frac{F_{t,T} - S_t}{S_t}$

Then, using the approximation for $\log(1 + x d) \approx x\,d$, we get $p = \frac{F_{t,T} - S_t}{S_t} \approx (i_d * \frac{T}{360} - i_f * \frac{T}{360})$

Solving for $F_{t,T}$, gets the linearized approximation to IRP.

CHAPTER 7 – BRIEF ASSESMENT

1. Assume the following information:

$S_{t.USD/AUD}$ = .80 USD/AUD
$S_{t,USD/GBP}$ = 1.40 USD/GBP
$S_{t,AUD/GBP}$ = 1.80 AUD/GBP

Is triangular arbitrage possible? If so, explain the steps that would reflect triangular arbitrage, and compute the profit from this strategy (expressed as a % per unit borrowed). Explain how market forces move to eliminate triangular arbitrage's profits.

2. Difficult. Let's complicate triangular arbitrage, by introducing bid-ask spreads. Assume the following information:

$S_{t,USD/AUD}$ = .81-.82 USD/AUD
$S_{t,USD/GBP}$ = 1.40-1.42 USD/GBP

Calculate an arbitrage-free cross rate (AUD/GBP) quote (with bid-ask spread).

3. Assume the following information:

S_t = 1.10 USD/EUR
i_{EUR} = 1.50%
i_{USD} = 2.75%
T = 180 days

(A) Determine the arbitrage-free 180-day forward rate (use IRP).
(B) Suppose Bank Q offers $F^Q_{t,180}$ = 1.12 USD/EUR. Given this information, is covered interest arbitrage possible? Design a covered arbitrage strategy and calculate its profits.
(C) Suppose Bank P offers $F^P_{t,180}$ = 1.08 USD/EUR. Given this information, is covered interest arbitrage possible? Design a covered arbitrage strategy and calculate its profits.

4. Assume the following information:

S_t = 1.40 USD/GBP
$F^Q_{t,270}$ = 1.42 USD/GBP
i_{GBP} = 2.50%
i_{USD} = 2.75%
T = 180 days

Calculate *p* (the forward premium) and the interest rate differential. What kind of capital flows the U.K. economy will experience?

CHAPTER 7 - BONUS COVERAGE: IRPT with Bid-Ask Spreads

Exchange rates and interest rates are quoted with bid-ask spreads.

Consider a trader in the interbank market:

She will have to buy or borrow at the other party's ask price.
She will sell or lend at the bid price.

There are two roads to take for arbitrageurs: borrow domestic currency or borrow foreign currency.

• Bid's Bound: Borrow Domestic Currency

At time $t = 0$, an arbitrager simultaneously would do:
(1) A trader borrows DC 1 at time $t = 0$ at $i_{ask,d}$
(2) Using the borrowed DC 1, she buys FC spot at $S_{ask,t}$, getting $(1/S_{ask,t})$
(3) She deposits the FC at the foreign interest rate, $i_{bid,f}$.
(4) She sells the FC forward for T days at $F_{bid,\,t,T}$.

Note: The arbitrager always gets the "worst" part of the bid-ask spread.

Cash flows (in DC) at time T:
- Arbitrager repays: $1 + i_{ask,d} * T/360$.
- Arbitrager gets: $(1/S_{ask,t})\ (1 + i_{bid,f} * T/360) * F_{bid,\,t,T}$.

In equilibrium, this strategy should yield no profit. That is,

$$(1/S_{ask,t})\ (1 + i_{bid,f} * T/360) * F_{bid,\,t,T} \leq (1 + i_{ask,d} * T/360).$$

Solving for $F_{bid,\,t,T}$:

$$F_{bid,\,t,T} \leq S_{ask,t} * \frac{\left(1+ i_{ask,d} * \frac{T}{360}\right)}{\left(1+ i_{bid,f} * \frac{T}{360}\right)} = \mathbf{U}_{\mathbf{bid}}.$$

• Ask's Bound: Borrow Foreign Currency

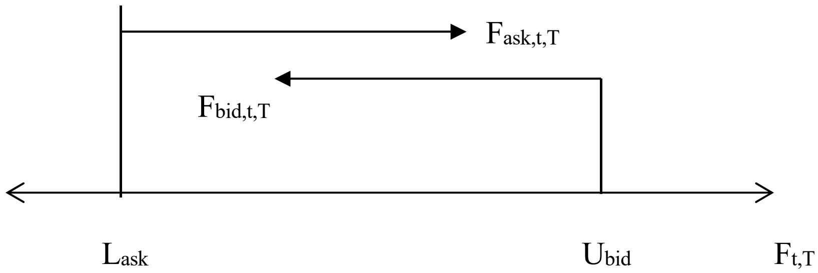
(1) The trader borrows FC 1 at time $t = 0$ at $i_{ask,f}$.
(2) Using the borrowed FC 1, she sells the FC spot for $S_{bid,t}$ units of DC.
(3) She deposits the DC at the domestic interest rate, $i_{bid,d}$.
(4) She buys the FC forward for T days at $F_{ask,\,t,T}$

Following a similar procedure as the one detailed above, we get:

$$F_{ask,\,t,T} \geq S_{bid,t} * \frac{\left(1+ i_{bid,d} * \frac{T}{360}\right)}{\left(1+ i_{ask,f} * \frac{T}{360}\right)} = \mathbf{L}_{\mathbf{ask}}.$$

Together with $F_{ask,\,t,T} > F_{bid,\,t,T}$, these bounds are used by traders to establish arbitrage-free quotes. Figure 7.4 illustrates the bounds.

Figure 7.4: Trading bounds for the Forward bid and the Forward ask.



Example: IRPT bounds at work.
Data: S_t = 1.6540 – 1.6620 USD/GBP
i_{USD} = 7¼-½,
i_{GBP} = 8 1/8 – 3/8,
$F_{t,one\text{-}year}$ = 1.6400 – 1.6450 USD/GBP.

Check if there is an arbitrage opportunity (we need to check the bid's bound and ask's bound).

i) Bid's bound covered arbitrage strategy:
1) Borrow USD 1 at 7.50% for 1 year ⇒ we will repay USD 1.07500 at T=1 year
2) Convert to GBP ⇒ we get GBP 1/1.6620 = GBP 0.6017
3) Deposit GBP 0.6017 at 8.25%
4) Sell GBP forward at 1.64 USD/GBP ⇒ we get (1/1.6620) x (1 + .08125)x1.64 = USD 1.06694
⇒ No arbitrage opportunity. For each USD we borrow, we lose USD .00806.

ii) Ask's bound covered arbitrage strategy:
1) Borrow GBP 1 at 8.375% for 1 year ⇒ we will repay GBP 1.08375 at T=1 year
2) Convert to USD ⇒ we get USD 1.6540
3) Deposit USD 1.6540 at 7.250%
4) Buy GBP forward at 1.645 USD/GBP ⇒ we get 1.6540x(1 + .07250)x(1/1.6450) = GBP 1.07837
⇒ No arbitrage opportunity. For each GBP we borrow, we lose GBP 0.0054.

Note: The bid-ask forward quote is consistent with no arbitrage. That is, the forward quote is within the IRPT bounds. Check:

$$U_{bid} = S_{ask,t} * \frac{(1+ i_{ask,d})}{(1+ i_{bid,f})} = 1.6620 \text{ USD/GBP} * \frac{(1.075)}{(1.08125)} = 1.6524 \text{ USD/GBP}$$

⇒ $U_{bid} \geq F_{bid,\,t,T}$, = 1.6400 USD/GBP.

$$L_{ask} = S_{bid,t} * \frac{(1 + i_{bid,d})}{(1+ i_{ask,f})} = 1.6540 \text{ USD/GBP} * \frac{(1.0275)}{(1.08375)} = 1.6368 \text{ USD/GBP}$$

⇒ $L_{ask} \leq F_{ask,\,t,T}$ = 1.6450 USD/GBP. ¶

Chapter 8 – Theories of FX Determination – Part 1

In Chapter 4, we briefly mentioned two theories of exchange rate determination: The Balance of Trade (BT) Approach and the Monetary Approach (MA)

Under the BT Approach, net trade flows (X-M) are the main determinants of S_t. According to this approach, we expect an increase (decrease) in the TB to depreciate (appreciate) the FC. That is,

$$e_{f,t} = (S_t/S_{t-1}) - 1 = f(TB_t), \quad \text{where } f' < 0.$$

Under the MA, S_t is determined by the relative money demand and money supply between the two currencies:

$$S_t = f(L_{d,T} / L_{f,T}, M_{Sd,T} / M_{Sf,T},,...), \quad \text{where } f_1 < 0 \ \& \ f_2 > 0.$$

In this chapter, we develop more theories to explain S_t. The emphasis will be on arbitrage, actually *pseudo-arbitrage*, theories, focusing on equilibrium in only one market. That is, we will rely on *partial equilibrium* stories to explain S_t.

Our goal is to find an explicit functional form for S_t, say $S_t = \alpha + \beta X_t$, where X_t. is a variable or set of variables determined by a theory. Different theories will have different X_t and or different $f(.)$.

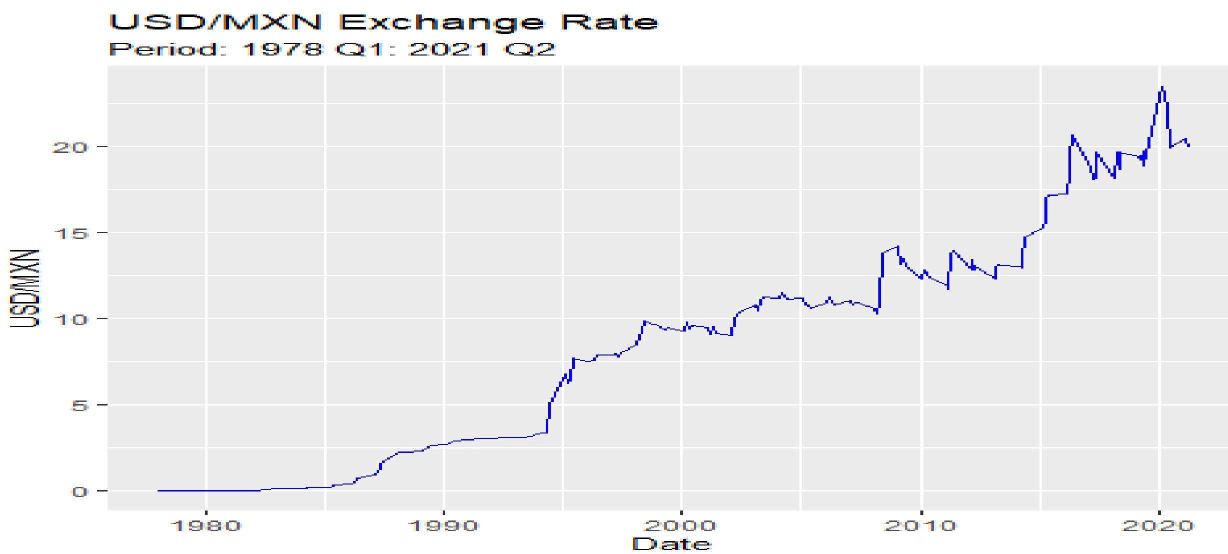
Eventually, we would like to have a precise mathematical formula to forecast S_{t+T}.

Q: How do we know the formula of S_t is any good?

• Testing a Theory

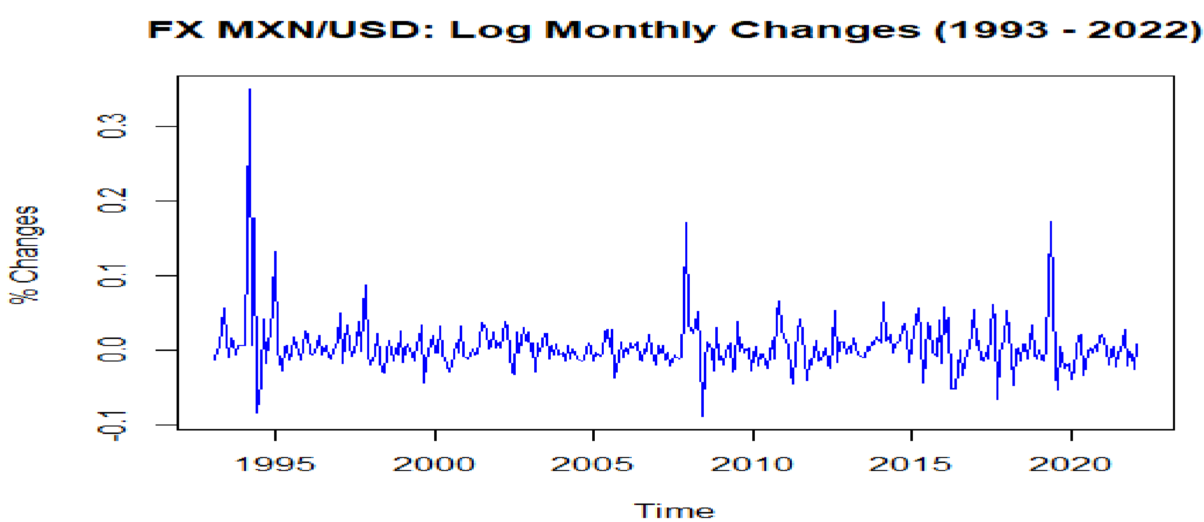
We will judge a theory by how well it explains the behavior of the observed S_t. For example, a good theory should match the observed behavior of the quarterly MXN/USD exchange rate for the 1978 - 2022 period, as shown in Figure 8.1.

Figure 8.1: Behavior of the MXN/USD (1978-2022)



Like many macroeconomic series, exchange rates have a trend, see Figure 8.1 above –in statistics, these trends in macroeconomic series are called *stochastic trends.* It is better to work with changes, not levels. As can be seen in Figure 8.2, the trend is gone after calculating changes in S_t.

Figure 8.2: Behavior of the Changes in MXN/USD (1993-2022)



Now, the trend, which in many cases is easy to explain, is gone. Our goal will be to explain $e_{f,t}$, the percentage change in S_t.

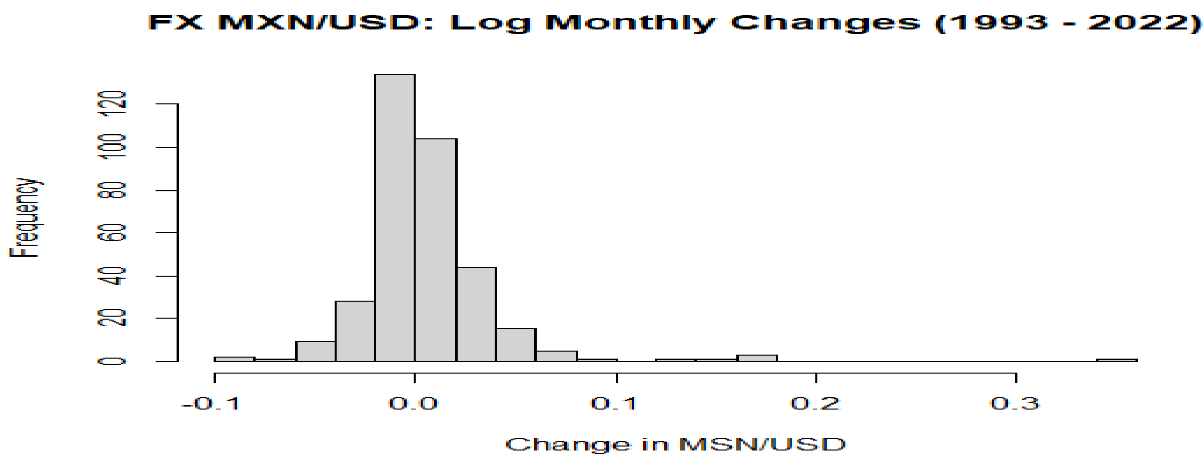
Goal: $S_t = f(i_d, i_f, I_d, I_f, \ldots)$. But, it will be easier to explain $e_{f,t} = (S_t - S_{t-1})/S_{t-1} = f(i_d, i_f, I_d, I_f, \ldots)$.
Once we get $e_{f,t}$, we get S_t $\Rightarrow S_t = S_{t-1} \times (1 + e_{f,t})$
The S_t that we will obtain will be an *equilibrium value*. That is, the S_t we will be calculated using a

model that assumes some kind of equilibrium in the FX market.

Q: How are we going to test our equilibrium values?
A: We would like our theory to match the data, say the mean and standard deviation of S_t.

Figure 8.3 plots the distribution of $e_{f,t}$(MXN/USD); calculated from monthly data during 1987-2017. Below Figure 8.3, we show the descriptive statistics for the distribution of $e_{f,t}$(MXN/USD).

Figure 8.3: Distribution of the Changes in MXN/USD (1993-2022)



Descriptive Stats for e_f (MXN/USD):

e_f (USD/MXN)	
Mean	**0.0052**
Standard Error	0.0019
Median	0.0004
Standard Deviation	**0.0351**
Sample Variance	0.0021
Kurtosis	**33.3631**
Skewness	**3.9122**
Minimum	-0.0887
Maximum	0.3500
Count	350

The usual (average, expected) monthly percentage change represents a **0.52%** appreciation of the USD against the MXN (annualized change: 6.24%). The standard deviation is **3.51%**. The mean, standard deviation, skewness and kurtosis are called *unconditional moments*. Theories also produce *conditional moments* -i.e., conditional on the theory. In general, we associate matching unconditional moments with long-run features of a model; while we associate matching conditional moments with short-run features of a model.

• Review from Chapter 7
Effect of arbitrage on FX Markets:

Local arbitrage → sets consistent rates across banks
Triangular arbitrage → sets cross rates
Covered arbitrage → sets a relation between $F_{t,T}$, S_t, i_d, i_f (IRPT)

$$\Rightarrow F_{t,T} = S_t * \frac{\left(1+i_d * \frac{T}{360}\right)}{\left(1+i_f * \frac{T}{360}\right)}$$

In this class, we will study the effect of "*arbitrage*" in goods (PPP) and financial flows (IFE) on FX Markets. We will generate explicit models for S_t.

8.1. Purchasing Power Parity (PPP)

PPP is based on the law of one price (LOOP): Same goods once denominated in a common currency should have the same price. If they are not, then, pseudo-arbitrage is possible.

Example: LOOP for Oil.
$P_{oil\text{-}USA}$ = USD 40.
$P_{oil\text{-}SWIT}$ = CHF 80.
LOOP: $P_{oil\text{-}SWIT}\ \mathbf{S_t^{LOOP}} = P_{oil\text{-}USA}$ $\Rightarrow \mathbf{S_t^{LOOP}} = P_{oil\text{-}USA}/P_{oil\text{-}SWIT}$ =USD 40/CHF 80 =0.50 USD/CHF.

Suppose S_t = 0.75 USD/CHF $\Rightarrow$ $P_{oil\text{-}SWIT}$ (in USD) = CHF 80 x 0.75 USD/CHF = USD 60.
That is, a barrel of oil in Switzerland is more expensive -once denominated in USD- than in the US.

Arbitrageurs/traders will buy oil in the U.S. (to export it to Switzerland) and simultaneously sell oil in Switzerland. This movement of oil will simultaneously increase the price of oil in the U.S. ($P_{oil\text{-}USA}$ ↑); decrease the price of oil in Switzerland ($P_{oil\text{-}SWIT}$ ↓); and appreciate the USD against the CHF (S_t ↓). ¶

LOOP Notes:
- LOOP gives an *equilibrium* exchange rate (EER, in the econ lit). Equilibrium will be reached when there is no trade in oil (because of pricing mistakes). That is, when the LOOP holds for oil.
- LOOP is telling us what S_t should be (in equilibrium): $\mathbf{S_t^{LOOP}}$. It is not telling what S_t is in the market. It is just an *implied* rate from market prices.
- Using the LOOP, we have generated a model for S_t. (Recall that a model is an attempt to explain and predict economic phenomena.) When applied to a price index, we will call this model, *the PPP model.*
- The generated model, like all models, is a simplification of the real world. For example, we have ignored (or implicitly assumed negligible) trade frictions (transportation costs, tariffs, etc.).

Problem for the LOOP: There are many traded goods in the economy.
Solution: Work with baskets of goods that represent many goods. For example, the CPI basket (in the U.S., we use the CPI-U, which reflects spending patterns for urban consumers), which includes housing (41%), transportation (17%), food & beverages (15%), health care (7%), recreation (6%), etc. The price of a basket is the weighted average price of the components. For example:

Price CPI-U basket = .41 * Price of housing + .17 * Price of transportation + ...

The price of the CPI basket is usually referred as the "*price level*" of an economy.

Note: Weights are different in different countries.

8.1.1 Absolute version of PPP

The FX rate between two currencies is simply the ratio of the two countries' general price levels:

S_t^{PPP} = Domestic Price level / Foreign Price level = P_d / P_f (Absolute PPP)

Example: Law of one price for CPIs.
CPI-basket$_{USA}$ = **USD 755.3**
CPI-basket$_{SWIT}$ = **CHF 1241.2**

$\Rightarrow S_t^{PPP}$ = **USD 755.3**/**CHF 1241.2** = 0.6085 USD/CHF.

If $S_t \neq$ 0.6085 USD/CHF, there will be trade of the goods in the basket between Switzerland and US.
Suppose S_t = **0.70 USD/CHF** > S_t^{PPP} = 0.6085 USD/CHF.

Then CPI-basket$_{SWIT}$ (in USD) = **CHF 1241.2** * **0.70 USD/CHF** = USD 868.70 > CPI-basket$_{USA}$

"Things" –i.e., the components in the CPI basket- are, on average, cheaper in the U.S. There is a potential profit from trading the CPI basket's components:

Potential profit: USD 868.70 – **USD 755.3** = USD 93.40

Traders will do the following "pseudo-arbitrage" strategy:
1) Borrow USD
2) Buy the CPI-basket in the US (CPI-basket$_{USA}$ ↑)
3) Sell the CPI-basket, purchase in the US, in Switzerland. (CPI-basket$_{SWIT}$ ↓) $\Rightarrow S_t^{PPP}$ ↑
4) Sell CHF/Buy USD (S_t (USD/CHF) ↓)
5) Repay the USD loan, keep the profits.

Note: Prices move and push S_t (market price) & S_t^{PPP} (equilibrium price) towards convergence. ¶

Under PPP, a USD buys the same amount of goods in the U.S. and in Switzerland. That is, a USD has the same *purchasing power* in the U.S. & in Switzerland. Vice versa, a CHF buys the same amount of goods in Switzerland and in the U.S.

• Absolute PPP: The Real Exchange Rate

The absolute version of the PPP theory is expressed in terms of S_t, the *nominal exchange rate*.

We can express the absolute version of the PPP relationship in terms of the *real exchange rate*, R_t. That is,

$$R_t = S_t \; P_f / P_d.$$

The real exchange rate allows us to compare foreign prices, translated into domestic terms, with domestic prices. It is common to associate R_t > 1 with a more efficient/productive domestic economy.

If absolute PPP holds $\Rightarrow$ **R_t** = 1.

Terminology: If **R_t** ↑, foreign goods become more expensive relative to domestic goods. We say there is "a *real depreciation* of the DC". Similarly, if **R_t** ↓, we say there is "a *real appreciation* of the DC."

Example: Suppose a basket –the Big Mac (sesame-seed bun, onions, pickles, cheese, lettuce, beef patty and special sauce)– costs CHF 6.50 and USD 4.93 in Switzerland and in the U.S., respectively.
P_f = **CHF 6.50**
P_d = **USD 4.93**
S_t = 0.9909 USD/CHF.

R_t = S_t P_{SWIT} / P_{US} = **0.9908 USD**/CHF * **CHF 6.50**/**USD 4.93** = **1.3065**.

Taking the Big Mac as our basket, the U.S. is more competitive than Switzerland. Swiss prices are higher (**R_t** - 1 = 30.7% higher!) than U.S. prices, after taking into account the nominal exchange rate. That is, with one USD, we consume 30.7% more in the U.S. than in Switzerland.

To bring the economy back to equilibrium –no trade on Big Macs-, we expect the USD to appreciate against the CHF. According to PPP, the USD is undervalued against the CHF:

$\Rightarrow$ Trading signal: Buy USD/Sell CHF.

Note: Obviously, we do not expect to see Swiss consumers importing Big Macs from the U.S.; but the components of the Big Mac are internationally traded. Trade would happen in the components! ¶

Indicator of under/over-valuation: **R_t** > 1 $\Rightarrow$ FC is overvalued.

Note: In the short-run, we will not take our cars to Mexico to be repaired, because a mechanic's hour is cheaper than in the U.S. But in the long-run, resources (capital, labor) will move, likely to produce cars in Mexico to export them to the U.S. We can think of the over-/under-valuation as an indicator of movement of resources.

Remark: If S_t changes, but P_f & P_d move in such a way that **R_t** remains constant, changes in S_t do not affect firms. There is no change in real cash flows.

Aside: Economists like to work with logs. Thus, using lower case letters to denote the log changes of variables, x=log(X_t), we rewrite the real exchange rate as:

$$r_t = s_t + p_{f,t} - p_{d,t}$$

If PPP holds, then $r_t = 0$. Then, $s_t = p_{f,t} - p_{d,t}$.

• Absolute PPP: **Real v. Nominal Exchange Rates**

Economists think that monetary variables affect nominal variables, like prices and the nominal exchange rate, S_t. But, monetary variables do not affect real variables. In this case, only relative demands and supplies affect **R_t**.

For example, an increase in U.S. output relative to European output (say, because of a technological innovation) will decrease P_{US} relative to P_{EUR} $\Rightarrow$ $\mathbf{R_t}$ $\uparrow$ (a real depreciation of the USD). On the other hand, a monetary approach to exchange rates, predicts that an increase in the U.S. money supply will increase P_{US} and, thus, an increase in S_t, but no effect on $\mathbf{R_t}$.

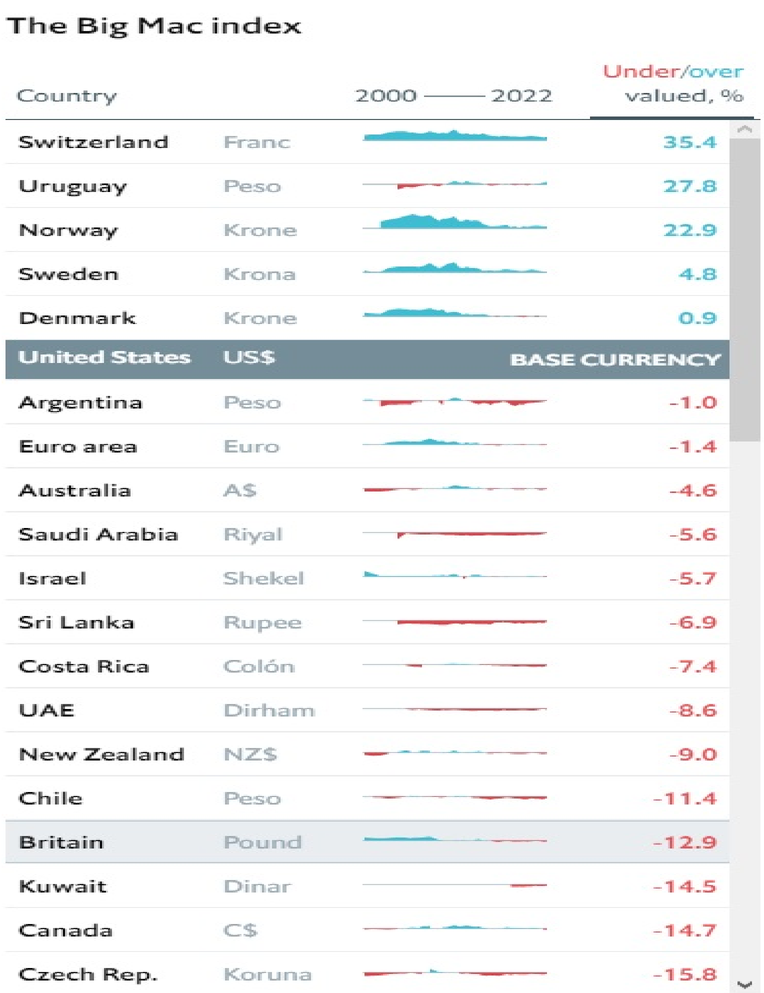
• Absolute PPP: Does it hold?
We use a basket of goods to test PPP. To get better results, it is a good idea to use the same basket (or comparable baskets). For example, the Big Mac.

Example: The Economist's Big Mac Index, shown in Exhibit 8.1, shows the over/undervaluation of a currency relative to the USD. That is, it shows the real exchange rate, $\mathbf{R_t}$ - 1.

$$\mathbf{R_t} = S_t \; P_{BigMac,d} \,/\, P_{BigMac,d,f}$$

Test: If Absolute PPP holds $\Rightarrow$ $\mathbf{R_t} = 1$ (& over/undervaluation=0!).

Exhibit 8.1: The Economist's Big Mac Index (December 2022)


The Big Mac index

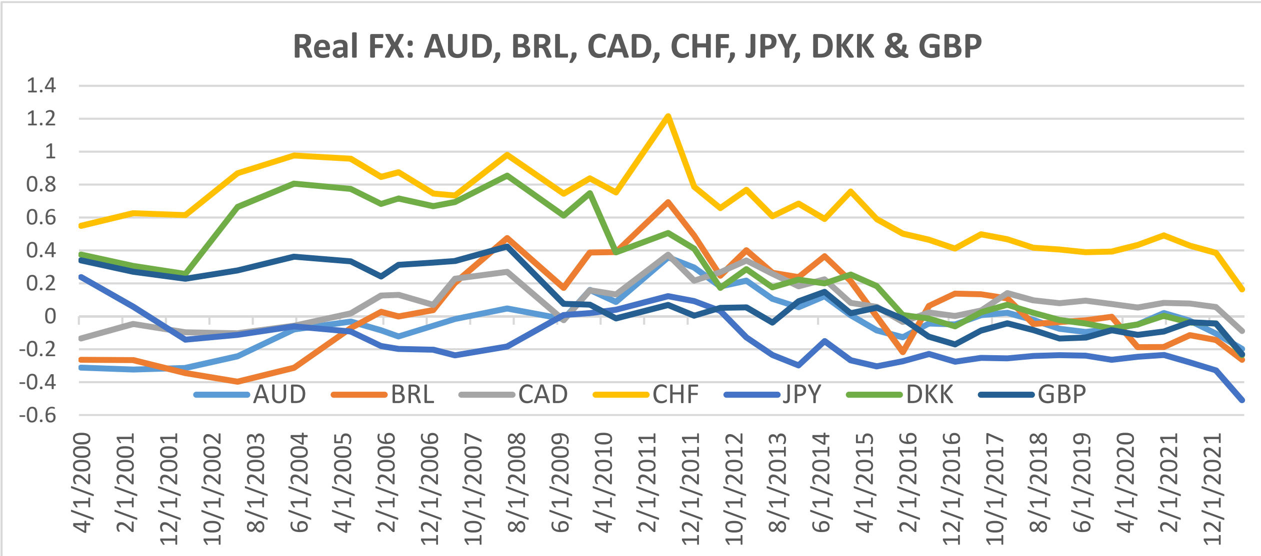
Country		2000 —— 2022	Under/over valued, %
Switzerland	Franc		35.4
Uruguay	Peso		27.8
Norway	Krone		22.9
Sweden	Krona		4.8
Denmark	Krone		0.9
United States	US$	BASE CURRENCY	
Argentina	Peso		-1.0
Euro area	Euro		-1.4
Australia	A$		-4.6
Saudi Arabia	Riyal		-5.6
Israel	Shekel		-5.7
Sri Lanka	Rupee		-6.9
Costa Rica	Colón		-7.4
UAE	Dirham		-8.6
New Zealand	NZ$		-9.0
Chile	Peso		-11.4
Britain	Pound		-12.9
Kuwait	Dinar		-14.5
Canada	C$		-14.7
Czech Rep.	Koruna		-15.8

Country		2000 —— 2022	Under/over valued, %
Bahrain	Dinar		-15.9
Lebanon	Pound		-16.5
Singapore	S$		-16.6
Brazil	Real		-17.2
Nicaragua	Córdoba		-21.2
Mexico	Peso		-21.8
Colombia	Peso		-22.4
Poland	Zloty		-23.6
Honduras	Lempira		-24.5
Turkey	Lira		-25.6
South Korea	Won		-26.0
Thailand	Baht		-27.2
Qatar	Riyal		-28.3
Hungary	Forint		-29.9
Oman	Rial		-31.2
Peru	Sol		-33.2
China	Yuan		-34.0
Jordan	Dinar		-34.3
Guatemala	Quetzal		-35.8
Pakistan	Rupee		-36.8

Check: http://www.economist.com/content/big-mac-index

There are big deviations from Absolute PPP, which can vary a lot over time. See Figure 8.4 below for two R_t series (April 2000 – December 2022): CHF/USD, yellow line; and BLR/USD, orange line.

Figure 8.4: PPP – Persistent deviation from $R_t = 1$ (2000-2022)



With some exceptions, the Big-Mac tends to be more expensive in developed countries (U.S.A., Euro area, Australia) than in less developed countries (Colombia, Guatemala, Pakistan).¶

Empirical Fact: Price levels in richer countries are consistently higher than in poorer ones. It is estimated that a doubling of income per capita is associated with a 48% increase in the price level. This empirical fact is called the *Penn effect*. Many explanations, the most popular: The *Balassa-Samuelson (BS) effect*.

• Absolute PPP: Qualifications

The big deviations from absolute PPP are usually attributed to different reasons:

(1) PPP emphasizes only trade and price levels. Other financial, economic, political factors are ignored.

(2) Absence of trade frictions. This is an implicit assumption: No tariffs, no quotas, no transactions costs. Realistic? It is estimated that transportation costs add 7% to the price of U.S. imports of meat and 16% to the import price of vegetables. Some products are heavily protected, even in the U.S. For example, peanut imports are subject to a tariff between 131.8% (for shelled peanuts) and 163.8% (for unshelled peanuts).

(3) Perfect competition. Imperfect competition, usually related to (2), can create price discrimination. For example, U.S. pharmaceuticals sell the same drug in the U.S. and in Canada at different prices.

(4) Instantaneous adjustments. Another implicit PPP assumption, related to another trade friction. Not realistic. Trade takes time and it also takes time to adjust contracts. Think of PPP as *long-run* model.

(5) PPP assumes P_f and P_d represent the same basket, not the usual situation for CPI baskets. This is why the Big Mac is a popular basket: it is standardized around the world with an easy to get price.

(6) Internationally non-traded (NT) goods (~50%-60% of GDP) –i.e., haircuts, hotels, restaurants, home & car repairs, medical services, real estate, etc. NT goods have a big weight on the CPI basket.

Suppose the proportion of NT in the price basket is α_N. Then, using log price notation, we can write the (log) price index as:

$$p_t = \alpha_N \, p_{NT,t} + (1 - \alpha_N) \, p_{T,t}$$

where $p_{NT,t}$ is the log price of NT goods and $p_{T,t}$ is the log price of taded (T) goods. If PPP holds for traded goods, $s_t + (p_{f,T,t} - p_{d,T,t}) = 0$, then, after some algebra:

$$r_t = \alpha_N (p_{f,NT,,t} - p_{d,NT,t} + s_t).$$

Does PPP hold for NT goods?

(7) The NT sector also has an effect on the price of traded goods. For example, rent, distribution and utilities costs affect the price of a Big Mac. (It is estimated that 25% of Big Mac's cost is due to NT goods.)

• Borders Matter

You may look at the Big Mac Index and think: "No big deal: there is also a big dispersion in prices within the U.S., within Texas, and, even, within Houston!" It is true that prices vary within the U.S. For example, in 2015, the price of a Big Mac (and Big Mac Meal) in New York was USD 5.23 (USD 7.45), in Texas was USD 4.39 (USD 6.26) and in Mississippi was USD 3.91 (USD 5.69).

Engel and Rogers (1996) computed the variance of LOOP deviations for city pairs within the U.S., within Canada, and across the border. They found that distance between cities within a country matter, but the border effect is very significant. To explain the difference between prices across the border using the estimate distance effects within a country, they estimate the U.S.-Canada border should have a width of 75,000 miles!

This huge estimate of the implied border width between the U.S. and Canada has been revised downward in subsequent studies, but a large positive border effect remains.

• Balassa-Samuelson Effect

Balassa (1964) and Samuelson (1964) developed a general equilibrium model of the real exchange rate (BS model). The model explains the above mentioned empirical fact: richer countries have consistently higher prices.

Labor costs affect all prices. We expect average prices to be cheaper in poor countries than in rich ones because labor costs are lower. Rich countries have higher productivity, and higher wages, in the traded-goods sector than poor countries do. In the NT goods sector, productivity is similar.

But, because of competition for labor, wages in NT goods and services are also higher in rich countries. Then, overall prices are lower in poor countries. For example, the productivity of McDonald's employees around the world is likely very similar, but the wages are not. In 2000, a typical McDonald's worker in the U.S. made USD 6.50/hour, while in China made USD 0.42/hour. This difference in NT costs may partly explain over/under-valuations when we compare currencies from developed to less developed countries.

Again, standard applications of PPP, like in the Big Mac example above, will not be very informative. We need to "adjust" prices to incorporate the effect of GDP per capita in the price level.

Practitioners tend to incorporate the Balassa-Samuelson effect into PPP calculations in a straightforward manner. Suppose we want to adjust Big Mac PPP-implied exchange rates. Then:

1) Estimate a regression using Big Mac Prices (in USD, $P_{BM,t}$) as the dependent variable against GDP per capita (GDP_p). That is, run the following regression:

$$P_{BM,t} = \alpha + \beta \text{ GDP\_p}_t + \varepsilon_t$$

2) Compute fitted values (GDP-adjusted Big Mac Prices). That is,

$$\hat{P}_{BM,\text{GDP-adjusted}} = \hat{\alpha} + \hat{\beta} \text{ GDP\_per\_capita}_t$$

Based on the GDP-adjusted Big Mac Prices, re-estimate the PPP implied over/under-valuation:

GDP-adjusted over/under valuation: (BM Price/$\hat{P}_{BM,\text{GDP-adjusted}}$) – 1

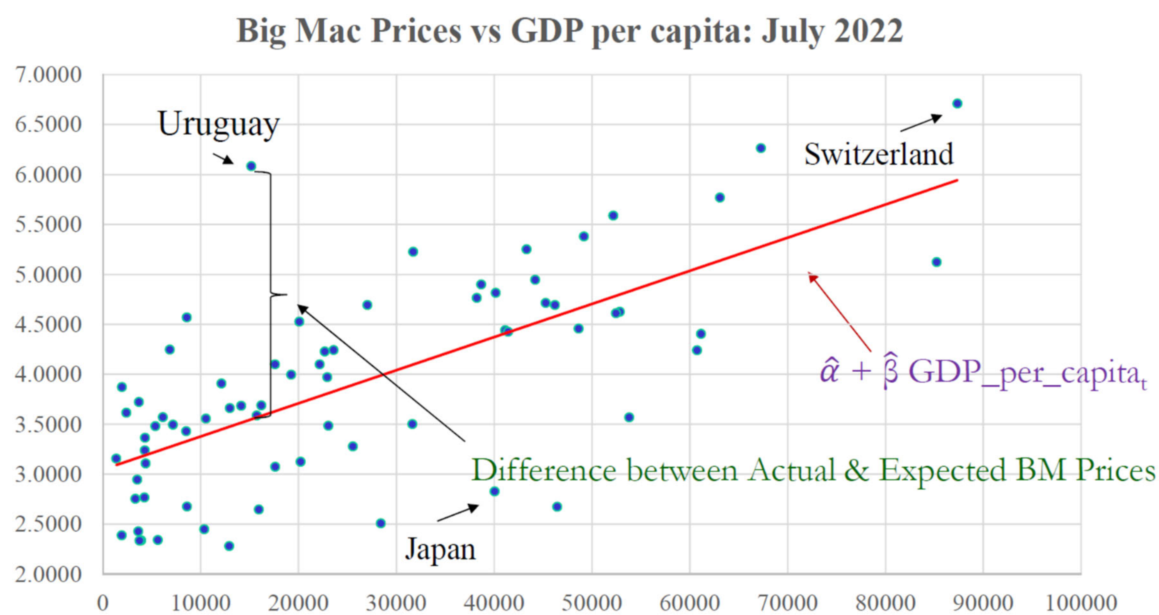
The regression line tells us what the "expected price" in a country is, once we take into consideration its GDP level.

Using data from The Economist for July 2022, we estimated the above regression:

$$\hat{P}_{BM,\text{GDP-adjusted}} = 3.045895 + 0.0000332 * \text{GDP\_per\_capita}_t$$

Figure 8.5 shows the regression line using data from in July 2022:

Figure 8.5: PPP – Regression to Adjust Big Mac Prices by GDP per capita



Now, using the computed red line above, we calculate the "Expected BM prices, given the GDP of a given country." For example, we compute the above value for Uruguay. Uruguay's GDP per capita in July 2022 was **USD 15,169.153**. Then,

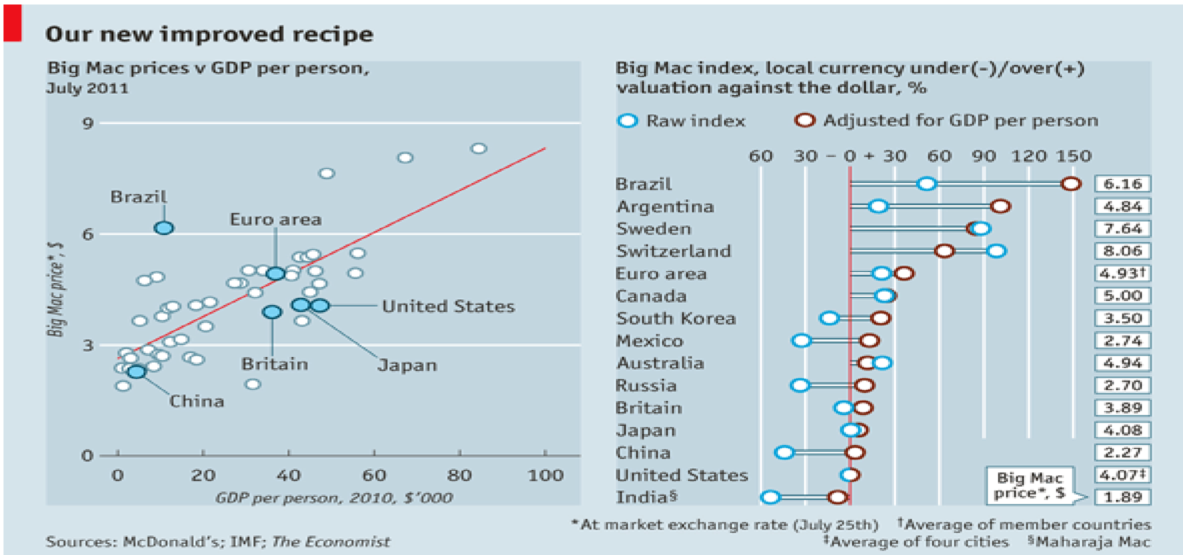
$\hat{P}_{BM,\text{GDP-adj}}$ (Uruguay) = 3.045895 + 0.0000332 * **15,169.153** = **3.549511**

That is, the expected USD Big Mac price, in Uruguay, given its GDP per capita, was **USD 3.55.** Since the observed local BM price was UYU 255, which translates to **USD 6.08** (= UYU 255 * 41.91 USD/UYU), then the *GDP-adjusted over/under valuation* was:

6.08 / **3.549511** – 1 = **71.29%** (**71.29%** overvalued)

On the other hand, we have Japan; which according to the adjusted index, its currency is undervalued by **35%**. That is, these adjustments to PPP implied exchange rates can be significant. See Exhibit 8.2 below from *The Economist* for July 2011.

Exhibit 8.2: The Economist's Adjusted-Big Mac Index (July 2011)



The Balassa-Samuelson effect can explain (or partially explain) why absolute PPP does not hold between a developed country and a less developed country, for example, after correcting for the BS effect, China's currency is no longer undervalued. But the BS effect cannot explain why PPP does not hold among developed countries (say, Switzerland and the U.S.) or among less developed countries (say, Brazil and Argentina).

• Pricing-to-market

Krugman (1987) offers an alternative explanation for the strong positive relationship between GDP and price levels: *Pricing-to-market* –i.e., price discrimination. Based on price elasticities, producers discriminate: the same exact good is sold to rich countries (lower price elasticity) at higher prices than to poorer countries (higher price elasticity). For example, Alessandria and Kaboski (2008) report that U.S. exporters, on average, charge the richest country a 48% higher price than the poorest country.

That is, the price of T goods consumed in the domestic (home) market, P_{TH}, is different from the T goods consumed in the foreign market, P_{TF}. Using log price notation: $p_{TH,t} \neq p_{TF,t}$.

Again, pricing-to-market struggles to explain why PPP does not hold among developed countries with similar incomes. For example, Baxter and Landry (2012) report that IKEA prices deviate 16% from the LOOP in Canada, but only 1% in the U.S. Similarly, The Economist (2019) reports that Pret a Manger, a coffee-shop chain, sells the same items in Boston at higher prices than in London, for instance, an eggsandwich costs GBP 1.79 (USD 2.15) in the U.K. and USD 4.99 in the U.S.

• Absolute PPP: Empirical Evidence

Several tests of the absolute version have been performed. The absolute version of PPP, in general, fails (especially, in the short run), even when using the same basket or the same good. No surprise here, see the Big Mac example above, where $\mathbf{R_t} \neq 1$. Trade frictions, especially transportation and distribution costs, are considered a major problem for absolute PPP.

8.1.2 Relative PPP

A more flexible version of PPP: The rate of change in the prices of products should be similar when measured in a common currency. (As long as trade frictions are unchanged). Thus, Relative PPP addresses the assumption of no trade frictions. (All the other qualifications still apply!)

The following formula states the relative version of PPP:

$$e_{f,T}^{PPP} = \frac{S_{t+T}^{PPP} - S_t}{S_t} = \frac{(1 + I_d)}{(1 + I_f)} - 1 \qquad \text{(Relative PPP)},$$

where

$e_{f,T}^{PPP}$ = percentage change in the value of FC from t to $t+T$.

I_f = ($P_{f,,t+T}/P_{f,t}$) -1 = foreign inflation rate from t to $t+T$.

I_d = ($P_{d,,t+T}/P_{d,t}$) -1 = domestic inflation rate from t to $t+T$.

Linear approximation (from a 1st-order Taylor series):

$$e_{f,T}^{PPP} \approx I_{d,t+T} - I_{f,t+T}$$

Since this relationship is not expected to hold at every time interval, it is usually rewritten in terms of conditional expectations (averages):

$$E_t[e_{f,T}^{PPP}] \approx E_t[I_d] - E_t[I_f].$$

We expect to observe a one-to-one relation between $(I_{d,t+T} - I_{f,t+T})$ and $e_{f,T}$.

Example: Suppose that, from t=0 to t=1, prices increase 10% in Mexico relative to those in Switzerland. Then, $S_{MXN/CHF,t}$ should increase 10%; say, from S_0=9 MXN/CHF to S_1=9.9 MXN/CHF. If, at t=1, S_1=11 MXN/CHF > $S_{t=1}^{PPP}$ = 9.9 MXN/CHF, then according to Relative PPP the CHF is overvalued. ¶

Example: Forecasting S_t (USD/ZAR) using PPP (ZAR=South Africa).

It's 2015. You have the following information:

$CPI_{US,2021}$=104.5

$CPI_{SA,2021}$ = 100.0

S_{2021} = 0.2035 USD/ZAR.

You are given the 2022 forecast for the CPI in the U.S. and South Africa:
$CPI_{US,2022} = 110.8$
$CPI_{SA,2022} = 102.5$.

You want to forecast S_{2022} using the relative (linearized) version of PPP. Then,
$E[I_{US,2022}] = (110.8/104.5) - 1 = .06029$
$E[I_{SA,2022}] = (102.5/100) - 1 = .025$

$S^F_{2022} = S_{2021} * [1 + I^F_{US, 2022} - I^F_{SA, 2022}]$
$= .2035$ **USD/ZAR** $* [1 + .06029 - .025] = .2107$ USD/ZAR.

You forecast an appreciation of the ZAR against the USD. ¶

• Relative PPP: Implications
(1) Under relative PPP, R_t remains constant (it can be different from 1!).
(2) Relative PPP does not imply that S_t is easy to forecast.
(3) Without relative price changes, a multinational corporation faces no real operating exchange risk (as long as the firm avoids fixed contracts denominated in foreign currency).

• Relative PPP: Absolute versus Relative
Absolute PPP compares price levels, while Relative PPP compares price changes (or movements). Under Absolute PPP prices are equalized across countries, but under Relative PPP exchange rates move by the same amount as the inflation rate differential (original prices can be different).

Relative PPP is a weaker condition than the absolute one: R_t can be different from 1.

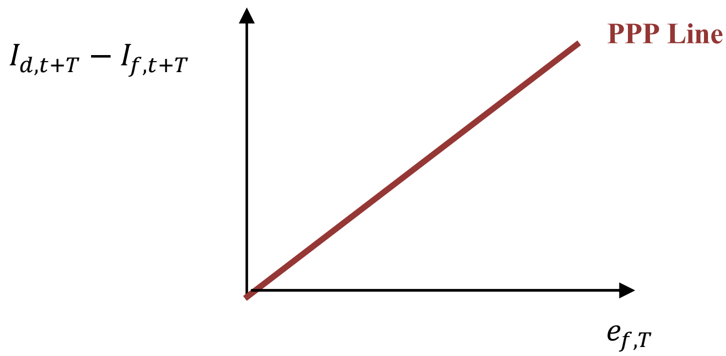
Example: Absolute vs Relative
Absolute PPP: "*A mattress costs GBP 200 (= USD 320) in the U.K. and BRL 800 (=USD 320) in Brazil –i.e., same cost in both countries*." (S_t =1.6 USD/GBP & S_t =0.4 USD/BRL)

Relative PPP: "*U.K. inflation was 2% while Brazilian inflation was 8%. Meanwhile, the BRL depreciated 6% against the GBP. Then, relative cost comparison remains the same*." ¶

• Relative PPP: General Evidence
Key: On average, what we expect to happen, $e^{PPP}_{f,t}$, should happen, $e_{f,T}$
⇒ Q: Is, on average, $e^{PPP}_{f,T} \approx I_{d,t+T} - I_{f,t+T} = e_{f,T}$?

Under PPP, we should see $e_{f,T}$ and $I_{d,t+T} - I_{f,t+T}$ aligned around a 45º line, like in Graph 8.1.

Figure 8.6: PPP Line



1. Visual Evidence
Figure 8.7 plots (I_d-I_f) between Japan and the U.S. against e_f JPY/USD), using 1974-2022 monthly data.

Figure 8.7: PPP Line for the JPY/USD (1974-2022)?

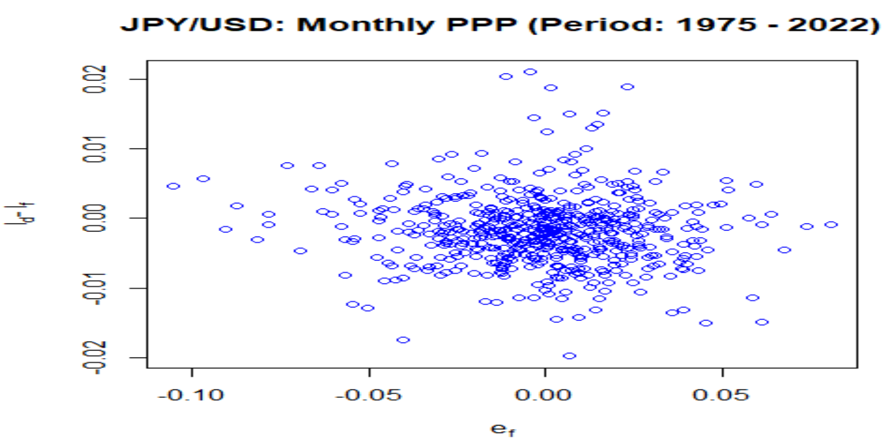
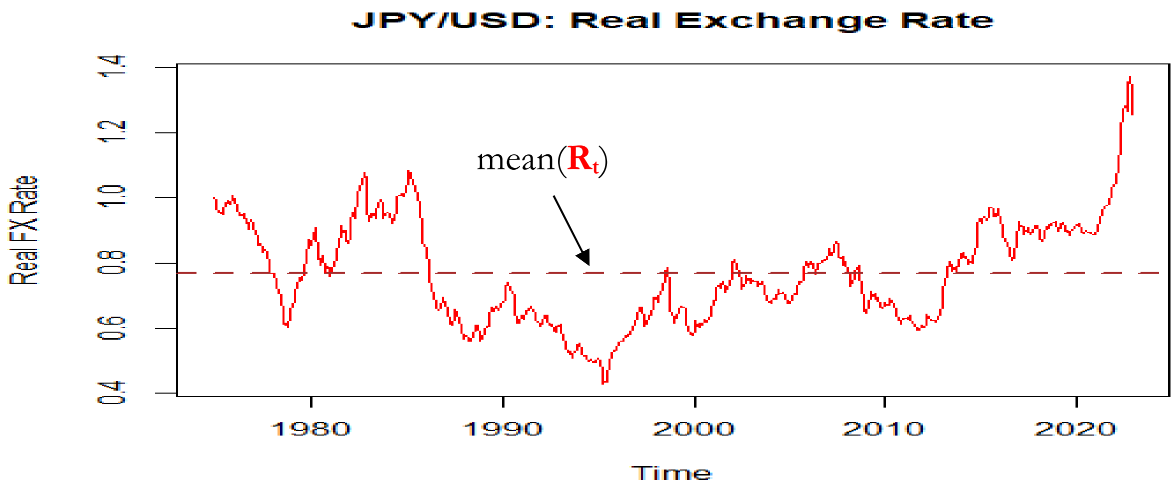


Figure 8.8-A plots **R_t** between Japan and the U.S. It can be used to check if **R_t** is constant (ideally, under absolute PPP, close to 1, but we do not have prices, but indices. **R_t** is arbitrary set to 1 in Jan 1971):

Figure 8.8-A: Real Exchange Rate between Japan and USA (1974-2022)

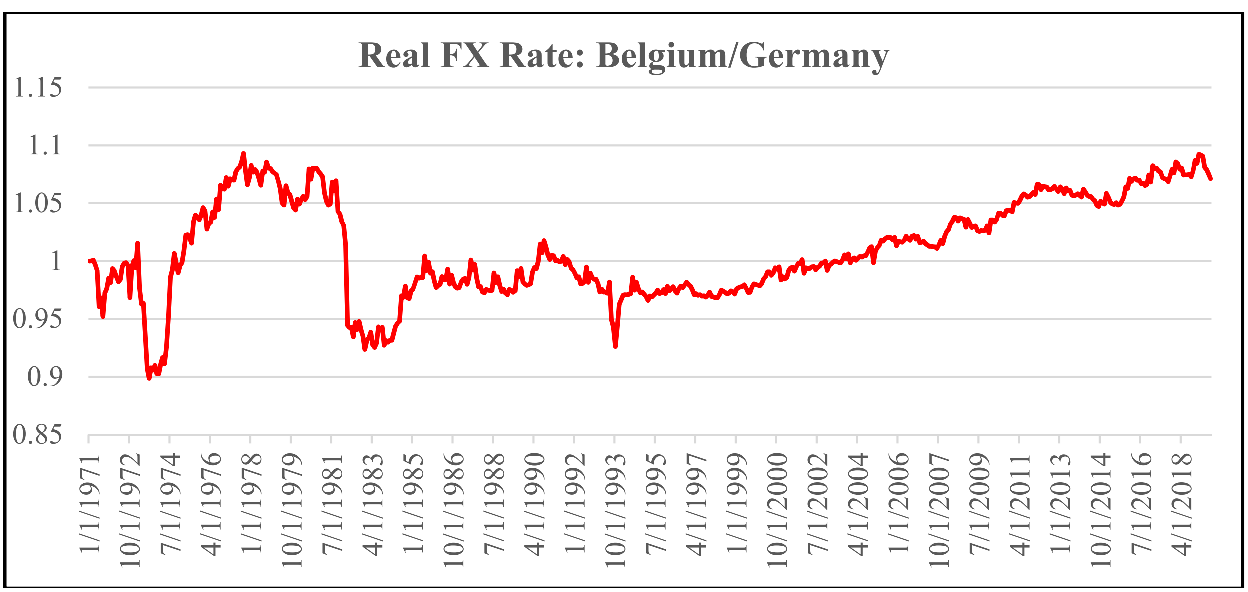


Clearly, $\mathbf{R_t}$ is not constant! In general, we have some evidence for *mean reversion* for $\mathbf{R_t}$ in the long run. Loosely speaking, $\mathbf{R_t}$ moves around some mean number, which we associate with a *long-run PPP parity* (for the JPY/USD the average $\mathbf{R_t}$ is 0.77). But, the deviations from the long-run PPP parity are very *persistent* –i.e., very slow to adjust. Note that the deviations from long-run PPP parity can be big (up to 66% from the mean) and happen in every decade.

Economists usually report the number of years that a PPP deviation is expected to decay by 50% (the *half-life)* is in the range of 3 to 5 years for developed currencies. Very slow!

Note that even for currencies with a fixed exchange rate, like Belgium and Germany, $\mathbf{R_t}$ is not constant, as illustrated in Figures 8.8-B.

Figure 8.8-B: Real Exchange Rate between Belgium and Germany (1970-2019)



2. Statistical Evidence

Let's look at the usual descriptive statistics for $(I_d - I_f)_t$ and $e_{f,t}$ using the 1974-2022 monthly data used above. For the JPY/USD, they have similar means, but quite different standard deviations (look at the very different minimum and maximum stats). A simple t-test for equality of means (t-test=-0.34) cannot reject the null hypothesis of equal means, which is expected given the large SDs, especially for $e_{f,t}$.

	I_{JP}	I_{US}	I_{US}-I_{JP}	$e_{f,T}$ (JPY/USD)	R_t
Mean	**0.00125**	**0.00303**	**-0.00179**	**-0.00139**	**0.7676**
SD	**0.00485**	**0.00322**	**0.00502**	**0.02622**	**0.1582**
Min	-0.01095	-0.01786	-0.01981	-0.08065	0.4295
Median	0.00102	0.00266	-0.00184	0.00022	0.7477
Max	0.02558	0.01420	0.02104	0.08066	1.3717

If we think of the average over the whole sample, as a long-run value, we cannot reject PPP in the long-run! But, the average relation over the whole sample is not that informative, especially with such a big SD. We are more interested in the short-run, in the contemporaneous relation between $e_{f,T}$ and $(I_d - I_f)_t$. That is, what happens to $e_{f,T}$ when $(I_d - I_f)_t$ changes?

To test the contemporaneous relation we have a more formal test, a regression:

$$e_{f,T} = (S_{t+T} - S_t)/S_t = \alpha + \beta\,(I_d - I_f)_T + \varepsilon_T, \quad \text{(where } \varepsilon_T \text{ is the regression error, } E[\varepsilon_T]=0).$$

The null hypothesis is: H_0 (Relative PPP holds): $\alpha=0$ & $\beta=1$

H_1 (Relative PPP does not hold): $\alpha\neq0$ and/or $\beta\neq1$

Tests: t-test (individual tests on the estimated α and β) and F-test (joint test):

(1) t-test = $t_{\theta=\theta_0} = [\hat{\theta} - \theta_0] / \text{S.E.}(\hat{\theta}) \sim t_v$ (v = N – K = *degrees of freedom*).

(2) $$F = \frac{[\text{RSS}(H_0) - \text{RSS}(H_1)]/J}{\text{RSS}(H_1)/(N-K)} \sim F_{J,N-K}$$ (J = # of restrictions in H_0).

Notation for tests:

$\theta = (\alpha, \beta)$

$\hat{\theta}$ = Estimated θ

e_t = residuals = $e_{f,t} - [\hat{\alpha} + \hat{\beta}\,(I_d - I_f)_t]$

H_0 (theory is true): $\theta = \theta_0$

N = # of observations

K = # of parameters in our model, in the PPP case 2: (α, β)

RSS = Residual Sum of Squares = $\Sigma_t (e_t)^2$.

J = # of restrictions in H_0, in the PPP case 2: **α=0** & **β=1** .
α = significance level –most popular, α =.05 (5 %).
t_v = t-distribution with *v degrees of freedom* (df). (When $v > 30$, it follows a normal).
$F_{J,N-K}$ = F-distribution with J df in the numerator and (N – K) df in the denominator.

Rules for tests:
If |t-test| > $|t_{v,\alpha/2}|$, reject H_0 at the α level. (When α = .05 & $v > 30$, $\mathbf{t_{.025}}$ = **1.96**.)
If F-test > $F_{J,N-K,\alpha}$, reject H_0 at the α level. (When α = .05 & (N – K) > 300, $\mathbf{F_{2,300+,.05}} \approx$ **3**.)

Example: We want to test relative PPP for the JPY/USD exchange rate (we use α = .05). We use the monthly Japanese and U.S. data from the graph (1/1975 - 12/2022). We fit the following regression:

$$e_{f,T} \text{ (JPY/USD)} = (S_t - S_{t-1})/S_{t-1} = \alpha + \beta\ (I_{JAP} - I_{US})_t + \varepsilon_t .$$

R^2 = 0.005621
Standard Error (σ) = .02617
F-stat (slopes=0 –i.e., **β=0**) = 3.244 (*p-value* = 0.07219)
F-test (H_0: **α=0** and **β=1**) = **19.185** (*p-value*: lower than 0.0001) ⇒ reject at 5% level ($\mathbf{F_{2,574,.05}}$ = **3.01**)
Observations = 576

	Coefficients	Stand Error	t Stat	P-value
Intercept ($\hat{\alpha}$)	-0.00209	0.001157	-1.804	0.0717
($I_{JAP} - I_{US}$) ($\hat{\beta}$)	-0.39148	0.217343	-1.801	0.0722

Note: You can find this example in my homepage: www.bauer.uh.edu/rsusmel/4386/ppp-example.xls

Let's test H_0, using t-tests ($t_{580,.025}$ = **1.96** –when N – K > 30, $t_{.05}$ = **1.96**):
$t_{\alpha=0}$ (t-test for **α = 0**): (-0.00209 – 0)/ 0.00116 = -1.804 (*p-value* = .072) ⇒ cannot reject at the 5% level
$t_{\beta=1}$ (t-test for **β = 1**): (-0.39148 – 1)/ 0.21734 = -6.402 (*p-value* < .00001) ⇒ reject at the 5% level

Let's test H_0, using the F-test ($F_{2,574,.05}$ = **3.01**):
RSS(H_0) = 0.4211
RSS(H_1) = 0.3930
J = 2; (N – K) = 574
F-test = {[0.4211 – 0.3930]/2}/{0.3930/579} = **19.185** > **3.015** ⇒ reject at the 5% level.

Regression Notes:
- If we look at the R^2, the variability of monthly ($I_{JAP} - I_{US}$) explain very little, 0.01%, of the variability of monthly $e_{f,T}$.
- We can modify the regression to incorporate the Balassa-Samuelson effect, by incorporating GDP differentials. For example:

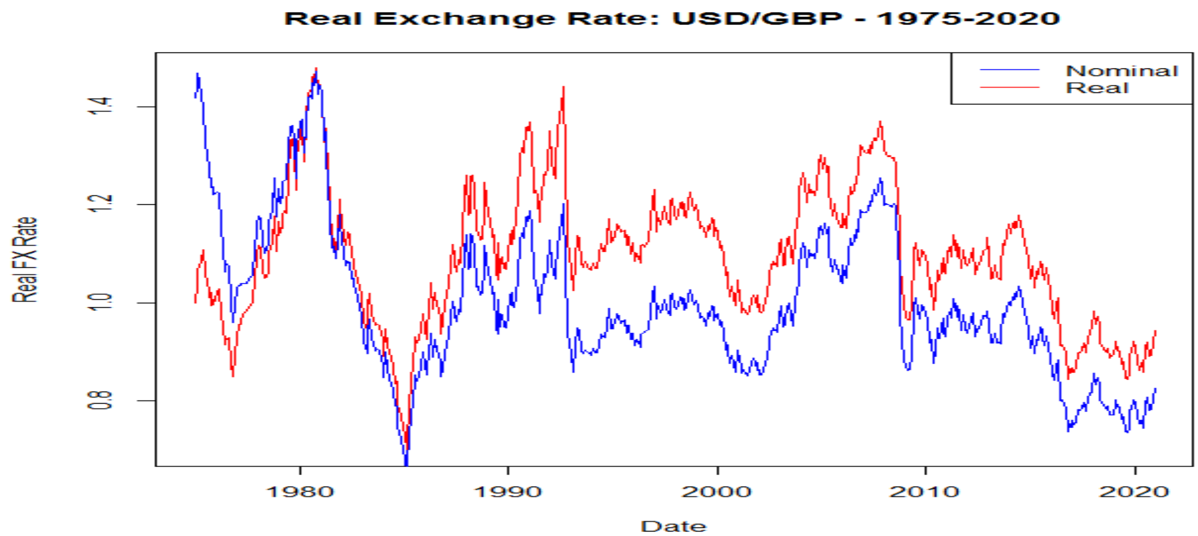
$$e_{f,T} \text{ (JPY/USD)} = \alpha + \beta\ (I_{JAP} - I_{US})_t + \delta\ (GDP_{cap,JAP} - GDP_{cap,US})_t + \varepsilon_t. \text{¶}$$

Relative PPP tends to be rejected in the short-run (like in the example above). In the long-run, there is a debate about its validity. As mentioned above there is some evidence of (slow) mean reversion. In the long-run, inflation differential matter: Currencies with high inflation rate differentials tend to depreciate.

• PPP: R_t and S_t

Research shows that R_t is much more variable when S_t is allowed to float. R_t's variability tends to be highly correlated with S_t's variability. This finding comes from Mussa (1986).

Figure 8.9: Nominal and Real Exchange Rate for the USD/GBP (1970-2020)



In Figure 8.9, above, we see the finding of Mussa (1986) for the USD/GBP exchange rate: After 1973, when floating exchange rates were adopted, R_t moves like S_t. As a check to the visual evidence: the monthly volatility of changes in R_t is 2.706% and the monthly volatility of changes in S_t is 2.622%, with a correlation coefficient of .983. Almost the same!

Recall that economists tend to think that nominal variables can affect nominal variables, but not real variables. The above graph shows that S_t moves like R_t, which we think is affected by real factors. We can incorporate real factors into the determination of S_t (using the definition of R_t, we solve S_t):

$$S_t = R_t \; P_d / P_f.$$

Now, we have S_t affected by real factors (through R_t) and nominal factors (through P_d / P_f).

• PPP: Sticky Prices

From the above USD/GBP graph, which is representative of the usual behavior of R_t and S_t, we infer that price levels play a minor role in explaining the movements of R_t (& S_t). Prices are *sticky/rigid* –i.e., they take a while to adjust to shocks/disequilibria.

A potential justification for the implied price rigidity: NT goods. Price levels include traded and NT goods; traded-goods should obey the LOOP. But, Engel (1999) and others report that prices are sticky also for traded-goods (measured by disaggregated producer price indexes). A strange result for many of us that observe gas prices change frequently!

Possible explanations:
(a) Contracts
Prices cannot be continuously adjusted due to contracts. In a stable economy, with low inflation, contracts may be longer. We find that economies with high inflation (contracts with very short duration) PPP deviations are not very persistent.

(b) Mark-up adjustments
There is a tendency of manufacturers and retailers to moderate any increase in their prices in order to preserve their market share. For example, changes in S_t are only partially transmitted or *pass-through* to import/export prices. The average ERPT (exchange rate pass-through) is around 50% over one quarter and 64% over the long run for OECD countries (for the U.S., 25% in the short-run and 40% over the long run). The average ERPT seems to be declining since the 1990s. Income matters: ERPT tends to be bigger in low income countries (2-3 times bigger) than in high countries.

(c) Repricing costs (*menu costs*)
It is expensive to adjust continuously prices; in a restaurant, the repricing cost is re-doing the menu. For example, Goldberg and Hallerstein (2007) estimate that the cost of repricing in the imported beer market is 0.4% of firm revenue for manufacturers and 0.1% of firm revenue for retailers.

(d) Aggregation
Q: Is price rigidity a result of aggregation –i.e., the use of price index? Empirical work using detailed micro level data –say, same good (exact UPC barcode!) in Canadian and U.S. grocery stores– show that on average product-level $\mathbf{R_t}$ –i.e., constructed using the same traded goods– move closely with S_t. But, individual micro level prices show a lot of idiosyncratic movements, mainly unrelated to S_t: Only 10% of the deviations from PPP are accounted by S_t.

• PPP: Puzzle
The fact that no single model of exchange rate determination can accommodate both the high persistent of PPP deviations and the high correlation between R_t and S_t has been called the "*PPP puzzle.*" See Rogoff (1996).

• PPP: Summary of Empirical Evidence
- R_t and S_t are highly correlated, domestic prices (even for traded-goods) tend to be sticky.
- In the short run, PPP is a very poor model to explain short-term exchange rate movements.
- PPP deviation are very persistent. It takes a long time (years!) to disappear.
- In the long run, there is some evidence of mean reversion, though very slow, for R_t. That is, $\mathbf{S_t^{PPP}}$ has long-run information: Currencies that consistently have high inflation rate differentials –i.e., (I_d-I_f) positive- tend to depreciate.

The long-run interpretation for PPP is the one that economist like and use. PPP is seen as a benchmark, a figure towards which the current exchange rate should move.

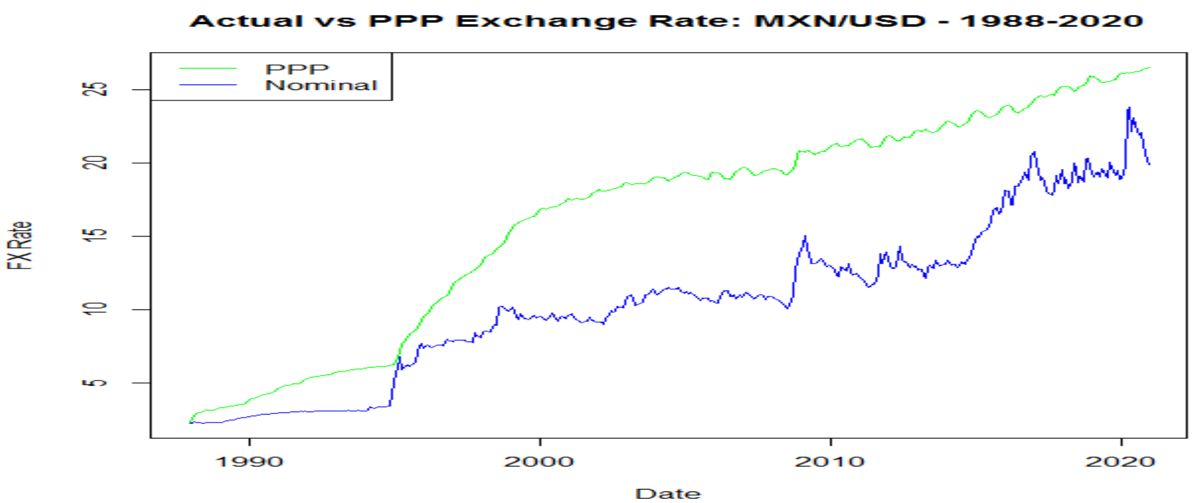
• **Calculating S_t^{PPP} (Long-Run FX Rate)**
We want to calculate $S_t^{PPP} = P_{d,t} / P_{f,t}$ over time. Steps:
(i) Divide and multiply S_t^{PPP} by $S_{t=0}^{PPP} = P_{d,o}/P_{f,o}$ (where t=0 is our starting point or base year).
(ii) After some algebra,

$$S_t^{PPP} = S_{t=0}^{PPP} * [P_{d,t} / P_{d,o}] * [P_{f,o}/P_{f,t}]$$

By assuming $S_{t=0}^{PPP} = S_o$, we can plot S_t^{PPP} over time. (Note: $S_{t=0}^{PPP} = S_o$ assumes that at time 0, the economy was in *equilibrium*. This may not be true. That is, be careful when selecting a base year.)

Figure 8.10 plots S_t^{PPP} and S_t for the MXN/USD exchange rate during the 1987-2020 period. During the sample, Mexican inflation rates were consistently higher than U.S. inflation rates –actually, 322% higher during the sample period). Relative PPP predicts a consistent appreciation of the USD against the MXM.

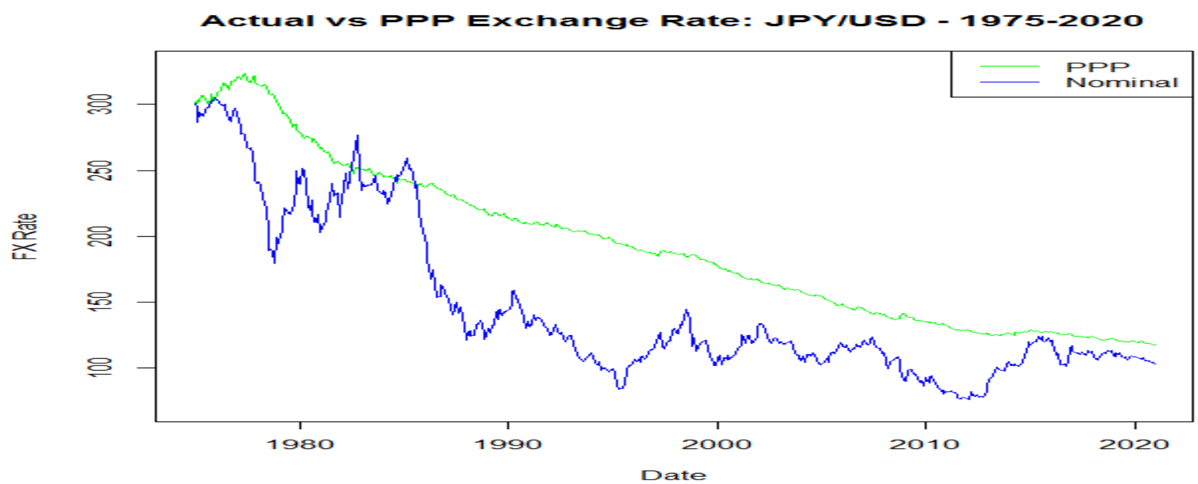
Figure 8.10: S_t^{PPP} and S_t for the MXN/USD (1987-2020)



In the short-run, Relative PPP is missing the target, S_t. But, in the long-run, PPP gets the trend right. (As predicted by PPP, the high Mexican inflation rates differentials against the U.S depreciate the MXN against the USD.)

Similar behavior is observed for the JPY/USD, as shown in Figure 8.11. The inflation rates in the U.S. have been consistently higher than in Japan (57% higher during the period), then, according to Relative PPP, the USD should depreciate against the JPY. PPP gets the long term trend right, but misses S_t in the short-run.

Figure 8.11: S_t^{PPP} and S_t for the JPY/USD (1971-2019)



Note that in both graphs, $\mathbf{S_t^{PPP}}$ is smoother than S_t.

• **PPP: Summary of Applications**

◇ Equilibrium ("*long-run*") exchange rates. A CB can use $\mathbf{S_t^{PPP}}$ to determine intervention bands.

◇ Explanation of S_t movements ("currencies with high inflation rate differentials tend to depreciate").

◇ Indicator of competitiveness or under/over-valuation: $\mathbf{R_t} > 1 \Rightarrow$ FC is overvalued (& Foreign prices are not competitive).

◇ International GDP comparisons: Instead of using S_t, $\mathbf{S_t^{PPP}}$ is used. (An additional advantage: since $\mathbf{S_t^{PPP}}$ is smoother, GDP comparisons will not be subjected to big swings.) For example, per capita GDP (IMF figures, in 2025) are reported below in Table 8.1:

Table 8.1: GDP per capita in Nominal and PPP Prices (in USD) – 2025

Country	GDP per capita (in USD) - 2025	
	Nominal	*PPP*
Luxembourg	140,941	152,915
USA	89,105	89,105
Japan	33,956	54,677
Costa Rica	19,095	31,463
Brazil	9,964	23,239
China	**13,688**	**28,978**
Vietnam	4,806	17,612
Algeria	5,691	18,525
Ethiopia	1,066	4,398
Mozambique	663	1,729

Example: Nominal vs PPP - Calculations for China

Data:

Nominal GDP per capita: CNY 98,404.03

S_t = **0.1391 USD/CNY**;
$\mathbf{S_t^{PPP}}$ = **0.2944 USD/CNY** $\quad (= P_{d=US}/P_{f=Ch})$
$\mathbf{R_t}$ = S_t / S_t^{PPP} = **0.1391**/**0.2944** = 0.4724864
⇒ "goods in the U.S. are 52.76% more expensive than in China."

- Nominal GDP_cap (USD) = CNY 98,404.03 * **0.1391 USD/CNY** = **USD 13,688**
- PPP GDP_cap (USD) = CNY 98,404.03 * **0.2944 USD/CNY** = **USD 28,978.**
⇒ "One USD has 111% more purchasing power in China." ¶

Chapter 8 - Appendix – Taylor Series

Definition: Taylor Series

Suppose f is an infinitely often differentiable function on a set $\boldsymbol{D}$ and $c \in \boldsymbol{D}$. Then, the series

$$T_f(x, c) = \Sigma_n \,[\, f^{(n)}(c)/n!\,]\,(x - c)^n$$

is called the (formal) *Taylor series* of f centered at, or around, c.

Note: If c=0, the series is also called *MacLaurin Series.*

Taylor Series Theorem

Suppose $f \in C^{n+1}([a, b])$ -i.e., f is $(n+1)$-times continuously differentiable on $[a, b]$. Then, for $c \in [a,b]$ we have:

$$f(x) = T(x,c) + R = \frac{f(c)}{0!}(x-c)^0 \;+\; \frac{f^{/}(c)}{1!}(x-c)^1 \;+\frac{f^{//}(c)}{2!}(x-c)^2 \;+\ldots+\; \frac{f^{(n)}(x_0)}{n!}(x-x_0)^n \;+R$$

$$\text{where } R_{n+1}(x) = \frac{1}{n!}\int f^{(n+1)}(p)(x-p)^n dp$$

In particular, the $T_f(x, c)$ for an infinitely often differentiable function f converges to f iff the remainder $R_{(n+1)}(x)$ →converges to 0 as $n \to \infty$.

Example: 1st-order Taylor series expansion, around c=1, of f(x)=5+2x + x^2

$f(x) = 5+2x + x^2$	$f(x_0=1) = 8$
$f'(x) = 2 + 2x$	$f'(x_0=1) = 4$
$f''(x) = 2$	$f''(x_0=1) = 2$
$f'''(x) = 0$	$f'''(x_0=1) = 0$

⇒ 1st-order Taylor's series formula (n=1):

$$f(x) \approx T(x; c) = 8 + 4\,(x-1) = 4 + 4x$$

• Now, for the Relative PPP approximation, we use a Taylor series expansion, $T_f(x, c)$, for a bivariate series:

$$T(x,y,c,d) = \frac{f(c,d)}{0!}(x-c)^0(y-d)^0 \;+\; \frac{f_x(c,d)}{1!}(x-c)^1 \;+\; \frac{f_y(c,d)}{1!}(y-d)^1 \;+$$
$$+\;\frac{1}{2!}[\,f_{xx}(c,d)(x-c)^2 + f_{xy}(c,d)(x-c)(y-d) + f_{yy}(c,d)(y-d)^2\,] + \ldots$$

Example: Taylor series expansion, around d=c=0, of f(x,y) = [(1+x)/(1+y)] -1

f(x,y)= [(1+x)/(1+y)] – 1 $\Rightarrow f(c=0,d=0)$ = [(1+0)/(1+0)] - 1 = 0

f_x = 1/(1+y) $\Rightarrow f_x(c=0,d=0)$ = 1

f_x = (-1)(1+x)/(1+y)^2 $\Rightarrow f_y(c=0,d=0)$ = -1

$\Rightarrow$ 1st-order Taylor's series formula:

$$f(x,y) \approx T(x,y; c,d) = 0 + 1\,(x-0) + (-1)\,(y-0) = x - y$$

Application to Relative PPP: $e_{f,T}^{PPP} = [(1 + I_d)/(1 + I_f)] - 1 \approx (I_d - I_f)$ ¶

Chapter 8 – Measuring the Role of NT Goods

We go back to the log definition of the real exchange rate, r_t:

$$r_t = s_t + p_{f,t} - p_{d,t}$$

The log price index, p_t, is influenced by NT goods and T goods. Suppose the proportion of NT in the price basket is α_N. Then, we can write the (log) price index as:

$$p_t = \alpha_N\, p_{NT,t} + (1 - \alpha_N)\, p_{T,t}\,,$$

where $p_{NT,t}$ is the log price of NT goods and $p_{T,t}$ is the log price of Traded goods.

After some algebra, and assuming α_N, is the same at home and in the foreign country, we get:

$$\begin{aligned} r_t = s_t + p_{f,t} - p_{d,t} &= s_t + \alpha_N\, p_{f,,NT,t} + (1 - \alpha_N)\, p_{f,,T,t} - \alpha_N\, p_{d,NT,t} - (1 - \alpha_N)\, p_{d,T,t} \\ &= s_t + \alpha_N\, (p_{f,NT,t} - p_{d,NT,t}) + (1 - \alpha_N)\, (p_{f,,T,t} - p_{d,T,t}) \\ &= s_t + (p_{f,T,t} - p_{d,T,t}) + \alpha_N\, \{(p_{f,NT,,t} - p_{f,T,t}) - (p_{d,NT,t} - p_{d,T,t})\} \end{aligned}$$

That is, the real exchange rate is affected by traded and NT goods. If PPP holds for traded goods, $s_t + (p_{f,T,t} - p_{d,T,t}) = 0$, then, the real exchange is a function of the relative prices of NT goods to traded goods in foreign and domestic markets:

$$r_t = \alpha_N\, \{(p_{f,NT,,t} - p_{f,T,t}) - (p_{d,NT,t} - p_{d,T,t})\}$$

It is possible to introduce into the model, domestic (home) production and consumption of traded goods. In this case, we define the traded goods log price as a weighted sum of the log prices of traded goods produced (and consumed) at home, $p_{TH,t}$, and traded goods produced in the foreign country and consumed in the home market, $p_{TF,t}$:

$$p_{T,t} = (\gamma/2)\, p_{TH,t} + (2 - \gamma)/2\, p_{TF,t}$$

where $(\gamma/2)$ is the proportion of traded good consumed in the home country that is produced in the home country. There is a "*home bias*" in consumption if $\gamma > 1$. Similar definition applies to foreign T goods prices.

$$\begin{aligned} r_t &= s_t + \alpha_N\, (p_{f,NT,t} - p_{d,NT,t}) + (1 - \alpha_N)\, (p_{f,,T,t} - p_{d,T,t}) \\ &= s_t + \alpha_N\, (p_{f,NT,t} - p_{d,NT,t}) + (1 - \alpha_N)\, \{[(\gamma_f/2)\, p_{f,TH,t} + (2 - \gamma_f)/2\, p_{f,TF,t}] - [(\gamma_d/2)\, p_{d,TH,t} + (2 - \gamma_d)/2\, p_{d,TF,t}]\} \end{aligned}$$

A home bias can affect PPP. If we assume no home bias (γ =1), then the real exchange rate is also a function of pricing to market in traded goods, in both markets:

$$r_t = s_t + \alpha_N (p_{f,NT,t} - p_{d,NT,t}) + (1 - \alpha_N)/2 \{[p_{f,TH,t} + p_{f,TF,t}] - [p_{d,TH,t} + p_{d,TF,t}]\}.$$

Chapter 8 – Measuring Persistence

We estimate a regression for R_t using as explanatory variable R_{t-1} –i.e., the lagged real exchange rate:

$$R_t = \mu + \rho R_{t-1} + \varepsilon_t,$$

In finance and economics, this very simple equation describes the behavior over time of a lot of variables. Given this equation, we use ρ as a measure of persistence.

Three cases:

(1) If ρ=0, past R_t's have no effect on today's R_t. There is no dynamics in R_t; no persistence of shocks to the real exchange rate –i.e., full adjustment to long-run PPP parity:

$$R_t = \mu + \varepsilon_t,$$

In this case, it is easy to calculate long-run PPP parity –i.e., the mean of R_t over time:

$$E[R_t] = \mu \qquad \text{(since } E[\varepsilon_t]=0).$$

Suppose last period there was a shock that deviate R_t from PPP parity. If ρ=0, last period's shock has no effect on today's R_t .On average, we are on the long run PPP parity, given by μ:

$$E_t[R_t] = \mu \qquad \text{(since } E_t[\varepsilon_t]=0.)$$

(2) If 0<ρ<1, there is a gradual adjustment to shocks, depending on ρ. The higher ρ, the slower the adjustment to long run PPP parity. Shocks are persistent. On average:

$$E_t[R_t] = \mu + \rho R_{t-1}$$

With a little bit of algebra we can calculate the mean of R_t over time:

$$E[R_t] = \mu + \rho E[R_{t-1}] \qquad \Rightarrow E[R_t] = \mu/(1- \rho)$$

(3) If ρ=1, we say that the process generating R_t contains a *unit root*. We also say R_t follows a *random walk* process. Shocks never disappear! On average:

$$E_t[R_t] = \mu + R_{t-1}$$

In this case, changes in R_t are predictable: on average, they would be equal to the estimated value μ:

$$E[R_t - R_{t-1}] = \mu \qquad \text{(since } E[\varepsilon_t]=0.)$$

But R_t would, however, not be predictable, even in the long run. Notice that the change each period would be equal to a constant plus an unpredictable random element, ε_t. In the long-run, R_t will be equal to the sum of the constant μ each period plus the sum of the ε_t's.

Half-life (H): how long it takes for the initial deviation from $\mathbf{R_t}$ and $\mathbf{R_{t=\infty}}$ (long run PPP parity) to be cut in half. It is estimated by

$$H = -\ln(2)/\ln(\rho)$$

Example: JPY/USD Real exchange rate (Monthly data from 1971–2013)

We estimate a regression for $\mathbf{R_t}$:

$$\mathbf{R_t} = \boldsymbol{\mu} + \rho\, \mathbf{R_{t-1}} + \varepsilon_t,$$

Regression Statistics	
Multiple R	0.986754
R Square	0.973682
Adjusted R Square	0.973631
Standard Error	0.032929
Observations	515

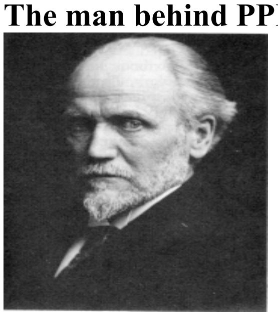
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept ($\boldsymbol{\mu}$)	0.017278	0.006803	2.539632	0.011391
$\mathbf{R_{t-1}}$ (ρ)	0.982179	0.007129	137.7669	0

Calculation of H: H = - ln(2)/ln(.982179) = 38.547 months (or 3.2122 years).

Note: ρ is very high $\Rightarrow$ slow adjustment (high persistence of shocks –i.e., PPP deviations!)

$E[\mathbf{R_t}]$ = long-run PPP parity = $\boldsymbol{\mu}/(1-\rho) = 0.017278/(1 - .982179) = 0.96953$. ¶

The man behind PPP - Karl Gustav Cassel, Sweden (1866 – 1945)



Apart from PPP theory, he produced an 'overconsumption' theory of the trade cycle (1918). He also worked on the German reparations problem. Two of his students, Ohlin and Myrdal, won the Nobel Prize in Economics.

Chapter 8 - Theories of FX Determination – Part 2

Goal: Get a formula for S_t. S_t = f(i_d, i_f, I_d, I_f,…)

• Review from Chapter 8 – Part 1:
Effect of LOOP (arbitrage through trade) on FX Markets.
Derive "equilibrium" (i.e., no-trade) S_t:

Absolute PPP: $S_t = P_d / P_f$ (Rejected, existence of transaction costs, borders a problem)

Relative PPP: $e_{f,} \approx I_d - I_f$ (Rejected in the short-run, some long-run support)

• In this class, we will continue the search for a functional form that explains S_t. We will go over IFE, another pseudo-arbitrage theory, and the expectations hypothesis, which actually is about the expected value of S_{t+T}.

8.2. International Fisher Effect (IFE)

IFE builds on the law of one price, but for financial transactions.

Idea: Expected returns to international investors who invest in money markets in their home country should be equal to the expected returns they would get if they invest in foreign money markets once adjusted for currency fluctuations. Exchange rates will be set in such a way that international investors cannot profit from interest rate differentials.

The "effective" T-day return on a foreign bank deposit is:

$$r_f \text{ (in DC)} = \left(1 + i_f * \frac{T}{360}\right)(1 + e_{f,T}) - 1.$$

On the other hand, the effective T-day return on a home bank deposit is:

$$r_d \text{ (in DC)} = i_d * T/360.$$

Setting r_d (in DC) = r_f (in DC) and solving for $e_{f,T}$ (= $e_{f,T}^{IFE}$) we get:

$$e_{f,T}^{IFE} = \frac{\left(1 + i_d * \frac{T}{360}\right)}{\left(1 + i_f * \frac{T}{360}\right)} - 1 \qquad \text{(IFE)}.$$

Using a linear approximation: $e_{f,T}^{IFE} \approx (i_{d,t+T} - i_{f,t+T}) * T/360.$

$e_{f,T}^{IFE}$ represents an expectation –i.e., $E[e_{f,,T}]$. It's the expected change in S_t from t to t+T that makes looking for the "extra yield" in international money markets not profitable.

Since the investors equalize expected returns, IFE assumes the international investors are *risk neutral* – i.e., they pay no attention to the riskiness of a FC investment. Under risk-aversion, a risk premium would be demanded!

If $e_{f,T} = e^{IFE}_{f,T}$ ⇒ No profits from *carry trades* –i.e., borrow the low interest rate currency, convert it to the currency with the higher interest rate and deposit at the higher interest rate. An investor would get the same expected return investing at the low interest rate, since the currency appreciation would compensate for the lower interest rate yield.

IFE Notes:
- Like PPP, IFE is built on implied assumptions (no barriers to capital mobility, no country risk, no default risk, no preference for domestic (certain) investments, etc.)
- IFE also produces an *equilibrium* exchange rate (EER). Equilibrium will be reached when there is no capital flows from one country to another to take advantage of interest rate differentials. The equilibrium S^{IFE}_{t+T} is:

  $S^{IFE}_{f+T} = S_t * (1 + e^{IFE}_{f,T})$ (Again, S^{IFE}_{f+T} represents an expectation –i.e., $S^{IFE}_{f+T} = E_t[S_{t+T}]$.)

Example: Forecasting S_t using IFE.
You work for Euroland Inc., a German manufacturer. You have the following information: $i_{USD,2022:I}$=1%, $i_{EUR,2022:I}$=0.5%, and **$S_{2022:I}$=1.1659 USD/EUR**. You want to forecast $S_{2003:II}$ using IFE.

$$E[S_{2022:II}] = S^{IFE}_{t,\,T=2022:II} = S_{2022:I} * \frac{(1 + i_{USD,2022:I} * \frac{T}{360})}{(1 + i_{EUR,2022:I} * \frac{T}{360})}$$

$$= \mathbf{1.1659\ USD/EUR} * \frac{(1 + 0.01 * \frac{184}{360})}{(1 + 0.005 * \frac{184}{360})} = \mathbf{1.168872\ USD/EUR}$$

That is, for the second semester of 2022, IFE expects an appreciation of the EUR against the USD. This appreciation of the EUR compensates EUR deposits for the higher interest rates in the U.S.¶

• IFE: Implications

If IFE holds, the expected cost of borrowing funds is identical across currencies. Also, the expected return of lending is identical across currencies.

Carry trades –i.e., borrowing the low interest currency to invest in the high interest currency- should not be profitable. But, if departures from IFE are consistent, investors can profit from them.

Example: Mexican peso depreciated by 5% a year during the early 90s.
Annual interest rate differential ($i_{MEX} - i_{USD}$) ranged between 7% and 16%.
The $E[e_{f,T}]$ = -5% > $e^{IFE}_{f,T}$ ⇒ Pseudo-arbitrage is possible (According to IFE, the MXN at t+T is overvalued!)

Carry Trade Strategy:
1) Borrow USD funds (at $i_{d=USD}$)
2) Convert to MXN at S_t
3) Invest in Mexican funds (at $i_{f=MXN}$)
4) *Wait until T*. Then, convert back to USD at S_{t+T}. (<= There is risk in waiting!)

Expected foreign exchange loss 5% ($E[e_{f,T}]$ = -5%)

Assume ($i_{USD} - i_{MXN}$) = -7%. (For example: i_{USD} = 5%, i_{MXN} = 12%, (T=1 year).)
The E[$e_{f,T}$] = -5% > $e_{f,T}^{IFE}$ = -7% ⇒ "on average" strategy (1)-(4) should work.

Expected return (MXN investment):

r_d (f) = (1 + i_{MXN} * T/360) * (1 + $e_{f,T}$) -1 = (1 + .12) * (1 - .05) -1 = 0.064

Payment for USD borrowing

r_d (d) = i_d * T/360 = .05 (Expected Profit = .014 per year)

Overall expected profits ranged from: 1.4% to 11%.

Note: Fidelity used this uncovered strategy during the early 90s. In Dec. 94, after the Tequila devaluation of the MXN against the USD, lost everything it gained before. Not surprised, after all the strategy is a "pseudo-arbitrage" strategy! These extreme risks are usually described as *crash risk.* ¶

The IFE pseudo-arbitrage strategy differs from covered arbitrage in the final step. Step (4) involves no coverage. It's an uncovered strategy. IFE is also called *Uncovered Interest Rate Parity* (UIRP).

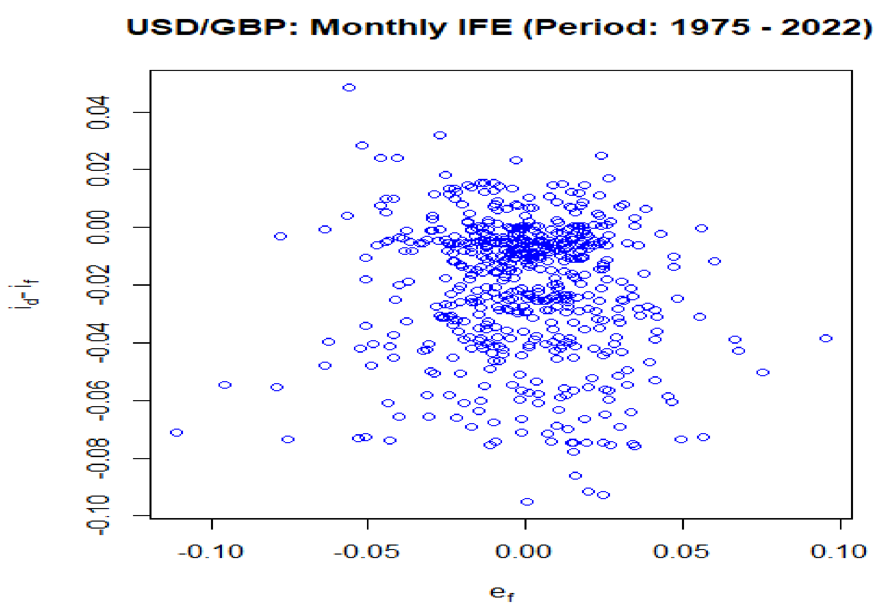
• IFE: Evidence

Testing IFE: Similar to PPP.

1. *Visual evidence*. Based on linearized IFE: $e_{f,T} \approx (i_d - i_f)_t$* T/360

Expect a 45 degree line in a plot of $e_{f,T}$ against $(i_d - i_f)_t$ ⇒ usually, rejects IFE.

Example: IFE plot for the monthly USD/GBP exchange rate (1975:Jan – 2022:December).



No 45 degree line ⇒ Visual evidence rejects IFE. ¶

2. *Do a regression*

$e_{f,T} = (S_{t+T} - S_t)/S_t = \alpha + \beta\ (i_d - i_f)_t + \varepsilon_t$ (where ε_t is the regression error, E[ε_t]=0).

The null hypothesis is: H_0 (IFE true): $\alpha = 0$ & $\beta = 1$
H_0 (IFE not true): $\alpha \neq 0$ and/or $\beta \neq 1$

Example: Testing IFE for the USD/GBP with monthly data (**1975 - 2022**).

$R^2 = 0.00577$

Standard Error = 0.002377

F-statistic (slopes=0) = 3.33 (*p-value* = 0.0686)

F-test (α=0 and β=1) = **182.4331** (*p-value* = lower than 0.0001)

$\Rightarrow$ rejects H_0 at the 5% level ($F_{2,193,.05}$ = **3.05**)

Observations = 576

	Coefficients	*Stand Error*	*t-Stat*	*P-value*
Intercept ($\hat{\alpha}$)	**-0.002676**	**0.001305**	-2.051	0.0408
($i_{USD} - i_{EUR}$) ($\hat{\beta}$)	**-0.077150**	**0.042590**	-1.825	0.0686

Let's test H_0, using t-tests ($t_{104,.05} = 1.96$) :

$t_{\alpha=0}$ (t-test for $\alpha = 0$): $(\mathbf{0.002676} - 0)/\mathbf{0.00194} = \mathbf{-2.051}$ $\Rightarrow$ cannot reject at the 5% level.

$t_{\beta=1}$ (t-test for $\beta = 1$): $(\mathbf{-0.077715} - 1)/\mathbf{0.04259} = \mathbf{-25.304}$ $\Rightarrow$ reject at the 5% level.

Formally, IFE is rejected in the short-run (both the joint test and the t-test reject H_0). Also, note that β is negative, not positive as IFE expects.

Note: During the 1975-2022 period, the average monthly ($i_{USD} - i_{GBP}$) was: **-1.9947%**/12 = **-0.166%**. That is, $e_{f,T}^{IFE}$ = **-0.166%** per month (IFE expects a 0.0003% monthly appreciation of the EUR, statistically speaking different from zero). But, the actual average monthly $e_{f,t}$ was **-0.113%** ($e_{f,t}$=0.11% per month; statistically speaking not different from zero), which is different from $e_{f,t}^{IFE}$.

If we use the regression to derive an expectation, the regression expects $E[e_{f,t}]$ = **-0.002676 - 0.077150***(-.019974) = **-0.00114**, which is very close to the sample average. That is, we expect a close to zero monthly change in the GBP against the USD. This zero change is still different from $e_{f,T}^{IFE}$.

Recall that consistent deviations from IFE point out that carry trades are profitable: During the 1975-2033 period, USD-EUR carry trades should have been profitable. ¶

Similar to PPP, there is no short-run evidence. As pointed out above, consistent IFE departures make carry trades profitable: Burnside (2008) show that the average excess return of an equally weighted carry trade strategy portfolio, based on up to 20 currencies and executed monthly over the period 1976–2007, was about 5% per year. Lower than excess returns for equity markets, but with a Sharpe ratio twice as big as the S&P500! (Annualized volatility of the carry trade returns was much less than that for stocks).

Big numbers! Usual explanation, the "risk-neutral" arbitrage strategy is not working! There are risks that

IFE is not taking into account.

But, again, similar to PPP, some long-run support for IFE:

⇒ Currencies with high interest rate differentials tend to depreciate.
(For example, the Mexican peso finally depreciated in Dec. 1994.)

8.3. Expectations Hypothesis of Exchange Rates

Expectations hypothesis (EH) of exchange rates:

$E_t[S_{t+T}] = F_{t,T}$.

Example: Suppose that over time, investors do not behave according to EH.
Data: **$F_{t,180}$ = 5.17 ZAR/USD.**
An investor expects: $E_t[S_{t+180}]$ = **5.34 ZAR/USD**. (A potential profit!)
Strategy for this investor:

1. Buy USD forward at **ZAR 5.17**
2. In 180 days, sell the USD for **ZAR 5.34.**

Now, suppose everybody expects $E_t[S_{t+180}]$ = **5.34 ZAR/USD**
⇒ *Disequilibrium*: Today, everybody buys USD forward. ($F_{t,180}$ ↑)
In 180 days, everybody will be selling USD. ($E_t[S_{t+180}]$↓)
⇒ Prices should adjust until EH holds.

Since an expectation is involved, sometimes you'll have a loss, but, on average, you'll make a profit. ¶

Key question behind EH: Are forward rates good predictors of future spot rates?

• Expectations Hypothesis: IFE (UIRP) Revisited

EH: $E_t[S_{t+T}] = F_{t,T}$.

Replace $F_{t,T}$ by IRP, say the linearized version:

$E_t[S_{t+T}] \approx S_t * [1 + (i_d - i_f) * T/360]$.

A little bit of algebra gives:

$(E[S_{t+T}] - S_t)/S_t \approx (i_d - i_f) * T/360$ <= IFE linearized!

• Expectations Hypothesis: Implications

$E_t[S_{t+T}] = F_{t,T} \Rightarrow F_{t,T}$ is an *unbiased* predictors of S_{t+T}.

That is, $S_{t+T} - F_{t,T}$ = unpredictable (surprise: $E_t[S_{t+T} - F_{t,T}] = E_t[\varepsilon_{t+T}] = 0$!). This result will be the basis for testing.

For a firm, EH means that the expected cash flows associated with hedging or not hedging currency risk are the same.

Example: You work for a company that wants to forecast the quarterly USD/GBP exchange rate. You are given the interest rate differential (in %) and S_t. Then, using IRP you calculate $F_{t,90}$:

$$F_{t,90} = S_t * [1 + (i_{USD} - i_{GBP})_t * T/360]. \qquad (\Rightarrow \mathbf{S^{EH}_{t+90}})$$

Suppose today it is the end of the second quarter of 2021 (2021:II). Data available:
$S_{t=2021:II}$ = 1.6883 USD/GBP
$(i_{US} - i_{UK})_{t=2021:II}$ = -0.304%.
Then,

$$F_{t,90} = 1.6883 \text{ USD/GBP} * [1 - 0.00304 * 90/360] = \mathbf{1.68702 \text{ USD/GBP}}$$

Then, you use $F_{t,90}$ to forecast S_{t+90} ($E_t[S_{t+90}] = \mathbf{S^{EH}_{t+90}}$). That is, $\mathbf{S^{EH}_{t+90}}$= 1.68702 USD/GBP.

You can also calculate the forecasting error, $\varepsilon_t = S_t$ - S^F_t, which you can use later to compare different forecasting models.

Doing this forecasting exercise each period generates the following quarterly forecasts and forecasting errors, ε_t:

Quarter	$(i_{US} - i_{UK})$	S_t	$\mathbf{S^{EH}_{t+90}} = \mathbf{F_{t,90}}$	$\varepsilon_t = S_t - S^F_t$
2020:II	-0.304	**1.6883**		
2020:III	-0.395	**1.6889**	**1.68702**	0.0019
2020:IV	-0.350	**1.5999**	**1.68723**	-0.0873
2020:I	-0.312	**1.5026**	**1.59850**	-0.0959
2021:II	-0.415	**1.5328**	**1.50143**	0.0314
2021:III	-0.495	**1.5634**	**1.53121**	0.0322
2021:IV		**1.5445**	**1.56146**	-0.0170

Calculation of the forecasting error for 2021:III: $\varepsilon_{t=2021:III}$ = **1.6889 -1.68702 =** 0.0019. ¶

• Expectations Hypothesis: Evidence
In general, expectations are unobservable. However, some companies and organizations survey "experts" and compile FX expectations (*Bloomberg*, in the U.S., *Japan Center for International Finance*, in Japan, *Banxico*, in Mexico, etc.). EH is not tested based on these surveys, but on the implications of the EH.

Under EH, $E_t[S_{t+T}] = F_{t,T} \qquad \Rightarrow E_t[S_{t+T}] - F_{t,T}] = 0$

Empirical tests of the EH are based on a regression:

$$(S_{t+T} - S_t)/S_t = e_{f,T} = \boldsymbol{\alpha} + \boldsymbol{\beta}\,(i_{US} - i_{UK})_t + \varepsilon_{t+T} \qquad \text{(where } E[\varepsilon_t] = 0)$$

where Z_t represents any economic variable that might have power to explain S_t, for example, $(i_d - i_f)$.

The null hypothesis is H_0: α=0 and β=0. (Recall (S_{t+T} - F_t) should be unpredictable!)

Usual Finding: $\beta < 0$ (and significant) when Z_t=(i_d-i_f). R^2 is low. In general, as the horizon increases (say, from 3-months to 5 years), β increases toward zero (also the significance of β decreases with the time horizon).

Note: EH can also be tested based on the Uncovered IRP (IFE) formulation:

$$(S_{t+T} - S_t)/S_t = e_{f,T} = \alpha + \beta\ (i_d - i_f)_t + \varepsilon_t$$

The null hypothesis is H_0: $\alpha = 0$ and $\beta = 1$.

Usual Result: $\beta < 0$ $\Rightarrow$ when ($i_d - i_f$) = 2%, the exchange rate appreciates by (β x .02) (instead of depreciating by 2% as predicted by UIRP!)

Example: Check the IFE test for the monthly USD/EUR. The estimated β was negative and significant (-0.26342). The R^2 was also low (0.057). ¶

Summary: Forward rates have little power for forecasting spot rates $\Rightarrow$ Puzzle!

8.3.1 Explanations for the Forward Bias

Explanation 1: Risk Premium

The risk premium of a given security is the return on this security, over and above the risk-free return.

Q: Is a risk premium justified in the FX market?
A: Only if exchange rate risk is not diversifiable.

After some simple algebra, we find that the expected excess return on the FX market is given by:

$$(E_t[S_{t+T}] - F_{t,T})/S_t = P_{t+T}.$$

A risk premium, P_{t+T}, in FX markets implies: $E_t[S_{t+T}] = F_{t,T} + S_t\ P_{t+T}$.

In general, we think of P_{t+T} as a function of the uncertainty related to S_{t+T} and the risk attitudes of investors (under risk neutrality, $P_{t+T} = 0$).

If P_{t+T}.is consistently different from zero, say positive, markets will display a forward bias.

Evidence for a risk premium: Weak.

Explanation 2: Errors in Forming Expectations

Investors make consistent errors in forecasting exchange rates.

$\Rightarrow$ It takes time for investors to learn about new market conditions.

Example: There is a new chairman on the Bank of Japan. It might take years to learn the Bank of Japan's new monetary policy. ¶

Explanation 3: The "Peso Problem"

For long periods of time investors assign a small (positive) probability to certain infrequent events (such as devaluations) which may never materialize in a limited sample period.

The expectation of such rare and extreme events will be reflected in today's forward exchange rate. The events may never materialize, but markets show a forward bias.

Example: The Mexican peso used to show a real and continuous appreciation until the Mexican government finally devalued the peso (generally after an election). Before the devaluation, the Mexican peso used to have a strong forward bias. ¶

8.4. The Martingale-Random Walk Model

A random walk is a time series independent of its own history. Your *last step* has no influence in your *next step*. The past does not help to explain the future.

(Technically, in a random walk process the uncorrelated steps are *independently and identically distributed* –i.e., they are independent and come from the same distribution. A martingale process only requires the steps to be uncorrelated.)

Intuitive notion: The FX market is a "*fair game*" –i.e., there are no exploitable trends.

• Martingale-Random Walk Model: Implications

The Martingale-Random Walk Model (RWM) implies:

$$E_t[S_{t+T}] = S_t$$

If S_t follows a RW, exchange rates cannot be forecasted: S_t is the forecast! That is, a firm should not spend any resources to forecast S_{t+T}.

Powerful theory: At time t, all the info about S_{t+T} is summarized by S_t. Only relevant information to forecast S_{t+T}: S_t $\Rightarrow$ Changes in S_t are unpredictable.

The RWM is an old model. It was first proposed by the French mathematician Bachelier in 1900 to describe the behavior of French bonds.

Theoretical Justification: Efficient Markets Hypothesis (EMH): All available information is incorporated into today's S_t. Under the practical version of the EMH, it is very difficult for investors to consistently obtain above average returns –i.e., forecast S_{t+T} consistently better than the competition.

Example: Forecasting with RWM
S_t= 1.60 USD/GBP
$E_t[S_{t+7\text{-day}}]$ = 1.60 USD/GBP
$E_t[S_{t+180\text{-day}}]$ = 1.60 USD/GBP
$E_t[S_{t+10\text{-year}}]$ = 1.60 USD/GBP.

Note: The forecast error is the change in exchange rates. That is, $\varepsilon_{t+T} = S_{t+T} - E_t[S_{t+T}] = S_{t+T} - S_t$. ¶

• Martingale-Random Walk Model: Evidence

Meese and Rogoff (1983, *Journal of International Economics*) tested the short-term forecasting performance of different models for the four most traded exchange rates. They considered economic models (PPP, IFE/UIRP, Monetary Approach, etc.) and the RWM.

⇒ They found that the RWM performed as well as any other model.
Metric used: MSE (mean squared error) ⇒ MSE = $\Sigma_t (S^F_{t+T} - S_{t+T})^2/Q$, t=1,2,...,Q.

Cheung, Chinn and Pascual (2005) checked the Meese and Rogoff's results with 20 more years of data
⇒ RWM still the best model in the short-run.

The results from Meese and Rogoff (1983) were very surprising. The paper started a big literature; which, in general, confirms the results in the short-run (say, up to 6-months or 1-year), but for longer horizons (say, 4 years), some models can do better. These long-horizon successes are based on models such as PPP and IFE and incorporate statistical features of FX rates and the predictable behavior of Central banks.

Example: MSE - Forecasting with Forwards and the RWM
You work for a company that wants to forecast the quarterly USD/GBP exchange rate. You are given the interest rate differential (in %) and S_t, which you used above to calculate the forward rate, $F_{t,90}$, and, then, to forecast $E_t[S_{t+90}] = S^{EH}_{t+90}$. You also use the RWM to forecast $E_t[S_{t+90}] = S^{RW}_{t+90} = S_t$. Then, to check the accuracy of the forecasts, you calculate the MSE.

Quarter	$(i_{US} - i_{UK})$	S_t	Forward Rate		Random Walk	
			$S^{EH}_{t+90} = F_{t,90}$	$\varepsilon_{t\text{-FR}} = S_t - S^{EH}_{t+90}$	$S^{RW}_{t+90} = S_t$	$\varepsilon_{t\text{-RW}} = S_t - S^{RW}_{t+90}$
2014:II	-0.304	**1.6883**				
2014:III	-0.395	**1.6889**	**1.6870**	0.0019	**1.6883**	0.0006
2014:IV	-0.350	**1.5999**	**1.6872**	-0.0873	**1.6889**	-0.0890
2015:I	-0.312	**1.5026**	**1.5985**	-0.0959	**1.5999**	-0.0973
2015:II	-0.415	**1.5328**	**1.5014**	0.0314	**1.5026**	0.0302
2015:III	-0.495	**1.5634**	**1.5312**	0.0322	**1.5328**	0.0306
2015:IV		**1.5445**	**1.5615**	-0.0170	**1.5634**	-0.0189
MSE				**0.00319**		**0.00327**

Both MSEs are similar, though the Forward Rate's MSE is a bit smaller (2% lower).

Calculation of MSE for Forward Rate:
MSE = $[0.0019^2 + (-0.0873)^2 + (-0.0959)^2 + 0.0314^2 + 0.0322^2 + (-0.0170)^2] / 6 =$ **0.00319.** ¶

• Martingale-Random Walk Model: Many Empirical Models Trying to Compete
As illustrated above, models of exchange rates determination based on economic fundamentals have problems explaining the short-run behavior of S_t (though, there is some hope for the long-run behavior of S_t). This is not good news if the aim of the model is to forecast S_t.

As a result of this failure, a lot of empirical models, modifying the traditional fundamental-driven models, have been developed to better explain *equilibrium exchange rates* (EERs). Some models are built to explain the medium- or long-run behavior of S_t, others are built to beat (or get closer to) the forecasting performance of the RWM.

A short list of the new models includes CHEERs, ITMEERs, BEERs, PEERs, FEERs, APEERs, PEERs, and NATREX. Below, I include Table 8.1, taken from Driver and Westaway (2003, Bank of England), which describes the main models used to explain EERs.

Table 8.1: Summary of Empirical Approaches to Estimating Equilibrium Exchange Rates

	UIP	PPP	Balassa-Samuelson	Monetary Models	CHEERs	ITMEERs	BEERs
Name	Uncovered Interest Parity	Purchasing Power Parity	Balassa-Samuelson	Monetary and Portfolio balance models	Capital Enhanced Equilibrium Exchange Rates	Intermediate Term Model Based Equilibrium Exchange Rates	Behavioural Equilibrium Exchange Rates
Theoretical Assumptions	The expected change in the exchange rate determined by interest differentials	Constant Equilibrium Exchange Rate	PPP for tradable goods. Productivity differentials between traded and nontraded goods	PPP in long run (or short run) plus demand for money.	PPP plus nominal UIP without risk premia	Nominal UIP including a risk premia plus expected future movements in real exchange rates determined by fundamentals	Real UIP with a risk premia and/or expected future movements in real exchange rates determined by fundamentals
Relevant Time Horizon	Short run	Long run	Long run	Short run	Short run (forecast)	Short run (forecast)	Short run (also forecast)
Statistical Assumptions	Stationarity (of change)	Stationary	Non-stationary	Non-stationary	Stationary, with emphasis on speed of convergence	None	Non-stationary
Dependent Variable	Expected change in the real or nominal	Real or nominal	Real	Nominal	Nominal	Future change in the Nominal	Real
Estimation Method	Direct	Test for stationarity	Direct	Direct	Direct	Direct	Direct

Table 8.1: Summary of Empirical Approaches to Estimating Equilibrium Exchange Rates (continuation)

FEERs	DEERs	APEERs	PEERs	NATREX	SVARs	DSGE
Fundamental Equilibrium Exchange Rates	Desired Equilibrium Exchange Rates	Atheoretical Permanent Equilibrium Exchange Rates	Permanent Equilibrium Exchange Rates	Natural Real Exchange Rates	Structural Vector Auto Regression	Dynamic Stochastic General Equilibrium models
Real exchange rate compatible with both internal and external balance. Flow not full stock equilibrium	As with FEERs, but the definition of external balance based on *optimal* policy	None	As BEERs	As with FEERs, but with the assumption of portfolio balance (so domestic real interest rate is equal to the world rate).	Real exchange rate affected by supply and demand (but not nominal) shocks in the long run	Models designed to explore movements in real and/or nominal exchange rates in response to shocks.
Medium run	Medium Run	Medium / Long run	Medium / Long run	Long run	Short (and long) run	Short and long run
Non-stationary	Non-stationary	Non-stationary (extract permanent component)	Non-stationary (extract permanent component)	Non-stationary	As with theoretical	As with theoretical
Real Effective	Real Effective	Real	Real	Real	Change in the Real	Change relative to long run steady state
Underlying Balance	Underlying Balance	Direct	Direct	Direct	Direct	Simulation

8.5. Recent Models with Risk Factors

Overall, a negative message for short-time forecasters. The RWM does very well in the short-run, especially, 1-3 months.

Recent literature focuses on building factor models for S_t, similar to the factor models used for equity & bond markets. These factor models have been mainly built to explain the profitability of carry trade portfolios. (Recall the puzzle behind the violation of the expectation hypothesis). Each factor represents, in theory, "a risk factor."

For example, Lustig, Roussanov and Verdelhan (2011) uses the following model for the returns of portfolio *j* of foreign currencies:

$$e_{f,j,t+1} = \alpha_j + \beta_j Dollar_{t+1} + \delta_j\ Carry_{t+1} + \varepsilon_{j,t+1}$$

with the following factors:
Dollar: Average change in the value of FCs. Plays the role of the "*Market*."
Carry: Average change in FX rates of high- vs low-interest rate FCs.

Lustig et al. (2011) find that this model "explains" the average carry portfolio returns –i.e., α_j is statistically speaking zero.

A couple of papers by Menkhoff, Sarno, Schemeling and Schrimpf (mainly, 2012 & 2016) find two additional factors that explain currency portfolio returns: a *Momentum factor*, representing a positive return in the previous period (or several periods), and a *Value factor*, representing if the currency is "weak" or "strong" in a PPP sense (undervalued or overvalued).

But, there are other factors proposed by researchers: an *Interest rate differential factor,* representing the return from lending at i_j & borrowing at i_t (USD), a *global volatility factor*, an *FX liquidity factor,* an *intermediary capital at risk factor,* etc.

<u>Remark</u>: These models tend to be more successful in explaining the "cross section" of portfolios or FX rates –i.e., the behavior of different portfolios of exchange rates or exchange rates at a given time–, than the time series of FX rates –i.e., the behavior of exchange rates over time.

CHAPTER 8 – BRIEF ASSESMENT

1. Assume the following cost for the CPI baskets:
CPI-basket$_{USA}$ = USD 755.3
CPI-basket$_{CAD}$ = CAD 928.8

(A) Calculate S_t^{PPP}.
(B) Suposse = 1.31 CAD/USD. Calculate R_t. Which country is more efficient?
(C) Describe how market forces act when S_t and S_t^{PPP} move towards convergence.

2. Suppose you have the following data:
S_{t-1} = 1.40 USD/GBP.
$I_{GBP,t}$ = 1.50%
$I_{USD,t}$ = 2.00%
(A) According to relative PPP, what should be S_t?
(B) Suppose S_t = 1.37 USD/GBP, according to relative PPP, is the GBP overvalued or undervalued?

3. Suppose you have the following information:
$S_{2021:I}$ = 1.31 USD/CAD.
$i_{USD,2021:I}$ = 2.00%
$i_{CAD,2021:I}$ = 2.5%.
T = 1 semester = 180 days.
(A) Using IFE, calculate $E[S_{2021:II}]$.
(B) Using the RW model, calculate $E[S_{2021:II}]$.

4. Suppose you have the following data:
$E[S_{2021:II}]$ = 1.31 USD/CAD.
$F_{t,\,2021:II}$ = 1.30 USD/CAD.
Describe how you can take advantage of this violation of the EH.

5. You run the following regression: changes in the JPY/USD exchange rate against inflation rate differentials (I_{JPY}-I_{US}). Below, you have the excel regression output. Let RSS(H_0)= 0.5214. Using individual t-tests and a joint F-test, test relative PPP.

Regression Statistics	
Multiple R	0.082399
R Square	0.00679
Adjusted R Square	0.004707
Standard Error	0.03282
Observations	479

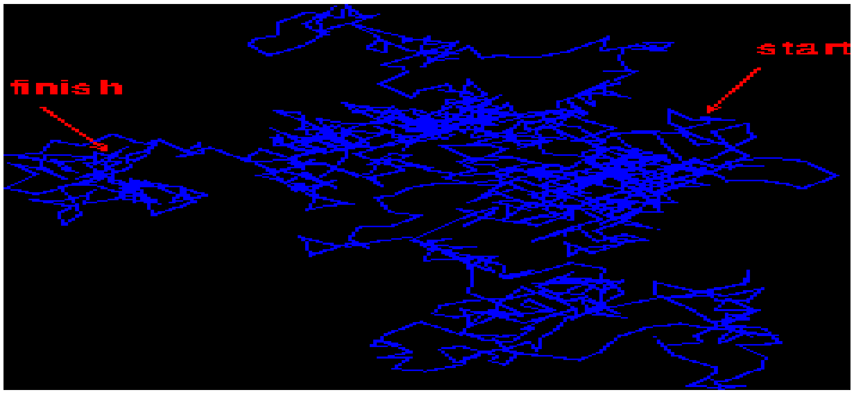
ANOVA

	df	*SS*	*MS*
Regression	1	0.003512	0.003512
Residual	477	0.513811	0.001077
Total	478	0.517323	

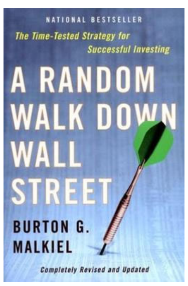
	Coefficients	*Standard Error*
Intercept	-0.00302	0.00153
X Variable 1	-0.62455	0.33511

CHAPTER 8 - BONUS COVERAGE I: A Random Walk

This is a computer generated random walk of 1,000 steps going nowhere:



The RW model does not only appear in Finance and Economics. Many physical processes such as Brownian motion, electron transport through metals, and round off errors on computers are modeled as a random walk. In the above computer generated RW, many steps are taken with the direction of each step independent of the direction of the previous one.



The RWM is an old model. It was formally introduced by the French mathematician Bachelier (1900), who used it to study bond prices on the Paris Bourse. Since then it has been proposed for all financial assets. Malkiel's (1973) *A Random Walk Down Wall Street* popularized the idea of the unpredictability of asset prices. (BTW, the book is in its 11^{th} edition and sold over 1.5 million copies). Lo and MacKinlay's (2002) *A Non-Random Walk Down Wall Street* summarized results that show that financial assets display statistically significant deviations from the RWM. There are some predictable components. Nonetheless, from a forecasting point of view, beating the RWM, in the short-run, is very, very difficult.

BONUS COVERAGE II: The man behind IFE - Irving Fisher (1867–1947).

Today, Fisher is remembered in neoclassical economics for his theory of capital, investment, and interest rates, first exposited in his *The Nature of Capital and Income* (1906) and elaborated on in *The Rate of Interest* (1907). His 1930 treatise, *The Theory of Interest*, summed up a lifetime's research into capital, capital budgeting, credit markets, and the factors (including inflation) that determine interest rates.

The Fisher equation, where the nominal interest rate is approximated by the real interest rate, k, plus the (expected) inflation rate, is named after him:

$$i = k + E[I]$$

But, for investors, he may be best remembered for predicting, three days before the October 1929 crash: *"Stock prices have reached what looks like a permanently high plateau."*

BONUS COVERAGE III: Asset Approach to Exchange Rates

The flows (exports and imports) approach to exchange rate determination was very popular until the late 1960s. But, these models did not work well. During the 1970s, economists began to think of currencies as any other asset. Thus, exchange rates are asset prices that adjust to equilibrate international trade in financial assets. Exchange rates are relative prices between two currencies and these relative prices are determined by the desire of residents to hold domestic and foreign financial assets. Like other asset prices, exchange rates are determined by expectations about the future. Therefore, past or present trade flows cannot influence exchange rates to the extent that they have already been expected. This approach, which treats currencies as assets, is called the *asset approach*.

• Monetary Approach (MA)

The asset approach assumes a high degree of capital mobility between assets denominated in different currencies. We need to specify the domestic and foreign assets to be included in the portfolio of a domestic resident. Since exchange rates are relative prices between two currencies, a simple model is to consider domestic money and foreign money. This simple asset model is called the *monetary approach* (MA) model.

BC.1 A Simple Monetary Approach Model

The traditional MA is a long-run theory that assumes that prices are flexible. Through PPP, the monetary approach relates the factors that affect prices with exchange rates. The determination of prices is based on the Quantitative Theory of Money (QTM):

$M_S\, V = P\, Y,$

V: velocity of money,
P: price level
Y: real output
M_S: Money supply (in equilibrium, M_S: L_d, L_d: Money demand, L stands for liquidity.)

This equation assumes that prices are fully flexible. If M_S changes then prices adjust instantaneously.

Solving for P, we obtain: $P = (M_S\, V)/Y.$

The MA model needs an equation that relates the QMT to exchange rates. We already know a theory that relates domestic and foreign prices to exchange rates: PPP. Using the subscripts d and f to denote domestic and foreign quantities, and after simple substitutions, the spot rate is determined by:

$$S_t = P_d/P_f = (V_d/V_f) * (Y_f/Y_d) * (M_{Sd}/M_{Sf}). \qquad \text{(BC.1)}$$

BC.1 assumes not only fully flexible prices, but also that PPP holds continuously. Assume V is constant in the short-run and after some algebra (taking logs and creating log differences), we get:

$$s_{t+T} = e_{f,t+T} = y_{f,T} - y_{d,T} + m_{Sd,T} - m_{Sf,T},$$

where small letters represent percent changes (growth rates) in the underlying variables.

BC.2 A More Sophisticated Monetary Approach Model

The previous monetary model was very simple. Implicitly, we have paid no attention to money demand and, implicitly, assumed that monetary variables are exogenous variables. However, in equilibrium, monetary variables are jointly determined by supply and demand. Let's complicate the MA model by introducing the demand for real-money holdings, L_D. In equilibrium, L_D equals M_S/P:

$M_S/P = L_D$.

Now, let us model L_D as a function of income, Y, and interest rates, i. For example,

$L_D = k\ Y^a\ e^{b\,i}$,

where k represents the inverse of velocity of money, V.

After some substitutions and using PPP, we obtain:

$\ln(S_T) = a[\ln(Y_{f,T}) - \ln(Y_{d,T})] + b(i_{f,T} - i_{d,T}) + [\ln(k_f) - \ln(k_S)] + [\ln(M_{Sd,T}) - \ln(M_{Sf,T})]$.

Again, like in the IFE model, interest rate differentials play a role in the determination of exchange rates. Under the MA, interest rate differentials play a role through the impact on L_D. The same can be said about income growth rate differentials, they influence S_t through L_D.

Note: Expectations about future S_t into the MA model. Recall the interest rate differentials provides information about the expected change in exchange rates, $\{E(S_{t+T})/S_t - 1\}$. That is, the S_t today depends on expectations about the expected S_{t+T}. Through several substitutions, it is easy to see that the exchange rate today depends on the expected path of future exchange rates.

BC.3 Monetary Approach: Implications

The MA presented has very precise implications. It predicts that S_t behaves like any other speculative asset price; S_t changes whenever relevant information is released.

"Relevant information": i_d, i_f, y_d, y_f, M_{Sd}, M_{Sf}. (Expectations about the future these variables matter.)

Example: Suppose the money supply in the U.S. market increases unexpectedly by 2% and all the other variables remain constant. According to the monetary approach, an increase in the money supply of 2% leads to an increase of 2% in S_t (a depreciation of the USD).

Now, suppose that investors expect the U.S. Fed to quickly increase U.S. interest rates to offset this increase in the money supply, then the USD might appreciate instead of depreciate. ¶

Chapter 9 - Forecasting Exchange Rates

In Chapter 8, we studied FX determination: S_t = f($(i_d - i_f)_t$, $(I_d - I_f)_t$, $(y_d - y_f)_t$, other)
Not very successful to explain S_t –especially in the short-run:
- PPP (Absolute and Relative): Rejected
- IFE: Rejected

Q: What determines S_t in the short-run?
A: Still an open question. Random Walk Model for S_t has a good forecasting performance.

Q: Can we forecast S_{t+T}?
A: It seems very difficult. But, firms and "experts" constantly try. In this chapter, we will also try.

• Brief Review and Notation
A forecast is an expectation: $E_t[S_{t+T}]$ $\Rightarrow$ Expectation of S_{t+T} taken at time t. T is the *forecast horizon*.

(Remember, in statistics, the expectation is an expected value. Think of it as an average.)

In general, it is easier to predict changes. In this class, we will concentrate on $E_t[e_{f,T}]$.

Note: From $E_t[e_{f,t+T}]$, we get $E_t[S_{t+T}]$ $\Rightarrow$ $E_t[S_{t+T}] = \boldsymbol{S_t} * (1+E_t[e_{f,t+T}])$

Based on a model for S_t, we generate $E_t[S_{t+T}]$:

$$S_t = f(X_t) \qquad \Rightarrow E_t[S_{t+T}] = E_t[f(X_{t+T})]$$

Example: For the PPP model, X_t = Inflation rate differentials $(I_{d,t} - I_{f,t})$:

$$f(X_t) = I_{d,t} - I_{f,t}$$

• Main Forecasting Methods
There are two pure approaches to forecasting FX rates:
(1) The *fundamental approach* (based on data considered fundamental).
(2) The technical approach (based on data that incorporates only past prices).

9.1. Method I: Fundamental Approach

• We generate $E_t[S_{t+T}] = f(X_t)$, where X_t is a dataset regarded as *fundamental* economic variables:
GNP growth rate, Current Account, Interest rates, Inflation rates, Money growth rate, etc.

• In general, the fundamental forecast is based on an *economic model* (PPP, IFE, combinations).
$\Rightarrow$ the economic model tells us how the fundamental data relates to S_t.
That is, the economic model specifies $f(X_t)$ -for PPP, $f(X_t) = I_{d,t} - I_{f,t}$

• The economic model usually incorporates:
◦ Statistical characteristics of the data (seasonality, etc.)
◦ Experience of the forecaster (what info to use, lags, etc.)

⇒ Mixture of art and science.

• Fundamental Forecasting involves several steps:

(1) Selection of Model (for example, PPP model) used to generate the forecasts.

(2) Collection of S_t, X_t (in the case of PPP, exchange rates and CPI data needed.)

(3) Estimation of model, if needed (regression, other methods). Test model.

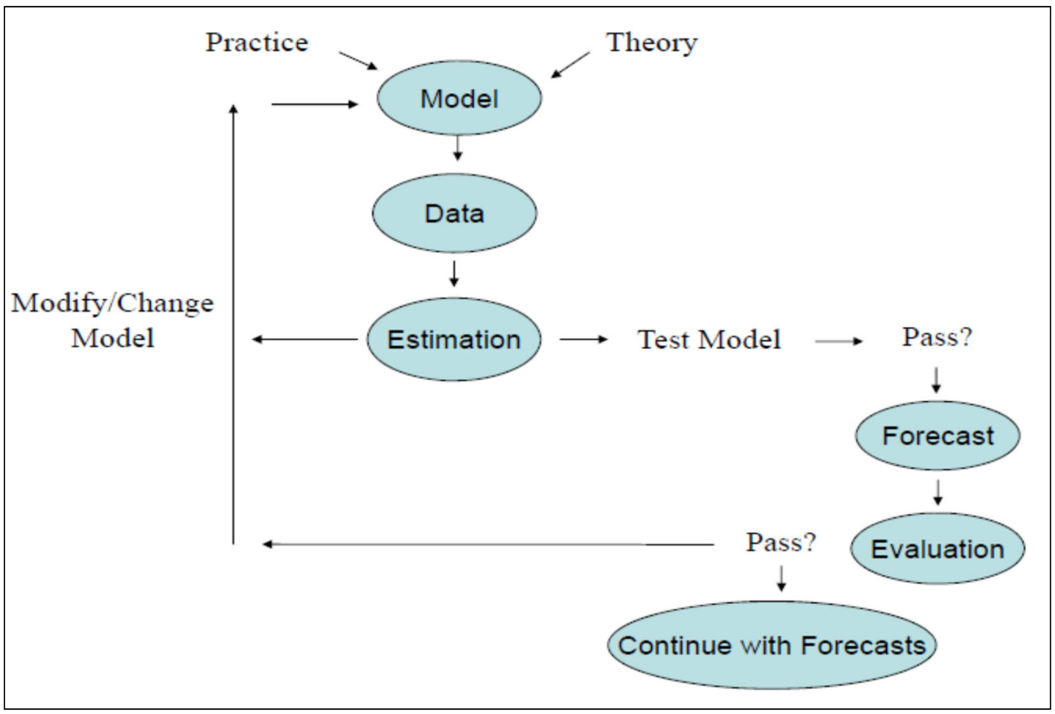
(4) Generation of forecasts based on estimated model. Assumptions about X_{t+T} may be needed.

(5) Evaluation. Forecasts are evaluated. If forecasts are very bad, model must be changed.

⇒ MSE (Mean Square Error) is a measure used to asses forecasting models.

Exhibit 9.1 shows a typical process to build out-of-sample forecasts model.

Exhibit 9.1
Fundamental Forecasting: Process for Building Forecasting Model



Example: Forecasting S_{t+T} with Relative PPP ($E_t[S_{t+T}]$)

Formulas needed:

Economic Model (PPP): $e_{f,t} = \frac{S_{t+1}}{S_t} - 1 \approx I_{d,t} - I_{f,t}$

Forecasting equation for $e_{f,t+1}$: $E_t[e_{f,t+1}] = e^F_{f,t+1} = \frac{S^F_{t+1}}{S_t} - 1 \approx I_{d,t+1} - I_{f,t+1}$

Forecasting S_{t+1}: $E_t[S_{t+1}] = S^F_{t+1} = S_t * [1 + e^F_{f,t+1}] = S_t * [1 + (I_{d,t+1} - I_{f,t+1})]$

Forecast error: $\varepsilon_{t+1} = S_{t+1} - S^F_{t+1}$ (quality of forecast)

Mean Square Error = **MSE** = $[(\varepsilon_{t+1})^2 + (\varepsilon_{t+2})^2 + (\varepsilon_{t+3})^2 + ... + (\varepsilon_{t+Q})^2]/Q$ (evaluation measure)

Notice that at time t, we do not know $I_{d,t+1}$ & $I_{f,t+1}$. We need a model or assumptions to forecast $E_t[I_{d,t+1}]$ & $Et[I_{d,t+1}]$.

Example (continuation): Forecasting S_{t+1} with Relative PPP ($E_t[S_{t+1}]$)

It's **February 2023**. We want to forecast March 2023 SEK/USD exchange rate (SEK = Swedish Kronor) using Relative PPP. That is, based on data available on 2023:2, we forecast, $S_{t=2023:3}$ ($S^F_{2023:3}$). This type of one period ahead forecast is called *one-step-ahead forecast*.

• *Forecasting Model*

$$E_t[e_{f,t+1}] = e^F_{f,t+1} = I_{SWED,t} - I_{US,t}$$
$$E_t[S_{t+1}] = S^F_{t+1} = S_t * (1 + I_{SWED,t} - I_{US,t})$$

• *Data*

We have CPI data and S_t data from Jan. 2023 to Feb. 2023. We want to forecast $S_{t=March,\,23}$.

We have already done: (1) Selection of Model; (2) Collection of S_t, X_t; and (3) No estimation is needed. We need to do (4) Generation of forecasts based on model and (5) Evaluation of forecasts.

Date	CPI_{SWED}	CPI_{US}	S_t	I_{SWED}	I_{US}		$\varepsilon_{t+1}=S_{t+1}-S^F_{t+1}$
1/1/2023	136.1820	300.356	10.3975			1.9334	-
2/1/2023	137.6847	301.509	**10.4492**	**0.0110**	**0.0038**	**1.9512**	-
3/1/2023	138.4708	301.744	10.4763	0.0057	0.0008	1.9318	**-0.0215249**
4/1/2023	139.1143	303.032	10.3484	0.0046	0.0043	1.9718	0.0312088

• *Generation of forecasts* (GF)

Calculations for the 2023:3 forecast:

GF.1. Inflation rates

$I_{SWED,2023:2} = (CPI_{SWED,2023:2}/CPI_{SWED,2023:1}) - 1 = (137.6847/136.1820) - 1 =$ **0.0110**.

$I_{US,2023:2} = (CPI_{US,2023:2}/CPI_{US,2023:1}) - 1 = (301.509/300.356) - 1 =$ **0.0038**.

GF.2. We need a forecast for $I_{SWED,2023:3}$ - $I_{US,2023:3}$

RW forecast: Last year inflation rate is a good predictor of this year inflation rate –i.e., $E_t[I_{t+1}] = I_t$

Then,

$$E_t[e_{f,t+1}] = e^F_{f,t+1} = I_{SWED,t} - I_{US,t}$$
$$E_t[S_{t+1}] = S^F_{t+1} = S_t * (1 + I_{SWED,t} - I_{US,t})$$

GF.3. Now, we can predict $e_{f,t=2023:3}$ and $S_{t=2023:3}$

$$E_{t=2023:2}[e_{f,t=2023:3}] = \boldsymbol{e^F_{f,2023:3}} = I_{SW,2023:2} - I_{US,2023:2} = \mathbf{.0110} - \mathbf{.00338} = \mathbf{0.0072}.$$

$E_{t=2023:2}[S_{t=2023:3} = S^F_{2023:3} = S_{2023:2} * [1 + e^F_{f,2023:3}] = 10.4492 * [1 + 0.0072] = 10.5007$

• *Evaluation of forecasts* (EVF)

EVF.1. Next month, in 2023:3, we will compute the forecast error, $\varepsilon_{2023:3}$:

$\varepsilon_{2023:3} = S_{2023:3} - S^F_{2023:3} = 10.4763 - 10.5007 = -0.0244.$

For comparison purposes, at the end of 2023:3, we can also generate a forecast error for the RW Model:

$\varepsilon^{RW}_{2023:3} = S_{2023:3} - S_{2023:2} = 10.4763 - 10.4492 = 0.0271$

EVF.2. Then, we repeating this one-step-ahead forecasting process until 2024:3. That is, we generate 14 one-step-ahead forecasts. By 2024:4, we will compute 14 forecasts errors, and, then, the MSE for the PPP and RW forecasts errors.

Date	S_t	$I_{SW} - I_{US}$	S^F_{t+1}	ε_{t+1}	$(\varepsilon_{t+1})^2$	$S^{F,RW}_{t+1}$	ε^{RW}_{t+1}	$(\varepsilon^{RW}_{t+1})^2$
1/1/2023	10.3975							
2/1/2023	**10.4492**	**0.0072**						
3/1/2023	**10.4763**	0.0049	**10.5007**	**-0.0244**	0.0006	**10.4492**	**0.0271**	0.0007
4/1/2023	10.3484	0.0004	10.4803	-0.1319	0.0174	**10.4763**	**-0.1279**	0.0164
5/1/2023	10.4643	0.0021	10.3696	0.0947	0.0090	10.3484	0.1159	0.0134
6/1/2023	10.7691	0.0086	10.5545	0.2146	0.0461	10.4643	0.3048	0.0929
7/1/2023	10.5002	-0.0016	10.7517	-0.2515	0.0633	10.7691	-0.2689	0.0723
8/1/2023	10.8291	-0.0044	10.4542	0.3749	0.1405	10.5002	0.3289	0.1082
9/1/2023	11.0848	0.0015	10.8456	0.2392	0.0572	10.8291	0.2557	0.0654
10/1/2023	11.0259	0.0017	11.1037	-0.0778	0.0061	11.0848	-0.0589	0.0035
11/1/2023	10.6694	0.0015	11.0427	-0.3733	0.1394	11.0259	-0.3565	0.1271
12/1/2023	10.2576	0.0050	10.7223	-0.4647	0.2159	10.6694	-0.4118	0.1696
1/1/2024	10.3593	-0.0045	10.2114	0.1479	0.0219	10.2576	0.1017	0.0103
2/1/2024	10.4266	-0.0019	10.3391	0.0875	0.0077	10.3593	0.0673	0.0045
3/1/2024	10.4113	-0.0026	10.3998	0.0115	0.0001	10.4266	-0.0153	0.0002
4/1/2024	10.8158	-0.0017	10.3931	0.4227	0.1787	10.4113	0.4045	0.1636
MSE					**0.06455**			**0.06058**

Calculating the MSE for the PPP and RW models 2023:3-2024:4 period:

$MSE^{PPP} = [(-0.0244)^2 + (-0.1319)^2 + \ldots. + (0.4227)^2]/14 = 0.06455$

EVF.3 Compare the MSE of the PPP forecasting model with the RWM. Under the RWM: $E_t[S_{t+1}] = S_t$
$\varepsilon_{2007:3} = S_{2007:3} - S^F_{2007:3} = S_{2007:3} - S_{2007:2} = 1.9318 - 1.9512 = -0.0194$.
$\varepsilon_{2007:4} = S_{2007:4} - S^F_{2007:4} = S_{2007:4} - S_{2007:3} = 1.9718 - 1.9318 = 0.0400$.
$MSE^{RW} = [(\mathbf{-0.0271})^2 + (\mathbf{-0.1279})^2 + \ldots + (0.4045)^2] /14 = \mathbf{0.06058}$

For these forecasts, on average, the RW model does better than the PPP model. ¶

Example: Forecasting FX with an Ad-hoc Model
A U.S. company uses an economic linear model to forecast monthly exchange rates (USD/GBP):
Economic Regression Model:

$$e_{f,t} = a_0 + a_1\, INF_t + a_2\, INT_t + a_3\, INC_t + \varepsilon_t, \qquad (*)$$

where
INF_t: inflation rates differential between U.S. and the U.K.
INT_t: interest rates differential between U.S. and the U.K.
INC_t: income growth rates differential between U.S. and the U.K.

Objective: Calculate $E_t[e_{f,t+1}]$
• *Forecasting Model*

$$E_t[e_{f,t+1}] = a_0 + a_1\, E_t[INF_{t+1}] + a_2\, E_t[INT_{t+1}] + a_3\, E_t[INC_{t+1}]. \quad \text{(Recall: } E_t[\varepsilon_{t+1}] = 0\text{)}.$$

Inputs for the forecast: 1) a_0, a_1, a_2, a_3 (estimated through a regression).
2) $E_t[INF_{t+1}]$ and $E_t[INC_{t+1}]$ (potential problem!)

• *Data*
Income growth rates, interest rates, inflation rates and exchange rates. Suppose we have quarterly data from 1978 to 2008 (21 years).
Suppose $S_{2008:IV}$ = **1.7037 USD/GBP**.

• *Estimation*

We run a regression to estimate (*). Excel output:

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.216036
R Square	0.046672
Adjusted R Square	0.022434
Standard Error	0.050911
Observations	122

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.014973	0.004991	1.925622	0.129173
Residual	118	0.305851	0.002592		
Total	121	0.320825			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.01082	0.007553	-1.43285	0.154545	-0.02578	0.004134
INF_t	0.648128	0.547068	1.184732	0.238504	-0.43521	1.731471
INT_t	-0.00482	0.002188	**-2.20088**	0.029691	-0.00915	-0.00048
INC_t	**0.000945**	0.001613	0.585963	0.559019	-0.00225	0.00414

Analysis:

t-statistics: only the interest rate differential coefficient is bigger than two (in absolute value).

R^2 = .047 (INF, INT & INC explain 4.7% of the variability of changes in the USD/GBP).

(Note: It doesn't look like a great model, but we'll use it anyway.)

• *Generation of forecasts*

i. Suppose we have the following forecasts for next month:

$E_t[INF_{t+1}]$ = **1.68**%, $E_t[INT_{t+1}]$ = -2.2%, $E_t[INC_{t+1}]$ = 1.23%.

Then,

$E_t[e_{f,t+1}]$ = -.010802 + .6481 * (**.0168**) + (-0.00482) * (-.022) + **.000945** * (0.0123) = **0.000204**.

⇒ The USD is predicted to depreciate 0.02% against the USD next month.

ii. Now, we can forecast S^F_{t+1}:

$E_t[S_{t+1}] = S^F_{t+1} = S_t * (1 + E_t[e_{f,t+1}])$ = **1.7037 USD/GBP** * (1.**000204**) = **1.704048 USD/GBP**.

• *Evaluation of forecasts*

Suppose $S_{2009:I}$ = **1.5239 USD/GBP**, we can calculate the forecast error:

$\varepsilon_{t+1} = S_{t+1} - E_t[S_{t+1}]$ = **1.5239 USD/GBP** – **1.704048 USD/GBP** = -0.180148 (Model)

$\varepsilon_{t+1} = S_{t+1} - E_t^{RW}[S_{t+1}] =$ **1.5239 USD/GBP** – **1.7037 USD/GBP** = -0.179800 (RWM).

Note: The RWM forecast error is smaller, but just by a very small amount.
$\Rightarrow$ RWM advantage: No complicated estimation/model, very similar forecasts! ¶

• Practical Issues in Fundamental Forecasting
◊ Are we using the "right model?" (Is Linear ad-hoc model OK?)
◊ Estimation of the model. (Is linear regression fine?)
◊ Some explanatory variables are contemporaneous. We need a model to forecast these variables too.

• **Fundamental Forecasting: Evidence**
Recall the Meese and Rogoff's (1983) findings. They tested the short-run forecasting performance of different models (PPP, monetary approach, IFE, pure statistical (time series) models, and the RWM) for the four most liquid exchange rates. The RWM performed as well or better than any other model.

More recently, Cheung, Chinn and Pascual (2005) revisited the Meese and Rogoff's results with 20 more years of data. They still found the RWM to be the "best" model in the short-run. For longer horizons, Cheung, Chinn and Pascual (2005), along other papers, they report that some models do better than the RWM.

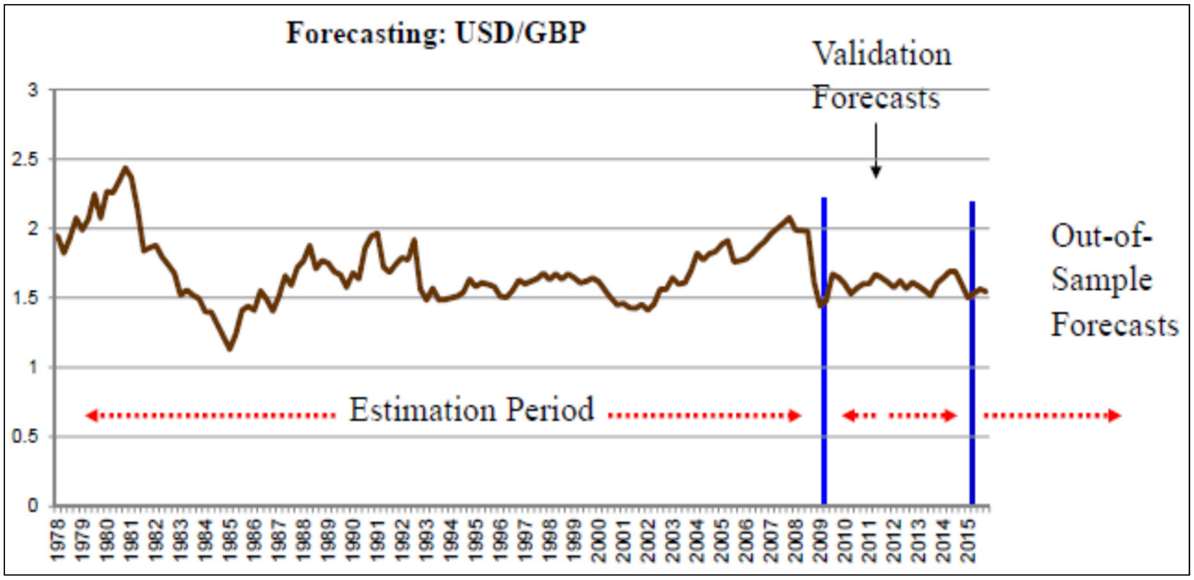
Note: The more modern approach to fundamental forecasting incorporates an attempt to forecast what the CB does to adjust interest rates. Usually, this involves the so-called "Taylor rule." Some economists find that this approach has some success over the RWM, especially over longer horizons (say, 6 to 12 months or longer).

Forecasting: Note on Estimation and Generation of Out-of-sample forecasts
In general, practitioners will divide the sample in two parts: a longer sample (*estimation period*) and a shorter sample (*validation period*). The estimation period is used to select the model *and* to estimate its parameters. The forecasts made inside the estimation period are not "true forecasts," are just *fitted values*.

The data in the validation period are not used during model and parameter estimation. The forecasts made in this period are "true forecasts," their error statistics are representative of errors that will be made in forecasting the future. A forecaster will use the results from this validation step to decide if the selected model can be used to generate outside the sample (*out-of-sample*) forecasts.

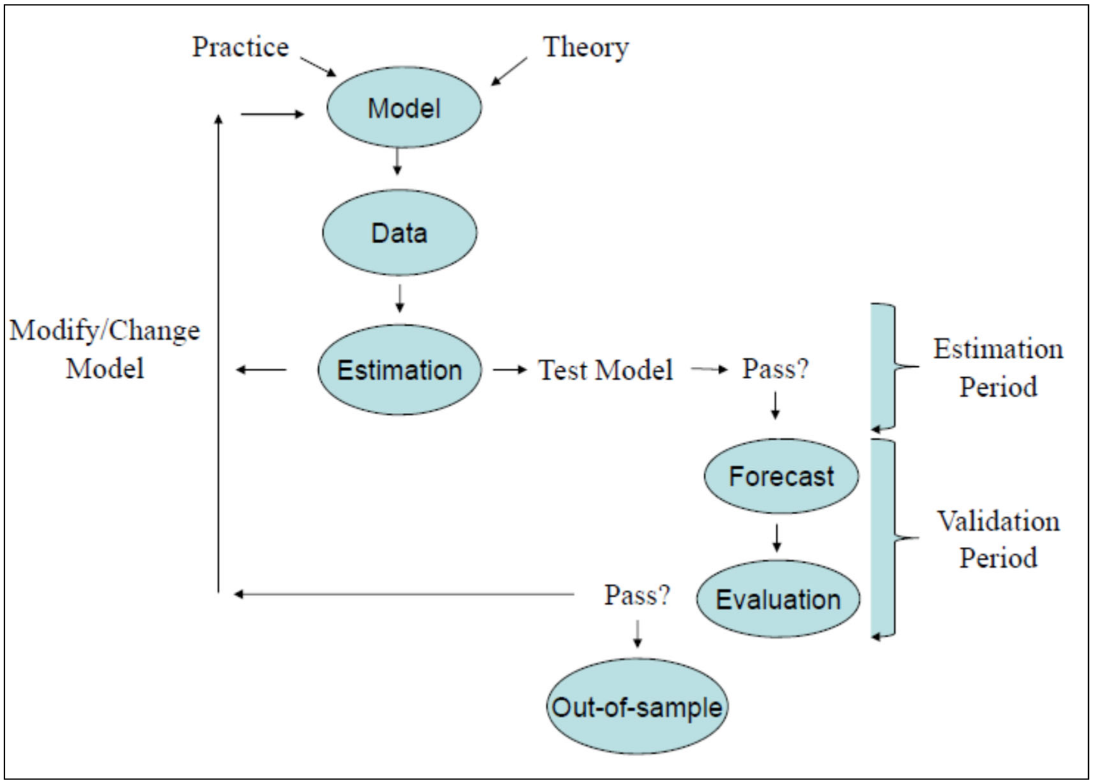
Figure 9.1 shows a typical partition of the sample. Suppose that today is March 2015 and a forecaster wants to generate monthly forecasts until January 2016. The estimation period covers from February 1978 to December 2009. Different models are estimated using this sample. Based on some statistical measures, the best model is selected. The validation period covers from January 2010 to March 2015. This period is used to check the forecasting performance of the model. If the forecaster is happy with the performance of the forecasts during the validation period, then the forecaster will use the selected model to generate out-of-sample forecasts.

Figure 9.1: Estimation, Validation & Out-of-sample Periods.



In Exhibit 9.2, we incorporate the partition of the data in the flow chart presented in Exhibit 9.1. It is easy to visualize how to generate out-of-sample forecasts.

Exhibit 9.2
Out-of-sample Forecasting: The Role of the Estimation and Validation Periods



9.2 Method II: Technical Analysis (TA) approach

We generate $E_t[S_{t+T}] = f(X_t)$, where X_t is a a small set of the available data: Past price information.

$\Rightarrow X_t = \{S_t, S_{t-1}, S_{t-2},....\}$

◊ TA does not pay attention to fundamentals (say, $I_{d,t} - I_{f,t}$). The market efficiently "discounts" public information regarding fundamentals.

$\Rightarrow$No need to research or forecast fundamentals.

◊ TA looks for the repetition of history; in particular, the repetition of specific price patterns.

$\Rightarrow$ Discovering these patterns is an art (not science).

◊ TA believes that assets move in *trends*. TA attempts to discover *trends* ("the trend is your friend") and *turning points*.

$\Rightarrow$ Based on these trends & turning points, TA generates signals.

◊ TA models range from very simple (say, looking at price charts) or very sophisticated, incorporating neural networks and genetic algorithms.

• TA: Two Popular Models

We will go over two popular well-known (& old!) models that produce *mechanical rules* –i.e., produce objective signals:

◊ *Moving Averages* (MA)

◊ *Filters*

(1) *MA model*: The goal of MA models is to smooth the erratic daily swings of FX to signal major trends. We will use the simple moving average (SMA).

An SMA is the unweighted mean of the previous Q data points:

$$\Rightarrow \text{SMA} = (S_t + S_{t-1} + S_{t-2} + \ldots + S_{t-(Q-1)})/Q$$

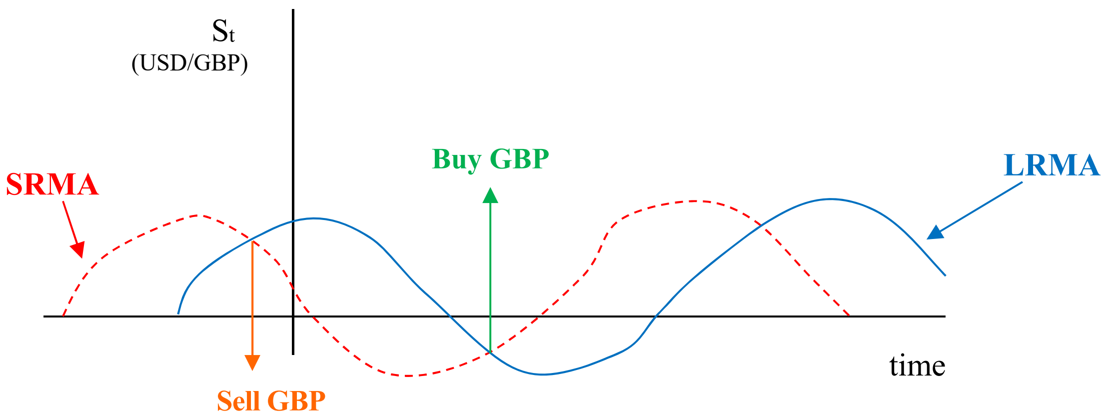
The *double MA system* uses two MA: Long-run MA (Q large, say 120 days) and Short-run MA (Q small, say 30 days). LRMA will always lag a SRMA (LRMA gives smaller weights to recent S_t).

Every time there is a crossing, a qualitative forecast is generated.

When SRMA crosses LRMA from below $\Rightarrow$ Forecast: FC to appreciate

When SRMA crosses LRMA from above $\Rightarrow$ Forecast: FC to depreciate.

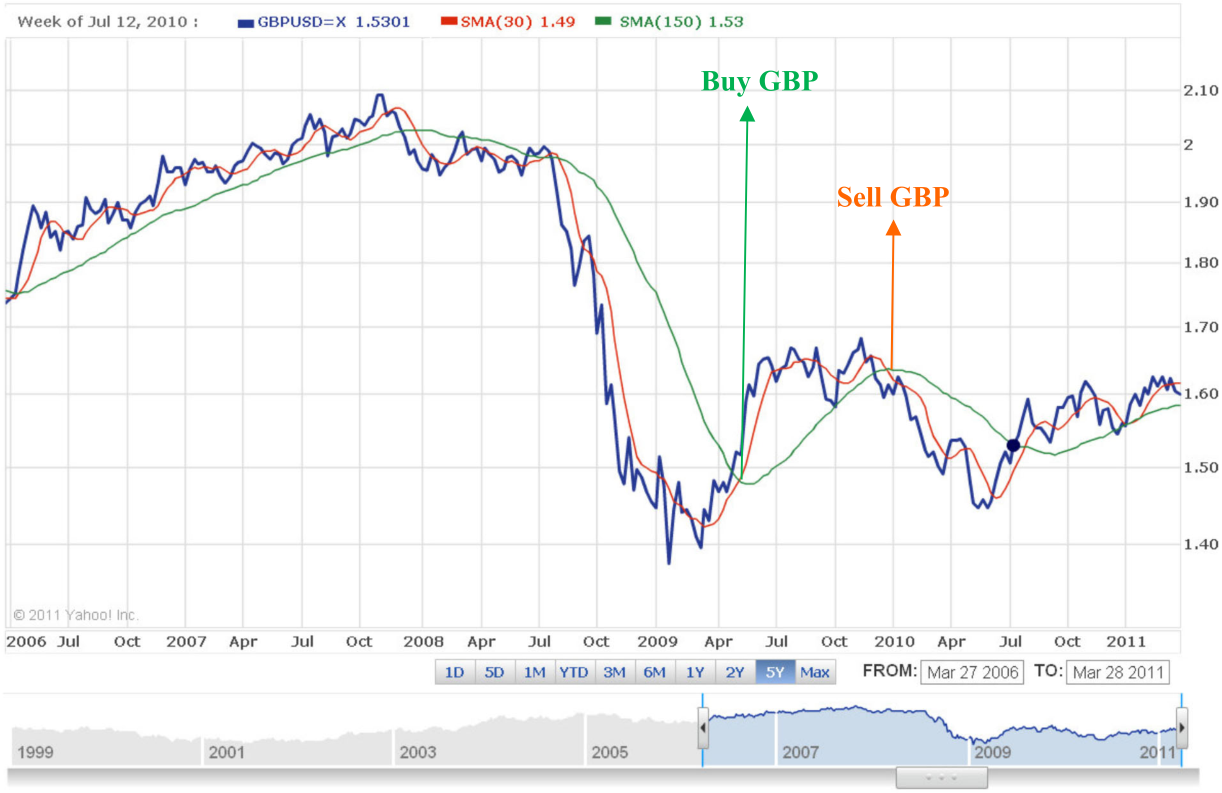
The *double MA system* uses the two MAs to forecast changes in S_t and generate trading signals.



Buy FC signal: When SRMA crosses LRMA from below.

Sell FC signal: When SRMA crosses LRMA from above.

Example: S_t (USD/GBP) Double MA (red=30 days; green=150 days).



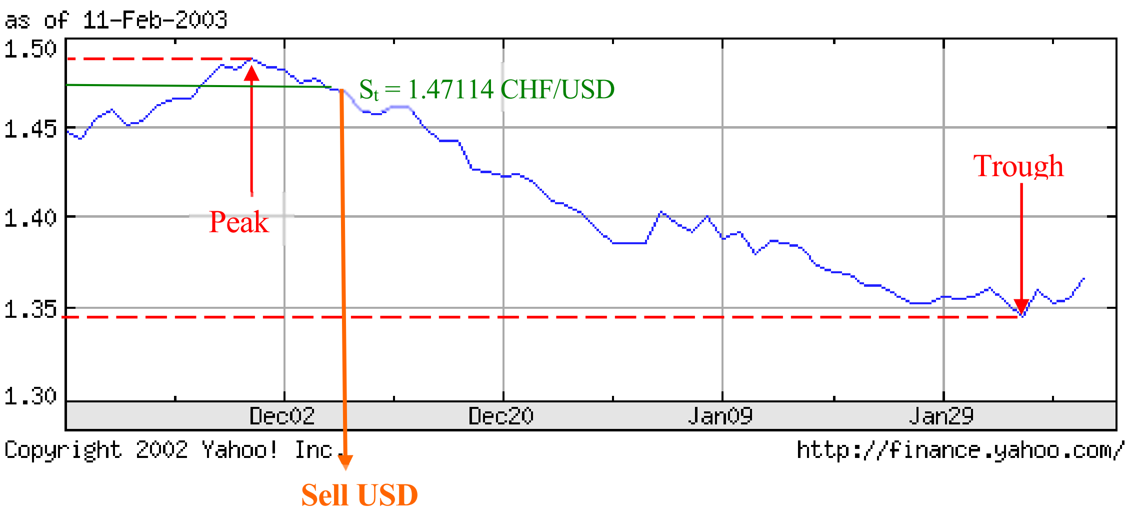
(2) *Filter models*: The filter, X, is a percentage that helps a trader forecasts a trend.
Simple Intuition:

When S_t reaches a peak ⇒ Sell FC
When S_t reaches a trough ⇒ **Buy FC**

Key: Identifying the peak or trough. We use the filter to do it:

When S_t moves X% above (below) its most recent peak (trough), we have a trading signal.

Example: X = 1%, S_t (CHF/USD)



Peak = 1.486 CHF/USD (X = CHF .01486) $\Rightarrow$ When S_t crosses 1.47114 CHF/USD, Sell USD

Trough = 1.349 CHF/USD (X = CHF .01349) $\Rightarrow$ When S_t crosses 1.36249 CHF/USD, Buy USD ¶

• TA: Newer Models
In both models, the TA practitioner needs to select a parameter (Q and X). This fact can make two TA practitioners using the same model, but different parameters, to generate different signals.

To solve this problem, there are several newer TA methods that use more complicated mathematical formulas to determine when to buy/sell, without the subjectivity of selecting a parameter. Clements (2010, *Technical Analysis in FX Markets*) describes four of these methods: Relative strength indicator (RSI), Exponentially weighted moving average (EWMA), Moving average convergence divergence (MACD) and (iv) Rate of change (ROC).

• TA: Summary
- ◊ TA models monitor the derivative (slope) of a time series graph.
- ◊ Signals are generated when the slope varies significantly.

• TA: Evidence
- *Against TA*
◊ Random walk model: It is a very good forecasting model.
◊ Many economists have a negative view of TA: TA runs against market efficiency (EM Hypothesis).

- *For TA*:
◊ Lo (2004) suggests that markets are adaptive efficient (AMH, adaptive market hypothesis): It may take time, but eventually, the market learns and profits should disappear.
$\Rightarrow$ Some TA methods may be profitable for a while.
◊ The marketplace is full of TA newsletters and TA consultants (somebody finds them valuable & buys

them).
◊ A survey of FX traders by Cheung and Chinn (2001) found that 30% of the traders are best classified as technical analysts.

- *Academic research*:
◊ Related to filter models in the FX market. Sweeney (1986, Journal of Finance): Simple filter rules generated excess returns (1973-1980). A 1% filter rule had a return of 2.8%, while a buy-and-hold strategy had a 1.6% return.
◊ TA in FX market: In general, in-sample results tend to be good –i.e., profitable–, but in terms of forecasting –i.e., out-of-sample performance– the results are weak. LeBaron (1999) speculates that the apparent success of TA in the FX market is influenced by the periods where there is CB intervention.
◊ Ohlson (2004) finds that the profitability of TA strategies in the FX market have significantly declined over time, with about zero profits by the 1990s.
◊ Park and Irwin (2007, Journal of Economic Surveys) survey the TA recent literature in different markets. They report that out of 92 modern academic papers, 58 found that TA strategies are profitable. Park and Irwin point out problems with most studies: data snooping, ex-post selection of trading rules, difficulties in the estimation of risk and transaction costs.

CHAPTER 9 – BRIEF ASSESMENT

You work in Austin for a local investment bank. You have available quarterly inflation rate (I), interest rate (i), and growth rate (y) data for the U.S. and Europe from 2016:1 to 2016:4. The USD/EUR in 2016:1 was equal to 1.0821 USD/EUR, which you believe is an equilibrium exchange rate. Your job is to do quarterly forecasts of the USD/EUR exchange rate for 2017:1. The investment bank uses the following ad-hoc model:

$$e_{f,t+1} = S_{t+1}/S_t - 1 = .75\,(I_{d,t+1} - I_{f,t+1}) + .25\,(y_{d,t+1} - y_{f,t+1}) \qquad \text{(M1).}$$

This model is based on the monetary approach. You have the following data:

Year	$y_{US} - y_{EUR}$	I_{US}-I_{EUR}	i_{US}-i_{EUR}	S_t (EUR/USD)
2016.1	0.17%	0.4473%	-0.5012%	1.0821
2016.2	0.24%	0.6976%	-0.0593%	1.1453
2016.3	0.31%	-0.1308%	0.6773%	1.1183
2016.4	0.57%	-0.3403%	0.8381%	1.0962

To forecast **income growth rates differentials** (y_t) your firm uses the following regression model (estimated regression is attached below):

$$y_{US,t} - y_{EUR,t} = \alpha + \beta\,(y_{US,t-1} - y_{EUR,t-1}) + \varepsilon_t.$$

To forecast **inflation rates** (I) your firm uses a RW model.

(A) Use the ad-hoc model (M1) to forecasts the USD/EUR exchange rate for the period 2017:1.
(B) Use the forward rate to forecast the USD/EUR exchange rate for the period 2017:1.
(C) Use S_t^{PPP} (long-run PPP, starting with $S_{t=2016.1}$) to forecast the USD/EUR exchange rate for the period 2016:4.
(D) Use the random walk to forecast the USD/EUR exchange rate for the period 2017:1.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.196241
R Square	0.03851
Adjusted R Square	0.032185
Standard Error	1.143971
Observations	154

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	7.967219	7.967219	6.088029	0.01472
Residual	152	198.9178	1.30867		
Total	153	206.885			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-0.03019	0.092218	-0.32737	0.743839	-0.21238
X Variable 1	0.19537	0.079181	2.467393	0.01472	0.038933

CHAPTER 9 - BONUS COVERAGE: TAYLOR RULE

According to the Taylor rule, the CB raises the target for the short-term interest rate, i_t, if:
(1) Inflation, I_t, raises above its desired level
(2) Output, y_t, is above "potential" output

The target level of inflation is positive (deflation is thought to be worse than positive inflation for the economy) The target level of the output deviation is 0, since output cannot permanently exceed "potential output."

John Taylor (1993) assumed the following reaction function by the CB:

$$i_t = I_t + \gamma\,(I_t - I_t^*) + \theta \text{ y-gap}_t + r^* \qquad \text{(Equation BC.1)}$$

where y-gap$_t$ is the output gap –a percent deviation of actual real GDP from an estimate of its potential level–, and r^* is the equilibrium level or the real interest rate, which Taylor assumes equal to 2%. The coefficients θ and γ are weights, which can be estimated (though, Taylor assumes them equal to .5).

Let I_t^* and r^* in equation BC.1 be combined into one constant term, $\mu = r^* - \gamma\, I_t^*$. Then,

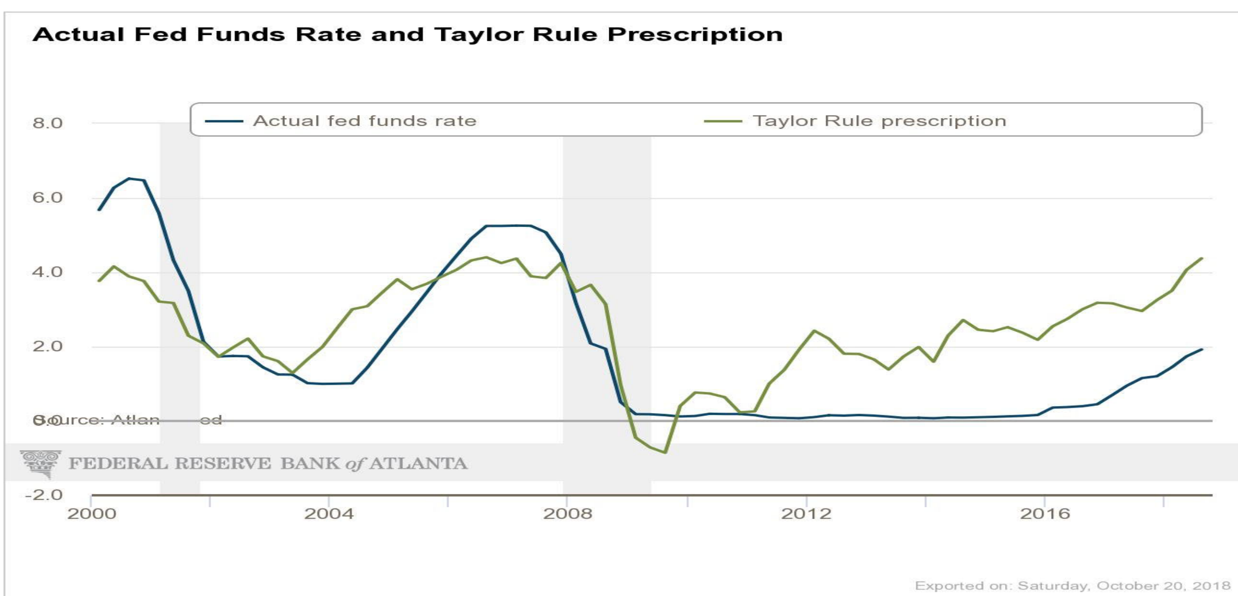
$$i_t = \mu + \lambda\, I_t + \theta \text{ y-gap}_t,$$

where $\lambda = 1 + \gamma$. Using Taylor's assumed coefficients ($\gamma = \theta = 0.5$), $r^* = 2\%$ and $I^*=2\%$, we predict that the Fed sets interest rates according to:

$$i_t = .01 + 1.5\, I_t + 0.5 \text{ y-gap}_t.$$

We graphed this prediction ("Taylor Rule Prescription") below in Figure 9.2 for the period 2000-2018, along with the actual Fed funds rate.

Figure 9.2
Taylor Rule: U.S. Federal Fund Rate (2000 - 2018)

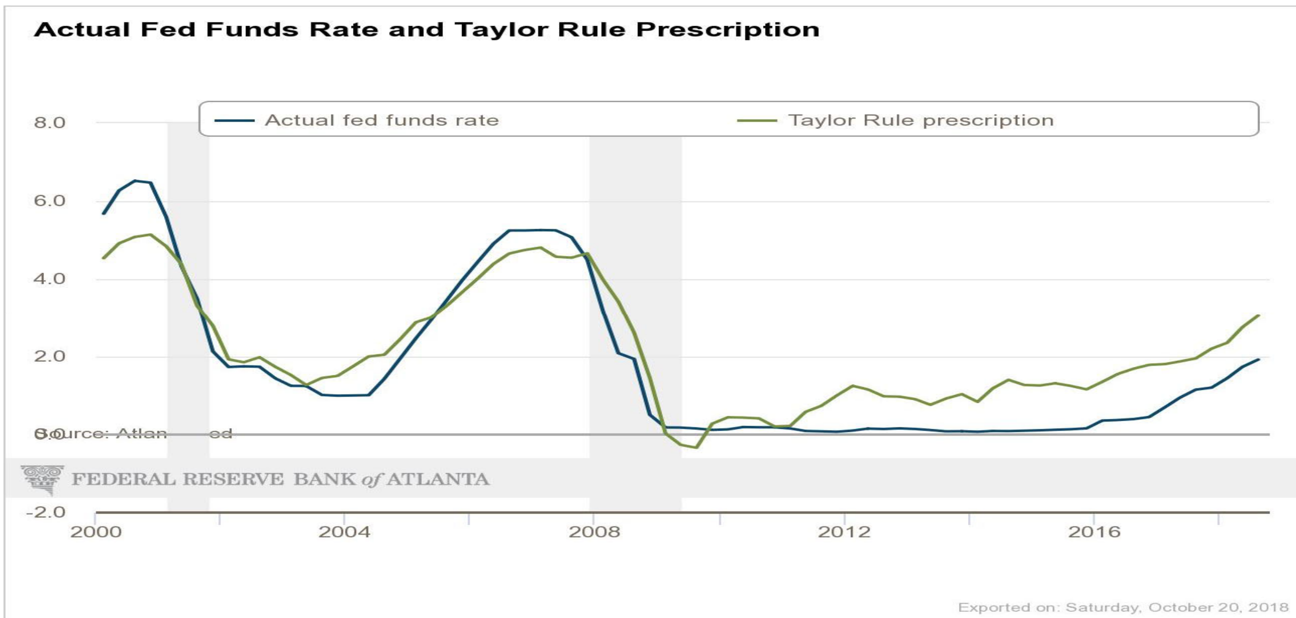


A popular variation to the Taylor rule (Equation BC.1) is to allow for gradualism in interest rate policy, reflecting the usual Central Bank practice of gradual, small adjustments in interest rates. This *modified Taylor rule* is:

$$i_{d,t} = \rho\, i_{d,t-1} + (1 - \rho)\, [r_t^* + I_{d,t} + \gamma\, (I_{d,t} - I_{d,t}^*) + \theta \text{ y-gap}_t],$$

where ρ is the smoothing parameter. If there is no gradual adjustment (ρ=0), the modified Taylor rule, reverts to the original rule. For example, using ρ=0.5 and the previous parameter values, in Figure 9.3 we graph the Taylor Rule prediction. It looks better.

Figure 9.3
Modified Taylor Rule: U.S. Federal Fund Rate (2000 - 2018)



For many countries, whose CB monitors S_t closely, the Taylor rule is expanded to include the real exchange rate, R_t:

$$i_t = \mu + \lambda\, I_t + \gamma \text{ y-gap}_t + \delta\, R_t.$$

Estimating this equation for the U.S. and a foreign country can give us a forecast for the interest rate differential, which can be used to forecast exchange rates.

Chapter 10 - Measuring FX Exposure – Part 1

At the firm level, currency risk is called FX *exposure*. Recall that currency risk describes how the value of an asset/liability fluctuates due to changes in S_t.

♦ **From Kellogg's 2014 Annual Report**
Almost everyone knows Kellogg, but the general public may not be aware that they do more than cereal. Kellogg is the world's largest cereal company; second largest producer of cookies and crackers; a major producer of snacks; and a major North American frozen foods company.

"Our operations face significant foreign currency exchange rate exposure and currency restrictions which could negatively impact our operating results.

We hold assets and incur liabilities, earn revenue and pay expenses in a variety of currencies other than the U.S. dollar, including the euro, British pound, Australian dollar, Canadian dollar, Mexican peso, Venezuelan bolivar fuerte and Russian ruble. Because our consolidated financial statements are presented in U.S. dollars, we must translate our assets, liabilities, revenue and expenses into U.S. dollars at then-applicable exchange rates. Consequently, changes in the value of the U.S. dollar may unpredictably and negatively affect the value of these items in our consolidated financial statements, even if their value has not changed in their original currency"

Three areas of FX exposure:
(1) *Transaction exposure*: Risk of transactions denominated in FX. The transaction should have a settlement or maturity date, T (today, 60 days, 90 days, 1 year, etc.).
(2) *Economic exposure*: Degree to which a firm's expected cash flows are affected by unexpected changes in S_t.
(3) *Translation exposure*: Accounting-based changes in a firm's consolidated statements that result from a change in S_t.

Example: The different FX exposures.
A. Transaction exposure.
Swiss Cruises, a Swiss firm, sells cruise packages to U.S. customers priced in USD. SC also has several U.S. suppliers that price in USD.

B. Economic exposure.
SC has the majority of its costs denominated in CHF. Almost 50% of its revenue is in USD. The CHF appreciates against the USD. SC cannot increase the USD prices of its cruise packages (competitive business). SC's net CHF cash flows will be affected.

C. Translation exposure.
SC has inventories in USD and a USD loan from a U.S. bank of equal USD amounts. These balance sheet items will be translated to CHF. Due to Swiss accounting rules, different exchange rates are used to translate USD inventories and the USD loan to CHF. Thus, an accounting gain/loss will be generated. ¶

Q: How can FX changes affect the firm?

• Transaction Exposure
Short-term CFs: Existing contractual obligations

• Economic Exposure
Future CFs: Erosion of competitive position

• Translation Exposure
Revaluation of balance sheet (book value vs market value)

Q #1: How do we measure these FX exposures?
Q #2: How do we use these measures to manage FX exposures?

10.1 Measuring TE

TE is easy to identify and measure, especially in the short-run, when firms can forecast future CF with high accuracy.

TE represents today's value of a future, certain transaction denominated in FC translated to the DC:

$$TE = \text{Value of transaction denominated in FC x } S_t$$

Example: Swiss Cruises has sold cruise packages to a U.S. wholesaler for USD 2.5 million. Payment is due in 30 days.
S_t = 1.45 CHF/USD.

$$TE = \text{USD } 2.5 \text{ M} * 1.45 \text{ CHF/USD} = \text{USD } 3.625 \text{ M. ¶}$$

MNCs measure Net TE. If a subsidiary has CF>0 in EUR and another subsidiary has CF<0 in EUR, net TE might be very low.

Example: Swiss Cruises.
SC has sold cruise packages to a U.S. wholesaler for USD 2.5 million.
SC has bought fuel oil for USD 1.5 million.
Both cash flows are going to occur in T=30 days.
S_t = 1.45 CHF/USD.

TE_{EUR} (in USD): (USD 2,500,000 - USD 1,500,000) * 1.45 CHF/USD = CHF 1,450,000. ¶

An MNC, like GE or MSFT, has many transactions denominated in FC, say EUR, GBP, JPY, MXN, etc. Since all net TEs by currencies are translated to DC, TE is easy to aggregate in a single number, the company's overall NTE:

$$NTE = TE_{EUR} + TE_{GBP} + TE_{JPY} + TE_{MXN} + \ldots$$

Usually, companies aggregate and report the overall NTE by maturity date, say "less than 90 days," and "more than 90 days."

MNCs measure Net TE. If a subsidiary has CF>0 in EUR and another subsidiary has CF<0 in EUR, NTE might be very low.

If we believe in the RW model, this is what we expect to happen at time T. Now, we know S_t will likely change at time T. We want to know how TE will be affected by changes in S_t. That is, we want to measure the FX risk involved with the transaction.

To do this, we need to say something about the variability (volatility) of S_t.

• **Range Estimates of Transaction Exposure**
Exchange rates are volatile, difficult to forecast. A range estimate of NTE will provide a more useful number for risk managers. The smaller the range, the lower the sensitivity of the NTE ⇒ The lower the FX risk.

Three popular methods for estimating a range for transaction exposure:
(1) Ad-hoc Rule: Usually, assume a change in $e_{f,t}$, for example ± 0.10.
(2) Simulation/Sensitivity Analysis: We look at empirical distribution (ED) of S_t, simulating S_{t+T}.
(3) Assuming a statistical distribution for S_t.

1. Ad-hoc Rule
Based on past experiences, a firm assumes that S_t can change (in either direction) by a fixed percentage. Then, it calculates the range of NTE under the assumed percentage.

Example: SC wants to estimates the sensitivity of NTE to changes in the S_t. They use the ±10% rule ($e_{f,t}$ = ± 0.10). (Recall: receivable USD 1 M due in 30 days.)
⇒ if S_t changes by ±10%, then NTE changes by CHF ±145,000. ¶

Note: This example presents a range for NTE. NTE ∈ [**USD 1.305M**, **USD 1.595 M**]. The wider the range, the riskier an exposure is.

The ± percentage used depends on the volatility of the portfolio of currencies in NTE:
Higher volatility in the currencies in the portfolio ⇒ A higher ± percentage.

2. Simulation/Sensitivity Analysis
Goal: Measure the sensitivity of TE to different exchange rates.

There are different ways to approach sensitivity analysis. Popular approaches: Look at the empirical distribution (ED), do a simulation.

Examples: Sensitivity of TE to extreme forecasts of S_t.
Sensitivity of TE to randomly simulated thousands of S_t. Then, draw a histogram to analyze the empirical distribution of TE.

Example ED-I: Using the ED for SC's Net TE (CHF/USD) over one month.
Statistics for the Empirical Distribution (ED) of monthly $e_{f,t}$ over the past 27 years (1990-2017), for 325 e_f's:

Minimun	**-0.12260**
0.25	-0.02066

Median	-0.00086
0.75	0.00192
Maximun	**0.12570**
Average (μ)	**-0.000886**
Standard Deviation (σ)	**0.03151**
Skewness	**0.21376**
Excess Kurtosis	**1.35745**

⇒ Extremes: **12.57**% (on September 2011) and **–12.26**% (on December 2008).

(A) Best case scenario: largest appreciation of USD: 0.1509
NTE: USD 1M * 1.45 CHF/USD * (1 + **0.12570**) = **CHF 1,632,265.**

(B) Worst case scenario: largest depreciation of USD: -0.1162
NTE: USD 1M * 1.45 CHF/USD * (1 + (-**0.12260**)) = **CHF 1,272,230.**

Based on these extremes, we estimate a range for TE

⇒ TE ∈ [**CHF 1,272,230**, **CHF 1,632,265**]

Practical Application: If SC is counting on the USD 1M to cover CHF expenses, from a risk management perspective, the expenses to cover should not exceed **CHF 1,281,510**. ¶

Note: Some firms may feel that this range, based on extremes, is too conservative. After all, the probability of the worst case scenario to happen is very low (only once in 248 months!). Under more likely scenarios, we may be able to cover more expenses with the lower bound.

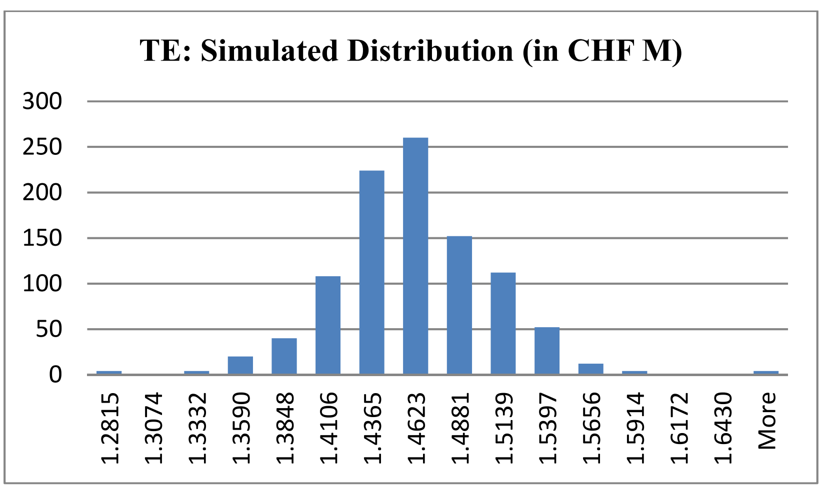
Simulating TE from Empirical Distribution
A different range can be constructed through sampling from the ED. Typical simulation:

(i) Randomly draw one scenario from the ED -say, $\mathbf{e_{f,t=Jun\ 1999}}$.
(ii) Calculate quantity of interest using simulated scenario -say, **TE** = USD 1M x S_t (1+ $\mathbf{e_{f,t=Jun\ 1999}}$).
(iii) Repeat (i)-(ii) *R* times. This is your *simulated distribution*. Analyze it as usual (calculate mean, SD, (1-α)% C.I., etc.)

Example ED-II: Simulation for SC's Net TE (CHF/USD) over one month.
Based on the ED, we will draw R = 1,000 $e_{f,t}$ realizations (past monthly $e_{f,t}$). Then, we calculate 1,000 TE for each scenario drawn. Steps:
i) Randomly draw $\boldsymbol{e_{f,t} = e_{f,sim,1}}$ from ED: Observation 519: $\boldsymbol{e_{f,t+30}}$ **= 0.0034**
(ii) Calculate $\mathbf{S_{sim,1}}$: $\mathbf{S_{t+30}}$ = **1.45 CHF/USD** * (1 + **.0034**) = **1.4549**
(iii) Calculate $\mathbf{TE_{sim,1}}$: **TE** = **USD 1M** * $\mathbf{S_{t+30}}$ = **1,454,937.57**
(iv) Repeat (i)-(iii) 1,000 times. Plot the 1,000 TEs in a histogram. (This is your simulated TE distribution.)

Lookup cell	$e_{f,t}$	Random Draw with Randbetween	Draw $e_{f,sim}$ with Vlookup	S_sim	TE(sim)
1					
2	0.0025	519	**0.0034**	1.4549	**1,454,937.57**
3	-0.0027	147	-0.0104	1.4349	1,434,895.83
4	**0.0001**	99	0.0125	1.4682	1,468,189.96
5	-0.0443	203	-0.0584	1.3653	1,365,272.92
6	-0.0017	82	-0.0727	1.3446	1,344,597.25
7	-0.0031	**4**	**0.0001**	1.4502	1,450,168.79
8	-0.0227	67	-0.0226	1.4172	1,417,218.22
9	-0.0099	136	0.0095	1.4638	1,463,838.02
10	0.0098	232	0.0191	1.4777	1,477,749.46

Note: You can find this example in my homepage: www.bauer.uh.edu/rsusmel/4386/chfusd-sim.xls



Based on this simulated distribution, we can estimate a 95% range (leaving 2.5% observations to the left and 2.5% observations to the right)

$\Rightarrow$ TE $\in$ [**CHF 1.356775 M**, **CHF 1.52688 M**]

Practical Application: If SC expects to cover expenses with this USD inflow, the maximum amount in CHF to cover, using this 95% CI, should be **CHF 1,356,775**. ¶

We can interpret the worst case scenario of the empirical CI as *Value-at-Risk* or VaR (see Appendix 10). The VaR(mean) measures the maximum expected loss in a given time interval, within a (one-sided) confidence interval. Since VaR can be measured as a percentage or a value, it is common to put a currency sign (say, "$") before the VaR to make explicit when the VaR is measured as a value. In this latter case, we will put the respective currency in front of the VaR.

In the previous example, the CHF VaR(mean) = CHF 1.45M – **CHF 1,356,775** = CHF 43.3225 is the maximum expected low in a month within a 97.5% CI.

3. Assuming a Distribution

Confidence intervals (CI) based on a distribution provide a range for TE. We will assume a normal distribution to construct a CI.

Example: A firm assumes that S_t changes ($e_{f,t}$) follow a normal distribution with mean μ and variance σ^2. That is, $e_{f,t} \sim N(\mu, \sigma^2)$. Based on this assumption, a firm can construct a $(1 - \alpha)\%$ CI:

$$[\mu - z_{\alpha/2} * \sigma,\ \ \mu + z_{(1-\alpha/2)} * \sigma] = [\mu \pm |z_{\alpha/2}|\ \sigma].$$

Then, a 95% ($\alpha = .05$, $z_{.025} = -1.96$) CI is given by

$[\mu \pm 1.96\ \sigma]$. (Instead of 1.96, you can use 2.) ¶

Example: CI range based on a Normal distribution.

Swiss Cruises believes that CHF/USD monthly changes ($e_{f,t}$) follow a normal distribution. SC estimates the mean and the variance from the empirical distribution from past 20 years.

μ = Monthly mean = **-0.000886** ≈ -0.09% (⇒ statistically speaking, μ =0!)

σ^2 = Monthly variance = 0.000992 (⇒ σ = **0.03151**, or 3.15%)

$e_{f,t} \sim N(-0.00152, \mathbf{0.03151}^2)$.

SC decides to construct a 95% CI for $e_{f,t}$. Then, a 95% confidence interval is given by:

[**-0.000886** ± 1.96 * **0.03151**] = [-0.06365; 0.06087].

Thus, $e_{f,t}$ is expected to be between -0.06365 and 0.06087 (with 95% confidence).

Based on this range for $e_{f,t}$, we derive bounds for the net TE:

(A) Upper bound

NTE: USD 1M * 1.45 CHF/USD * (1 + 06087) = **CHF 1,538,267**.

(B) Lower bound

NTE: USD 1M * 1.45 CHF/USD * (1 – 0.06365) = **CHF 1,359,164**.

⇒ TE ∈ [**CHF 1.3592 M**, **CHF 1.5383 M**]

Interpretation of CI: If we have 100 transactions, with the same terms, we expect that in 95 of those transactions the TE will lie within the estimated 95% confidence interval.

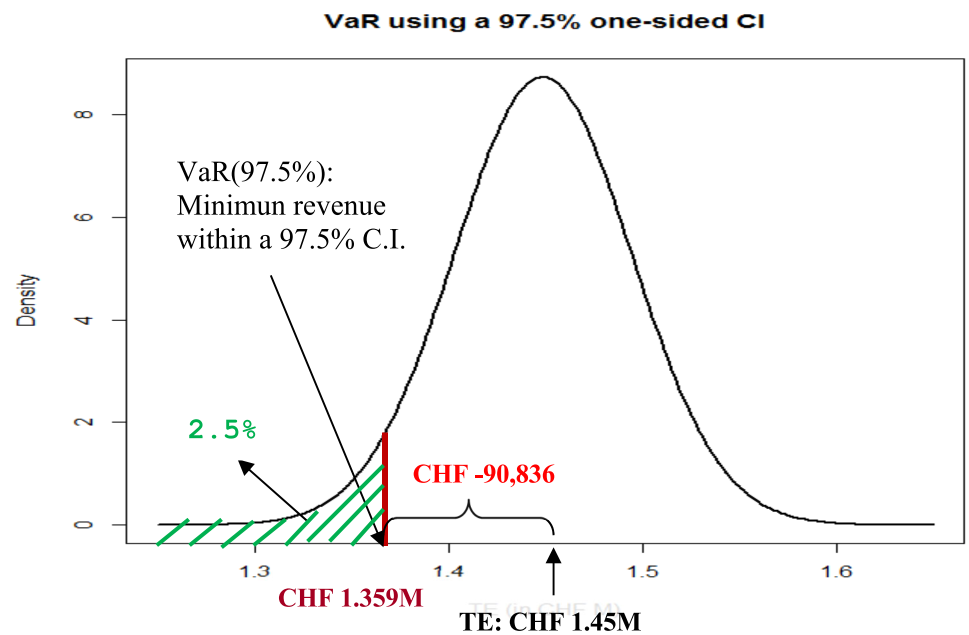
Note 1: VaR interpretation (VaR measures the worst case scenario within a one-sided $(1 - \alpha)$ CI):

CHF 1,359,164 is the minimum revenue to be received by SC in the next 30 days, within a 97.5% CI. Notation: CHF VaR(.975) = **CHF 1,359,164**..

If SC expects to cover expenses with this USD inflow, the maximum amount in CHF to cover, within a 97.5% CI, should be **CHF 1,359,164**.

The VaR is often expressed as a potential loss, relative to today's value of the cash flow at risk (or expected value, using the RWM!). In this case, we call it VaR(mean):

CHF VaR(mean, 97.5%) = **CHF 1,359,164** – CHF 1,450,000 = **CHF -90,836.**



The VaR(mean) can be expressed as:
CHF VaR(mean, 97.5%) = CHF 1.45 M * [-0.000886 – 1.96***0.03151] = CHF -0.090836 M**

Given that the mean is statistically speaking, that is, we can assume $\mu = 0$, and, thus, the

CHF VaR(mean, 97.5%) ≈ CHF 1.45 M * (-1.96) * **0.03151 = CHF -0.089551 M**

We can generalize the above result as:

VaR(mean, $(1 - \alpha)$) ≈ NTE * $(-z_\alpha)$ * σ.

Note 2: For a given data set, using logarithmic (geometric) returns, it is easy to extend the results to different maturities. Suppose we are interested in building a 95% C.I. for TE in q months, using data based on frequency n (say, n=1 month). Assuming independence of returns, the approximation formulas for mean and SD are:

q-mo mean = n-mo mean x q/n

q-mo SD = n-mo SD x $\sqrt{(q/n)}$

Suppose, in the above example, the maturity of the cash flows is extended to 3 months. Using the monthly data, we create a 95% C.I. for 3-mo TE. Then, q=3 and n=1:
3-mo mean = **-0.000886** x *3* = -0.00266
3-mo SD = **0.03151** x $\sqrt{3}$ = 0.05458

95% C.I. for $e_{f,t}$: [-0.00266 ± 1.96*0.05458] = [-0.10963; 0.10431]

(A) Upper bound
NTE: USD 1M x 1.45 CHF/USD * (1 + 0.10431) = CHF 1,601,254.

(B) Lower bound
NTE: USD 1M x 1.45 CHF/USD * (1 – 0.10963) = CHF 1,290,960. ¶

In Table 5.1, we noticed that $e_{f,t}$ does not follow a normal distribution, mainly because it has "fat tails," as shown by an excess kurtosis significantly different from zero. We can introduce departures from normality in different ways; usually, by assuming a fat-tail distribution, like the *t-distribution*, or using the Cornish-Fisher (CF) approximation. The CF approximation uses a Taylor expansion of the normal density, which makes the approximate density a function of skewness (SK) and excess kurtosis (EK). Under the CF approximation, we have new z_α values, z_α^{CF}:

$$z_\alpha^{CF} = z_\alpha + \frac{SK}{6}\{(z_\alpha)^2 - 1\} + \frac{EK}{24}\{(z_\alpha)^3 - 3z_\alpha\} + \frac{SK^2}{36}\{2(z_\alpha)^5 - 5z_\alpha\}$$

Notice that if SK = EK = 0, then, $z_\alpha^{CF} = z_\alpha$.

For α = .025, $z_{.975} = 1.96 \Rightarrow z_{\alpha=.975}^{CF} = 1.96 + 0.474 * SK + 0.069 * EK + 1.335 * (SK)^2$.
$z_{.025} = -1.96 \Rightarrow z_{\alpha=.025}^{CF} = -1.96 + 0.474 * SK - 0.069 * EK - 1.335 * (SK)^2$.

Example: For the CHF/USD used above we have SK = **0.214** & EK = **1.357** (& μ = 0). Then,
$z_{\alpha=.975}^{CF} = 1.96 + 0.474 * (\mathbf{0.214}) + 0.069 * (\mathbf{1.357}) + 1.335 * (\mathbf{0.214})^2 = 2.216$
$z_{\alpha=.025}^{CF} = -1.96 + 0.474 * (\mathbf{0.214}) - 0.069 * (\mathbf{1.357}) - 1.335 * (\mathbf{0.214})^2$= -2.013.
Then,
CHF VaR(mean, (1 – α)) ≈ CHF 1.45M * (-2.013) * **0.03151** = **CHF -0.091973.** ¶

♦ **Real World Example: Transaction Exposure: The Case of Kellogg**
The Kellogg Company is the world's largest cereal company; second largest producer of cookies and crackers; and a major producer of snacks and frozen foods. The principal markets for these products include the U.S. and the Europe. Kellogg's operations are managed in two major divisions –U.S. and International- with International further delineated into Europe, Latin America, Canada, Australia, and Asia. Operating profits for fiscal year 2014 were USD 1,024 million on sales of USD 14.58 billion.

Primary exposures include the USD versus the EUR, GBP, MXN, AUD, CAD, VEF, and RUB, and in the case of inter-subsidiary transactions, the British pound versus the euro.

The total notional amount of foreign currency derivative instruments at year-end 2014 was USD 764 million, representing a settlement receivable of USD 23 million. The total notional amount of foreign currency derivative instruments at year-end 2013 was USD 517 million, representing a settlement obligation of USD 1 million. All of these derivatives were hedges of anticipated transactions, translational exposure, or existing assets or liabilities, and mature within 18 months. Assuming an unfavorable 10% change in year-end exchange rates, the settlement receivable would have become a settlement obligation of USD 53 million at year-end 2014 and the settlement obligation at year-end 2013 would have increased by approximately USD 52 million.
Source: Kellogg Annual Report 2014. ♦

CHAPTER 10 - BONUS COVERAGE I: *TE Simulation in R*

Excel is not a very flexible way to construct a simulated C.I. We can use R to do; for this, you need to install R in your computer (go to https://www.r-project.org to download the latest version).

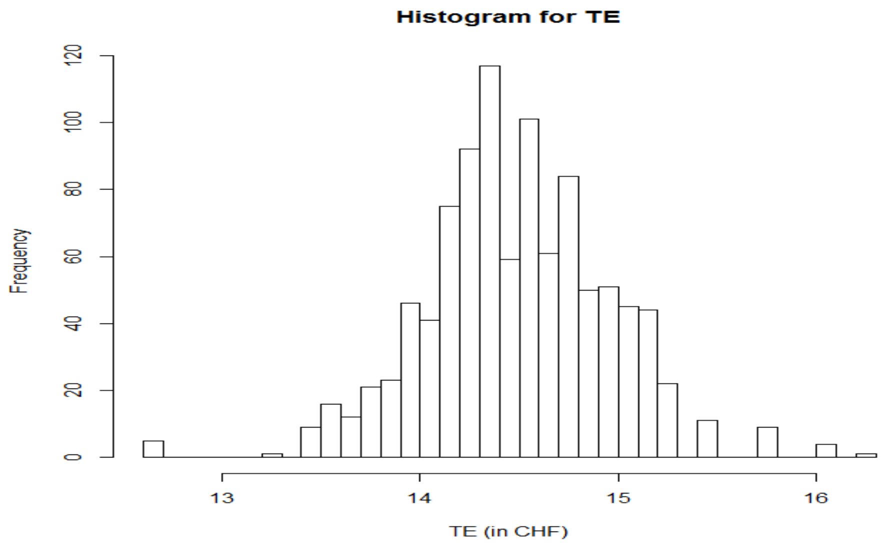
• Code in R (cut and paste; play with parameters R & alpha):

```
chfusd <- read.csv("http://www.bauer.uh.edu/rsusmel/4386/chfusd.csv",sep=",")    # Data
summary(chfusd)                              # Distribution of Data (S_t)
names(chfusd)                                # Repeats Header info ("DATA" & "CHF_USD"

S <- chfusd$CHF_USD                          # Defines S_t as the CHF_USD column of the data
T <- length(S)                               # Check total T (1971:1 to 2017:1)
Tstart <- 229                                # Start of sample period: 1990:1
e <- matrix(0,T-1,1)                         # create vector of 0 to put the e_f,t
Val <- 1                                     # Value of transaction in FC (in M)
S_0 <- 1.45                                  # Today's S_t

for (i in 2:T){                              # loop to calculate log (or arithmetic) returns
#   e[i] <- (S[i]/S[i-1]-1)
   e[i] <- log(S[i])-log(S[i-1])
}

Tsart <- Tsart-1                             # adjust Tstart (we lost one observation in the above loop
summary(e)                                   # summary stats for the whole sample of e
summary(e[Tstart:T-1])                       # summary stats for sample of interest  of e
sd(e[Tstart:T-1])                            # Standard Deviation of e during sample of interest

# simulation
R = 1000                                             # Number of simulations
alpha = .05                                          # Specify (1-alpha)% Confidence Interval
R_low <- R*alpha/2
R_low
R_high = R*(1-alpha/2)
R_high
x_sam <- sample(e[Tstart:T-1], size=R, replace=TRUE)  # generate R e_f draws from ED
TE <- Val*S_0*(1+x_sam)                              # calculate R TE values


# Sort and Histogram
STE <- sort(TE)                                      # sort TE (from lowest to highest)
print(STE[R_low])                                    # print TE_lower bound
print(STE[R_high])                                   # print TE_upper bound


hist(TE,main="Histogram for TE",
   xlab="TE (in CHF)", breaks=30)                    # TE histogram
```

• You should get something similar to:

```
> print(STE[R_low])# print TE_lower bound
```

```
[1] 1.356775
> print(STE[R_high])# print TE_upper bound
[1] 1.52688

> hist(TE,main="Histogram for TE",
+      xlab="TE (in CHF)", breaks=30)# TE histogram
>
```

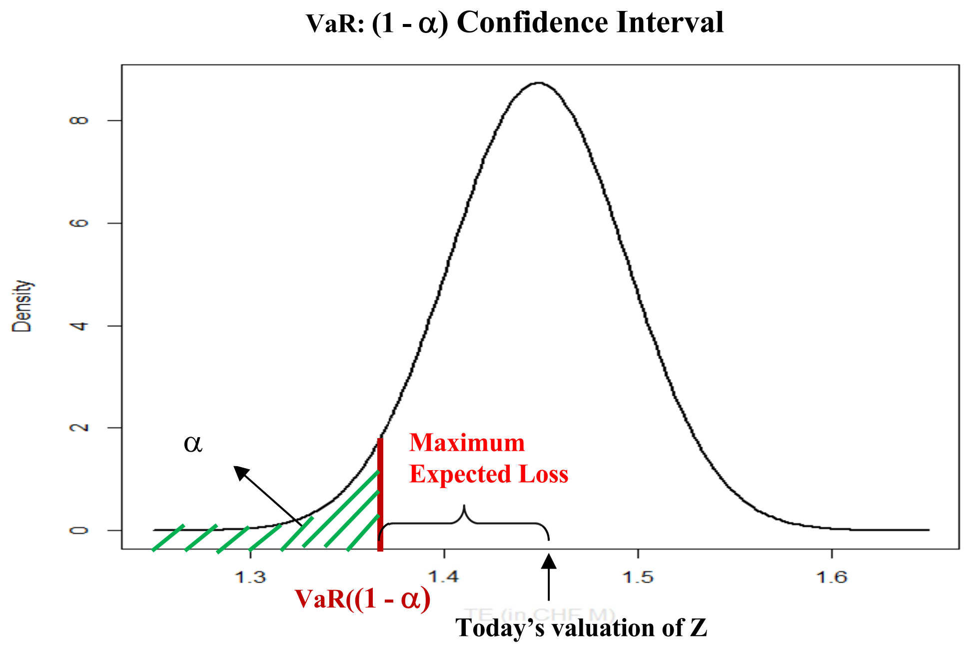


CHAPTER 10 - BONUS COVERAGE II: *Value-at-Risk (VaR)*

• VaR provides a number, which measures the market risk exposure of a portfolio of a firm over a given length of time. VaR measures the maximum expected loss in a given time interval, within a (one-sided) confidence interval. (This is what we called before VaR(mean).)

Let $R_{t+1} = (Z_{t+1} - Z_t)/Z_t$ be the profit/loss of a financial firm in day t+1 for holding portfolio/asset Z_t (say, $Z_t = S_t$). Then, VaR is defined by:

$$\text{Prob}[R_{t+1} > \text{VaR}_{t+1}(1-\alpha)] = (1-\alpha)$$



Note: To calculate the VaR of a portfolio, we need to specify a time interval and the significance level for the confidence interval.

Interpretation of VaR: VaR of a FX portfolio.
Time interval: 1 day
Level of significance (α): 5% (z_α=1.645, 95% C.I.)
VaR of FX portfolio: USD 10,000.

This VaR amount (USD 10,000) represents the potential loss of the FX portfolio in about one every twenty days within a 95% one-sided C.I.

Banks report the VaR for their trading desk. They use α=.01% ((z_α=-2.33, 99% C.I.) and T=10 days. Regulators use the reported VaR to calculate capital requirements (capital charge). Say,

Capital charge = VaR x k, k>3.

Example: Microsoft uses a VaR computation, within a 97.5% confidence interval, to estimate the maximum potential 20-day loss in the fair value of its foreign currency denominated investments and account receivables, interest-sensitive investments and equity securities. At the end of June 2001, Microsoft calculated a VaR of negligible for foreign currency instruments, USD 363 million for interest sensitive instruments, and USD 520 million for equity investments. ¶

• Calculating VaR.

Assume that $R_{t+1} \sim N(\mu, \sigma^2)$, where the mean and variance are constant (in general, not a realistic assumption, since volatility changes over time). Then,

$$VaR_{t+1}(1-\alpha) = \mu + z_\alpha * \sigma$$

where z_α represents the quantile from the standard normal distribution at level α.

Example: Suppose an FX trader, trading the CHF/USD, assumes $e_{f,t} \sim N(\mu=\mathbf{-0.000886}, \sigma^2 = (\mathbf{0.03151})^2)$. The calculation of μ and σ was done using monthly data. Then, the FX trader calculates the maximum expected loss next month (T = 1) with a 99% confidence level as ($z_{\alpha=.01} = -2.33$):

$$VaR_{t+1}(.99) = \mathbf{-0.000886} - 2.33 * \mathbf{0.03151} = \mathbf{-0.0743043}.$$

If the value of the portfolio traded is **CHF 1.45 M**, then the CHF $VaR_{t+1}(.99)$ for the portfolio is:

CHF VaR(mean, .99) = **CHF 1.45 M** * (**-0.0743043**) = **CHF -0.1077412 M**. ¶

If the mean and the variance are time-varying, the VaR_{t+1} becomes:

$$VaR_{t+1}(1-\alpha) = \mu_{t+1} + z_\alpha * \sigma_{t+1}$$

Example: Suppose the FX trader, based on time-varying model of the variance, believes the variance next month will increase to **5%**. Then,

$$VaR_{t+1}(.99) = \mathbf{-0.000886} - 2.33 * \mathbf{0.05} = \mathbf{-0.117386}.$$

The CHF $VaR_{t+1}(.99)$ for the portfolio will be:

CHF VaR(mean, .99) = **CHF 1.45 M** * (**-0.117386**) = **CHF -0.1702097 M**. ¶

• Extending VaR to T periods: √T Rule

So far we have calculated the VaR at 1 period (above, 1 month) horizon. Suppose, we want to calculate for T periods, say T=10 (as required by bank regulators). Following the logarithmic approximations discussed in the text, the risk is scaled by √T and the mean is scaled by T.

Example: Suppose an FX trader, trading the CHF/USD, assumes monthly $e_{f,t} \sim N(\mu=\mathbf{-0.000886}, \sigma^2 = (\mathbf{0.03151})^2)$. Now, the FX trader wants to calculate the maximum expected loss in the next 3 months (T = 3) with a 99% confidence level as ($z_{\alpha=.01} = -2.33$):

$$VaR_{t+1}(.99) = [3\,(\mathbf{-0.000886}) - 2.33 * \sqrt{3} * \mathbf{0.03151}] = \mathbf{-0.12982}.$$ ¶

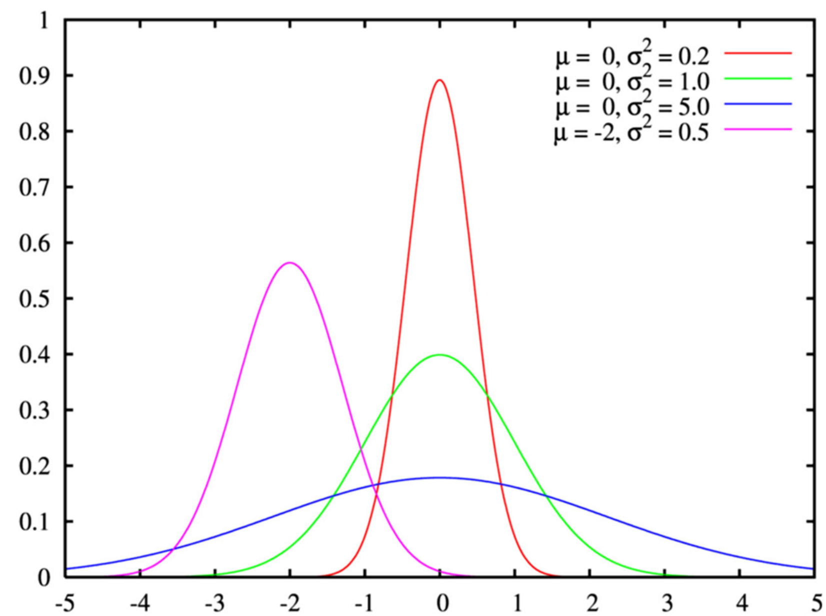
This rule is very simple, but it relies on the assumption that (logarithmic) returns are independent. For example, in the previous example, we implicitly assumed monthly changes in the CHF/USD are independent. But, if the independence assumption is not true, the √T rule is not precise. If the correlation is positive, as it tends to be for many assets, the rule tends to underestimate the risk in the portfolio.

CHAPTER 10 - BONUS COVERAGE III: *The Normal Distribution*

Suppose the random variable X has a probability distribution function (pdf) given by:

$f_X(x) = [1/(2\pi\sigma^2)^{1/2}] \exp\{-(x - \mu)^2/(2\sigma^2)\}$ $\quad\quad -\infty < x < \infty$,

where μ and σ^2 are any number such that $-\infty<\mu<\infty$, and $0<\sigma^2<\infty$. Then X is said to follow a *normal distribution*. We will use the following notation: $X \sim N(\mu,\sigma^2)$. The pdf has the following bell shape:



If Z follows a *standard normal distribution* then $Z \sim N(0,1)$, that is the green function in the above graph. Using the formula of the pdf normal distribution, tables for the cdf of the standard normal distribution have been tabulated.

1.B.1 Useful Results of the Normal Distribution

Let $X \sim N(\mu,\sigma^2)$. Then,

(i) $E[X] = \mu$ (the mean, μ, is also the mode and the median)
(ii) $Var(X) = E[(X - \mu)^2] = \sigma^2$
(iii) The shape of the pdf is a symmetric bell-shaped curve centered on the mean.
(iv) Let $Z = (X - \mu)/\sigma$. Then, $Z \sim N(0,1)$.
(v) If δ and ß are any numbers with $\delta <$ ß, then

$$P[\delta< X < ß] = P[(\delta - \mu)/\sigma < Z < (ß - \mu)/\sigma] = F_Z[(ß - \mu)/\sigma] - F_Z[(\delta-\mu)/\sigma],$$

where F_Z represents the cdf of Z.

Example: Let X be the annual stock returns (in percentage points) in the U.S. Assume that $X \sim N(11.44, 16.22^2)$. (The mean and variance of X have been obtained from annualizing the 1980-1990 U.S. weekly mean return and variance.) Suppose you are the manager of a portfolio that tracks the U.S. Index. You want to find the probability that your portfolio's return (X) is lower than -30% next year (i.e., a market crash).

$P[X < -30] = P[Z < (-30 - 11.44)/16.22] = P[Z < -2.55] = F_Z[-2.55] = 1 - F_Z[2.55] = 1 - .9878 = .0122.$

That is, the probability that next year stock return is lower than 30% is 1.22%. ¶

Example: Go back to the previous example. Now, suppose you want to determine a minimum return, say τ%, with probability .95. That is, you want to find the probability that your portfolio's return exceeds a level τ with probability .05. That is,

$.95 = P[X > \tau] = P[Z > (\tau - 11.44)/16.22] = 1 - F_Z[(\tau - 11.44)/16.22].$

From the Normal Table, we obtain that if $F_Z(z) = .05$, $z = -1.645$.

Then, $(\tau - 11.44)/16.22 = -1.645 \quad\quad \Rightarrow \tau = 11.44 - 1.645\,(16.22) = -15.323.$

That is, there is a 95% probability that next year's portfolio return will be bigger than -15.323%. ¶

Using the above properties, it is very easy to construct confidence intervals for the random variable X, which is normally distributed with mean μ and variance σ^2. The key to construct confidence intervals is to select an appropriate z value, such that

$$X\ \varepsilon[\mu \pm z_{\alpha/2}\,\sigma] \quad \text{with a probability } (1-\alpha).$$

For a 99% confidence interval (i.e, α=.01) z is equal to 2.58.
For a 98% confidence interval (i.e, α=.02) z is equal to 2.33.
For a 95% confidence interval (i.e, α=.05) z is equal to 1.96 (≈2).
For a 90% confidence interval (i.e, α=.10) z is equal to 1.645.

Chapter 10 - Measuring FX Exposure – Part 2

Three areas of FX exposure
- Transaction exposure: associated with specific transactions (in FC).
- Economic exposure: associated with futures cash flows –true exposure for owners.
- Translation exposure: associated with a firm's consolidated statements.

TE is simply to calculate: Value in DC of a specific transaction denominated in FC.

We can measure TE, and analyze the sensitivity of TE to changes in S_t.

Use a statistical distribution or a simulation.

The less sensitive TE is to S_t, the lower the need to pay attention to changes in S_t.

MNCs have measures for NTE for:
- A single transaction
- All transactions (Netting + taking into account co-movements of transactions. A portfolio approach)

The portfolio approach incorporates correlations.

Recall that the co-movement between two random variables can be measured by the correlation coefficient. The correlation between the random variables X and Y is given by:

$$Corr(X,Y) = \rho_{XY} = \sigma_{XY}/(\sigma_Y\sigma_Y).$$

Interpretation of the correlation coefficient ($\rho_{xy} \in [-1, 1]$):
- If $\rho_{xy} = 1$, X changes by 10%, Y also changes by 10%.
- If $\rho_{xy} = 0$, X changes by 10%, Y is not affected --(linearly) independent.
- If $\rho_{xy} = -1$, X changes by 10%, Y also changes by -10%.

Figure 10.1: Co-movement by Major Currencies (1999-2012)

Note: As shown in Figure 10.1, currencies from developed countries tend to move together -i.e., positive correlations. But, there are periods where the correlations can be quite negative.

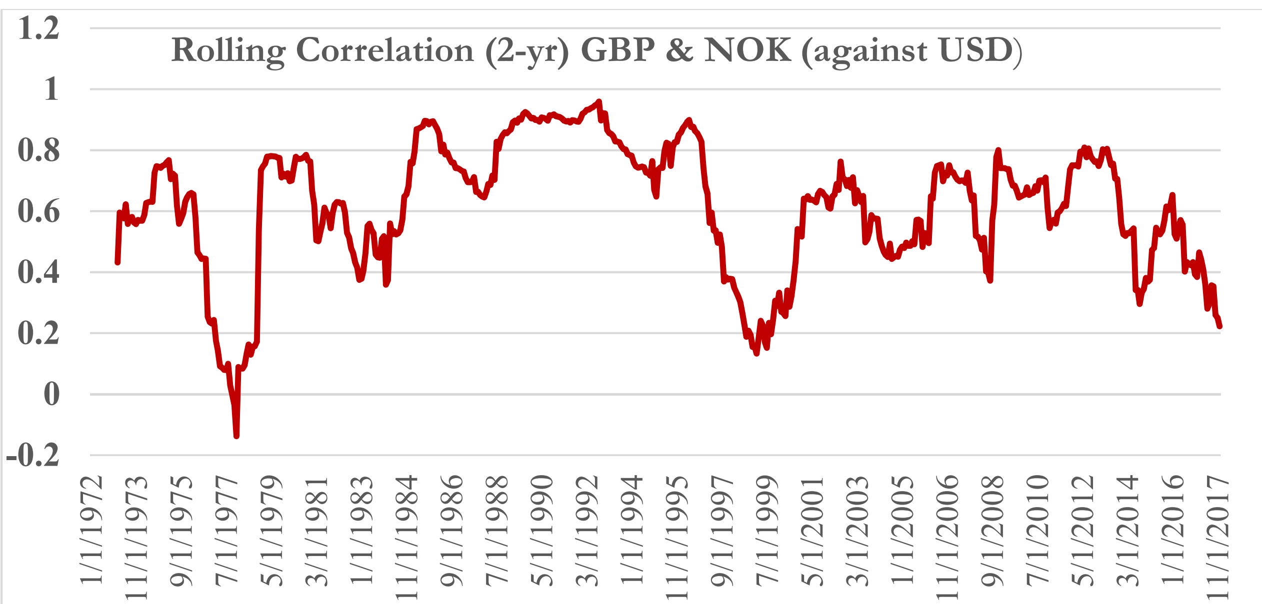
• MNC take into account the correlations among the major currencies to calculate NTE
⇒ Portfolio Approach.

A U.S. MNC: Subsidiary A with CF(in EUR)>0
Subsidiary A with CF(in GBP)<0
$\rho_{GBP,EUR}$ is very high and positive.
Net TE might be very low for this MNC.

Hedging decisions: Not made transaction by transaction. Rather, they are made based on the exposure of the portfolio.

Example: Swiss Cruises.
Net TE (in USD): USD 1 million. Payment: 30 days.
Loan repayment: CAD 1.50 million. Payment: 30 days.
S_t = 1.47 CAD/USD.
$\rho_{CAD,USD}$ = .843 (1971-2017)
Swiss Cruises considers the Net TE (overall) to be close to zero. ¶

Note: As seen in the previous graphs, currencies tend to move together, but not always. Correlations vary a lot across currencies. In general, regional currencies are highly correlated. From 1972-2017, the GBP and NOK (Norwegian Kroner) had an average correlation of .58, while the GBP and the JPY had an average correlation of .04. Correlations also vary over time.



• Sensitivity Analysis for Portfolio Approach
Do a simulation. That is, assume different scenarios (pay attention to the correlations!)

Example: IBM has the following CFs in the next 90 days

	Outflows	Inflows	S_t	Net Inflows
GBP	100,000	25,000	1.60 USD/GBP	(75,000)
EUR	80,000	200,000	1.05 USD/EUR	120,000

NTE (in USD) = EUR 120,000 * 1.05 USD/EUR + (GBP 75,000) * 1.60 USD/GBP =
= **USD 6,000** (this is our baseline case)

Situation 1: Assume $\rho_{GBP,EUR} = 1$. (The correlation between the EUR and the GBP is high.)
Scenario (i): EUR appreciates by 10% against the USD ($e_{f,EUR}$=.10)

Since $\rho_{GBP,EUR} = 1$, S_t = 1.05 USD/EUR * (1 + .10) = 1.155 USD/EUR
S_t = 1.60 USD/GBP * (1 + .10) = 1.76 USD/GBP

NTE (in USD) = EUR 120,000*1.155 USD/EUR+(GBP 75,000)*1.76 USD/GBP =
= **USD 6,600**. (10% change = **USD 600**)

Scenario (ii): EUR depreciates by 10% against the USD ($e_{f,EUR}$=-.10)

Since $\rho_{GBP,EUR} = 1$, S_t = 1.05 USD/EUR * (1 – .10) = 0.945 USD/EUR
S_t = 1.60 USD/GBP * (1 – .10) = 1.44 USD/GBP

NTE (in USD) = EUR 120,000*1.155 USD/EUR + (GBP 75,000)*1.76 USD/GBP =
= **USD 5,400**. (-10% change = **USD -600**)

Now, we can specify a range for NTE $\Rightarrow$ NTE $\in$ [**USD 5,400**, **USD 6,600**]

Note: The NTE change is exactly the same as the change in S_t. If a firm has matching inflows and outflows in different currencies –i.e., the NTE is equal to zero-, then changes in S_t do not affect NTE. That's very good.

Of course, we will draw more than 2 scenarios, say 10,000 draws for $e_{f,EUR}$ and then draw a histogram with the 10,000 NTEs. Finally, we can draw a (1-α)% Confidence interval.

Situation 2: Suppose the $\rho_{GBP,EUR} = -1$ (NOT a realistic assumption!)
Scenario (i): EUR appreciates by 10% against the USD ($e_{f,EUR}$=.10)

Since $\rho_{GBP,EUR} = -1$, S_t = 1.05 USD/EUR * (1 + .10) = 1.155 USD/EUR
S_t = 1.60 USD/GBP * (1 - .10) = 1.44 USD/GBP

NTE (in USD) = EUR 120,000*1.155 USD/EUR + (GBP 75,000)*1.44 USD/GBP =
= **USD 30,600**. (410% change = **USD 24,600**)

Scenario (ii): EUR depreciates by 10% against the USD ($e_{f,EUR}$=-.10)

Since $\rho_{GBP,EUR} = -1$, S_t = 1.05 USD/EUR * (1 - .10) = 0.945 USD/EUR
S_t = 1.60 USD/GBP * (1 + .10) = 1.76 USD/GBP

NTE (in USD) = EUR 120,000*0.945 USD/EUR + (GBP 75,000)*1.76 USD/GBP =
= **(USD 18,600).** (-410% change = **USD -24,600**)

Now, we have a range for NTE $\Rightarrow$ NTE $\in$ [(**USD 18,600**), **USD 30,600**]

Note: The NTE has ballooned. A 10% change in exchange rates produces a dramatic increase in the NTE range. Having non-matching exposures in different currencies with negative correlation is very dangerous.

Again, we will draw more than 2 scenarios, say 10,000 and then draw a histogram with the 10,000 NTEs. Finally, we can draw a (1-α)% Confidence interval.

In both situations, given the high correlations, IBM only draws one variable ($e_{f,EUR}$). For the other situations, where the correlation is not very high, IBM will draw from the empirical distribution (ED). In this case, IBM will randomly draw pairs together –say, $e_{f,EUR}$ & $e_{f,GBP}$- and then calculate NTE's for each draw. ¶

Alternatively, IBM can assume a distribution (say, bivariate normal) with a given correlation (estimated from the data) and, then, draw many scenarios for the S_t's to generate an empirical distribution for the NTE. From this simulated distribution, IBM will get a range –and a VaR- for the NTE.

Real World: Walt Disney Company's *VALUE AT RISK (VaR)*
According to Disney's 2006 Annual Report:
The Company utilizes a VaR model to estimate the maximum potential one-day loss in the fair value of its interest rate, foreign exchange and market sensitive equity financial instruments. The VaR model estimates were made assuming normal market conditions and a 95% confidence level. Various modeling techniques can be used in a VaR computation. The Company's computations are based on the interrelationships between movements in various interest rates, currencies and equity prices (a variance/co-variance technique) These interrelationships were determined by observing interest rate, foreign currency, and equity market changes over the preceding quarter for the calculation of VaR amounts at fiscal 2006 year end.

The estimated maximum potential one-day loss in fair value, calculated using the VAR model, is as follows (unaudited ,in millions):

(in millions)	Interest Rate Sensitive Financial Instruments	Currency Sensitive Financial Instruments	Equity Sensitive Financial Instruments	Combined Portfolio
VaR (year end 05)	USD 22	USD 10	USD 1	USD 21
Average VaR	USD 19	USD 13	USD 0	USD 22
Highest VaR	USD 22	USD 15	USD 1	USD 24
Lowest VaR	USD 18	USD 10	USD 0	USD 18

10.2 Measuring Economic Exposure

EE: Risk associated with a change in the NPV of a firm's expected cash flows, due to an *unexpected* change in S_t.

Very general definition: It can be applied to any firm (domestic, foreign, MNC, exporting, importing, purely domestic, etc.).

Q: How can we measure the degree to which CFs are affected by *unexpected* $e_{f,t}$?
A: Remember Random Walk. All changes in S_t are unexpected.

Example: On February 2, 2015, Owens-Illinois (OI), the giant U.S. manufacturer of glass containers, reported its fourth-quarter results. OI reported that sales declined 9% year over year to USD 1.6 billion due to a stronger USD that adversely impacted sales by 6%. OI forecasted that, in 2015, earnings will be negatively impacted by the strong USD. The strong USD is expected to reduce translated sales by nearly 10%. This is *economic exposure.* ¶

• The degree to which a firm is subject to EE depends on:
  - The type and structure of the firm
  - The industry structure in which the firm operates.

In general, importing and exporting firms face a higher EE than purely domestic firms do.

Industry structure is also very important. In general, monopolistic firms face lower EE than firms that operate in competitive markets.

Example: Suppose a U.S. firm face almost no competition in the domestic market. This U.S. firm is able to transfer to its prices almost any increase of its costs due to changes in S_t. Thus, this firm faces no EE, since its CFs are unaffected by changes in S_t. ¶

But, the degree of EE for a firm is an empirical question.

• Economic exposure is: - Subjective.
  - Difficult to measure.

Idea: To measure EE we need to relate future cash flows to changes in S_t.

1. A Measure Based on Accounting Data
It requires to estimate the net cash flows of the firm (EAT or EBT) under several FX scenarios. (Easy with an excel spreadsheet.)

Example: IBM HK provides the following info:
Sales and cost of goods are dependent on S_t

	S_t = 7 HKD/USD	S_t = 7.70 HKD/USD
Sales (in HKD)	300M	400M
Cost of goods (in HKD)	150M	200M
Gross profits (in HKD)	150M	200M
Interest expense (in HKD)	20M	20M
EBT (in HKD)	**130M**	**180M**

EBT (in USD) at S_t = 7 HKD/USD: **USD 130M**/7 HKD/USD = **USD 18.57M**
EBT (in USD) at S_t = 7.7 HKD/USD: **USD 180M**/7.70 HKD/USD = **USD 23.38M**

A 10% depreciation of the HKD, increases the HKD cash flows from HKD 130M to HKD 180M, and the USD cash flows from **USD 18.57M** to **USD 23.38** or a 25.9%.

Q: Is EE significant?
A: We can calculate the elasticity of CF to changes in S_t.
For example, in USD, a 10% depreciation of the HKD produces a change of 25.9% in EBT, for a 2.59 elasticity. It looks quite significant. But you should note that the change in exposure is USD 4.81M. This amount might not be very significant for IBM! A judgment call maybe needed here. ¶

2. An Easy Measure of EE Based on Financial Data

Sometimes, accounting data are not very relevant, since it measure the past. EE deals with futures cash flows. If available, changes in stock prices –i.e., returns- should be used –recall that stock prices measure discounted future cash flows.

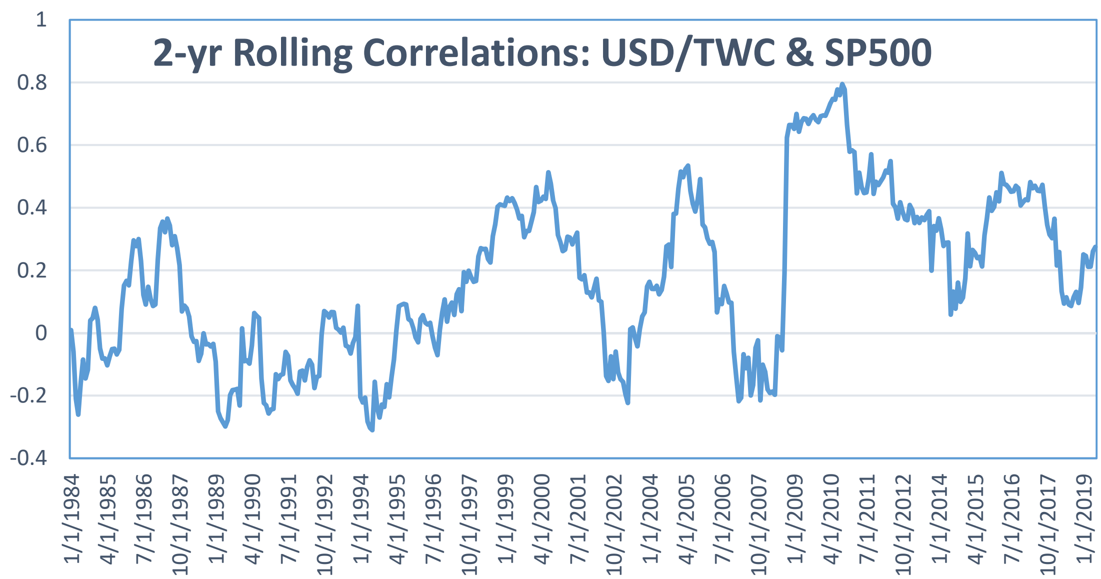
• We want to measure the correlation between ΔCF and $e_{f,t}$.

⇒ we can use the correlation coefficient between ΔCF and $e_{f,t}$.

Example: Kellogg's and AT&T's EE.
Using monthly stock returns for Kellogg's (Kret) and monthly changes in S_t (USD/TWC) from 1/1984-7/2019, we estimate $\rho_{K,e}$ (correlation between $Kret_t$ and $e_{f,t}$) = **0.102**. TWC represents a Trade Weighted Basket of Major Currencies. It looks small, but away from zero. We do the same exercise for AT&T (T), obtaining $\rho_{T,e}$ = **0.026**, small and close to zero. ¶

Interesting result: Correlations between returns and changes in exchange rates are time-varying. Recessions and crises affect the relation. Below, in Figure 10.2, we calculate the 12-month rolling correlation between the S&P returns and percentage changes in the USD/TWC, $e_{f,t}$, from 1991:Jan to 2019:Jan:

Figure 10.2: Correlation between S&P returns & changes in the USD/TWC 1984-2019



After the financial crisis of 2007-2008, there is a higher correlation between stock returns and changes in exchanges rates. The average correlation is **0.173**, which does not seem to be representative of the whole sample.

It is better to run a regression on ΔCF against unexpected $e_{f,t}$, it gives us a test.

Steps:

(1) Collect data on CF and S_t (available from the firm's past).

(2) Estimate the regression: $\Delta CF_t = \alpha + ß\, e_{f,t} + \xi_t$,

⇒ ß measures the sensitivity of ΔCF to changes in $e_{f,t}$.

⇒ the higher ß, the greater the impact of $e_{f,t}$ on CF.

⇒ the higher R^2, the greater the explanatory power of $e_{f,t}$.

(3) Test for EE ⇒ H_0 (no EE): $\beta = 0$

H_1 (no EE): $\beta \neq 0$

(That is, evaluation of regression: t-statistic of ß and R^2.)

Note: One thing to do: Replace ΔCF_t by stock returns. A better measure.
Stock returns measure changes in discounted future cash flows.

Example: Kellogg's EE.
Now, using the data from the previous example, we run the regression: $Kret_t = \alpha + ß\, e_{f,t} + \xi_t$,

$R^2 = 0.0104$
Standard Error = 2.575
Observations = 424

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept (α)	0.3043	0.1263	**2.409**	0.0164

$e_{f,t}$ (β)	0.4787	0.2266	**2.112**	0.0353

We reject H_0, since $|t_\beta$ = **2.11**| > 1.96 (significantly different than zero).
Note, however, that the R^2 is low! (The variability of e_f explains 1% of the variability of Kellogg's returns.) ¶

Example: AT&T's EE.
Now, using AT&T data, we run the regression: $Tret_t = \alpha + ß\ e_{f,t} + \xi_t$,

R^2 = 0.0007
Standard Error = 2.714
Observations = 424

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept (α)	0.2005	0.1331	1.506	0.133
$e_{f,t}$ (β)	0.1299	0.2388	**0.544**	0.587

We cannot reject H_0, since $|t_\beta$ =**-0.54**| < 1.96 (not significantly different than zero).
The R^2 is extremely low: the variability of e_f explains less than 0.1% of the variability of AT&T's returns. ¶

• Sometimes the impact of ΔS_t is not felt immediately by a firm.
⇒ contracts and short-run costs (short-term adjustment difficult).

Example: For an exporting U.S. company a sudden appreciation of the USD increases CF in the short term. But, later, the export contract will be renegotiated.

Run a modified regression: $\Delta CF_t = \alpha + \beta_0\ e_{f,t} + ß_1\ e_{f,t-1} + ß_2\ e_{f,t-2} + ß_3\ e_{f,t-3} + \ldots + ß_Q\ e_{f,t-Q} + \xi_t$.
⇒ Sum of the β's measures the sensitivity of CF to changes in S_t ($e_{f,t}$). ¶

Practical issue: number of lags (Q in the modified regression)?
Usual practice: include at most two years of information.

Example: Kellogg runs the following regression to estimate EE with lags (t-stats in parenthesis):

$$\underset{}{\Delta CF_t =} \underset{(1.90)}{.006} + \underset{(2.87)}{.478\ e_{f,t}} + \underset{(1.97)}{.264\ e_{f,t-1}} + \underset{(1.08)}{.180\ e_{f,t-2}}. \qquad R^2 = .045.$$

K's CF (in USD) sensitivity to $e_{f,t}$ is 0.742 (= .478 +. 264).
⇒ a 1% depreciation of the USD increases CF (in USD) by 0.742%. ¶

• Note on regressions to measure EE
Changes in S_t ($e_{t,t}$) is not the only variable affecting a company's stock returns. A company grows, adds assets, then higher sales and EPS are expected. Also, the economy and the stock market grow over time. We need to be careful and "control" for these other variables, to isolate the effect of $e_{f,t}$.

A multivariate regression will probably be more informative, where we can include other independent ("control") variables (income growth, inflation, sales growth, assets growth, etc.), not just $e_{f,t}$ as determinants of the change in CFs (or stock returns).

We can also borrow from the investments literature and use the three popular Fama-French factors (Market, Size (SMB), Book-to-Market (HML)) as controls. Then, we can run a regression to check if a company faces EE:

$$\text{Stock Return}_t = \alpha + \beta\, e_{f,t} + \delta_1 \text{ Market Return}_t + \delta_2 \text{ HML}_t + \delta_3 \text{ SMB}_t + \varepsilon_t$$

Example: Using the Fama-French Factors to compute Kellogg's EE.
Now, using the data from the previous example, we run the regression:

$$\text{Kret}_t = \alpha + \beta\, e_{f,t} + \delta_1 \text{ Market Return}_t + \delta_2 \text{ HML}_t + \delta_3 \text{ SMB}_t + \varepsilon_t$$

$R^2 = 0.1291$
Standard Error = 2.424
Observations = 424

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.12321	0.12172	1.012	0.3120
Market (R_m-R_f)	0.21486	0.02864	**7.501**	3.79E-13
Size (SMB)	-0.08947	0.04086	**-2.190**	0.0291
B-M (HML)	0.03758	0.04338	0.866	0.3868
$e_{f,t}$ (β)	0.12455	0.21855	**0.570**	0.5690

Note: You can find this, the previous (K and IBM) and other (DIS) examples in my homepage: www.bauer.uh.edu/rsusmel/4386/kellogg-euro.xls

A higher R^2 is mainly due to the market factor. But, looking at EE, once we control for other factors (the FF factors), we cannot reject H_0, since $|t_\beta = \mathbf{0.57}| < 1.96$ (not significantly different than zero); that is, at the 5%, we cannot reject the null hypothesis of no economic exposure. ¶

Evidence: The above regressions have been done repeatedly for firms around the world. (Without the FF factors, we have already done it for AT&T and with the FF factors, we have already done it for Kellogg.) On average, for large firms (MNCs) EE is small –i.e., β is small– and not significant at the 5% level. See Ivanova (2014).

♦ **Real World Example: Economic Exposure - The Case of Ericsson**
Ericsson is very dependent on the behavior of the SEK and on economic conditions in Sweden. Around 40% of all employees and 25% of total production is located in Sweden, but Sweden accounts for just 3% of all sales. With this substantial cost base in SEK, for example, an appreciation of the SEK against the major currencies will have a negative impact on Ericsson's cash flows. As a matter of fact, during the year 2000, the depreciation of the EUR against the SEK had a negative impact on Ericsson compared to Ericsson's competitors with costs denominated in EUR. Usually, Ericsson does not hedge economic exposure. **Source**: Ericsson Annual Report 2000. ♦

Chapter 10 - Measuring FX Exposure – Part 3

Review from Chapter 10 – Parts 1 & 2:
- TE is easy to calculate: Value in USD of specific transaction or portfolio of transactions.
    ◊ Correlations are very important.

- EE more difficult to measure. More subjective.
    ◊ Accounting-based measures need to simulate EAT under different S_t.
    ◊ Finance-based measures need ΔCF_t & $e_{f,t}$. Use returns, not ΔCF_t. Run a regression.

- Testing for EE: Use a linear regression model.
    ◊ Stock Returns$_t = \alpha + \beta\, e_{f,t} + \xi_t$
        H_0 (No EE): $\beta = 0$
        H_1 (EE): $\beta \neq 0$.

Evidence: For large companies (MNCs, Fortune 500), β is not significantly different than zero. We cannot reject H_o: No EE.

• In this class, we will cover the last FX exposure: Translation exposure.

10. 3 Translation Exposure

Translation exposure: Risk from consolidating assets and liabilities measured in foreign currencies with those in the reporting currency.

Assets and liabilities in a FC must be restated in terms of a DC. This translation follows rules set up by a parent firm's government or an accounting association –in the U.S., FASB.

Problem: The translation involves complex rules that sometimes reflect a compromise between historical and current exchange rates.

- Historical rates may be used for some equity accounts, fixed assets, inventories.
- Current exchange rates are used for current assets, liabilities, expenses and income.

Every item translated at historical rates is not exposed to changes in S_t.
Note: Different exchange rates are used, imbalances will occur.

Key issue: What to do with the resulting imbalance? It is taken to either current income or equity reserves.

Measuring Translation Exposure

There are several methods to translate foreign currency accounts into the reporting currency. Two methods that predominate:
    ◊ Temporal method (monetary/nonmonetary method)

◊ Current rate method

<u>Terminology</u>:
Monetary: there is a date attached to the asset or liability.
Three exchange rates can be used:

S_0: Historical exchange rate.

S_t: Current exchange rate at the date of balance.

$S_{AVERAGE}$: Average exchange rate for the period.

FASB #8 - *Temporal Method* (1976-1982)
- Translate nonmonetary assets at S_0, assets and liabilities use S_t
- Translate most income statements items at the $S_{AVERAGE}$
- Translate shareholder equity at S_0
- Bookkeeping exchange gains or losses are passed to the Income statement

FASB #52 - *Current Rate Method* (since 12/15/1982)
- Translate most amounts at S_t
- Income statement items are translated at S_0 or $S_{AVERAGE}$
- Translate shareholder equity at S_0
- Exchange gains or losses are not reflected in income statement rather accumulate in an adjustment account in stockholders' equity: C*umulative translation adjustment* (CTA).
- Distinguished between functional currency (usually local currency) and reporting currency (currency the parent firm uses to prepare own financial statements)

- Exceptions to FASB #52

1. Subsidiaries who mostly deal with parent, functional currency: USD ⇒ translate using temporal method.
2. Subsidiaries in hyperinflationary countries (100%+ over 3 years), functional currency: USD ⇒ translate using temporal method.

Example: IBM Hong Kong has the following balance sheet.

IBM Hong Kong Balance Sheet in millions of HKD

	Balance accounts	CR exposure	Temporal exposure
Assets			
Cash	300	300	300
Accounts receivable	850	850	850
Inventory	400	400	N.ex.
Net fixed plant and equip.	1,000	1,000	N.ex.
Total assets	2,550		
Total exposed assets		2,550	1,150
Liabilities and Capital			
Accounts payable	200	200	200
Notes payable	300	300	300
Long-term debt	900	900	900
Shareholder's equity	1,150	N.ex.	N.ex.
Total liabilities and capital	2,550		
Total exposed liabilities		1,400	1,400
Net exposed assets		1,150	-250

At S_t = .128 USD/HKD, IBM's exposure (in USD):
Current rate method: HKD 1,150,000,000 x .128 USD/HKD = USD 147,200,000
Temporal method: HKD -250,000,000 x .128 USD/HKD = USD -32,000,000 ¶

Real World Example: Translation Exposure - The Case of Ericsson
Ericsson has many subsidiaries outside Sweden.

For most of the subsidiaries, the local currency is the currency in which the companies operate ⇒ local currency is the functional (business) currency.
Financial statements are translated to SEK using the current rate method.
For some subsidiaries ("integrated companies"), having very close relations with the Swedish operations ⇒ SEK is the functional currency
Financial statements are translated using the temporal method.

Translation exposure in foreign subsidiaries is hedged:
• Monetary net in companies translated using the temporal method (translation effects in investment affecting the income statement) is hedged to 100%.
• Equity in companies translated using the current rate method (translation effects reported directly in stockholders' equity in the balance sheet) is hedged selectively up to 20% of the total equity.

The translation differences reported in equity, during the year 2000, were SEK 2.0 billion, mainly due to a weaker SEK. **Source**: Ericsson Annual Report 2000.

CHAPTER 10 – BRIEF ASSESMENT

1. It is March 3, 2017. Malone, a U.S. company, exports mining equipment to South Africa. Malone expects to receive a payment of ZAR 500 million in August 3, 2017 (ZAR=South African Rand).

(A) Calculate TE
(B) Use the information given in the attached Excel output (based on 15 years of 5-mo changes) to calculate:
i) The VaR associated with Malone's open position (use a 97.5% C.I.).
ii) The VaR-mean (97.5%). Interpret this number.
iii) The worst case scenario for Malone.

The information below is based on monthly percentage changes from 2001:9 to 2016:12.

5-mo % change ZAR/USD	
Mean	3.117%
Standard Error	0.854%
Median	1.803%
Mode	#N/A
Standard Deviation	9.355%
Sample Variance	0.875
Kurtosis	143.329
Skewness	48.399
Range	61.127%
Minimum	-22.970%
Maximum	38.157%
Sum	374.077
Count	183

2. You work for Vandelay Industries, U.S. MNC. Vandelay gives you the following projections for next year:

Currency	Total inflows	Total outflows	Current Exchange rate
GBP	GBP 25,000	GBP 40,000	1.40 USD/GBP
KUD	KUD 600,000	KUD 400,000	0.40 USD/KUD (KUD=Kuwaiti Dinar)

(A) What is Vandelay's net transaction exposure (NTE)?
(B) Suppose the GBP and the KUD are perfectly and positively correlated (ρ=1). The USD/GBP exchange rate increases to 1.68 USD/GBP. What is the **change** in net transaction exposure for Vandelay?
(C) Suppose the GBP and the KUD have zero correlation (ρ=0). The USD/GBP exchange rate increases to 1.68 USD/GBP. What is the **change** in (expected) net transaction exposure for Vandelay?

3. HM Sweden provides the following info:
Sales and cost of goods are dependent on S_t (SEK/USD, SEK=Swedish Kroner). All numbers are in millon kroners.

	S_t = 7 SEK/USD	S_t = 6.3 SEK/USD
Sales (in SEK)	400	550
Cost of goods (in SEK)	150	200
Gross profits (in SEK)	250	350
Depreciation (in SEK)	50	50
Interest expense (in SEK)	20	20
Taxes (in SEK)	70	110

A. Calculate the elasticity of free CF (measured as EAT + Depreciation) to changes in S_t.
B. Interpret the elasticity.

4. You want to test if MSFT faces EE. You collect data from January, 1990 to April 2017, for a total of 328 observations. You run two regressions, using monthly data:

$$\text{returns}_t = \alpha + \beta\, e_{f,t} + \xi_t,$$

and

$$\text{returns}_t = \alpha + \beta\, e_{f,t} + \delta_1 (R_{market,t} - R_f) + \delta_2\, HML_t + \delta_3\, SMB_t + \varepsilon_t.$$

Using the excel output (shown below) test if MSFT has faced EE during your sample.

R Square 0.011907

	Coefficients	*SE*	*t Stat*
Intercept	0.018569	0.005069	3.662978
$e_{f,t}$	0.499677	0.2521	1.982063

R Square 0.327083

	Coefficients	*SE*	*t Stat*
Intercept	0.011673	0.004262	2.739086
$R_{market,t} - R_f$	1.250846	0.105388	11.86891
HML	-0.16682	0.134013	-1.24478
SMB	-1.53667	0.593604	-2.58871
$e_{f,t}$	-0.28523	0.2186	-1.30478

Chapter 11 - Managing TE – Part 1

We have two ways to manage TE (to hedge FX exposure):
- Using Internal Methods (special contracts/organization/restructure)
- Using External Methods (market tools)
  - ◊ Forwards/Futures
  - ◊ Options
  - ◊ Money Market (same as IRP)

11.1 Internal Methods

◊ Risk Shifting: Pricing in DC (no FX risk, but no flexibility to accommodate clients).

Example: Boeing exports planes to TAM Airlines, a Brazilian company. The transaction is priced (& settled) in USD. Boeing faces no FX risk from this transaction; TAM takes all the FX risk. ¶

◊ Risk Sharing: Two parties can agree -using a customized hedge contract- to share the FX risk involved in the transaction.

Example: Levi's buys cotton for USD 1 million from Nakatami Cotton (NC). Payment in JPY.
Risk sharing agreement:
• If $S_t \in$ [98 JPY/USD, 140 JPY/USD] $\Rightarrow$ transaction unchanged. (Levi's pays USD 1M to NC)
The range where the transaction is unchanged is called *neutral zone*.
• If $S_t <$ 98 JPY/USD or $S_t >$ 140 JPY/USD $\Rightarrow$ both companies share the risk equally, by setting a different exchange rate to settle the transaction.

Suppose that when Levi's has to pay NC, S_t = 180 JPY/USD.
The S_t used in settling the transaction is 160 JPY/USD (=180 - 40/2).

$\Rightarrow$ Levi's's final cost = JPY 160 million = **USD 888,889** < **USD 1M**. ¶

◊ Leading and Lagging (L&L): Accelerating or decelerating the timing of FC payments:

$\Rightarrow$ *leading* or *lagging* the movement of funds.

L&L is done between the parent company and its subsidiaries or between two subsidiaries.

Example: Managing TE with L&L.
Parent company: IBM (US company).
Subsidiaries: Mexico, Brazil, and Hong Kong. (IBM Mexico and IBM owe payables to IBM HK.)
Situation: IBM Hong Kong's exposure, due to payables in FC, is too large.

IBM orders IBM Mexico and IBM Brazil to accelerate (lead) its payments to IBM HK. ¶

◊ Natural hedging: Natural hedges are created by payment obligations and/or receivables that have, at least, partially offsetting foreign currency risk.

Example: A U.S. company imports machine parts from Germany priced in euros. This transaction exposure is partially offset by sales of machines to Spain, also priced in euros. ¶

In situations where natural hedges exist, companies should only consider hedging the net transaction exposure, not the individual transaction.

11.2 External Methods

Use market instruments to hedge TE exposure:

- ◊ Forwards/Futures
- ◊ Options
- ◊ Money Market (same as IRP, without covering step)

We will go over two cases: (1) Receivables in FC
(2) Payables in FC

Example 1: CASE I - Receivables in FC

MSFT exports Windows to Switzerland for CHF 3M Payment due in 90 days.
S_t = 0.60 USD/CHF
TE(in USD) = CHF 3M * 0.60 USD/CHF = USD 1.8M

To manage TE, MSFT considers the following tools: forwards/futures, options, Money market instruments (used to replicate IRPT). MSFT also considers keeping the position open –i.e., no hedging.

Hedging Tools- Futures/Forwards/Options/Money Market Hedge/Do Nothing

Data:
Interest USD = **5%** - 5.125%
Interest CHF = 4% - **4.25%**
$F_{t,90\text{-day}}$ = .650 USD/CHF - .651 USD/CHF
Put (**X_p = 0.64 USD/CHF; p_p = USD .059-.060**)
Call (X_c = 0.63 USD/CHF; p_c = USD .019-.020)
T = 90 days
Possible scenarios for S_{t+90} (distribution for S_{t+90} based on the ED)

S_{t+90} (USD/CHF)	Probability
0.58	.10
0.62	.10
0.65	.50
0.68	.30

1. Forward Hedge – Sell Forward CHF
   Sell CHF forward at **$F_{t,90\text{-day}}$ = .65 USD/CHF**
   Amount to be received in 90 days = CHF 3M * 0.65 USD/CHF = USD 1.95M

Note**:** No uncertainty. MSFT will receive USD 1.95M, regardless of S_{t+90}.

2. MMH (Replication of IRP) – borrow FC, convert to DC, deposit in domestic bank
   Today, we do the following: (1) Borrow CHF at **4.25%**
   (2) Convert to USD at 0.60 USD/CHF
   (3) Deposit in US Bank at **5%**

   MMH Calculations:
   Amount to be borrowed = CHF3M/(1+**.0425***90/360) = **CHF 2.9684M**
   CHF 2.9684M * 0.60 USD/CHF = **USD 1.781M** = amt to be deposited in US Bank
   Amount to be received in 90 days = **USD 1.781M** (1+**.05***90/360) = **USD 1.8032M**

Note**:** There is no uncertainty about how many USD MSFT will receive for CHF 3M.

*Compare FH vs MMH***:** MSFT should select the **FH.** MMH is *dominated* by FH.

3. Option Hedge -Buy CHF puts: **X_p = 0.64 USD/CHF**, **p_p = USD .06/CHF**
   Floor = **0.64 USD/CHF** * CHF 3M = USD 1.92 M - Total premium cost
   Premium cost = CHF 3M * **USD .06/CHF** = USD .18M
   Opportunity Cost (OC) = USD .18M***.05***.25=USD .0025M

   Total premium cost = Premium cost + OC = **USD .1825M**

Scenarios

S_{t+90} (USD/CHF)	Probability	Exercise?	Amount received (Net of cost, in USD)
0.58	.20	Yes	1.92M - **.1825M** = 1.7375M
0.62	.20	Yes	1.92M - **.1825M** = 1.7375M
0.65	.50	No	1.95M - **.1825M** = 1.7675M
0.68	.30	No	2.04M - **.1825M** = 1.8575M

E[Amount to be received in 90 days] = (1.7375)*.2 + (1.7675)*.5 + (1.8575)*.3 = **1.7885M**

Notes:
1. An option establishes a worst case scenario. In this case, MSFT establishes a *floor*, a minimum amount to be received: USD 1.92M (or net USD 1.7375).
2. The opportunity cost (OC) is included to make a fair comparison with FH and MMH, which require no upfront payment. (OC=Time value of money!)

*Compare FH vs OH***: FH** seems to be better; but preferences matter. A risk taker may like the 30% chance of doing better with the **OH**.

4. No Hedge (Leave position open, that is, do nothing and wait 90 days)

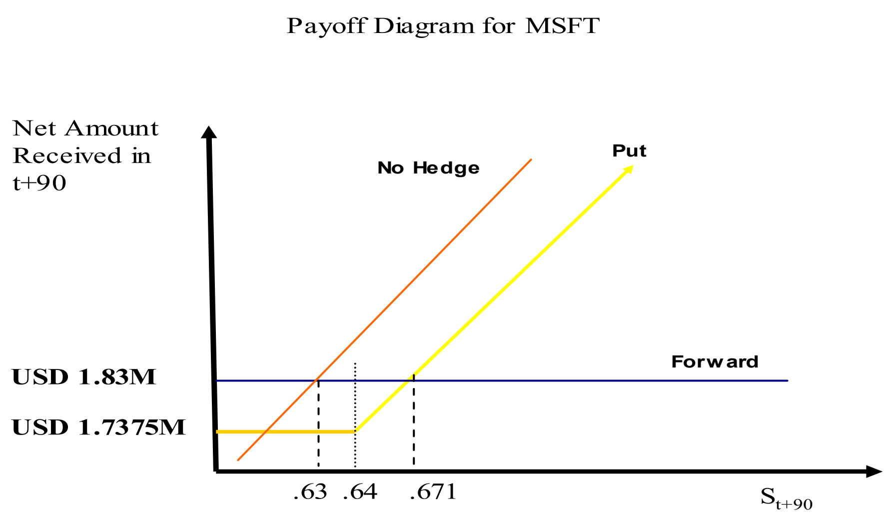
Scenarios

S_{t+90} (USD/CHF)	Probability	Amount received (Net of cost)
0.58	.10	USD 1.74M
0.62	.10	USD 1.86M
0.65	.50	USD 1.95M
0.68	.30	USD 2.04M

E[Amount to be received in 90 days] = **USD 1.947M**

Compare FH vs NH: **NH** seems to be better. But, preferences matter (a very conservative manager might not like the 20% chance of the NH doing worse than the FH).

Graph 11.1: General CF Diagram for all Strategies



Graph 11.1 displays the CF for all hedging strategies. In general, the preference of one alternative over another will depend on the probability distribution of S_{t+90}. If the probability of S_{t+90}>.63 USD/CHF (the break even S_{t+90} that makes the CF under the FH and the NH equal) is very low, then the forward hedge dominates.

Q: Where do the probabilities come from? We can estimate them using the empirical distribution (ED).

Example 2: CASE II - Payables in FC
MSFT has payable in GBP for GBP 10M in 180 days.
S_t = 1.60 USD/GBP
TE(in USD) = USD 16M
MSFT decides to manage this TE with the following tools:
Hedging Tools: Futures/Forwards/Options/Money Market Hedge/Do Nothing

Data:
Interest USD = **5%** - **5.25%**
Interest GBP = **6%** - 6.5%
$F_{t,180\text{-day}}$ = 1.578 - **1.580 USD/GBP**
Put (X_p = 1.64 USD/GBP; p_p = USD .05)
Call (**X_c = 1.58 USD/GBP**; p_c = USD .03)

Distribution for S_{t+90}

S_{t+90} (USD/GBP)	Probability
1.55	.30
1.59	.60
1.63	.10

Which alternative is best? The hedge that delivers the least USD amount

1. FH – Buy forward GBP
Amount to be paid in 180 days = GBP 10M * **1.580 USD/GBP** = **USD 15.8M**

2. MMH – Borrow DC, convert to FC, deposit in foreign bank
Today, we do the following: (1) Borrow USD at **5.25%**
(2) Convert to GBP at 1.60 USD/GBP
(3) Deposit in UK Bank at **6%**

MMH Calculations (we go backwards):
Amount to deposit = 10M/[1+(.06*180/360)] = **GBP 9.708M**
Amount to borrow = **GBP 9.708M** * 1.60 USD/GBP = **USD 15.533M**
Amount to repay = **USD 15.533** *(1+.0525*180/360) = **USD 15.94M**

Compare FH vs MMH: **FH is better**

3. Option Hedge – Buy GBP calls: **X_c= 1.58 USD/GBP**, **p_c = USD .03/GBP**
Cap = GBP 10M * **1.58 USD/GBP** = **USD 15.8M**
Total premium cost = Total premium + OC = 10M*USD **.03/GBP***(1+**.05***.5) = **USD .31M**

Scenarios

S_{t+90} (USD/GBP)	Probability	Exercise?	Amount paid (Net of cost, in USD)
1.55	.30	No	USD 15.5M + **.31M** = USD 15.81M
1.59	.60	Yes	USD 15.8M + **.31M** = USD 16.11M
1.63	.10	Yes	USD 15.8M + **.31M** = USD 16.11M

E[Amount to be paid in 180 days] = **USD 16.02M**

Compare FH vs OH: **FH** is better always**.** (Preferences do not matter.)

Note: Again, the option establishes a worst case scenario. In this case, MSFT establishes a *cap*, a maximum amount to be paid: USD 15.8M (or net USD 16.11M).

4. No Hedge –leave position open; that is, do nothing and wait.
E[Amt] = GBP 10M [1.55(.3)+1.59(.6)+1.63(.1)] = **USD 15.82M**

*Compare FH vs OH***:** **FH** is the most likely choice; but *preferences matter*.

- **Summary of Strategies**

	Receivables in FC	Payables in FC
Forward Hedge (FH)	Sell FC at $F_{t,T}$	Buy FC at $F_{t,T}$
Money Market Hedge (MMH)	Borrow FC at i_{FC}, Convert to DC at S_t, Deposit DC at i_{DC}	Borrow DC at i_{DC}, Convert to FC at S_t, Deposit FC at i_{FC}
Option Hedge (OH)	Buy FC puts; pay p_p	Buy FC calls; pay p_c

11.2.1 Options hedging (with different X)

With options it is possible to play with different strike prices –different insurance coverage.

Key Intuition: The more the option is out of the money, the cheaper it is.
The higher the cost, the better the coverage.

Example: Revisit MSFT payables situation: MSFT has to pay GBP 10M in 180 days.
Notation: X_j = Strike Price (j = call; put)
p_j = Option premium (j = call; put)
S_t = 1.60 USD/GBP
Options available:
X_c = 1.56 USD/GBP, p_c = USD .08, T=180 days (call)
X_c = 1.58 USD/GBP, p_c = USD .07, T=180 days (call)
X_c = 1.63 USD/GBP, p_c = USD .05, T=180 days (call)
X_c = 1.65 USD/GBP, p_c = USD .04, T=180 days (call)
X_p = 1.58 USD/GBP, p_p = USD .055, T=180 days (put)
X_p = 1.61 USD/GBP, p_p = USD .095, T=180 days (put)

1. Out-of-the-Money ($S_t < X$)
Alternative 1: Call used: X_c = 1.63 USD/GBP, p_c = USD .05
Cost = Total premium = GBP 10M * USD .05/GBP = ***USD 500K***
Cap = worst amount to be paid = 1.63 USD/GBP * GBP 10M = USD 16.3M
(Net cap = **USD 16.8**)
Alternative 2: Call (X_c = 1.65 USD/GBP, p_c = USD .04)
Cost = GBP 10M * USD .005/GBP = ***USD 400K***
Cap = 1.65 USD/GBP * GBP 10M = USD 16.5M ⇒ Net cap = **USD 16.9M**

Note: The tradeoff is very clear: The higher the cost, the better the coverage.

2. (Closest At-the-money) In-the-money ($S_t \geq X$)
Call used: X_c = 1.58 USD/GBP, p_c = USD .07
Cost = Total premium = ***USD 700K***
Cap = USD 15.8M ⇒ Net cap = **USD 16.5M**

Compare to Out-of-the-money: Advantage: Lower cap.

Disadvantage: Its cost.

Companies do not like to pay high premiums. Many firms finance the expense of an option by selling another option. A typical strategy: A collar (form a portfolio with one put and one call: Long one option, short the other).

<u>3. Collar</u> (buy one call, sell one put. In general, both are OTM)
Buy Call (X_c = 1.63 USD/GBP, p_c = USD .05);
Sell Put (X_p = 1.58 USD/GBP, p_p = USD .055)
Collar's premium = USD .05 - USD .055 = **USD -0.005** (negative!)

Cost = GBP 10M * USD (**-.005/GBP**) = ***USD -50K***
Cap = 1.63 USD/GBP * GBP 10M = USD 16.3M
Floor = Best case scenario = 1.58 USD/GBP * GBP 10M = USD 15.8M
⇒ Net cap = **USD 16.25**; Net floor = **USD 15.75M**

<u>Notes</u>:
⋄ With a collar you get a lower cost (advantage), but you give up the upside of the option (disadvantage) ⇒ there is always a trade-off!
⋄ Zero cost insurance is possible ⇒ sell enough options to cover the premium of the option you are buying.

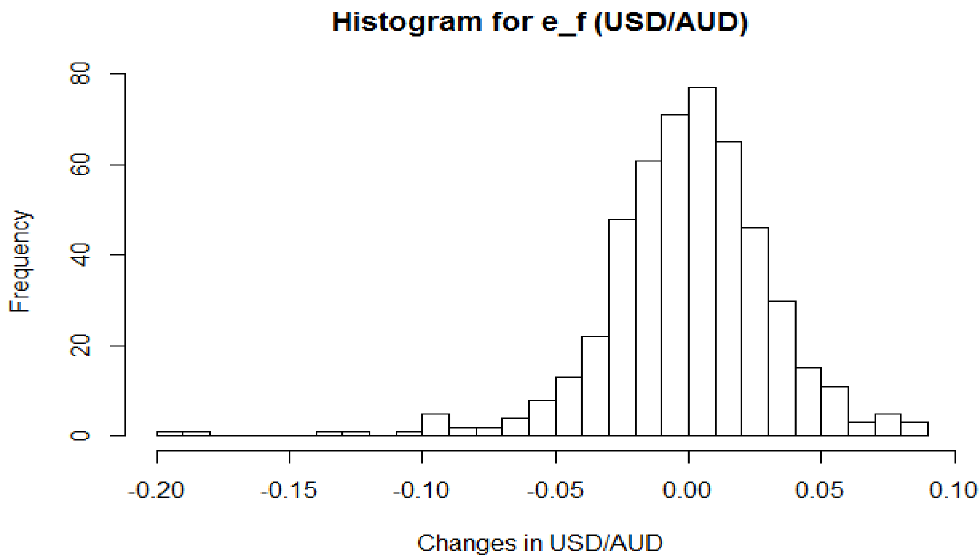
CHAPTER 11 - BONUS COVERAGE: Getting probabilities from the Empirical Distribution

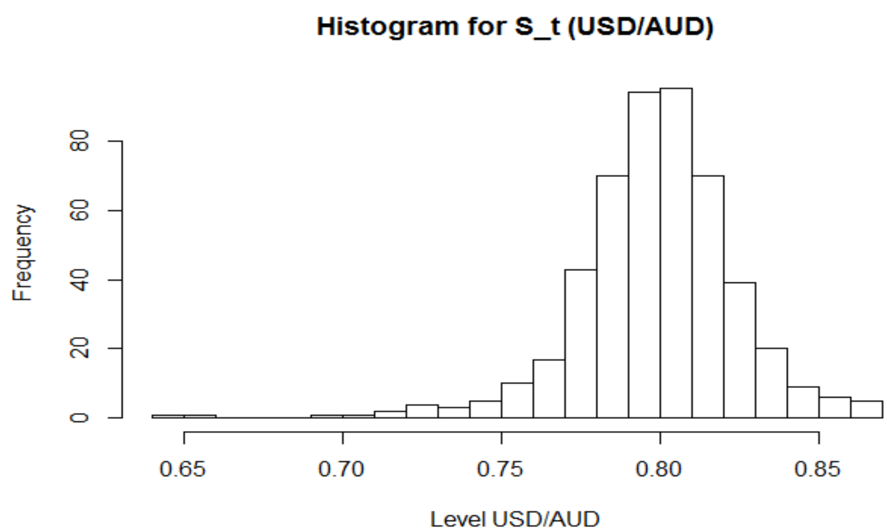
Firms will use probability distributions to make hedging decisions. These probability distributions can be obtained using the empirical distribution, a simulation, or by assuming a given distribution. For example, a firm can assume that changes in exchange rates follow a normal distribution. Here, we present an example on how to use the empirical distribution.

Example: We want to get probabilities associated with different exchange rates. Let's take the historical monthly USD/AUD exchange rates 1976:1-2017:1. First, we transform the data to changes ($e_{f,t}$). Excel produces a histogram, with bins and frequency. Below we show the bins for $e_{f,t}$ frequency and relative frequency. We calculate $S_{t+30} = S_t * (1+e_{f,t})$. Today, S_t =0.7992 USD/AUD.

$e_{f,t}$ (USD/AUD)	*Frequency*	*Rel frequency*	S_t =.7992*(1+$e_{f,t}$)
-0.17761	1	0.002049	0.657257
-0.16533	1	0.002049	0.667066
-0.15306	0	0	0.676874
-0.14079	0	0	0.686682
-0.12852	0	0	0.69649
-0.11624	1	0.002049	0.706298
-0.10397	1	0.002049	0.716106
-0.0917	2	0.004098	0.725914
-0.07943	4	0.008197	0.735722
-0.06715	4	0.008197	0.745531
-0.05488	6	0.012295	0.755339
-0.04261	12	0.02459	0.765147
-0.03034	29	0.059426	0.774955
-0.01806	56	0.114754	0.784763
-0.00579	86	0.17623	0.794571
0.006481	91	0.186475	0.804379
0.018753	82	0.168033	0.814187
0.031025	54	0.110656	0.823996
0.043298	29	0.059426	0.833804
0.05557	18	0.036885	0.843612
0.067843	8	0.016393	0.85342
0.080115	3	0.006148	0.863228
More	5	0.010246	0.871128

You can plot the histogram to get the above empirical distributions.





Chapter 11 - Managing TE – Part 2

Hedging with Options gives us more instruments to choose from $\Rightarrow$ different strike prices (X):
1. Out of the money (cheaper)
2. In the money (more expensive)

• Review: Reading Newspaper Quotes
Typical Newspaper Quote

PHILADELPHIA OPTIONS **(**PHLX is the exchange)
Wednesday, March 21, 2007 (Trading Date)

		Calls		Puts		
		Vol.	Last	Vol.	Last	$\Rightarrow$ (Vol.=Volume, Last=*Premium*)
Australian Dollar					**79.92**	$\Rightarrow$ (S_t=.7992 USD/AUD)
10,000 Australian Dollars-cents per unit.						$\Rightarrow$ (AUD 10,000=*Size*, prices in USD cents)
78	June	9	3.37	20	1.49	
79	April	20	1.79	16	0.88	
80	May	15	1.96	8	2.05	
80	June	11	2.29	9	2.52	
82	June	1	1.38	2	3.61	
↑	↑		↑		↑	
X=*Srike Price*	T=*Maturity*		*Call Premium*		*Put Premium*	

$\Rightarrow$ (Contracts traded)

Example: Payable AUD 100M in Mid-June
S_t= .7992 USD/AUD

$X_{call\text{-}June}$ = .78 USD/AUD, P = USD .0337
$X_{put\text{-}June}$ = .78 USD/AUD, P = USD .0149
$X_{call\text{-}June}$ = .80 USD/AUD. P = USD .0229
$X_{put\text{-}June}$ = .80 USD/AUD. P = USD .0252
$X_{call\text{-}June}$ = .82 USD/AUD, P = USD .0138
$X_{put\text{-}June}$ = .82 USD/AUD. P = USD .0361

1. <u>Out-of-the-money</u>: $X_{call\text{-}June}$ = 0.82 USD/AUD (or $X_{call\text{-}June}$ = .80 USD/AUD, almost ATM)
   - $X_{call\text{-}June}$ = 0.82 USD/AUD, Premium = USD .0138

Cost = Total premium = AUD 100M * USD .0138/AUD = ***USD 1.38M***
Cap = AUD 100M x 0.82 USD/AUD = USD 82M (Net cap = **USD 83.38M**)

- $X_{call\text{-}June}$ = 0.80 USD/AUD, Premium = USD .0229 (almost ATM)

Cost = Total premium = AUD 100M * USD .0229/AUD = ***USD 2.29M***
Cap = AUD 100M x 0.82 USD/AUD = USD 80M (Net cap = **USD 82.29M**)

2. <u>In the Money</u>: $X_{call\text{-}June}$ = 0.78 USD/AUD, Premium = USD .0337

Cost = Total premium = ***USD 3.37M***

Cap = USD 78M (Net cap = **USD 81.37M**)

Note**:** The higher the cost, the lower the cap established for the AUD 100M (payables). ¶

Example: Receivables AUD 20M

1. Out-of-the-money: $X_{put\text{-}June}$ = 0.78 USD/AUD

Cost = Total premium = AUD 20M * USD .0149/AUD = ***USD 298K***

Floor = 0.78 USD/AUD x AUD 20M = USD 15.6M (Net Floor = **USD 15.302M**)

2. In the money: $X_{put\text{-}June}$ = 0.82 USD/AUD, (or $X_{put\text{-}June}$ =.80 USD/AUD –ATM)
   - $X_{put\text{-}June}$ = 0.82 USD/AUD

Cost = Total premium = AUD 20M * USD .0361/AUD = ***USD 722K***

Floor = 0.82 USD/AUD * AUD 20M = USD 16.4M (Net Floor = **USD 15.678M**)

- $X_{put\text{-}June}$ = 0.80 USD/AUD (ATM option)

Cost = Total premium = ***USD 504K***

Floor = USD 16M (Net Floor = **USD 15.496M**)

Note**:** The higher the cost, the higher the floor for the AUD 20M (receivables). ¶

Lesson from these 2 examples:

1) Options offer the typical insurance trade-off:

Better coverage (lower cap, higher floor) ⇒ Higher cost (higher premium)

2) Insurance is expensive. For example, for the $X_{put\text{-}June}$ = 0.80 USD/AUD case, it costs **USD .504M** to insure **USD 15.496M** (a 3.2% premium).

Q: Is it possible to lower the cost of insurance lower?

A: With a Collar (buy put, sell call/buy call, sell put).

Example: Buy $X_{put\text{-}June}$ = 0.78 USD/AUD (P = USD .0149)

Sell $X_{call\text{-}June}$ = 0.82 USD/AUD (P = USD .0138)

Cost = 20M x [USD .0149 - USD .0138] = ***22K*** (very close to zero!)

Floor = USD 15.6M (Net Floor = **USD 15.578M**)

Cap = 20M x 0.82 USD/AUD = USD 16.4M (Net Cap = Best case scenario = **USD 16.378M**)

A collar is cheaper, but it limits the upside of the option.

Note: zero (or almost zero) cost insurance is possible! ¶

Real World: Walt Disney Company

According to Disney's 2006 Annual Report:

The Company utilizes option strategies and forward contracts that provide for the sale of foreign currencies to hedge probable, but not firmly committed transactions. The Company also uses forward contracts to hedge foreign currency assets and liabilities. The principal foreign currencies hedged are the AUD, GBP, JPY and CAD. Cross-currency swaps are used to effectively convert foreign currency denominated borrowings to USD denominated borrowings. By policy, the Company maintains hedge coverage between minimum and maximum percentages of its forecasted foreign exchange exposures generally for periods not to exceed five years. The gains and losses on these contracts offset changes in the value of the related exposures.

CHAPTER 11 – BRIEF ASSESMENT

1. It is March 3, 2017. Malone, a U.S. company, exports mining equipment to South Africa. Malone expects to receive a payment of ZAR 500 million in August 3, 2017 (ZAR=South African Rand). Malone decides to hedge this exposure using an August forward contract, which expires on August 3, 2012. The 1-month, 3-month and 5-month South African interest rates are 8.5%, 8.7% and 9%, while the 1-month, 3-month and 5-month U.S. interest rates are 0.3%, 0.5% and 0.8%, respectively. On March 3, the spot exchange rate is 15.62 ZAR/USD and the August 3 forward trades at 16.15 ZAR/USD. A Bank offers Malone OTC options with expiration August 3 with the following prices (in USD cents –i.e., 6.3 USD cents=USD 0.063):

ZAR August 6.3 p (put)	0.07
ZAR August 6.3	0.24

(A) Calculate the amount to be received on August 3, using a forward hedge.
(B) Calculate the amount to be received on August 3, using the PHLX option.

2. MSFT has a payable in GBP. Details:
Amount = GBP 10M
T= 180 days.
S_t = 1.35 USD/GBP
TE (in USD) = USD 13.5M
MSFT decides to manage this TE with the following tools:
Hedging Tools: Futures/Forwards/Options/Money Market Hedge/Do Nothing

Data:
Interest USD = 2% - 2.25%
Interest GBP = 3% - 3.5%
$F_{t,180\text{-day}}$ = 1.341 - 1.344 USD/GBP
Put (X_p = 1.34 USD/GBP; p_p = USD .03)
Call (X_c = 1.38 USD/GBP; p_c = USD .02)
Distribution for S_{t+90}

S_{t+90} (USD/GBP)	Probability
1.33	.30
1.37	.60
1.42	.10

Which alternative is best?

3. A U.S. company has AUD 20M receivables in mid-June 2007. Using the PHLX quotes, reported below, construct the following hedges (calculating total premium cost and worst case scenario):
(A) OTM
(B) ITM
(C) Collar (using out-of-the money options)

PHILADELPHIA OPTIONS

Wednesday, March 21, 2007

		Calls		Puts	
		Vol.	Last	Vol.	Last
Australian Dollar					**79.92**
10,000 Australian Dollars-cents per unit.					
78	June	9	3.37	20	1.49
79	April	20	1.79	16	0.88
80	May	15	1.96	8	2.05
80	June	11	2.29	9	2.52
82	June	1	1.38	2	3.61

Chapter 12 – Managing Economic Exposure (EE)

Review from Chapter 10.
- EE: It measures how future CFs are affected by changes in S_t (e_f).
- Measures: 1) Accounting measures (simulate EAT under different exchange rates)
  2) Regressions using CFs or stock market returns.

Q: Is EE significant –i.e., should we do something about it?
A) Use a regression. Measure an elasticity and make a judgment call.

If we determine that EE is significant, then a firm should try to manage it.

EE measures how changes in FX rates affect CFs. It is easy to see that importers benefit from a strong domestic currency (the cost of buying foreign goods decreases as S_t decreases); while exporters benefit from a weak domestic currency (domestic exports become to foreign buyers as S_t increases). But, not only importers and exporters face economic exposure, many purely domestic firms are exposed too.

Example: As the USD becomes stronger, more U.S. tourism goes to visit the active volcano Arenal, in Costa Rica. Restaurants in Cost Rica buy and sell everything in CRC (CRC = Costa Rican Colón), thus having no direct EE. But, as U.S. tourism increases (decreases) in Arenal, the cash flows of restaurants in Arenal will also increase (decrease). Thus, even smaller Costa Rican restaurants (called *sodas*) face EE. In this case, they behave like an exporter. ¶

12.1 Understanding Economic Exposure

Let's look at the simplified cash flow of an MNC's subsidiary, which exports its production, Q, at the international price, P, denominated in foreign currency (FC):

Revenue: Price in FC x Quantity = PQ
Cost: Variable + Fixed = α PQ + Fixed Costs (α: proportion of PQ as VC, 0<α< 1)
Gross profits: (1- α) PQ – Fixed Costs
EBT = [(1 - α) PQ – Fixed Costs] - IE (IE: Interest Expense)
EAT = [(1- α) PQ – Fixed Costs - IE] (1-t) (t: tax rate)

Costs & IE have, potentially, two components: a FC & a DC. Say, for VC: α_{FC} & α_{DC}; and for $IE=IE_{DC}+IE_{FC}$. Usually, Fixed Costs are in DC, not sensitive to FC.

EE: How do changes in S_t affect CFs of the firm (say, EAT)? Let's take a first derivative:

$$\frac{\partial EAT}{\partial S_t} = \left[(1-\alpha_{FC})\frac{\partial PQ}{\partial S_t} - \frac{\partial IE_{FC}}{\partial S_t}\right](1-t)$$

where we assume the DC components of VC and IE are independent of the FC part.

If the derivative is 0, EAT is not affected by changes in S_t. That is, there is no EE. For example, if $\alpha_{FC}=1$ & $IE_{FC}=0$, EAT is not sensitive to changes in S_t. Obviously, $\alpha_{FC}=1$ is not a very interesting case! But, as $\alpha_{FC}\rightarrow 1$, EE decreases. That is, the better the FC match, between Revenue and Cost, the smaller the EE.

The degree to which P and Q affect EE depends on the type and structure of the firm and the industry structure in which the firm operates. In general, importing and exporting firms face a higher degree of EE than purely domestic firms do.

Also, in general, monopolistic firms face lower EE than firms in competitive markets (monopolistic firms can increase prices in response to changes in S_t.).

Note: The amount exposed is not total revenue in FC, but the difference between Revenue in FC and Cost in FC. If Revenue in FC > Cost in FC, *selective hedging of receivables* –i.e., no full hedging of receivables in FC- may work well to reduce short-term EE.

Example: Foreign Auto Exporters
During the last semester of 2014, the USD appreciated against the major currencies (13% against the EUR, and 15% against the JPY). Because of the expected loose monetary policies from the ECB and the Bank of Japan, the strong USD was expected to continue in 2015. According to earnings forecasts, reported by the WSJ, Germany's three large car manufacturers were expected to increase their (unhedged) earning by EUR 12 billion (USD 14.2 B).

On the other hand, according to Nissan Motor Co.'s Chief Executive Carlos Ghosn, Nissan was planning to make more vehicles for the U.S. market in Japan in 2015, but the profit impact was expected to be "marginal," because it makes so many of its vehicles in North America.
Source: Wall Street Journal, Jan 12, 2015. ¶

Example: H&M vs. Zara
In late June 2015, Sweden's Hennes & Mauritz, the world's second-biggest fashion retailer, warned it expects the strong USD to translate into rising sourcing costs throughout the year after it hurt second-quarter profits.

H&M, which buys the bulk of its clothes in Asia on USD contracts while selling most of them in Europe, is more exposed to the strong USD than bigger rival Inditex, the Zara owner which produces more garments in house and sources most of them in or near Europe.

And it is harder for the budget brand to pass on costs by raising prices as it faces growing competition from discounters like Primark and Forever 21, which pose less of a threat to mid-market brand Zara.
Source: Reuters, July 2015. ¶

As both examples show, a better match ⇒ lower EE. Zara has a better match between FC receivables and FC costs than H&M, and, thus, lower EE. Similar situation applies to Nissan relative to the big three German automakers. Moreover, according to Nissan's executive Ghosn, Nissan has a very good match in USD, creating a very low EE.

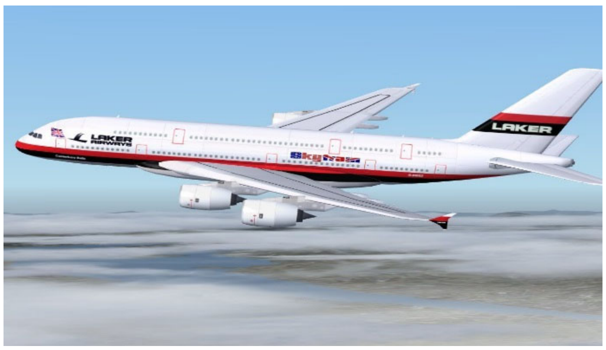
12.2 Managing Economic Exposure

Q: How can a firm get a good match? Play with α_{FC} to establish a manageable EE. For example, if FC and IE are small relative to variable, then, the bigger α_{FC}, the smaller the exposed CF (EAT) to changes in S_t.

When a firm restructures operations (shift expenses to FC, by increasing α_{FC}) to reduce EE, we say a firm is doing an *operational hedge*.

Note: In math terms, EE measures a first derivative: $\delta EAT/ \delta S_t$.

Case Study 1: Laker Airways (Skytrain) (1977-1982)



Skytrain: Low cost carrier, no-reservation, no-frills, from LON to NY (1977): GBP 59 one-way ticket (≈1/3 of the competition). Huge success. Rapid expansion, financed with debt.

Situation: UK airline expands rapidly: Laker buys airplanes from MD (a DC10-10 in the picture), financing in USD.

• Cost structure

As most major airlines before Airbus, Laker Airways had three major categories of costs:
(i) fuel, typically paid for in USD
(ii) operating costs incurred in GBP (administrative expenses and salaries), but with a non-negligible USD cost component (advertising and booking in the U.S.)
(iii) financing costs from the purchase of U.S.-made aircraft, denominated in USD.

• Revenue structure

Sale of transatlantic airfare (probably, evenly divided between GBP and USD), plus other GBP denominated revenue.

Currency mismatch (gap):

Revenues	Payables
mainly GBP, USD	mainly USD, GBP

Q: How did S_t affect CFs?
1977-1981: USD depreciates against the GBP (from 1.71 USD/GBP to 2.12 USD/GBP).
1981-1982: USD strong appreciation against the GBP (reaching 1.60 USD/GBP).
⇒ 1982: Laker Airlines files for bankruptcy.

Solutions to Laker Airlines problem (economic exposure):
- More sales in US
- Borrow in GBP
- Transfer cost out to GBP/Shift expenses to GBP (increasing α_{FC}/reduce α_{DC})

- Diversification (always a good risk management technique)

Q: Why operational hedging?
Financial hedging –i.e., with FX derivative instruments- is inexpensive, but tends to be short-term, liquid only for short-term maturities. Operational hedging is more expensive (increasing α_{FC} by building a plant, expansion of offices, etc.) but a long-term instrument.

Moreover, financial hedging only covers FX risk (S_t through P), but not the risk associated with sales in the foreign country (Q-risk). For example, if the foreign country enters into a recession, Q will go down, but not necessarily S_t. An operational hedge will work better to cover Q-risk.

Idea: To avoid EE, we would like to have constant CFs at different exchange rates (CFs: Free CFs, EAT). A firm can restructure operations to reduce EE.

Typical operational hedges: Move production abroad (build/expand a plant), buy more inputs abroad.

Example: A U.S. firm exports to the Australia. Two different FX scenarios:

(1) **S_t = 1.00 USD/AUD**

Sales	in US	USD 11M	
	in Aus	AUD 15M	
Cost of goods	in US	USD 5M	
	in Aus	AUD 8M	

(2) **S_t = 1.10 USD/AUD**

Sales	in US	USD 12M
	in Aus	AUD 18M
Cost of goods	in US	USD 5.5M
	in Aus	AUD 10M

Taxes:	US	30%
	Aus	40%
Interest:	US	USD 5M
	Aus	AUD 1M

CFs under the Different Scenarios (in USD)

	S_t = 1 USD/AUD	**S_t = 1.1 USD/AUD**
Sales	11M +15M = 26M	12M + 19.8M=31.8M
CGS	5M + 8M = 13M	5.5M + 11M = 16.5M
Gross profit	5M + 7M = 13M	5.5M + 11M = 15.3M
Int	5M + 1M = 6M	5M + 1.1M = 6.1M
EBT	6M	9.2M
Tax	0.3M + 2.4M = 2.7M	0.45M + 3.08M = 3.53M
EAT	**4.3M**	**5.67M**

Q: Is the change in EAT significant?
Let's calculate the CF-exchange rate elasticity: Change in EAT(%)/$e_{f,t}$ = .3186/.1= 3.186
⇒ A 1% depreciation of the USD, EAT increases by 3.2% (probably, very significant!). That is, this company benefits by an appreciation of the AUD against the USD. The firm faces economic exposure. ¶

How can a U.S. exporting firm avoid (or reduce) economic exposure? (Short answer: Match!)

1. Increase US sales
2. Borrow more in AUD (increase outflows in AUD)
3. Increase purchases of inputs from Australia (increase CGS in AUD)

Note: A U.S. importing firm can reduce EE by taking the reverse steps.

Diversification always helps to reduce economic exposure. By diversifying a company takes a portfolio approach to inflows and outflows denominated in different currencies.

Example: In the previous (baseline) example, we'll play with scenarios (one at a time).
(A) US firm increases US sales by 25% (unrealistic!)
EAT(S_t = 1 USD/AUD) = USD 6.225M
EAT(S_t = 1.1 USD/AUD) = USD 7.77M
⇒ a 1% depreciation of the USD, EAT increases by only 2.48%.

(B) US firm borrows only in AUD: AUD 6M
EAT(S_t = 1 USD/AUD) = USD 4.8M
EAT(S_t = 1.1 USD/AUD) = USD 5.87M
⇒ a 1% depreciation of the USD, EAT increases by 2.23%.

(C) US firm increases Australian purchases by 30% (decreasing US purchases by 30%)
EAT(S_t = 1 USD/AUD) = USD 3.91M
EAT(S_t = 1.1 USD/AUD) = USD 4.845M
⇒ a 1% depreciation of the USD, EAT increases by 2.39%.

(D) US firm does (A), (B) and (C) together
EAT(S_t = 1 USD/AUD) = USD 6.335M
EAT(S_t = 1.1 USD/AUD) = USD 7.145M
⇒ a 1% depreciation of the USD, EAT increases by 1.28%.

Note: You can find this example (and play with different values) in my homepage: www.bauer.uh.edu/rsusmel/4386/ee-example.xls ¶

Remark: Some firms will always be exposed. For example, U.S. small firms that only do business in the U.S. and import parts from abroad (say, a store selling Chinese food and goods in Houston's Chinatown) do not have a lot of opportunities to reduce EE. For them, a strong USD is good for their CFs; while a weak USD is not. Large firms have more leeway in adjusting their business structure to reduce EE.

Case Study 2: Walt Disney Co.

Four divisions (in 2006): Entertainment, Consumer Products, Theme Parks and Resorts, and Media Networks.

S_{06} = 108.113 TWC/USD (TWC = Trade-weighted currency)
$Price_{06}$ = USD 30.90

Inflows (2006 **Revenue: USD 34.3B, Operating income: USD 6.49B, EPS: USD 2.06**):
- Media (ABC, ESPN, Disney Channel, A&E. *Low*). **Revenue: 14.75B, OI: 3.61B**
- Parks & Resorts (Disney Cruise Line & 10 parks: Euro Disney, Tokyo Disney + HK park, U.S. (30% from abroad). *Medium*). **Revenue: 9.95B, OI: 1.53B**
- Studios (Disney, Pixar, Touchstone. 50+% from abroad. *High*). **Revenue: USD 7.2B, OI: 0.73B**
- Consumer products (Licensing, Publishing, Disney store (Europe). *Medium*) **Revenue: USD 2.4B, OI: 0.62B**

Outflows - 80% in USD

S_{06} = 108.113 TWC/USD (TWC = Trade-weighted currency index)
$Price_{06}$ = USD 30.90

UPDATE (2006-2013):
- DIS bought Marvel for USD 4B in 2009 and Lucasfilm for USD 4B in 2012.
- DIS introduced a new division: Interactive Media (Kaboosee.com, BabyZone.com, Playdom (social gaming), etc.)
- DIS ordered two new cruises with 50% more capacity each in 2011.
- Shangai theme park to be opened in 2016.

Economic Exposure? Yes. Probably: Medium

• Note: To check our intuition, we can calculate a pseudo-elasticity to check EE. We need data. Let's use 2013 data:

Inflows (2013 **Revenue: USD 45.04B, Operating income: USD 10.72B, EPS: USD 3.38**):
S_{13} = 101.923 TWC/USD (USD depreciated by 5.73% against the TWC)
$Price_{13}$ = USD 65.30.

Summary:

	2006 (in USD)		2013 (in USD)	
	Revenue	**Operating Income**	**Revenue**	**Operating Income**
Media	14.75B	3.61B	20.35B	6.82B
Parks & Resorts	9.95B	1.53B	14.09B	2.22B
Studios	7.2B	0.73B	5.98B	0.66B
Consumer Products	2.4B	0.62B	3.56B	1.11B
Interactive Media			1.06B	-0.09B
Total	**34.3B**	**6.49B**	**45.04B**	**10.72B**

13-06 Change in Revenue = USD 10.74B (31.31%)
13-06 Change in OI = **USD 10.72B** – **USD 6.49B** = USD 4.23B (**65.18%)**
13-06 DIS Stock Return (r_{DIS}) = **111.32%**
13-06 $e_{f,t}$ = - 0.05725 (or 5.73% depreciation of the USD)

CF-elasticity = % Change in OI / $e_{f,t}$ = **.6518**/-.05725 = -11.385

If stock market numbers are more trusted than accounting numbers, recalculate CF-elasticity:
CF-elasticity = $r_{DIS}/e_{f,t}$ = **1.1132**/-.05725 = **-19.445**. (Interpretation: a 1% USD depreciation, increases stock returns by **19.445%**.)

According to these elasticities, both very high, DIS behaves like a net exporter, a depreciation of the USD increases cash flows.

• Managing Disney's EC

1. increase expenses in FC
    a. make movies elsewhere
    b. move production abroad
    c. Borrow abroad
2. Diversify revenue stream
    a. Build more parks abroad
    b. New businesses

• Let's revisit the measurement Disney's EE.
Q: Is the pseudo-elasticity informative? Is S_t the only variable changing from 2006 to 2013?
A: No! DIS added assets, then more revenue and OI are expected. Also the economy and the stock market grew during these dates. We need to be careful with these numbers. We need to "control" for these changes, to isolate the effect of $e_{f,t}$.

A multivariate regression will probably be more informative, where we can include other independent ("control") variables (income growth, inflation, sales growth, assets growth, etc.), not just $e_{f,t}$ as determinants of the change in OI (or DIS stock return).

We can also borrow from the investments literature and add as regressors thepopular 3 Fama-

French factors: Market ($(r_M - r_f)$, Size (SMB), and Book-to-Market (HML). In this case, we run:

$$r_{DIS,t} = \alpha + \gamma_1 (r_M - r_f)_t + \gamma_2 \text{ SMB}_t + \gamma_3 \text{ HML}_t + \beta\, \boldsymbol{e_{f,t}} + \varepsilon_t$$

Example: Disney's EE.
Using Disney's monthly excess returns from the past 35 years (1984:Jan, 2019:June), we run a regression against $e_{f,t}$ (using USD/TWC) and the Fama-French factors (Market, SMB, HML):

$R^2 = 0.4188$
Standard Error = 1.6115
Observations = 424

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.18460	0.13040	-1.4160	0.1576
$\boldsymbol{e_{f,t}}$	**0.19250**	0.23412	**0.8223**	0.4114
$(r_M - r_f)$	0.51853	0.03068	**16.900**	>.00001
SMB	-0.02080	0.04377	-0.4750	0.6348
HML	0.10089	0.04647	**2.1708**	0.0305

Note that the coefficients corresponding to $e_{f,t}$ is **0.1925.** That is, a 1% depreciation of the USD, increases stock returns by 0.1925%. A substantially smaller, and more realistic, figure than the one implied by the elasticity above.

After controlling for other factors that also affect Disney's excess returns, we cannot reject H_0, since $|t_\beta = \mathbf{-0.82}| < 1.96$ (at 5% level, no EE).

The results do not change if we use a longer sample (1973-2019) or a shorter sample (1993-2019). The β coefficient is not statistically (the t-stat is never bigger than 1 in absolute value).

Q: Why is economic exposure not showing up? Disney has been diversifying and taking a lot of the measures discussed above to reduce economic exposure for many years. It seems to be working. ¶

• **EE: Evidence**
Using a regression like the one above for Disney, Ivanova (2014) estimates the EE for 1,231 U.S. firms. She finds that the mean β is 0.57 (a 1% USD depreciation increases returns by 0.57%). However, only 40% of the EE are statistically significant at the 5% level. In general, large firms have lower exposures (average β is 0.063).

He and Ng (1998) and Doukas et al. (2003) find that only 25% of Japanese firms have significant EE.

Interesting result: Ivanova reports that 52% of the EEs come from U.S. firms that have no international transactions (a higher S_t "protects" these domestic firms).

Example: We check Ivanova's results for big firms, using the S&P 100 in the above EE regression.

We regress SP100 returns from past **38 years** (1984:Apr – 2022:Jan) against $e_{f,t}$ (USD/TWC) & the 3 FF factors:

$R^2 = 0.9664$
Standard Error = 0.8136
Observations = 454

	Coefficients	Std Error	t-stat	P-value
Intercept	-0.0247	0.0389	-0.6357	0.5253
$e_{f,t}$	**-0.0225**	0.0231	**-0.9756**	0.3298
Market $(r_M - r_f)_t$	0.9988	0.0090	110.5233	>.00001
SMB	-0.2459	0.0133	-18.4659	>.00001
HML	0.0068	0.0126	0.5381	0.5907

Since $|t_\beta = $ **-0.98**$| <$ **1.96** ⇒ No evidence of EE for big U.S. firms. ¶

12.3 Should a Firm Hedge?

There are two views with respect to hedging at the firm level:
- Based on the Modigliani-Miller Theorem (MMT). It states that hedging adds nothing to the value of a firm.
- Exploits some of the basic assumptions underlying the MMT. This second view analyzes specific situations where hedging might add value to a firm.

1. MMT: Hedging is Irrelevant

When we value a firm, the financing source of those good investments is irrelevant. Different mechanisms of financing determine how the CFs are divided among the different classes of investors (shareholders or bondholders).

The MMT depends on a set of assumptions about financial markets. These assumptions basically require that a firm operates in perfect markets (i.e., no transaction costs, no distortions, etc.).

Implications for hedging: If the methods of financing and the character of financial risks do not matter, managing them is not important, and, thus, should not add any value to a firm. On the contrary, since hedging is not free, hedging might reduce the value of a firm.

Modigliani and Miller also show that if investors want to reduce the financial risks associated to holding shares in a firm, they can diversify their portfolios by themselves.

2. Hedging Adds Value

The assumptions behind the MMT are routinely violated and, then the MMT does not hold. Under these circumstances, hedging adds value to a firm. The added value of hedging is still open to discussion.

<u>2.1 Investors might not be able to replicate an optimal hedge</u>
Investors might not be big enough to have access to optimal hedges. Or investors might not have enough information about CFs, denominated in different currencies, of the firm.

<u>2.2 Hedging as a tool to reduce the risk of bankruptcy</u>
If CFs are very volatile, a firm might be faced with the problem of needing cash to meet its debt obligations. Thus, firms, like MNCs, with good access to credit markets have no need to hedge. (Surprisingly, U.S. largest corporations are the biggest hedgers.)

<u>2.3 Hedging as a tool to reduce investment uncertainty</u>
Firms should hedge to ensure they always have sufficient cash flows to fund their planned investments.

<u>2.4 Hedging as a tool to reduce investment uncertainty</u>
Tax convexity –i.e., tax liability is progressively increasing with income– works in favor of hedgers. Thus, firms that hedge can expect to reduce their taxes by reducing income volatility. In addition, given that firms that hedge can borrow more, they can take advantage of the tax deductibility of interest.

- **Hedging: Some Conclusions**

• We have seen two extreme views:
(1) Hedging adds no value (actually, may decrease value). In practice, this view understands the potential benefits (lower distress costs and taxes), but diversified investors can manage risk exposure by themselves.
(2) Hedging adds value. In practice, this view understands that markets are efficient, but the reduction in uncertainty improves stock prices.

• There is an intermediate view:
- Hedging is likely to add value for:
    - ◊ Small firms with undiversified ownership.
    - ◊ Firms with a lot of debt.
    - ◊ Firms with limited growth opportunities if financially constrained.
    - ◊ Firms with risk that cannot be hedged by market instruments.

- **Who Hedges? And How?**

U.S. Evidence
A 1998 Wharton U.S. survey on hedging reported the following main findings:
- *Size matters*: 83% of big firms hedge, while on 12% of small firms hedge.
- *Industry matters*: primary product firms (68%) and manufacturers (48%) hedge more than service firms (42%).
- *Hedge only a fraction of the total FX exposure*. The average firm hedges less than 50% of the perceived FX exposure. This practice is called *selective hedging.*

- *Short-dated hedges*: 82% of firms use FX derivatives with a maturity of 90 days or less.
- *Standard options most popular*. Firms use standard European-style or American-style options much more than such exotic options as average rate, basket, or barrier options.
- *Speculation*: 32 % of firms that use FX derivatives reported that their market view of exchange rates leads them to "actively take positions" at least occasionally.

More Results:
- For equity markets, FX hedging in the long run does not significantly improve returns –see Statman and Fisher (2003), Thomas (1988).
- For equity markets, FX hedging does not increase well-diversified portfolio returns, nor always reduces risk. MSCI Barra Research Paper No. 2009-12**.**
- For bond markets, fully FX hedging is the best policy for risk-minimizing investor. Schmittmann (2010), IMF Working Paper 10/151.
- For the gold industry, firms engaging in selective hedging do not add to their performance. Brown, et al. (2006) "Are firms successful at selective hedging?" *Journal of Business*, 79, 2925-2949.
- For the gold industry, firms engaging in selective hedging are closer to financial distress. Adam et al. (2012) "Why do Firms engage in selective hedging?" SFB 649 Working Paper, Humboldt University.

Canadian Evidence

The Bank of Canada conducts an annual survey of FX hedging. The main findings from the 2011 survey are:
• Companies hedge approximately 50% of their FX risk.
• Usually, hedging is for maturities of six months or less.
• Use of FX options is relatively low, mainly because of accounting rules and restrictions imposed by treasury mandate, rules or policies.
• Growing tendency for banks to pass down the cost of credit (credit valuation adjustment) to their clients.
• Exporters were reluctant to hedge because they were anticipating that the CAD would depreciate. On the other hand, importers increased both their hedging ratio and duration.

Australian Evidence

The National Bank of Australia also conducts a survey, every four years since 2001, to gauge Australia's aggregate foreign currency exposure.
• The banking sector hedges all of its net FC liability exposure, while other financial corporations hedge only part of their net FC exposure.
• Overall, financial sector liabilities in FC (bonds, loans and deposits) had a hedge ratio of 60%, while assets in FC had a hedge ratio of 30%.
• 80% of FC denominated debt security liabilities was hedged using derivatives, reflecting a hedge ratio of 84% for short-term debt liabilities and 77% for long-term debt securities.
• Non-financial corporations hedged close to 30% of FC denominated liabilities, while there was almost no hedging of FC denominated assets.

CHAPTER 12 – BRIEF ASSESMENT

1. Padres Company does business in the U.S. and Australia. In attempting to assess its economic exposure, it compiled the following information:

• Its U.S. sales are somewhat affect by the Australia dollar's value because it faces competition from Australian exporters. It forecasts the U.S. sales based on the following exchange rate scenarios:

S_t (USD/AUD)	Revenue from U.S. (in million)
.70	USD 180
.85	USD 250

• Its AUD revenues on sales to Australian residents invoiced in AUD are expected to be AUD 400,000,000.
• Its anticipated cost of goods sold is estimated at USD 60 million from the purchase of U.S. material and AUD 100 million from the purchase of Australian materials.
• Fixed operating expenses are USD 20 million.
• Variable operating expenses are estimated at 15 percent of total sales (including Australian sales, translated to a USD amount).
• Interest expense is estimated at AUD 30 million on existing Australian loans, and USD 20 million on existing USD loans.
• Income tax is paid at the U.S. effective tax rate of 27%.

A. Create a forecasted income statement for Padres under each of the two exchange rate scenarios.
B. Explain how Padres' projected earnings before taxes are affected by possible exchange rate movements.
C. Explain how Padres can restructure its operations to reduce the sensitivity of its earnings to exchange rate movements, without reducing its volume of business in Australia.

2. In the previous exercise, calculate the CF-elasticity under the following scenarios (one at a time):
(A) Padres Co. increases US sales by 25% (unrealistic!)
(B) Padres Co. only in AUD:
(C) Padres Co. increases Australian purchases by 30% (decreasing US purchases by 30%)
(D) Padres Co. does (A), (B) and (C) together.

3. Below, we report GE's net income (in millions, USD) and earnings per share, EPS, along the USD/TWC exchange rate for the period 2012-2016. (Whole income statement on my homepage: http://www.bauer.uh.edu/rsusmel/4386/ GE_Income_Statement.csv). Does GE face EE?

	2016	2015	2014	2013	2012
Net income (in M)	8,175	-6,126-	15,233	13,057	13,641
EPS	0.89	-0.61	1.5	1.27	1.29
USD/TWC	1.044244	1.05869	1.114673	1.308284	1.361726

CHAPTER 12 - BONUS COVERAGE: Brief Laker Airways Story

After a legendary six-year battle won in the courts, Freddie Laker obtained a permit for his Laker Airways, established in 1966, to operate the Laker Skytrain service on both sides of the Atlantic, using two DC-10 planes. The Skytrain was a no-reservation, low cost air service, which revolutionized the air transport industry. It was the first low-cost transatlantic operation. Skytrain flew from New York to London and back for USD 236 (USD 400 less than the going rate). Breakfast was USD 1.25 extra.

On September 26, 1977, the first Skytrain flight departed London for New York, and subsequently went on to carry over 50,000 passengers before the end of the year with each flight over 80 percent full. The success was such that the Skytrain service was expanded to include a London to Los Angeles service in 1978, London to Miami in 1980 and London to Tampa in 1981.

During this time of expansion, the USD was weak against the GBP, and U.S. trips were relatively cheap for U.K. residents. Freddie Laker was able to expand the Skytrain concept by buying more DC-10s, financing them in USD. Thus, Skytrain's debt payments were in USD, while Skytrain's revenues were primarily in GBP.

Although popular with the public, Laker Airways became embroiled in price wars with more powerful companies. (Rumors and stories of collusion against Laker Airways are still told today.) The start of the Reagan presidency, with a consistent USD appreciation against European currencies, did not help Laker Airways' fortunes. On February 5, 1982, Laker Airways was forced to file for bankruptcy, owing GBP 270 million.

Thousands of pounds poured into a "Save Laker" fund, set up by members of the public sympathetic to the flamboyant tycoon. The "Save Laker" fund collected over GPB 1 million in donations. But it was too little too late. Within weeks Sir Freddie was attempting to re-launch an airliner by transferring the Laker Airways licenses to a new company. The Civil Aviation Authority officially blocked his efforts in May after objections from other airlines and the public.

Freddie Laker retired to Florida, then the Bahamas. He died in Miami aged 83 on 10 February 2006.

Richard Branson, founder of Virgin Atlantic, credited Freddie Laker for some of the success of Virgin Atlantic. "Perhaps his best advice was to make sure that I took British Airways to court before they bankrupted us — not after, as he (Laker) did."

Taken From "A brief history of price-fixing," by Simon Calder
The Independent (London), Jun 24, 2006

In the bad old days when airlines were run by, and for the benefit of governments and civil servants, colluding on fares was not illegal - it was compulsory. National airlines cosily agreed fares between themselves. Indeed, when the inspectors called on airlines, it was to uncover evidence of cutting fares, rather than artificially inflating them. Airlines from Laker Airways to British Caledonian were fined for the heinous practice of lowering their prices to allow more people to fly. Indeed, it was one such raid at Gatwick that prompted the late, great Sir Freddie Laker to start his Skytrain enterprise.

One day in 1970, Laker was summoned to the airport because Civil Aviation Authority staff were interrogating his passengers. His airline was involved in "affinity group charters", which at the time represented the only way for an ordinary working man or woman to travel the Atlantic. The big airlines had the scheduled business sewn up, and governments had imposed such a stranglehold on charters that only genuine clubs and societies were allowed on board transatlantic flights at reasonable rates. You can guess the result: all sorts of spurious associations were created to circumvent the stifling regulations. Everyone knew somebody who knew a dodgy agency that dabbled in cheap transatlantic air fares, and issued specious membership cards to the "Left Hand Club" to go with the tickets. Which made these flights prime targets for government inspectors seeking to stop people traveling - as happened to a Laker Airways departure from Gatwick to New York in 1970.

Sir Freddie later told me he was more appalled by the fact that they were "chucking old women off the aeroplanes" than by the hefty fine that he had to pay for the temerity of trying to take people across the Atlantic at an affordable price.

That episode led directly to the creation of the Laker Skytrain, which was allowed to cut prices and transform travelers' lives.

Chapter 13 - DFI

In this chapter we start the second part of the course. In the first part, we have concentrated on issues related to FX Rates. From now on, we will study issues related to a company dealing in an international environment.

The first topic involves *Direct Foreign Investment* (DFI), a decision a firm makes to invest in a foreign country. The chapter is motivated through a firm's evaluation of two alternatives:
- A domestic firm can produce at home and export production.
- A domestic firm can also invest to produce abroad (& do a DFI).

Note: Depending on the author/organization DFI can also be called Foreign Direct investment (FDI).

DFI Definition: It is a controlling ownership in a business enterprise in one country by an entity based in another country. DFI is different from investing in foreign stocks, which is a more passive investment.

The World Bank/OECD defines DFI as the net inflows of investment to acquire a lasting management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor. DFIs can be done through mergers & acquisitions, setting up a subsidiary, a joint venture, etc.

From the point of view of national accounts, DFI is calculated as the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments.

According to the World Bank, the total DFI in 2013 was USD 1.65 trillion (7.3% growth with respect to 2012), with China getting the biggest part (USD 347.8 billion), followed by the U.S. (USD 235.9 billion), Brazil (USD 80.8 billion) and Hong Kong (USD 70.7 billion).

13.1. Why DFI instead of exports?

DFI requires capital, sometimes a lot of capital, and, thus, DFI decisions are difficult to reverse. So, why choose DFI over the simpler exports?

A:
- ◊ Avoid tariffs and quotas
- ◊ Access to cheap inputs
- ◊ Reduce transportation costs & trade frictions
- ◊ Local management
- ◊ Take advantage of government subsidies
- ◊ Access to new technology
- ◊ Access to local expertise (including: local contacts, dealing with red tape, etc.)
- ◊ Reduce economic exposure

- ◊ Diversification
- ◊ Real option (an investment today helps to make investments elsewhere later).

Q: What is the main disadvantage of a DFI?
A: A DFI usually requires a large investment, which is not easy to revert. There is a higher risk relative to exports, where the decision to export can easily be changed. To penetrate a new market and limit risk, licensing agreements and joint ventures (a "limited DFI") are used by MNCs.

13.2 Diversification through DFI

MNCs have many DFI projects. Since all investments have risks, they will select the project that will improve the company's risk-reward profile (think of a company as a portfolio of projects). We will evaluate projects according to risk-adjusted performance measures (RAPM).

We need to know how to calculate E[r] and Var[r] for a portfolio. Suppose X and Y are two investments, then the return on the portfolio of the two investments (X+Y):

$$E[r_{x+y}] = w_x * E[r_x] + (1 - w_x) * E[r_y]$$
$$Var[r_{x+y}] = \sigma^2_{x+y} = w_x^2(\sigma_x^2) + w_y^2 (\sigma_y^2) + 2\, w_x\, w_y\, \rho_{x,y}\, \sigma_x\, \sigma_y$$

We need given this information, we can evaluate the risk-reward profile of the portfolio using the *Sharpe Ratio* (SR), also called *reward-to-variability ratio (*RVAR), defined as:

$$SR = \text{Reward-to-variability ratio} = E[r_i - r_r]/ \sigma_i = RVAR$$

But, total volatility (σ) may not be the appropriate measure of risk for a portfolio. Another measure of a portfolio's risk is β. To calculate the β of the X+Y portfolio, you should remember that the beta of a portfolio is the weighted sum of the betas of the individual assets:

$$\beta_{x+y} = w_x * \beta_x + (1 - w_x) * \beta_y$$

Now, we can define another RAPM, the *Treynor Ratio* (TR), or *reward-to-volatility ratio* (RVOL):

$$\text{Treynor Ratio} = TR = \text{Reward-to-volatility ratio} = E[r_i - r_f]/ \beta_i = RVOL$$

Note: SR uses total risk (σ), this measure is appropriate when total risk matters –i.e., when most of an investor's wealth is invested in asset i. When the asset i is only a small part of a diversified portfolio, measuring risk by total volatility is inappropriate. TR emphasizes systematic risk, the appropriate measure of risk, according to the CAPM.

Example: A US company $E[r] = 13\%$; $SD[r] = 12\%$ (recall SD = σ), $\beta=.90$
Two potential DFIs: Colombia and Brazil
(1) Colombia: $E[r_c] = 18\%$; $SD[r_c] = 25\%$, $\beta_c = .60$
(2) Brazil: $E[r_b] = 23\%$; $SD[r_b] = 30\%$, $\beta_b = .30$

$r_f = 3\%$
$\rho_{ExistPort, Col} = 0.40$
$\rho_{EP,Brazil} = 0.05$
$w_{Col} = .30$, $\Rightarrow (1 - w_{col}) = w_{EP} = .70$
$w_{Brazil} = .35$, $\Rightarrow (1 - w_{Brazil}) = w_{EP} = .65$

The US company evaluates the Projects according to SR and TR.

We need to calculate for each project E[r], σ =SD[r], β:

$E[r_{EP+Col}]$, $Var[r_{EP+Col}]$, β_{EP+Col}

$E[r_{EP+Brazil}]$, $Var[_{EP+Brazil}]$, $\beta_{EP+Brazil}$

Recall: The higher the SR or RVOL, the better the project

Calculate the SR for both countries (we'll work with excess returns, directly):

1. Colombia

$E[r_{EP+Col} - r_f] \quad = w_{EP}*E[r_{EP} - r_f] + (1- w_{EP})*E[r_{col} - r_f]$

$= .70*.10 + .30*.15 = 0.115$

$\sigma_{EP+Col} = (\sigma^2_{EP+Col})^{1/2}$

$\sigma^2_{EP+Col} = w_{EP}^2(\sigma_{EP}^2) + w_{Col}^2(\sigma_{Col}^2) + 2\ w_{EP}\ w_{Col}\ \ \rho_{EP,Col}\ \sigma_{EP}\ \sigma_{Col}$

$= (.70)^2*(.12)^2 + (.30)^2*(.25)^2 + 2*.70*.30*0.40*.12*.25 = 0.0177210$

$\Rightarrow \sigma_{EP+Col} = (0.017721000)^{1/2} = 0.1331$

$\beta_{EP+Col} = w_{EP} *\beta_{EP} + w_{Col}*\beta_{Col}$

$= .70*.90 + .30*.60 = 0.81$

$SR_{EP+Col} = \ E[r_{EP+Col} - r_r]/ \sigma_{EP+Col} = .115/.1331 = 0.8640$

$TR_{EP+Col} = \ E[r_{EP+Col} - r_r]/ \beta_{EP+Col} = .115/.81 = 0.14198$

<u>Interpretation of SR</u>: An additional unit of total risk (1%) increases returns by .864%

<u>Interpretation of TR</u>: An additional unit of systematic risk increases returns by .142%

2. Brazil

$E[r_{EP+Brazil} - r_f] = 0.135$

$\sigma_{EP+Brazil} = 0.1339$

$\beta_{EP+Brazil} = 0.69$

$SR_{EP+Brazil} = 0.135/0.1339 = 1.0082$

$TR_{EP+Brazil} =.135/.69 = 0.19565$

<u>Interpretation of SR:</u> An additional unit of total risk increases returns by 1.0082%

Under both measures, Brazilian project is superior.

Now, compare existing portfolio of the company with the Brazilian project

$SR_{EP} = (.13 - .03)/.12 = .833$

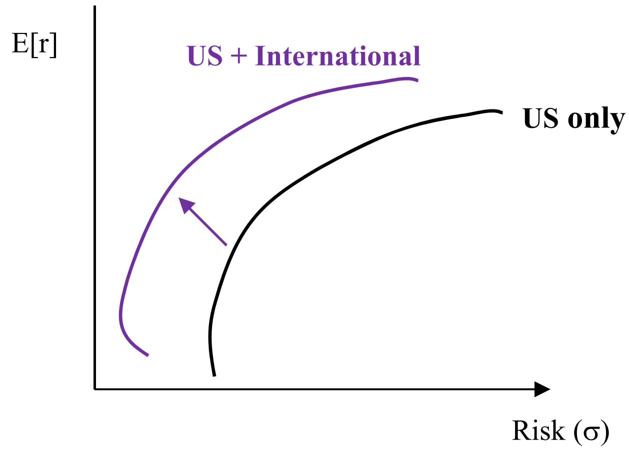
$TR_{EP} = (.13 - .03)/.90 = .111$

Using both measures, the company should diversify internationally through DFI in Brazil Why?
Because it improves the risk-reward profile for the company.

Note: There is another RAPM - *Jensen's alpha measure*
It estimates a constant (α) on a CAPM-like regression. You regress the excess returns on a portfolio against the excess market returns (and/or Fama-French factors.) The Jensen's alpha measure is often used to rank mutual funds.

13.3. Aside: Diversification and International Investments

Recall the Efficient Frontier:



When you go international, you improve the tradeoff and move the frontier up, in the northwest direction.

Key**:** The correlation of the project that we are considering to add to our existing portfolio should be low to achieve a significant movement in the efficient frontier.

• Risk-Return in international investments

Table 13.1 reports the USD mean annual returns on MSCI equity indexes from 11 developed markets, along with the World and EAFE Indexes (based on monthly data, 1970-2017 period).Over the past 47 years, Hong Kong and Singapore show the best returns in Developed Markets, but we need to take into consideration the risk taken by an investor. Using the Sharpe ratio (with a 4.74% risk-free rate) to measure the risk-return trade-off, Switzerland and Japan have the best performances over the past 47 years.

Table 13.1: MSCI Index USD Annual Returns: (1970-2017)

Market	Return	Standard Dev	Sharpe Ratio
U.S.	8.19	15.04	0.2295
Canada	8.22	19.35	0.1801
France	9.02	22.17	0.1927
Germany	9.37	21.67	0.2135
Italy	5.08	25.38	0.0315
Switzerland	10.44	17.83	0.3193
U.K.	7.77	21.44	0.1411
Japan	9.94	20.74	0.2506
Hong Kong	16.80	33.72	0.3578
Singapore	12.26	27.79	0.2705
Australia	7.68	23.79	0.1233
World	7.70	14.58	0.2026
EAFE	8.00	16.78	0.1945

We can use the above numbers to compute the equity risk premium. If we consider that the average U.S. T-bill rate during the 1970-2017 period was 4.74%, the realized equity risk premium for the U.S. is **3.45%** (= 8.19 – 4.74). There is no agreement on what the equity risk premium should be; in general, the reported numbers for the U.S. market are between 3% and 8%, which place our 3.45% estimate on the lower side of the range.

Since stock returns are calculated with error (even for large portfolios, like the above indexes), using a long data set is important: the longer the data set, the smaller the sampling error and, thus, the more precise the estimation. Dimson, Marsh and Staunton (2011) used data from 1900-2010 to report for mainly 19 developed markets an equity returns. For example, they calculated mean annual return (standard deviation in parenthesis) for the U.S., Switzerland and Italy are 7.2% (19.8%), 5.1% (18.9%), and 9.8% (32%), respectively. The numbers are a bit different from the ones reported in Table 13.1, though within the usual estimation error.

For emerging markets, the estimation error is considerable, given that quality data, following international standards, started to be collected in 1988 (Brazil, Greece, Ireland, Malaysia, Mexico, Thailand, etc.), and for Russia, India and China, considered then the major "*frontier markets*," data started to be collected in 1993 (along with Israel, Pakistan, Poland, South Africa, etc.). In Table 13.2, we report annual USD returns, standard deviation and Sharpe Ratio (using the U.S. T-bill average rate in the period, 2.43%) for the period 1993-2017 for some emerging markets, two emerging market indexes (EM-Asia and EM-Latin America), and, for reference purposes the U.S., World and EAFE Indexes.

In general, we observe the typical emerging market behavior: high returns and high volatility. In terms of Sharpe ratios, in Table 13.2, the U.S. market provided the best trade-off, closely followed only by the Russian market.

Table 13.2: MSCI Index USD Annual Returns: (1993-2017)

Market	Return	Standard Deviation	Sharpe Ratio
Brazil	16.58	37.54	0.3768
China	5.40	33.25	0.0785
Greece	-0.18	35.46	-0.0736
India	12.05	28.99	0.3318
Malaysia	6.54	27.82	0.1477
Mexico	10.00	27.75	0.2728
Pakistan	6.79	34.91	0.1248
Poland	18.62	44.78	0.3615
Russia	22.65	50.09	0.4035
South Africa	11.30	26.30	0.3373
EM-Asia	7.24	24.13	0.1990
EM-Latin America	10.65	27.68	0.2969
U.S.	8.72	14.25	0.4409
World	7.06	14.44	0.3207
EAFE	5.48	16.06	0.1899

We see a big dispersion in expected returns (and risk!) in international markets, which cannot be explained by the usual World CAPM. Several papers have been proposed to explain these differences, among them:
◊ Global economic risks –Ferson and Harvey (1994).
◊ Inflation risk –Chaieb and Errunza (2007).
◊ Liquidity risk –Karolyi, Lee, and van Dijk (2012), Malkhozov, et al. (2014).
◊ Momentum and a global cash-flow-to-price factor –Hou, Karolyi, and Kho (2011).
◊ Investment restrictions –Karolyi and Wu (2014).
◊ Currency risk –Dumas and Solnik (1995).

There is also an international version of the 3-factor Fama-French model, extended by Fama and French (1998, 2012), which finds that only two factors matter in their model: world (say, a global equity benchmark) and value (HML).

• Empirical facts related to international investments

Empirical fact 1: Low Correlations (first reported by Gruber (1970).) Correlations in international equity markets tend to be moderate to low. This fact puzzles economists. Table 13.3 reports return correlations for several international market indexes.

Correlations between neighboring markets tend to be higher: Correlation between the U.S. and Canada is 0.74; the U.S. and Japan is 0.36. (Data: 1970-2015).

Average correlation between the US and international markets is around .40.

Table 13.3: MSCI Index Returns: Correlation Matrix (1970-2015)*

A. European Markets

MARKET	Bel	Den	France	Gerrn	Italy	Neth	Spain	Swed	Switz	U.K.	World
Belgium	1.00	0.59	0.72	0.70	0.54	0.75	0.56	0.55	0.68	0.59	0.69
Denmark		1.00	0.53	0.59	0.48	0.62	0.51	0.54	0.55	0.49	0.61
France			1.00	0.73	0.59	0.73	0.59	0.57	0.68	0.63	0.73
Germany				1.00	0.56	0.78	0.58	0.64	0.71	0.54	0.71
Italy					1.00	0.55	0.57	0.50	0.50	0.57	0.57
Netherlands						1.00	0.59	0.63	0.75	0.69	0.81
Spain							1.00	0.57	0.50	0.47	0.62
Sweden								1.00	0.57	0.52	0.69
Switzerland									1.00	0.62	0.72
U.K.										1.00	0.73
World											1.00

B. Pacific Markets

MARKET	Australia	HK	Japan	Korea	Singap	Taiwan	U.S.	World
Australia	1.00	0.32	0.37	0.50	0.51	0.33	0.56	0.65
Hong Kong		1.00	0.34	0.40	0.57	0.41	0.39	0.48
Japan			1.00	0.48	0.39	0.24	0.36	0.67
Korea*				1.00	0.46	0.33	0.45	0.53
Singapore					1.00	0.45	0.53	0.60
Taiwan*						1.00	0.35	0.38

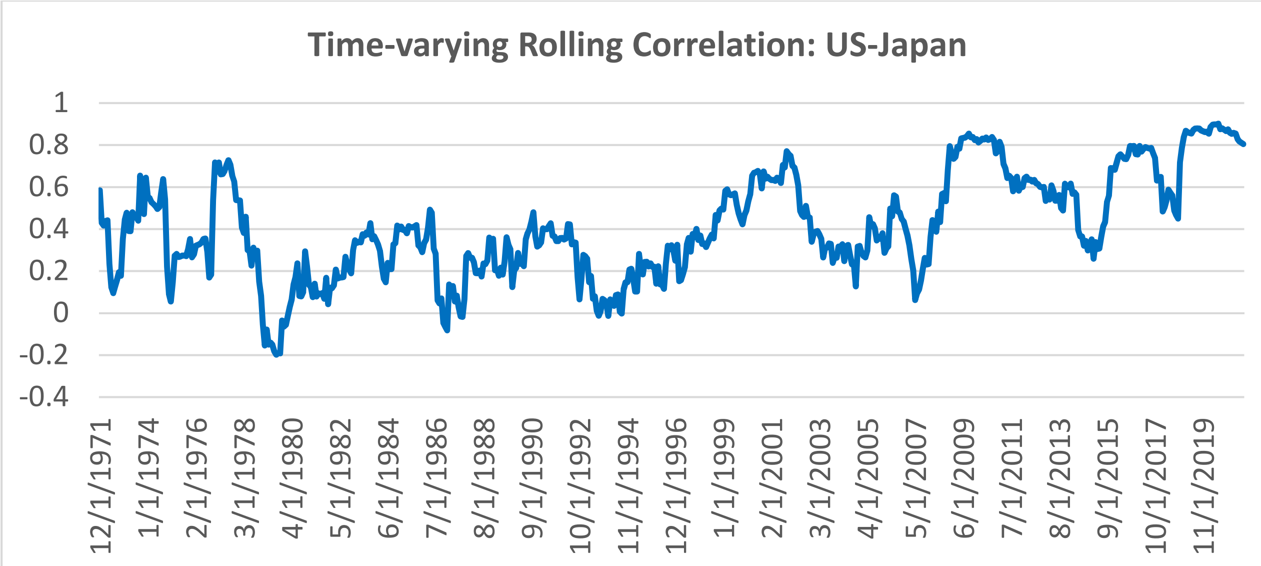
C. North American Markets

MARKET	Canada	U.S.	Mexico	World	EAFE	EM-LA	EM-ASIA
Canada	1.00	0.74	0.54	0.77	0.62	0.60	0.65
U.S.		1.00	0.58	0.88	0.62	0.57	0.61
Mexico *			1.00	0.56	0.49	0.72	0.52

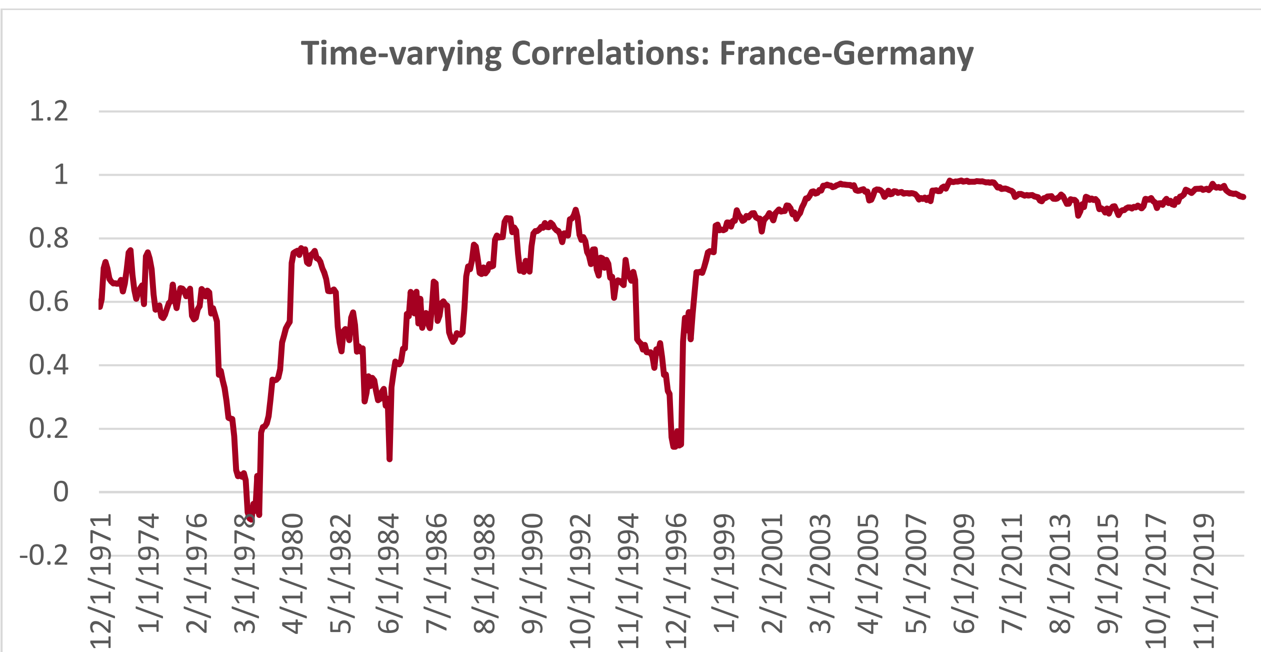
Notes:
*: The sample for South Korea, Taiwan, Mexico, the EM-Latin America and the EM-Asia indexes start in January 1988.

Empirical fact 2: Correlations are time-varying
Correlations change over time. In general, during bad global times, correlations go up:
$\Rightarrow$ When you need diversification, you tend not to have it!

In the graph below, we plot the US-Japan rolling monthly correlations from 1970:Jan -2021:Jun. There is a lot of movement for the correlation coefficient (average correlation close to 0.35).

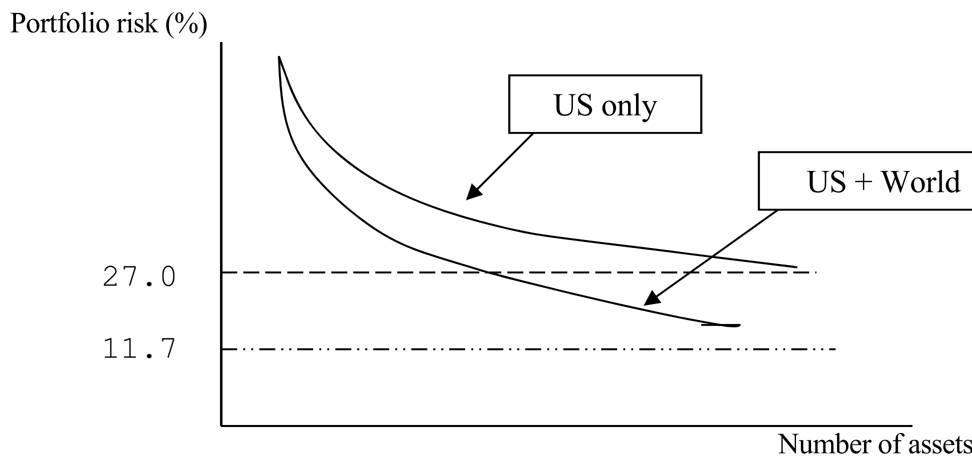


Also, note that in the graph the correlation has become stronger in the last 20 years. This increase in correlations is even more pronounced for regional markets. For example, below we plot the 2-year rolling correlation between the returns of the stock indexes of Germany and France from 1970: Dec to 2021:Jun. The return correlation between both markets has become very close to one; that is, investing in Germany or in France is almost the same!



Empirical Fact 3: Risk Reduction (from Solnik, B. (1974), "Why Not Diversify Internationally?" *Financial Analyst Journal*, 20, 48-54).

Figure 13.2: Effect of International Investment on Risk



Solnik's observes that past 12 stocks, the risk in a portfolio levels off, around 27%. For international stocks, the risk levels off at 11.7%. (See Figure 13.2.)

More recent work, sets the asymptotic lower risk level for in a U.S. domestic portfolio levels off, around **20%**. (large caps only, **17%**; small caps only **25%**).

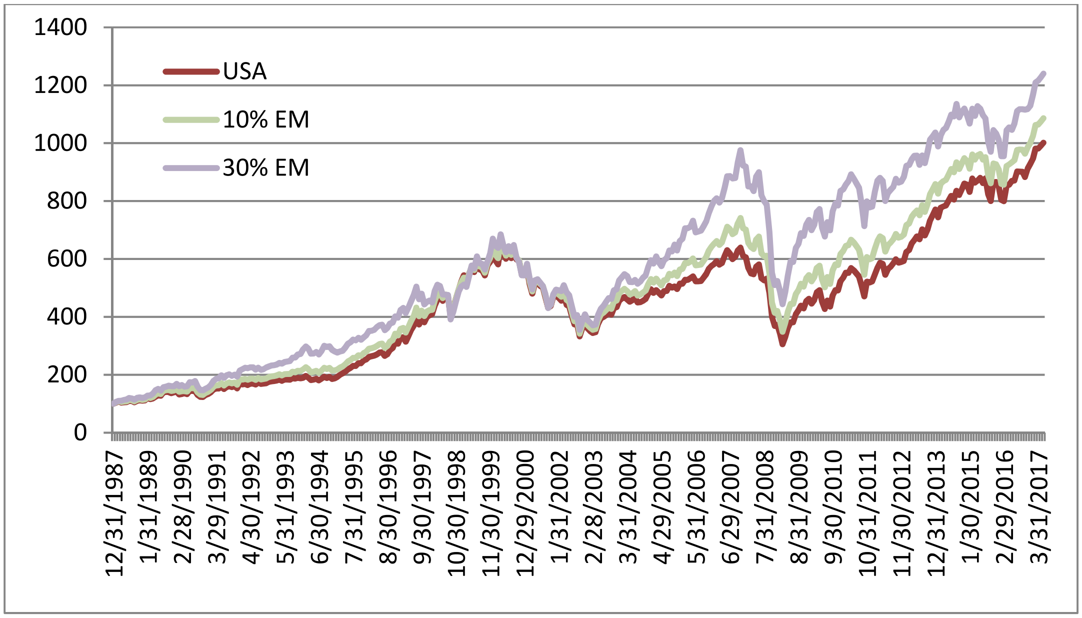
Empirical Fact 4: Returns Increase (from P. Jorion and S. J. Khoury (1996), **Financial Risk Management: Domestic and International Dimensions**, published by Blackwell.)

Portfolios with international stocks have outperformed domestic portfolios in the past years.

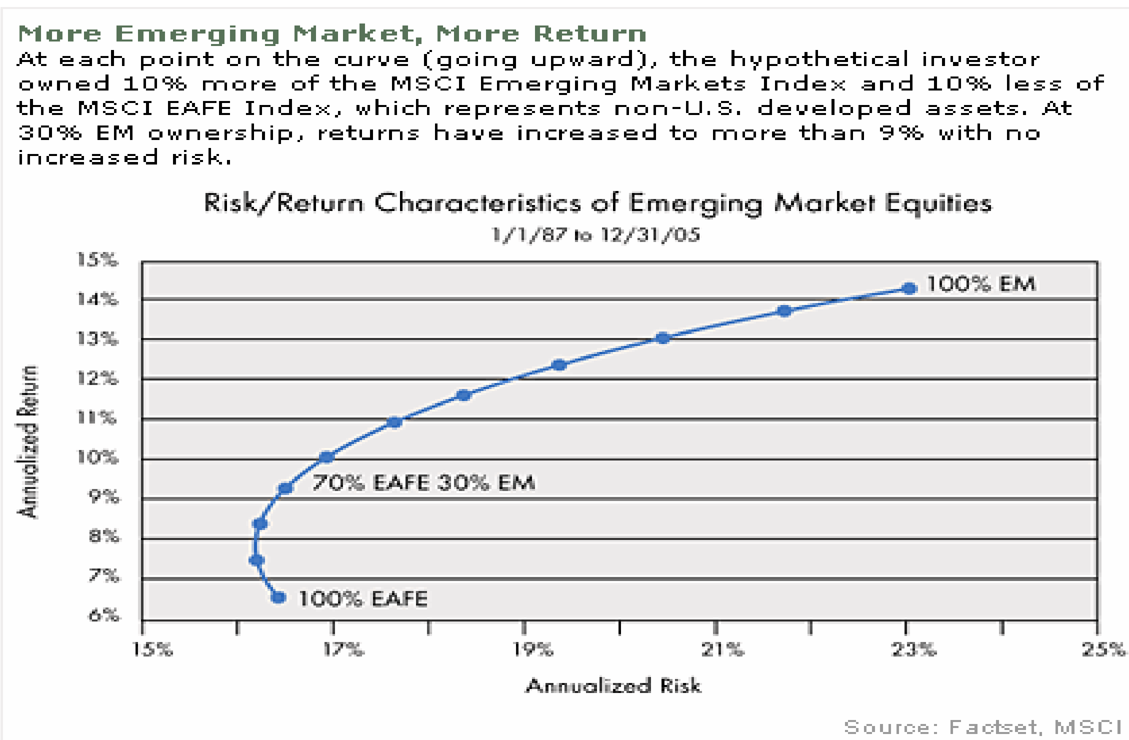
Example: The U.S. market return and volatility from 1970-2021 were 7.71% and 15.62%, respectively (RVAR=.15). A portfolio with a 25% weight with Japan would have produced a market return and volatility of 8.32% and 14.53%, respectively. (RVAR=.23). ¶

Recent Past (1988:Jan-2017:May): The case of emerging markets (see Graph 13.1 below).
Three portfolios:
- A US purely domestic portfolio, with 7.76% annualized return.
-A 90% US, 10% EM portfolio, with 8.01% annualized return (or extra 85% over 29.5 years).
- A 70% US, 30% EM portfolio, with 8.55% annualized return (or extra 239% over 29.5 years!).

Graph 13.1: The Case for Emerging Markets (1988-2017)

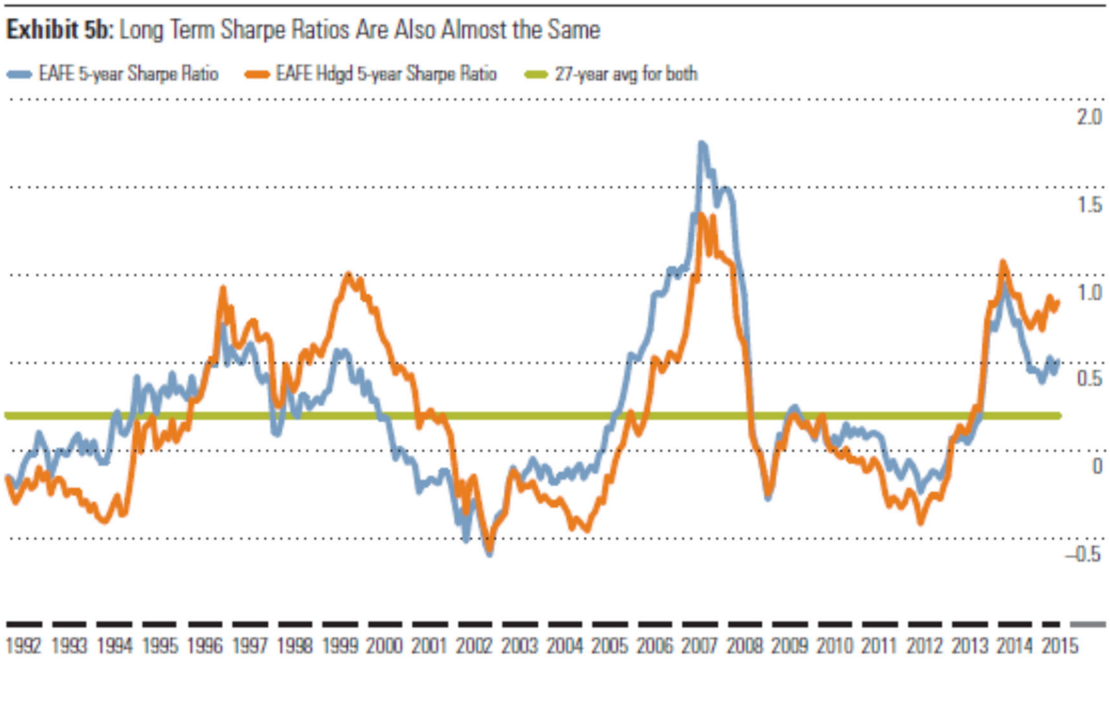


Q: Do we see the potential for a free lunch? The numbers point to a positive answer.



Q: Does hedging FX risk affect the risk-return of a exposed portfolio?
Unhedged international portfolios add an additional risk to a portfolio: FX. Unhedged international portfolios have higher volatility, but if we look at the long-term risk-adjusted performance of hedged

and unhedged international portfolios we get similar results. During periods of USD appreciation, hedging adds to returns, but during periods of USD depreciation the opposite occurs. On average, Sharpe ratios are very similar. See Graph below taken from Oey (2015, Morningstar research note).



Source: Morningstar Direct

Q: How to take advantage of facts 3 and 4?
A: True diversification: invest internationally.

Empirical Fact 5: Investors do not diversify enough internationally (first discussed by French and Poterba (1991, *American Economic Review*).
⋄ A 2002 report by UBS on the proportion of foreign bonds and foreign equities in the total equity and bond portfolio of local residents for several OECD countries:
- Most internationally diversified investors: Netherlands (62%), Japan (27%) and the U.K. (25%).
- U.S. ranks at the bottom of list: only 12% of internationally diversified investors.
⋄ 2010 data put the proportions of the U.K. at 50% and of the U.S. at 28%, an improvement.

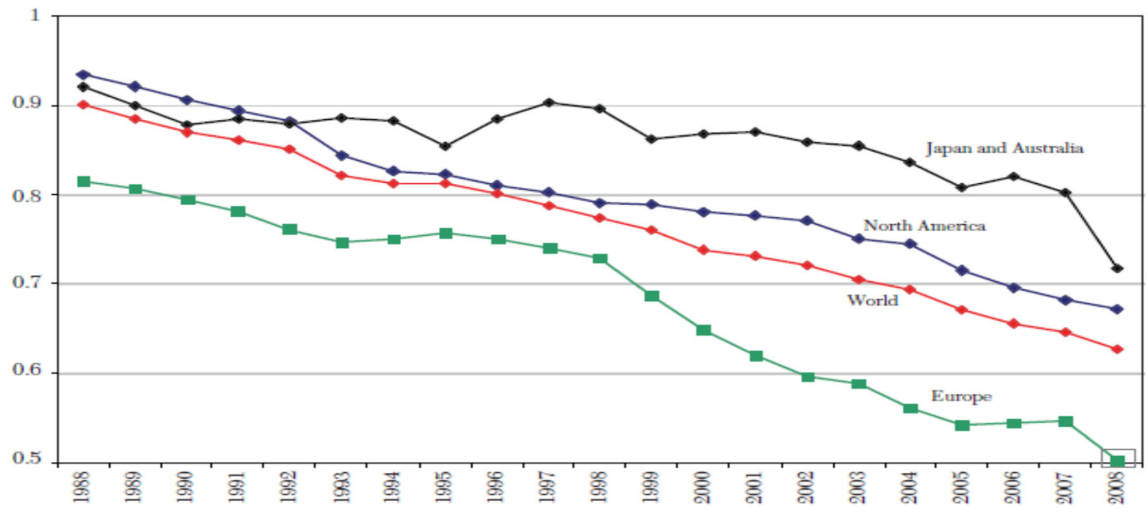
⋄ Does home bias hurt your portfolio? Yes!
In 2004, the Kansas City Fed estimates that:
(a) With the actual 12% share of foreign equity investments, the mean return and SD for the US equity portfolio were 10.30% and 14.47%.
(b) Increasing to 41% the share of foreign equity investments increases the mean return to 10.44% and decreases the SD to 13.78% for the U.S. equity portfolio.
⇒ Sharpe Ratio up ⇒ US equity portfolio is inefficient!

(From Meirelles Aurélio (2006) “Going Global: The Changing Pattern of U.S. Investment Abroad,” *Kansas City Federal Reserve*, Quarter III.)

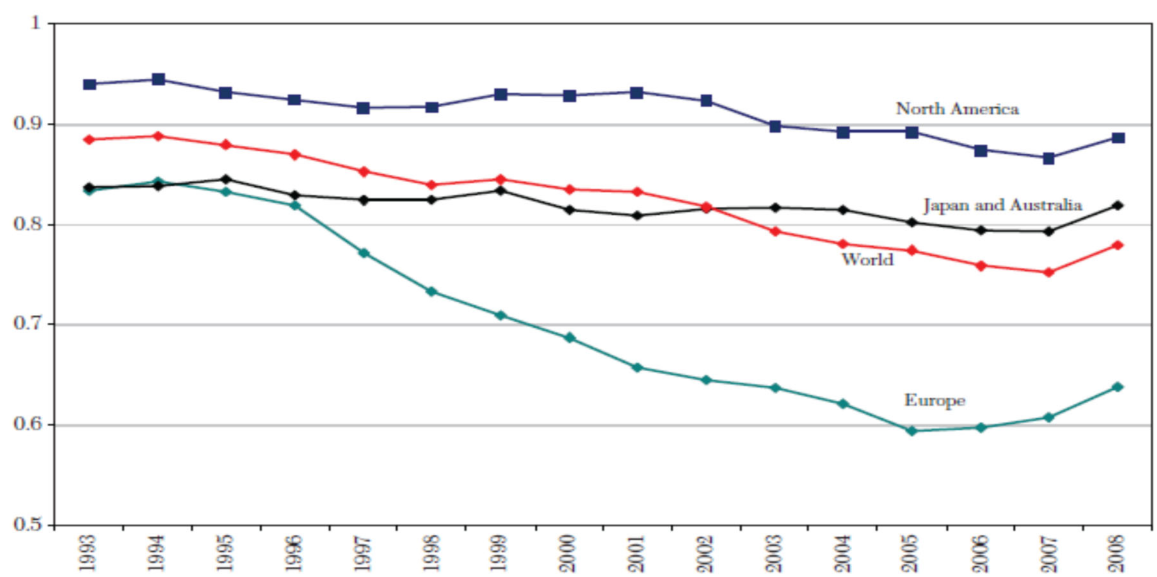
⋄ Popular measure for Equity Home Bias (EHB) –only equity, not bonds and other assets:

$$EHB_i = 1 - \frac{\text{Share of Foreign Equity in Country i Equity Holding}}{\text{Share of Foreign Equity in World Market Portfolio}}$$

EHB has been decreasing over time, from Coeurdacier and Rey (2013):



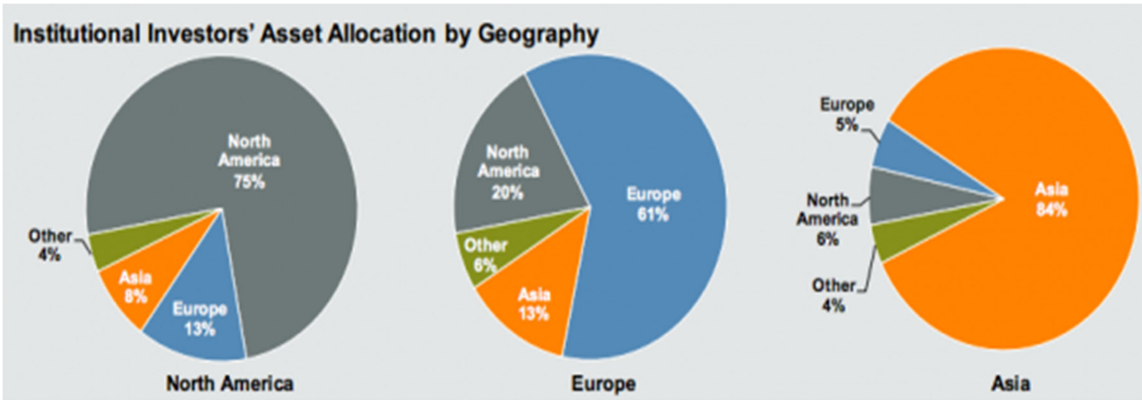
For bonds, the BHB (Bond Home Bias) also shows a similar pattern over time:



Europe the more diversified region.

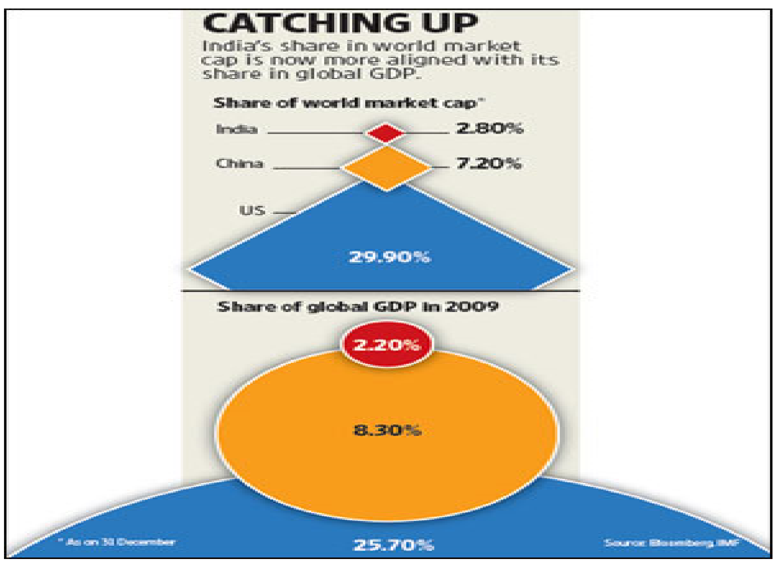
Emerging markets have very low EHB. For example, Brazil = .98, China = .99.

Institutional Investors also have a home bias (maybe driven by domestic investors' tastes?). Data from 2013:

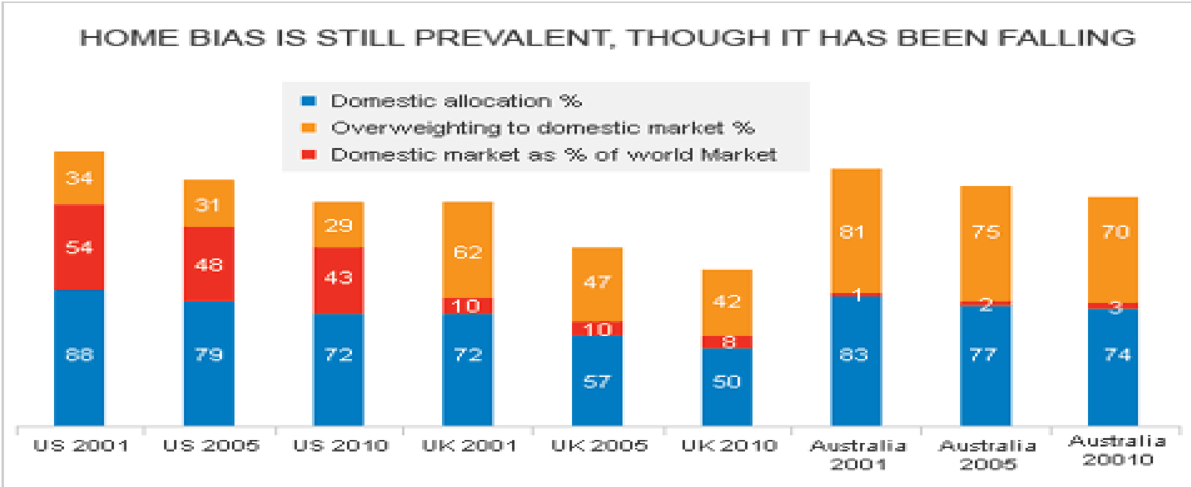


Source: Ipreo, BNY Mellon, McKinsey Global Institute, J.P. Morgan Asset Management "Guide to the Markets – Asia."

◊ <u>Aside Question:</u> What should drive your exposure?
- Global GDP?
- Market capitalization?



<u>Puzzle</u>: Home Bias (Investors tend to ignore the benefits of international diversification.)



Source: International Monetary Fund's Coordinated Portfolio Investment Survey (2011), Barclays Capital, and Thompson Reuters Datastream.

◊ Proposed explanations for home bias and low correlations:
(1) Real exchange rate risk (local assets show a better correlation with the domestic consumption basket).
(2) Information costs/frictions (locals may have better information about local assets).
(3) Controls to the free flow of capital.
(4) Currency & country/political risk.
(5) Behavioral biases (investors trust more the local information/signals; *cognitive bias*).
(6) Indirect exposure through local assets (local firms may be already exposed to international markets)

CHAPTER 13 – BRIEF ASSESMENT

1. Cammy Inc., a U.S. firm, plans to invest in a new project that will be located either in Ecuador or in Colombia. Assume the U.S. risk free rate is 3%. You have the following data on expected returns, volatility, correlations, and weights for each project:

	Cammy	Ecuador	Colombia
Expected return	10%	20%	30%
Standard deviation	15%	25%	50%
Correlation with existing Cammy's portfolio	1.00	.35	.11
Weight on overall portfolio	-	.20	.10
Beta	.90	1.10	1.40

A. Based on the Sharpe Ratio, which project would you recommend to Cammy?
B. Based on the Treynor Ratio, which project would you recommend to Cammy?
C. Is Cammy, under both criteria, better off without adding any project?

2. Two traders, working for a bank, dealing in different markets.

Trader I position (FX futures):

Annualized profits: USD 12 million.
Position: USD 41 million.
Volatility (σ): 15% annualized

Trader II position (FX spot):

Annualized profits: USD 23 million.
Position: USD 68 million.
Volatility (σ): 25% annualized

Use the RAROC (see Bonus material) measure to determine which trader provides the bank a better risk-return trade-off.

CHAPTER 13 - BONUS COVERAGE: Another RAPM: RAROC

Bankers Trust created a modification of RVAR to evaluate the performance of its managers, the so-called risk-adjusted return on capital (RAROC) system.

RAROC adjusts returns taking into account the capital at risk, which is defined as the amount of capital needed to cover 99 percent of the maximum expected loss over a year. The one-year horizon is used for all RAROC comparisons, regardless of the actual holding period. All traders can be compared using the same measure.

Example: Two traders, working for a bank, dealing in different markets.

Trader I position (Mexican bonds):

Annualized profits: USD 3.3 million.
Position: USD 45 million.
Volatility (σ): 21% annualized

Trader II position (Spot exchange rates):

Annualized profits: USD 3 million.
Position: USD 58 million.
Volatility (σ): 14% annualized

1) Calculate the worst possible loss in a 99% Confidence Interval –i.e., VaR(99%).
Using a normal distribution: The 1% lower tail of the distribution lies 2.33σ below the mean.

Mexican bonds: 2.33 x 0.21 x USD 45,000,000 = USD 22,018,500.
Spot FX: 2.33 x 0.14 x USD 58,000,000 = USD 18,919,600.

2) Calculate RAROC:
Mexican bonds: RAROC = USD 3,300,000/USD 22,018,500 = .1499.
Spot FX: RAROC = USD 3,000,000/USD 18,919,600 = .1586.

Conclusion: Once adjusted for risk, Trader II provided a better return.¶

• SUMMARY: RAPM - Pros and Cons

- RVOL and Jensen's alpha:
  - Pros: They take systematic risk into account. Appropriate to evaluate diversified portfolios. Comparisons are fair if portfolios have the same systematic risk, which is not true in general.
  - Cons: They use the CAPM ⇒ Usual CAPM's problems apply.

- RVAR
  - Pros: It takes unsystematic risk into account ⇒ can be used to compare undiversified portfolios. Free of CAPM's problems.
  - Cons: Not appropriate when portfolios are well diversified. SD is sensible to upward movements, something irrelevant to Risk Management.
- RAROC
  - Pros: It takes into account only left-tail risk.
  - Cons: Calculation of VaR is more of an art than a science.

Chapter 14 - Multinational Capital Budgeting

MNCs receive project proposals from foreign subsidiaries. In general, they have several competing ones.

14.1. How to Evaluate the Desirability of Projects?

A: NPV. The evaluation of MNC's project is similar to the evaluation of a domestic one.

Simple definitions:
EBIT = Revenue – Cost of goods – Selling and general administrative expenses – Depreciation
NOPLAT (Net operating profit less adjusted taxes) = EBIT * (1 - t)   – t: corporate tax rate
Gross CF = GCF = NOPLAT + Depreciation
FCF (Free Cash Flows) = GCF – CAPEX – ΔNWC   – NWC: Net Working Capital

A typical evaluation of a project will discount future FCF, using a constant *appropriate* –i.e., reflecting the risk of the CFs- discount rate. An evaluation may also add a project's benefits not reflected in CFs (subsidies, additional tax advantages, etc.) and any associated value from real options (option to expand, delay or cancel).

• **Data Needed for Multinational Capital Budgeting**:
1. CFs (Revenues[P & Q] and Costs[VC & FC])
2. Initial Outlay (I.O. or CF_0)
3. Maturity (T)
4. Salvage Value (SV_T)
5. Depreciation
6. Taxes (local and foreign, withholding, tax credits, etc.)
7. Exchange Rates (S_t)
8. Required Rate of Return (*k*)
9. Restrictions to Capital Outflows

In general, CFs are difficult to estimate. A point estimate (a single estimated number) is usually submitted by the subsidiary. The Parent will attempt to adjust for CFs uncertainty. Usually, this is done through the discount rate, *k:* Higher CF's uncertainty, higher *k.*

• **International Taxation: Tax Neutrality**
DFIs are subject to foreign and/or local taxes. All countries attempt to eliminate double taxation to achieve *tax neutrality*:

⇒ Tax neutrality: No tax penalties associated with international business.

Two approaches to achieve tax neutrality:

(1) Capital import neutrality (CIN), based on territorial income.
(2) Capital export neutrality (CEN), based on worldwide income.

(1) CIN Approach (most European countries, Canada, Hong Kong, Singapore)
- No penalty or advantage attached to the fact that capital is foreign-owned
- Foreign capital competes on an equal basis with domestic capital.

- Local tax authorities exempt foreign-source income from local taxes.
⇒ For MNCs: Exclusion of foreign branch profits from U.S. taxable income (*exclusion method*).

(2) CEN Approach (U.S., Brazil, South Korea, Israel, India, Mexico)
- No tax incentive for firms to export capital to a low tax foreign country.
- Overall tax is the same whether the capital remains in the country or not.
- Local authorities "gross up" the after-tax income with all foreign taxes; then apply the home-country tax rules to that income, and give credit for foreign taxes paid.
⇒ For MNCs: Inclusion of "pre-tax" foreign branch profits in U.S. taxable income (gross-up income). A tax credit is given for foreign paid taxes (*credit method*).

• **Typical Problem**: Agency Problem - Subsidiary vs. Parent
The subsidiary will want to undertake projects (prestige of subsidiary in host country, local political pressure, incentives for local revenue, etc), whereas the Parent only cares about Profitability. Subsidiary can misstate Revenues, Costs, and Salvage Value.

Example: Project in Hong Kong (Data provided in HKD)
- T = 4 years
- CF_0 = HKD 70M

Price for Product = HKD			Quantity =
	20	Year 1	1.00M
	25	Year 2	0.95M
	30	Year 3	0.90M
	35	Year 4	0.85M

- VC = HKD 5/unit
- FC = HKD 3M
- Depreciation = 10% of initial outlay (HKD 7M/year)
- Taxes: HKD 17%, US 35% (CEN system: Gross-up, credit for foreign taxes)
  Withholding tax=10%
- S_t = 7 HKD/USD (use RW to forecast future S_t's)
- SV_4 = HKD 25M
- k = 15%

1. Subsidiary's NPV (in HKD including local taxes)

	Year 1	**Year 2**	**Year 3**	**Year 4**
Revenues	20M	23.75M	27M	29.75M
Cost	5M	4.75M	4.5M	4.25M
	3M	3M	3M	3M
Gross Profit	**12M**	**16M**	**19.5M**	**22.5M**
Dep.	7M	7M	7M	7M
EBIT	**5M**	**9M**	**12.5M**	**15.5M**
Taxes	.85M	1.53M	2.125M	2.635M
NOPLAT	**4.15M**	**7.47M**	**10.375M**	**12.865M**
Free CFs	11.15M	14.47M	17.375M	19.865M
Free CF +SV	**11.15M**	**14.47M**	**17.375M**	**44.865M**

NPV (in HKD) = -70M + 11.15M/1.15 + 14.47M/1.15^2 + 17.375M/1.15^3 +
+ 44.865M/1.15^4 = - HKD 12.2869M <0

Note: If SV_4 is changed to HKD 80M, then NPV = 19.16M ⇒ Subsidiary would accept the project. **(**This is likely to happen: the subsidiary will never submit a project to the parent company with a NPV<0.) Thus, SV is very important!

2. MNC's NPV (in USD, including all taxes)

	Year 1	**Year 2**	**Year 3**	**Year 4**
CFs to be remitted	**HKD 11.15**	**14.47**	**17.375**	**19.865+25**
S_t = 7 HKD/USD				
CFs in USD	1.59M	2.067M	2.48M	2.84M+3.57M
Withholding	.159M	.2067M	.248M	.284M
CFs remitted	1.431M	1.86M	2.3M	2.56M+3.57M
(US Tax)	(.6M)	(.8M)	(.975M)	(1.125M)
Tax Credit	.281M	.425M	.552M	.660M
Net Tax	**.319M**	**.375M**	**.423M**	**.465M**
Free CF +SV	**1.114M**	**1.486M**	**1.811M**	**2.09M+3.57M**

NPV = - USD 10M + 6.5195M = **- USD 3.48M** < 0 ⇒ No to the project.

A subsidiary will never submit a project like this (they want to undertake the project.) A subsidiary will inflate some numbers, for example, SV_T.

If $SV_{T=4}$ = **HKD 80M**, then

NPV(USD M) = 10 – {1.114/1.15 +1.486/1.15^2 +1.811/1.15^3 +(2.095+**80**/7)/1.15^4}
= **USD 1.01181 M** > 0 ⇒ Yes.

Note: Computation of US Tax, using the credit method:

	Year 1	**Year 2**	**Year 3**	**Year 4**
Gross-up	12.0	16.0	19.5	22.5
US-tax	4.20	5.60	6.83	7.88
Foreign Tax credit	1.97	2.98	3.86	4.62
Net US tax (in HKD M)	2.235	2.623	2.963	3.254
US-tax (in USD M)	0.600	0.800	0.975	1.125
Foreign Tax credit (in USD M)	0.281	0.425	0.552	0.660
Net US tax (in USD M)	**0.319**	**0.375**	**0.423**	**0.465**

Remark: Not all the countries collect taxes like in the U.S., based on worldwide income. ¶

14.2. Adjusting Projects for Uncertainty

MNCs use different techniques to adjust for uncertainty in the estimated CFs submitted by the subsidiaries.

• Adjusting discount rate, *k*

In general, CF's uncertainty is incorporated in the evaluation process through the discount rate, k: The higher the uncertainty, the higher k. In general, k incorporates economic and political uncertainty in the local country. But k is a point estimate, an *average risk*. Using an average risk may cost an MNC: it may wrongly reject (accept) projects that have a below (above) average risk

Sometimes, it is better not to work with a point estimate for k, but with a range instead. In this case, an MNC may construct a range for k, say $\{k_{LB}, k_{UB}\}$, to create a range for $\{\text{NPV}(k_{LB}), \text{NPV}(k_{UB})\}$.

Example: A range for NPV based on $\{k_{LB}, k_{UB}\}$ for the HK project.
Suppose the Parent decides to build a range for NPVs based on $\{k_{LB}=.135, k_{UB}=.165\}$ (using SV_4 = **HKD 80M** to get NPV > 0):

$\Rightarrow$ Range for NPV: {USD 0.535M; USD 1.519M}.

The lower end of the range is positive (under the higher k_{UB}=.165). This is good for the project. ¶

• Sensitivity Analysis/Simulation

In addition to adjusting k, an MNC may use sensitivity analysis for CFs to derive an expected value for the CFs, and then an E[NPV]. You may remember that calculating an E[CF] is not the same as adjusting for risk (recall the St. Petersburg paradox).

Sensitivity analysis when CF uncertainty is introduced by the subsidiaries can be very informative to evaluate proposals from subsidiaries. Recall the agency problem: Subsidiaries may not be forthcoming about true profitability of projects.

1) Sensitivity Analysis of the impact of Revenues and Costs on the NPV of project

◊ Play with different scenarios/Simulation

Steps:
- a. Assign a probability to each scenario/Simulate from a distribution
- b. Get an NPV for each scenario.
- c. Calculate a weighted average (weight=probability) NPV $\Rightarrow$ E[NPV]
- d. If possible, use a risk-reward measure (a RAPM), say a Sharpe Ratio.

◊ Breakeven Analysis (same as what we do below for SV).

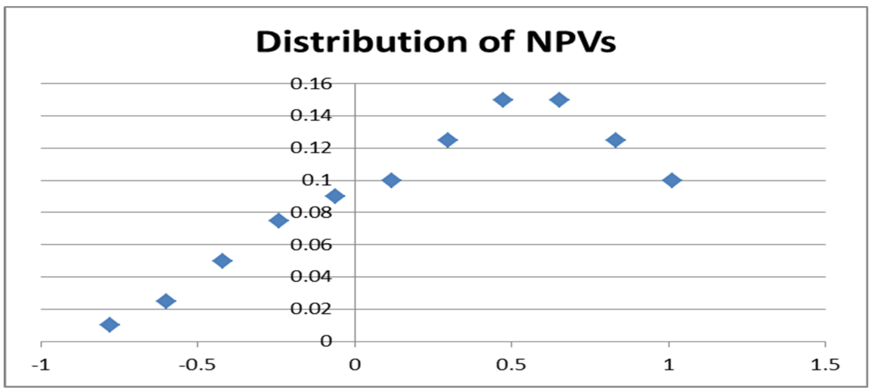
<u>Note</u>: Decisions

A Parent can base a decision using some risk-reward rule. For example, a firm may look at the SR (using E[NPV] and SD[NPV]), the range –i.e., the difference between best and worst case scenarios-, establishing some ad-hoc tolerable level for the probability of negative NPV, etc. Experience tends to play an important role in an MNC's decisions.

Example: Scenarios for CFs and E[NPV] & SD[NPV] for HK project

We create different scenarios for the CFs=Gross Profits (as a percentage of the CFs submitted by the subsidiary).

% of CFs	Probability	NPV (in M)
0.60	**0.01**	**-0.77918**
0.64	**0.025**	**-0.60009**
0.68	**0.05**	**-0.42099**
0.72	**0.075**	**-0.24189**
0.76	**0.09**	**-0.06279**
0.80	0.1	0.116313
0.84	0.125	0.295412
0.88	0.15	0.474512
0.92	0.15	0.653611
0.96	0.125	0.832711
1	0.1	1.01181
E[NPV]		**0.35541**
SD[NPV]		0.64477
Prob[NPV<0]	0.25	



• *Descriptive Stats*
E[NPV] = **USD 0.355411 M**
SD[NPV] = USD 0.644769 M
Prob[NPV<0]= **0.25**
SR= E[NPV]/SD[NPV] = 0.551221
95% C.I. (Normal) = {USD -0.90834M; USD 1.61916M} ¶

• *Decision*
Rule: Among the projects with E[NPV]>0, The Parent will compare the SRs (or CIs) for different projects and select the project with the higher SR (or the CI with the smallest negative part). ¶

2) Sensitivity Analysis of the impact of SV on NPV
◊ Try different scenarios with different values for SV (same as above for CFs). For example:

% of SVs (in HKD)	Probability	NPV (in M)
0.60 (=HKD 48)	**0.05**	**-1.60192**
0.64 (=HKD 51.2)	**0.065**	**-1.34055**
0.68 (=HKD 54.4)	**0.085**	**-1.07917**
0.72 (=HKD 57.6)	**0.1**	**-0.8178**
0.76 (=HKD 60.8)	**0.125**	**-0.55643**
0.80 (=HKD 64)	**0.15**	**-0.29505**
0.84 (=HKD 67.2)	**0.125**	**-0.03368**
0.88 (=HKD 70.4)	0.1	0.227692
0.92 (=HKD 73.6)	0.085	0.489064
0.96 (=HKD 76.8)	0.065	0.750437
1.00 (=HKD 80)	0.05	1.01181
E[NPV]		**-0.29505**
SD[NPV]		0.866876
Prob[NPV<0]	**0.70**	

⋄ Breakeven Analysis: Calculate SV^{BE}, such that $NPV(SV^{BE}) = 0$.

$$\Rightarrow SV^{BE} = \{IO - \Sigma_t CF_t/(1+k)^t\}*(1+k)^T$$

The higher SV^{BE}, the more dependent the project is on an uncertain CF. To make the NPV>0, we need $SV_T > SV^{BE}$. (Not good!)
Q: Is the SV_T reasonable? SV^{BE} helps to answer this question.

Example: Calculate SV^{BE} for HK project.

SV^{BE} $= \{10M - \{1.114M/1.15 + 1.486M/1.15^2 + 1.811M/1.15^3 + 2.09M/1.15^4\}*1.15^4$
= USD 10.21583 (or HKD 71.51075M)

Check:
NPV(USD M) = $10 - \{1.114/1.15 + 1.486/1.15^2 + 1.811/1.15^3 + (2.09+51.51075/7)/1.15^4\} = 0$

A parent company compares the SV^{BE} with the reported SV value:

SV^{BE} = HKD 71.51075M < SV_4 = **HKD 80M**. (Too big!)

Note: You can find the whole set of examples regarding the HK project (and play with different values) in my homepage: www.bauer.uh.edu/rsusmel/4386/npv-int2.xls ¶

Remark: If SV^{BE} is negative, it is good for the evaluation of the project. Its profitability does not depend at all on an uncertain –and difficult to estimate- future CF.

• Judgment call

We presented several techniques that can be used by an MNC to measure and evaluate a project's risk. But, in practice there is a lot of subjective judgment. MNCs also incorporate their own and/or a consultant's experience to make a decision. Introducing a judgment call in the process is acceptable, given that in building scenarios, changing *k,* assuming distributions, experience also plays a very important role.

Example: Ad-hoc decision
Rule: The Parent not only requires E[NPV]>0, but as an additional control for risk that the probability of NPV<0 be lower than 30%. In the HK example, the probability of a negative NPV is 25%, which would be acceptable under this ad-hoc risk-reward rule.

Note: This ad-hoc rule double counts risk, since NPV is calculated using risk-adjusted discount rates! ¶

14.3. Real Options View

The original HK project (with SV = HKD 25M) has an NPV<0. Under the usual view, a company will reject this project. But, an MNC may undertake a negative NPV project if there maybe future benefits to the company associated with the project. For example, an expansion, development of contacts, power to influence future political events, etc.

An MNC may view a DFI as an option –a *real option*. The initial investment is a sunk cost needed to have the option to expand later, similar to an option premium, p:

$$p = \text{NPV}_{\text{Initial Investment}} < 0$$

The MNC will have some targets for the initial investments (revenue, market share, etc.) that will play the role of a *strike price, X:*

If Realized Target > X $\quad\Rightarrow$ Expand (exercise *real option*).

Finally, the MNC undertakes project if

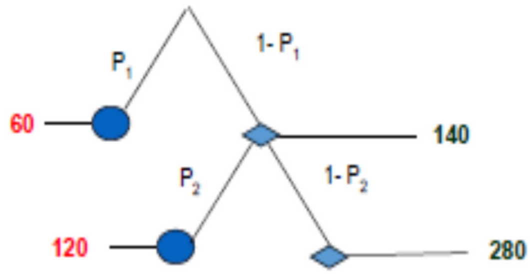
$$\text{E[NPV]} = \text{NPV}_{\text{Initial Investment}} + \text{Option Value of Expansion}$$

Think of a real option as a two-phase project:
1) First phase: Test the Market
2) If test is successful: Expand

These real options are different from financial call options. In general, it is difficult to value these options, since, unlike a call option on a stock, there is no underlying, liquid, financial asset. In addition, real options –in our case, the option to expand- can have a very long life (even perpetual).

Example: Suppose Malouf Coffee is considering expanding to Mexico by opening two stores: a small one and a big one. If the expansion is done simultaneously, the upfront investment is **230.** There is a 70% probability of failure. The associated CFs under failure and success are **60** and **140**, respectively, for the small store; and double the CFs under both scenarios for the big store.

Alternatively, Malouf Coffee can do the expansion in two phases, with an Initial Investment = **100** & Expansion Investment (the big store) = **70** if X (CFs) > 120 (k = .15) and the following CFs:



Suppose $P_1 = .70$ & $P_2 = .50$.

The numbers reflect the fact that Malouf Coffee can double the CFs in the second phase at a lower investment cost (**70**), taking advantage of the initial investment and successfully learning about the business. Learning (better marketing, distribution, Mexican contacts, etc) also appears in the form of a lower the probability for the bad outcome (**120**). Then:

$$E[NPV] = \mathbf{-100} + (.70)*\mathbf{60}/1.15 + (.30)*\{(\mathbf{140 - 70})/1.15 + [\mathbf{120}*.50 + \mathbf{280}*.50]/1.15^2\}$$
$$= 0.1512 > 0.$$
$\Rightarrow$ Malouf Coffee expands to Mexico.

Notice that ex-ante, the NPV of opening one store in Mexico is negative:
$$E[NPV] = \mathbf{-100} + [(.70)*\mathbf{60} + (.30)*\mathbf{140}]/1.15 = -26.9565 < 0.$$

But, Malouf Coffee decides to do the initial NPV<0 investment because it allows Malouf Coffee to learn about the Mexican market.

Clearly, if Malouf Coffee does not use the option approach and evaluates the expansion in Mexico under the scenario of opening the stores simultaneously, we get:
$$E[NPV] = \{\mathbf{-(100 + 130)} + [(.70)*(\mathbf{60 + 120}) + (.30)*(\mathbf{140 + 280})]/1.15\} = -10.86957 < 0.$$
$\Rightarrow$ Malouf Coffee does not expand to Mexico.

Note: The valuation is higher when the real option is introduced. The option has value! ¶

The value of the real option comes from the fact that the firm learns from observing the CFs in the real world during the testing phase and, then, adapts the behavior (expand, delay, or close the project) accordingly. It is an attempt to limit the downside.

Technical Note: The discount rate in the second-phase should be lower!

In general, it is not easy to determine P_1 & P_2 and future CFs –i.e., not easy to calculate the expectation E[NPV]. Option valuation methods are used to get an idea of the value of the option to expand. In general, simulation methods are used.

Many MNCs went to China in the early 1990s with negative NPV projects. Years later, many of them substantially expanded their initial investment (BMW, Nike, Starbucks), while many others closed the projects and left the market (Home Depot, Mattel).

CHAPTER 14 – BRIEF ASSESMENT

1. Dennis Corporation, a U.S.-based MNC, has a subsidiary in Nicaragua that manages coffee fields. The subsidiary believes it could also enter into the sugar export business. The following data has been compiled for the analysis (in córdobas (NIO), Nicaragua's currency):

- Initial outlay: NIO 60 million
- Life of the project: 3 years
- Revenue per year: NIO 40 million
- Cost of Goods per year: NIO 10 million
- Interest expense per year: NIO 2 million
- Depreciation: 10% of initial outlay
- Salvage value: NIO 15 million
- Exchange rate: 25 NIO/USD
- Forecasted exchange rates:

  $E_t[S_{t+1}]$=24 NIO/USD; $E_t[S_{t+1}]$=22 NIO/USD; $E_t[S_{t+1}]$=20 NIO/USD.
- The Nicaraguan government imposes a 20% tax on profits.
- The Nicaraguan government also imposes a 10% withholding tax on funds remitted to the U.S. parent house (excluding salvage value).
- The U.S. government imposes a 10% tax on remitted funds, excluding salvage value. Tax credit is allowed.
- All the cash flows will be remitted to the parent company.
- The required rate of return is 12%.

i.- What is the evaluation of the project for Dennis Corporation's Nicaraguan subsidiary?
ii.- What is the evaluation of the project for Dennis Corporation?
iii. Calculate SV^{BE}.
iv.- Would you recommend the project to Dennis Corporation?

2. Following the previous exercise, what happened to the evaluation of the project if:
(A) Dennis decides to increase required rate of return to 15%.
(B) Dennis decides to decrease SV to NIO 5 million
(C) Dennis decides to use the RW model to forecast exchange rates.
(D) Dennis adds NIO 10 million to the net present value, as the value of the option to expand.
(E) Dennis believes there are four scenarios regarding annual revenue:

- 50% probability annual revenue will be as stated by subsidiary –i.e., NIO 40 million.
- 25% probability annual revenue will be 10% lower.
- 15% probability annual revenue will be 20% lower.
- 10% probability annual revenue will be 30% lower.

3. Suppose Fox Sports is considering buying the soccer league TV rights of Panamá, El Salvador, Guatemala, Nicaragua and Honduras. The success of the investments depends on the number of subscribers. If the number is "high", the total expected 5-year return (in USD) is 40% for Fox Sports per market; if the number is "low," the total expected 5-year return (in USD) is -20% for Fox Sports per market. Suppose, the probability of a high number of subscribers is 60%. To simplify suppose the upfront initial investment per market is USD 100. Evaluate the investment under 2 situations (a & b below), using a discount rate of 14%:

a.- Fox Sports decides to test one market, say Panama. If successful in test market, Fox Sports will enter the other (& assume Fox Sports now knows it will be successful in all the other markets).

b.- Fox Sports decides to buy all TV rights simultaneously.

c.- Explain why the results are different.

Chapter 16 - Country Risk (CR)

Review from Chapter 14
- MNCs make decisions on DFI projects on the basis of NPVs.
- MNCs use discount rates to establish NPV for projects
    - the higher the discount rate, the lower the chances of a project to have a NPV>0.

Q: Where do discount rates come from?
A: For projects abroad, a key element is Country risk (CR)

In this chapter, we will study country risk and how it impacts projects.

Country Risk: Introduction

CR reflects the (potentially) negative impact of a country's economic and political situation on an MNC's, a lender's or an investor's CFs.

Country Risk
Definition: Country risk (CR) is the risk attached to a borrower or an investment by virtue of its location in a particular country.

For example, when ConocoPhillips invested in Venezuela in the 1990s to help develop the Petrozuata, Hamaca and Coroco projects, it added an additional risks to its investment portfolio: Venezuelan country risk.

Note: CR is different than FX risk. CR risk can be zero and FX can be huge for a given country. The reverse, though unusual, can also happen.

• **Q: What are the determinants of CR?**
We look for variables that have a negative effect (reduce and/or disrupt) on the CFs of a lender/investor. We consider variables that have the potential to produce expropriations, change in regulations/taxes, exchange rate/banking crisis, revolutions, wars, etc. A good economy, sound institutions (independent branches of government) tend to be good indicators for CR.

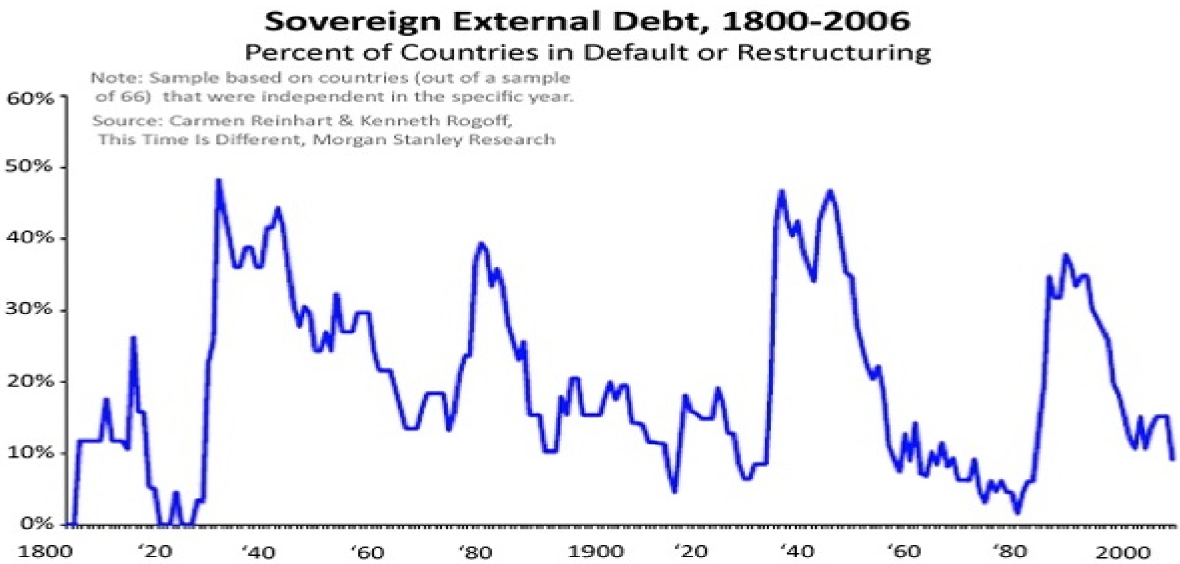
In general, we tend to put the determinants of CR in groups. For example:
- Economic variables, such as GDP growth, government deficit, debt, trade balance, S_t, etc.
- Political variables, such as orientation of government, potential for change in regulations/policies, etc.
- Legal variables, such as quality of court system, protections of investors/creditors, etc.
- Social variables that can contribute to the stability of a country, such as poverty, corruption, etc.

Global factors also matter. For example, if the world economy is doing well it is likely that the economy of a particular country is doing well, reducing country risk.

• **Q: Why does country risk analysis matter?**
A: Look at the 2014 Ukraine crisis and the 2011 Greek crisis. Look at the Argentine debt default on

Dec. 2001. Value of Russian, Ukrainian, Greek and Argentine assets went down significantly after those crises. Or look at the above mentioned ConocoPhillips' investment in Venezuela. In 2007, the Venezuelan government expropriated all ConocoPhillips investments without fair compensation. Banks, MNCs, bondholders, and investors realize the relevance of country risk analysis.

Sovereign debt crises are not rare. See graph below from Reinhart and Rogoff (2011), which does not even include the debt defaults/restructures of Ecuador (2008), Iceland (2008) and Greece (2011).



• **Credit and Interest Rate Risk for Bonds: Brief Review**
Bonds are subject to two types of risk:

1) *Interest rate risk*: The risk associated to changes in interest rates.
2) *Credit/default risk*: The risk associated to the probability of default combined with the probability of not receiving principal and interest in arrears after default.

Credit rating agencies describe (measure) the credit risk with a credit rating (a letter grade). Credit ratings are usually estimated using financial characteristics of firms, such as the interest coverage ratio and the leverage ratio.

Note: It is not entirely clear what a credit rating means. Some economists (myself included) say it is a measure of the probability of default over a specified horizon. Other economists say it is a measure of expected loss.

Rule: Regardless of the interpretation of a rating, the higher the grade, the lower the yield of the bond (measured as a spread over risk-free rate; where the risk-free rate is the yield of government bonds).

16.2 Construction of a Country Risk Grade (Score)

CR is associated with credit (default) risk, which is influenced by political risk and economic risk.

• **Measuring CR**
CR is, in general, reported as a grade: A very good, C bad.

Same credit rating rule applies: The higher the grade for a country, the lower the discount rate used to evaluate projects in that country.

We will associate CR with a spread over a risk-free rate (in the U.S. or USD debt segment: US Treasuries). That is, CR influences the interest on the debt issued by a government of a country. Many times the spread is called *sovereign default spread* or, just, country risk (CR).

Example: Setting yields for Mexico (actually, the Mexican government)
The Mexican government wants to borrow in USD for 3 years.
Yields on Mexican government debt = US Treasuries + spread (risk premium, a function of CR)
Mexico's grade: BBB (a spread of 140 bps (1.40%) over US Treasuries).
3-yr US Treasuries yield = 3%.

$$\text{Yield}_{\text{Mex}}\text{ (USD)} = 3\% + 1.40\% = 4.40\% \qquad (\textit{sovereign default spread}: 1.40\%)$$

If the Mexican government wants to borrow in MXN, we have to introduce the expected change in S_t (measured as an annualized $e_{f,t}$). Using linearized IFE (with MXN as the DC):

$$\text{Yield}_{\text{Mex}}\text{ (MXN)} \approx \text{Yield}_{\text{Mex}}\text{ (USD)} + E[e_{f,t}].\ ¶$$

• There are two approaches to measure CR (and get a grade):
(1) Qualitative – collect data, get an opinion from "experts," form a "consensus" grade.
(2) Quantitative – collect data, process the data with a computer model, get a grade.

(1) Qualitative Approach: Talk to experts (politicians, union members, economists, etc) to form a consensus opinion about the risk of a country. The consensus opinion becomes the grade. This process is "subjective."

(2) Quantitative Approach: Start with some quantifiable factors that affect CR. Use a formula to determine numerical scores for each factor. Calculate a weighted average of the factors' numerical scores. This weighted average determines the final grade. This process is (or seems more) "objective."

We will emphasize the Quantitative Approach.

16.3 Quantitative Approach – Getting a CR Grade: Risk Rating Method (Check list)

The Check list approach provides a weighted average of grades for four major aspects of a country:

i. Economic Indicators (EI) (financial condition)
ii. Debt management (DM) (ability to repay debt)
iii. Political factors (PF) (political stability)
iv. Structural factors (SF) (socioeconomic conditions)

The scores (between 0 and 100) for each factor are a function of "fundamental data". For example, the economic indicator's grade depends on GDP per capita, GDP growth, inflation, interest rates, etc. Debt management's grade depends on growth of money, trade balance, foreign and domestic debt, fiscal balance, etc.

A formula is used to compute the scores for each factor and the final score is computed as a weighted average of the four scores. For example, for Country J:

$\text{Score}(EI_{\text{Country J}}) = \alpha_1$ GDP per capita$_j$ + α_2 GDP growth$_j$ + α_3 Inflation$_j$ + α_4 interest rates$_j$ + ...
Final Score for Country J = w_{EI} Score(EI_j) + w_{DM} Score(DM_j) + w_{PF} Score(PF_j) + w_{SF} Score(SF_j)

Note: The weights should be positive and should up to 1 –i.e., $w_{EI} + w_{DM} + w_{PF} + w_{SF} = 1$.

Once a final score is determined a Table, like Table 16.1 is used to translate the final score into a rating, given by a letter grade. For example if Final Score of Country J is 83, we will give it a AA rating.

• Q: Where are the weights and the formulae for the grades coming from?
This method seems more "objective," because it is based on hard economic data, but weights and formulas might be "subjective." It is more an art, than an exact science.

A regression can be used to determine the factors and the coefficients (estimates of α_i's) used in the formulas.

• The model can deliver different forecasts: Short-term, Medium-term, and Long-term. The weights and grades can change depending on your horizon.
For example:
(a) Short-term: More weight to debt management and political factors.
(b) Long-term: More weight to economic indicators and structural factor.

• Each model assigns a score between 0 and 100.
Each grade is associated with a spread in basis points (bps) over base rate, usually the risk free rate.
The following Table presents a standard conversion table. (Suppose for 1-year maturities.)

TABLE 16.1
Conversion Table of a Country's Grade into a Rating and Spreads over US Treasuries

Overall grade	Rating	Interpretation	Spread (in bps)	Average
91-100	AAA	Excellent	5-40	20
81-90	AA		30-80	50
71-80	**A**		***60-100***	***80***
61-70	BBB	Average risk	100-170	130
51-60	BB		160-350	240
41-50	B		340-570	440
31-40	CCC	Excessive risk	360-680	650
21-30	CC		650-900	770
10-20	C		900+	1000
0-10	D	In Default	(debt in arrears)	

Notes:
◦ A rating of BBB or better is considered "*investment grade*."

◊ A rating of BB or less is considered "*junk*" (also called "*high-yield*," "*speculative grade*"). In the U.S., the usual spread of junk debt is between 400 to 600 bps over 1-yr T-bills. Range is very wide: Spreads can go over 2600 bps.
◊ This Table is for short-maturities. As time to maturity increases, the spread (in bps) also increases.
◊ Spreads are not constant over time, global and credit market conditions matter. We pointed out above that global factors matter. If developed markets are doing well, in general we tend to see that liquidity and appetite for risk in credit markets increases. These two factors will drive down spreads.
◊ This Table gives spreads over T-bills, in USD. If we are interested in converting the YTM in USD into a YTM in the local currency, we use IFE combined with relative PPP to estimate E[e_f]. That is, using the linearized version of both formulas, we get:

$$YTM_D \text{ (in local currency)} \approx YTM_D \text{ (in USD)} + (I_D - I_{US}).$$

Example: Suppose country DX wants to borrow short-term & medium-term in USD. Bertoni Bank evaluates the country risk of country DX.

	Short-term Horizon			Medium-term Horizon		
Factor	Weight	Grade		Weight	Grade	
Economic	.3	80	24	.3	70	21
Debt management	.3	90	27	.2	70	14
Political	.3	67	12	.2	50	15
Structural	.1	75	15	.3	60	12
Total			**78.6**			**63**

Short-term ranking: A
Medium-term ranking: BBB

That is, the short-term debt of country DX will get a spread in the ***60-100 bps*** range, say **78** bps over US Treasuries; while the medium-term debt will get a higher spread, say 138 bps.

Suppose the short-term US Treasuries yield 3% (s.a.). Then, the short-term debt of country DX yields

$$YTM_{DX} \text{ (in USD)} = 3\% \text{ (s.a.)} + \mathbf{0.78\%} \text{ (s.a.)} = 3.78\% \text{ (s.a.)}.$$

Based on the past 10 years, the expected inflation in country DX is 5% and in the U.S. is 2%, then

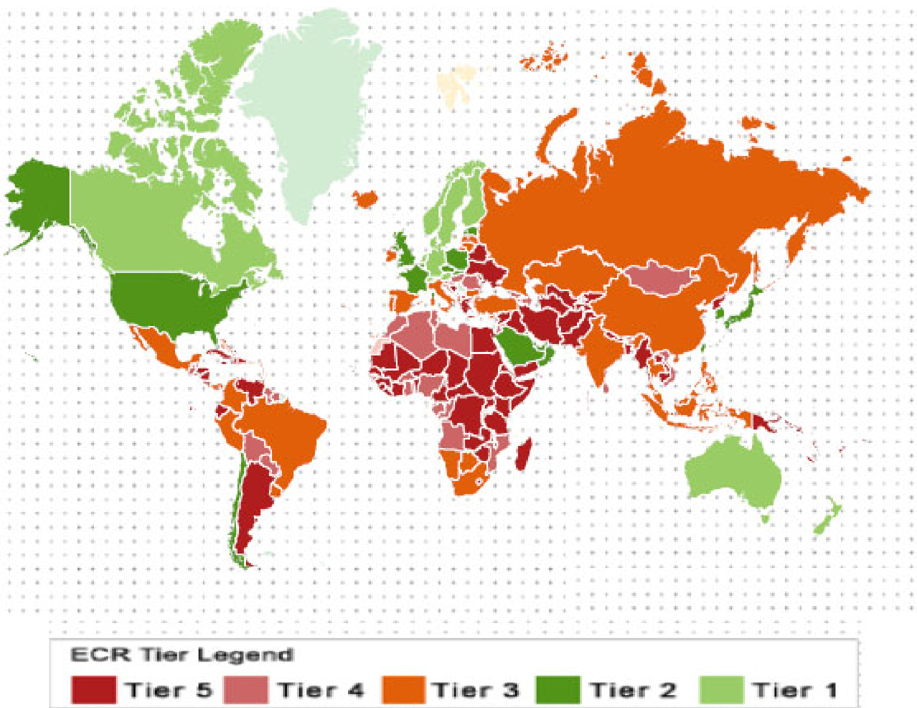
$$YTM_{DX} \text{ (in DX currency)} = 3.78\% + 3\% = 6.78\%\ .$$ ¶

Remark: The observed spread, the sovereign default spread, –i.e., the difference between the US Treasuries yield and another government debt yield (in USD)– is a good proxy for CR. The CDS (Credit Default Swap) market allows investors to buy insurance against CR. The insurance premium paid (say, 1.60% per year) is also a good indicator for CR! (Both indicators should be similar!)

Example: Weights and Factors in Practice (*Euromoney*) – March 2014
The British magazine *Euromoney* produces semi-annual country risk analysis of 189 countries using a panel of more than 400 experts. *Euromoney* rates nine categories with a score (0 to 100).
• Factors and weights:
Economic performance: GDP growth - 25% weight

Political Risk	- 25% weight
Debt indicators: Debt/GDP	- 10% weight
Debt in default or rescheduled	- 10% weight
Credit rating: Moody's or S&P's or Fitch IBCA's rating	- 10% weight
Short-term credit market access	- 5% weight
Access to bank finance: Commercial bank credit	- 5% weight
Access to Capital markets	- 5% weight
Discount default factor: Spread over US Treasury bills:	- 5% weight

Based on the weighted average for each country, each country is placed on a Tier (Tier 1=AAA, Tier 5=C). A world country risk weighted average is also calculated: 42.86 (B rating or Tier 4)



- **Measures to reduce CR**
  - A cap on the total amount invested in a particular country
  - Diversification
  - Credit/Political Risk Derivatives

Diversification and Country Risk
Taken From **"Profits in a Time of War,"** The Economist, Sep 20, 2014.

An excessive concentration on one country is a classic mistake. After China's revolution in 1949 HSBC, then a purely Asian bank, lost half its business. Iran's nationalisation in 1951 of the Anglo-Iranian Oil Company's assets devastated the firm, a precursor of BP.

There are modern echoes of these episodes. Repsol, a Spanish oil firm, fell in love with Argentina, leaving it vulnerable when YPF, the firm it bought there, was nationalised in 2012. First Quantum, of Canada, had made a third of its profits from a mine that the Democratic Republic of Congo nationalised in 2009. But as they have expanded over the past two decades, multinationals have spread themselves more. Only a dozen big, global, listed firms have over a tenth of their sales in Russia. BP is the country's largest foreign investor but gets only about 10% of its value from its stake in Rosneft, an oil giant. McDonald's Moscow outlets, once a symbol of détente, are temporarily shut, victims of a diplomatic tit-for-tat. Even so, the burger giant makes less than 5% of its profits in Russia.

This picture is true in other hotspots. Telefonica, a Spanish firm, and Procter & Gamble (P&G), together have billions of dollars trapped in Venezuela, which has introduced capital controls. But it represents less than 5% of their sales. Ben van Beurden, the boss of Royal Dutch Shell, recently said diversification is "the only way to inoculate yourself".

- **Review of CR**
  - ◊ Pros
    - - It is simple (many factors simplify to a letter)
    - - It allows cross-country and across time comparison.
  - ◊ Cons
    - - It is too simple.
    - - In practice, ratings tend to converge (*herding*).
    - - Not a lot of predictive power.

The last point –i.e., the lack of predictive power– is a major criticism. For example, a month before the 1997 Asia crisis, South Korea was rated as Italy and Sweden. Then, Fitch went from rating Korea as AA- (investment grade) to B- (junk) in one month. Other rating agencies replicated the same dramatic sudden change in Korea's CR rating.

Similar sudden downgrades occurred during the 2009-2012 European debt crisis with Greece, Cyprus, Ireland, Italy, Portugal, and Spain.

Given the lack of predictive power of CR, a single indicator may not be enough to capture the overall risk of a country. There are other indexes that may be help to signal the *true* riskiness of a country – i.e., indicators that can be correlated with the underlying true country risk. For example, *FDI confidence index* (produced by A.T. Kearny), *Global competitiveness index (GCI)* (produced by World Economic Forum), *Index of economic freedom* (produced by the Heritage Foundation and the Wall Street Journal), *Opacity index* (produced by PWC and The Milken Institute), etc.

Examples of CR Ratings:

1) *From A.M. Best, December 2018* (http://www.ambest.com/ratings/countryrisk.asp):
A.M. Best uses country risk analysis to determine how the factors outside an insurer's control affect its ability to meet its obligations to its policyholders. These analyses include, amongst others, the assessment of local accounting rules, government policies and regulation, economic growth and social stability. A.M.

Best has a five-tier scale and assigns a Country Risk Tier I-V based on each country's level of risk (I-lowest risk, V-highest risk).

Australia, Austria, Canada, Japan, Luxembourg, Singapore, Sweden, Switzerland, UK, USA	Tier I
Bermuda, Cayman Islands, Chile, HK, Italy, Ireland, New Zealand, Spain, South Korea, Taiwan	Tier II
China, Cyprus, Kuwait, Malaysia, Malta, México, Portugal, Poland, Qatar, UAE, Thailand	Tier III
Bahrain, Brazil, India, Indonesia, Jordan, Kazakhstan, Morocco, Panamá, Russia, Turkey	Tier IV
Argentina, Ghana, Honduras, Kenya, Lebanon, Libya, Nigeria, Pakistan, Ukraine, Venezuela	Tier V

2) *From Coface, Q3 2018* (http://www.coface.com):
Coface is France's export credit underwriter, offering insurance against the risk that when you sell something to a foreign company, they won't pay their bills (for whatever reason, from bankruptcy to international war).

Country	Rating	Business Defaulting Risk
Austria, Germany, Luxembourg, Netherlands, Norway, Switzerland,	A1	Very Low
Australia, Belgium, HK, Japan, New Zealand, South Korea, Taiwan, USA	A2	Low
Canada, Chile, Hungary, Ireland, Lithuania, Malaysia, Poland, U.K.	A3	Satisfactory
Botswana, Bulgaria, Italy, Indonesia, Kenya, Perú, Thailand, Uruguay	A4	Reasonable
Brazil, China, Ghana, Kazakhstan, México, Russia, South Africa	B	Fairly High
Argentina, Lebanon, Ethiopia, Ghana, Serbia, Togo, Turkey, Uganda	C	High
Angola, Chad, Guyana, Haiti, Madagascar, Nepal, Nicaragua, Pakistan	D	Very High
Cuba, Iraq, Libya, Mozambique, Syria, Sudan, Yemen, Zimbabwe	E	Extreme

Example: Spread on government European bonds – Oct 31, 2018.
Base Rate: German government bonds
$\Rightarrow$ Higher observed spreads, higher CR.

Yields online between 9:00am to 5:30pm CET Monday to Friday

European Bond Yields and Spreads

2yr | 5yr | **10yr**

Country	Yield	Spread*	Close†	Change‡
Germany (0.25% 15 Aug 2028)	0.39	-	0.37	0.02
France (0.75% 25 Nov 2028)	0.75	+37	0.75	0.01
Belgium (0.8% 22 Jun 2028)	0.78	+39	0.78	0.00
Italy (2.8% 1 Dec 2028)	3.43	+305	3.49	-0.05
Spain (1.4% 30 Jul 2028)	1.55	+117	1.57	-0.02
Denmark (0.5% 15 Nov 2027)	0.34	-5	0.32	0.02
Finland (0.5% 15 Sep 2028)	0.65	+26	0.64	0.01
Netherlands (0.75% 15 Jul 2028)	0.52	+14	0.51	0.02
Austria (0.75% 20 Feb 2028)	0.60	+21	0.58	0.01
Czech Republic (2.5% 25 Aug 2028)	2.16	+177	2.15	0.01
Ireland (0.9% 15 May 2028)	0.96	+58	0.94	0.02
Slovenia (1% 06 Mar 2028)	1.14	+76	1.14	0.00
Hungary (3% 27 Oct 2027)	3.73	+335	3.64	0.09
Portugal (2% 17 Oct 2028)	1.87	+149	1.88	-0.01
Slovakia (1% 12 Jun 2028)	1.08	+69	0.99	0.09

* Spread To Benchmark † Day Close Yield Value (at 16:00 CET) ‡ Daily Yield Change

Time snapshot: 31/10/2018 - 5:29 PM CET

From MTS Indices: http://www.mtsindices.com/european-bond-spreads. ¶

CHAPTER 16 – BRIEF ASSESMENT

1. Suppose the Brazilian government wants to borrow in USD for 7 years. You want to set the YTM in USD and in BRL. You have the following data:
Brazil's grade: BB (associated with a spread of 280 bps (2.80%) over US Treasuries).
7-yr US Treasuries yield = 2.5%.
$E[I_{US}] = 2\%$
$E[I_{BR}] = 6\%$

2. Suppose Colombia wants to borrow for 3-yers (medium-term) in USD. Given the information below determine the YTM for Colombian debt. (Use Table 16.1 and a linear interpolation method to set the spread).

	Medium-term Horizon	
Factor	Weight	Grade
Economic	.30	90
Debt management	.25	90
Political	.25	70
Structural	.20	60

3-year US Treasuries yield: 2.1%.

3. What is the effect on Colombia's YTMs of the following events?
(A) Commodity prices, say coffee prices, decrease.
(B) The Colombian government runs an unexpectedly large government deficit.
(C) Colombian economy grows more than expected.
(D) The US Fed increases interest rates.

Chapter 17 – The Cost of Capital in an International Context

Review from Chapter 16
- Country Risk (CR) affects discount rates
- Different countries will have different risk free rates (k_f).
- High CR, high risk-free rate k_f.

Q: How do MNCs set discount rates for projects in foreign countries?

In this chapter, we study the determination of the cost of capital for international projects. The cost of capital is the cost of a MNC's funds for a project/investment. In equilibrium, it also represents the required return on a project/investment.

We will use the WACC to calculate an MNC's cost of capital of projects, which can be used as the discount rate for those projects.

17.1 Brief Review: Capital Structure

A firm can raise new capital by:
- ◊ Issuing new equity (E) –a firm gives away ownership and has to pay dividends
- ◊ Issuing debt (D) –a firm borrows and has to pay interest payments.

The firm can also use retained earnings for new investments, which we will consider E. (According to the *pecking order theory*, retained earnings are the first source of funds for a company.)

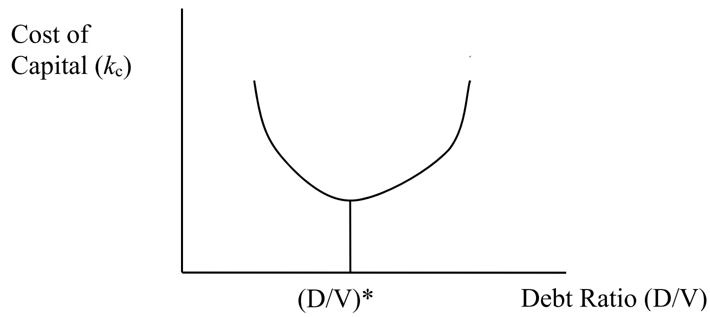
Recall that the *investment decision* (NPV evaluation based on CFs and risk of project) is separate from the *financing decision* (selection of E and D).

• Trade-off Theory of Capital Structure

Firms will use the E and D mix that minimizes the cost of capital, k_c. There is a U-shape relation between cost of capital and the amount of debt relative to the total value of the firm (V=E+D).

<u>Trade-off</u>: Debt has its (tax) advantages, but also its disadvantages (bankruptcy). E and D need to be combined optimally.

Before the optimal Debt Ratio, (D/V)*, the tax advantages dominate and decrease the cost of capital; after (D/V)*, the increased probability of bankruptcy dominates and increases the cost of capital.



The capital structure that a firm desires is called their *target structure.* It should be close to (D/V)*.

• Target Debt-Equity Ratio in Practice
Suppose that GE's target debt-equity ratio is 70%-30%. It is unlikely that GE will raise funds with a 70-30 debt-equity split for every project. For example, for a Brazilian project, GE may use a 60-40 D/E split. The target (D/V)* reflects an average; it is not a hard target for each project. That is, for other projects GE will use D/E in order to compensate and be close to the target debt-equity ratio.

It is expensive to issue shares for each project. It is common for companies to finance projects using retained earnings first (the easiest and cheapest form of E) and then use debt for the remaining part −following the *Pecking order theory.*

17.2 Measuring the Cost of Capital

The cost of capital (discount rate) used should reflect both the riskiness and the type of cash flows under consideration. If the cash flows are cash flows due to E (D), then the appropriate cost of capital is the cost of equity, k_e (cost of debt, k_d). In general, firms use both E & D to finance projects.

We will use weighted average cost of capital (WACC), k_c, where t is the effective tax rate:

$$k_c = \frac{D}{D+E}\, k_d * (1-t) + \frac{E}{D+E} k_e$$

• Cost of debt (k_d)
The cost of debt of a project (k_d): The interest a firm has to pay to borrow from a bank or the bond market to fund a project. Sometimes k_d is called *pre-tax cost of debt.*

It is easy to determine for a firm: A firm calls a bank/investment bank to find out the interest rate it has to pay to borrow capital.

It is also easy to determine for companies that borrow from debt markets, which are rated. If the company is not rated or most of the debt is old bank debt, it is more difficult to calculate a current k_d. In these cases, we benchmark k_d with similar companies (similar size, similar industry, similar D/V, etc.)

Q: How does a bank set the interest rate for a given firm?
A: Base rate (say, a risk free rate like T-bills, k_f) + spread (reflecting the risk of the company/project, which includes CR). We will see this in Chapter 18.

Note: Interest payments are tax deductible ⇒ After-tax cost of debt = k_d * (1-t)

• Cost of equity (k_e)
The cost of equity of a project (k_e): The required (expected) return on equity a firm has to pay to investors. This is an *equilibrium* result. A model is needed to determine required rates of return on equity. We can use the CAPM or other risk-return models, for example a multifactor model, with the 3- or 5-Fama-French factors. (Recall that only undiversifiable risk is priced in expected returns.)

We will use the CAPM, which produces a required rate of return on equity, to value the cost of equity:

$$k_e = k_f + \beta\ (k_M - k_f)$$

k_f: Risk-free rate (ideally, the rate on a *zero coupon government bond* matching the time horizon of the investment). In practice, short-term government security rates, say 90-day T-bill rates.
k_M: Expected return on a market portfolio (in practice, the long-run return on a well-diversified market index).
$(k_M - k_f)$: Equity Risk premium (ERP), what investors demand for investing in an average risk investment, relative to the risk-free rate. In practice, the difference between the above calculated k_M & k_f.
β: Systematic risk of the project/firm = Cov(k_e,k_M)/Var(k_M). In practice, a coefficient estimated by a regression against excess market returns or risk premium, $(k_M - k_f)$.

β: Systematic Risk of the project/firm = Cov(k_e,k_M)/Var(k_M) (in practice, a coefficient estimated by a regression against excess market returns or risk premium, $(k_M - k_f)$, using 5 years of data).

Q: Which CAPM: World or Domestic?
A: The $(k_M - k_f)$ and β used depends on the view that a company has regarding capital markets. If capital markets are integrated (or if the shareholders are world-wide diversified) the appropriate equity risk premium should reflect a world benchmark (say, MSCI World Index), $(k_M - k_f)_W$. But, if markets are segmented (or if the shareholders hold domestic portfolios), then the appropriate equity risk premium should be based on a domestic benchmark (say, the Bovespa Index for Brazilian companies), $(k_M - k_f)_D$. The risk-free rate should also be adjusted accordingly. Then,

- World CAPM: $k_e = k_{e,W} = k_{f,W} + \beta_W\ (k_M - k_f)_W$
- Domestic CAPM: $k_e = k_{e,D} = k_{f,D} + \beta_D\ (k_M - k_f)_D$

The difference between these two models can be significant. According to Bruner et al. (2008), on average, there is a 5.55% absolute difference for emerging markets and a 3.58% absolute difference for developed markets. The betas (β_W and β_D) tend to be different too: the average absolute difference is 0.44 for emerging markets and 0.21 for developed markets.

Given that the evidence for integrated capital markets is weak, especially for emerging markets; we tend to think of financial markets as partially integrated. Then, a weighted average can be used to calculate k_e, where the weights can be ad-hoc or represent some measure of integration, say, based on international trade or international investments of a country as a proportion of GDP:

- Partially Integrated CAPM: $k_e = w_D\, k_{e,D} + (1 - w_D)\; k_{e,W}$

In general, we tend to find that World CAPM produces low expected returns. The Fama-French 3-factor model tends to produce higher (and more realistic) expected returns. Many ad-hoc adjustments are used in the private sector.

Notes:
◊ Dividends are not tax deductible. There is an advantage to using debt!
◊ Time-consistency with k_f. The same maturity should be used for k_e and k_d. That is, if you use long-term bonds to calculate k_d, you should also use long-term data to calculate k_e.
◊ In Chapter 16 we discussed country risk. For practical purposes, many emerging market government bonds may not be considered risk-free. Thus, the government bond rate includes a default spread, which, in theory, should be subtracted to get k_f.
◊ If the company is publicly traded, getting β is simple: β is estimated by the slope of a regression against a market index. If the company is not publicly traded, we need to benchmark β. That is, we use the βs of publicly traded similar companies.
◊ There are many issues associated with the estimation of β: choice of index, noisy data, adjustment by leverage, mean reversion, etc. We will not get into these issues.

Issues:
Q: Real or Nominal? If the CFs are nominal (the usual situation), then k_e should be calculated in nominal terms.
Q: Which k_f to use? Local or Foreign? The k_f that reflects the risk of the cash flows. If the CFs are in MXN, then k_f should be a Mexican treasury rate (for example, CETES).
Q: Which maturity for k_f to use? The maturity that reflects the duration of the cash flows. In practice, the duration of the project is matched to the maturity of k_f (potentially a problem for many emerging markets where there is no long-term debt market).
Q: Which β to use? The β of the company or the β of the project? β should reflect the systematic risk of the project.

Example: GE wants to do an investment in Brazil.
Equity investment: BRL 100M
Debt issue: BRL 150
Value of Brazil investment = D + E = BRL 250 (⇒ 60-40 D/E split)
Brazilian Tax Rate = t = 34% (25% corporate rate + 9% social contribution on net profits)
Cost of capital of project = k_c = ?

• Cost of debt (k_d)
GE decides to use a domestic CAPM, with the following data.
GE can borrow in Brazil at 60 bps over Brazilian Treasuries (k_f)
k_f = 11.90% (3-year Brazil government bond yield)
k_d (for GE) = .1190 + .0060 = **.1250** (12.50%)

• Cost of equity (k_e)
Similar projects in Brazil have a beta of 1.1 ($\beta_{GE\text{-}Brazil}$ = 1.1)
Return of the Brazilian market (BOVESPA) in the past 20 years: 14% (k_M = 14%)
$k_e = k_f + \beta\,(k_M - k_f)$ = .1190 + 1.1 * (.14 − .1190) = **0.1421** (14.21%)

• Cost of Capital –WACC- (k_c)

$$k_c = \frac{D}{D+E}\, k_d * (1-t) + \frac{E}{D+E}\, k_e$$

k_c = (.60) x **.1250** x (.66) + (.40) x **.1421** = **.10634** (10.634%)

This is the discount rate that GE should use to discount the cash flows of the Brazilian project. That is, GE will require a **10.634%** rate of return on the investment in Brazil. ¶

Remark: Every time the cost of capital increases, the NPV of projects goes down. Anything that affects k_c, it will also affect the profitability (NPV) of a project.

Application: Argentina defaults in some of its debt. Argentine country risk increases, $k_{f,Arg}$ goes up and $k_{c,Arg}$ also goes up. Then, NPV projects in Argentina can become negative NPV projects:
⇒ MNCs may suddenly abandon Argentine projects.

Estimating the Equity Risk Premium (ERP): $(k_M - k_f)$
To compute the ERP, we need to determine a market portfolio (S&P? MSCI World?), and a method (and sample period) to compute the expectation. There are three different methods to compute k_M:

1) Surveys. Usually an average of ERPs provided by individual investors, institutional investors, managers and, even, academics.

2) Historical data. Expectations are computed using past data. This is the most popular approach. For example, compute k_M with the historical sample mean equity market return, $\bar{X}$. If we use this approach, it pays to use as much data as possible –more data, lower S.E. We think of k_M as a *long-run* average of market returns.

3) Forward-looking data. An (implied) ERP is derived from market prices, for example, market indexes, options & futures on market indexes, etc. Of course, we also need a model (a formula) that extracts the ERP from market prices.

Once we compute k_M and chose a corresponding k_f, we are ready to determine the ERP. But, we make decisions along the way. For example, using Robert Shiller's historical S&P monthly data,

with **150 years of data**, we produce an estimate of the ERP = E[$(r_M - r_f)$] = $(k_M - k_f)$. = **4.34%**.
This ERP estimate involves the following decisions:
– Computation of returns (log returns)
– Method of computing ERP (Historical data)
– Sample period (1871-2021)
– Market portfolio (S&P Composite Index)
– Risk-free rate (10-year U.S. bond rate).

Robert Shiller's data gives us a monthly S&P return (**0.007378**). Then:
Annualized Market return = **0.007378** * 12 = **0.088536**
Annualized risk-free rate = **0.04511**
ERP = **0.088536** - **0.04511** = **0.043426** (**4.34%**)

Aside: Many economists consider this estimated ERP as "*too high.*" Why? The degree of risk aversion to justify it is unreasonable high.

Estimating the Equity Risk Premium: Historical Method and Precision of Estimates
Risk premiums are estimated with error. To deal with this issue, practitioners, using the historical data method, like to use as many years as possible to build the long-run average. Remember, the sample average, $\bar{X}$, comes with an associated standard error:

$$\text{S.E.}(\bar{X}) = {}^{s}\!/\!{\sqrt{T}}$$

where s is the standard deviation (SD) and T is the length of the data.

Thus, more data means a lower standard error -i.e., more precision. This may be a problem for emerging markets, where there is limited reliable return data.

Example: Suppose we have 2 markets: a Developed Market (DM) with T=100 annual observation and an annualized standard deviation (SD) equal to 15%; & an Emerging Market (EM) with T=50 and SD=30%.
We can calculate the S.E. for both markets.
S.E._{DM} = .15/sqrt(100) = .015 (or 1.5%)
S.E._{EM} = .30/sqrt(50) = .0424 (or 4.24%).

Note: A 95% C.I. for an EM around 0% goes from [-8.5% to 8.5%]. Not very precise! ¶

But, note that even with more than **100 years of data** for developed markets there is no consensus on an ERP. As a matter of fact, in a recent review paper, by two Federal Reserve economists, Duarte and Rosa (2015) list over 20 different approaches to estimate the ERP in the U.S. Using data from 1960 to 2013, Duarte and Rosa (2015) report estimates from -0.4% to 13.1%, with a 5.7% average for all model. A wide range!

Table 17.1 presents ERP estimates in international markets, translated to USD, using monthly data from 1970 to 2021. The estimates range from **0.88%** (Italy) to **11.56%** (Hong Kong), with a

3.17% world average. Again, a wide range.

Table 17.1:
MSCI Index USD Equity Returns and ERP – Developed Markets: (1970-2021)

Market	Equity Return	Standard Deviation	ERP
U.S.	8.31	**15.01**	**0.0382**
Canada	7.95	19.21	0.0346
France	8.80	21.95	0.0431
Germany	8.80	21.48	0.0431
Italy	**5.37**	**25.25**	**0.0088**
Switzerland	10.34	17.64	0.0585
U.K.	7.37	21.20	0.0288
Japan	9.56	20.46	0.0506
Hong Kong	**16.06**	**33.23**	**0.1156**
Singapore	11.71	27.48	0.0722
Australia	7.35	23.42	0.0273
World	**7.66**	**14.54**	**0.0317**
EAFE	7.69	16.64	0.0306

Table 17.2 reports equity returns and ERP estimates for EM, with, as expected, higher numbers.

Table 17.2:
MSCI Index USD Equity Returns and ERP – Emerging Markets: (1987*-2021)

Market	Equity Return	Standard Deviation	ERP
Argentina (404)	24.21	51.49	0.1972
Brazil (404)	**22.23**	**47.67**	**0.1774**
Mexico (404)	17.67	29.26	0.1318
Poland (344)	15.88	43.24	0.1139
Russia (320)	**21.09**	**47.54**	**0.1660**
India (344)	**12.10**	**28.35**	**0.0760**
China (344)	**4.90**	**31.94**	**0.0041**
Korea (404)	11.75	34.08	0.0726
Thailand (404)	11.58	32.24	0.0606
Egypt (320)	11.61	31.69	0.0862
South Africa (344)	9.47	26.31	0.0498
World (620)	**7.66**	**14.54**	**0.0317**
EM Asia	8.85	23.13	0.0436

Estimating the Equity Risk Premium: Ad-hoc adjustments
Given the imprecision of ERP estimates, for a market with limited reliable return history, say Brazil, Hungary or a generic Country J, it is sometimes easier to adjust a $(k_M - k_f)$ from a well-established market, say, the U.S., to get a more precise estimate of that market's ERP_J.

There are several ways to do this adjustment. These approaches are mainly intuitive, with simplicity in mind (taken from Damodaran (2012)):

◊ *Country Risk Approach*: The U.S. market risk premium is increased by country risk (CR_J, the sovereign default spread of the bond issued by Country J):

$$(k_M - k_f)_J = (k_M - k_f)_{US} + CR_J \qquad (\Rightarrow \text{no distinction between bond and equity risk!})$$

◊ *Relative Equity Market Approach*: The U.S. market risk premium is modified by the volatility of the Country J's equity market, σ_J, relative to the volatility of the U.S equity market, σ_{US}:

$$(k_M - k_f)_J = (k_M - k_f)_{US} * \sigma_J / \sigma_{US} \qquad (\Rightarrow \text{problem: } \sigma_J \text{ is also an indicator of liquidity!})$$

◊ *Mixed Approach*: The U.S. market risk premium is increased by combining Country J's CR, equity market volatility and bond market volatility. We expect equity spreads to be higher than debt spread. Then, we need to adjust the CR upward. One way to do this is to use the relative volatility of Country J's equity market to the volatility of Country J's bond market, $\sigma_{J,bond}$:

$$(k_M - k_f)_J = (k_M - k_f)_{US} + CR_J * \sigma_J / \sigma_{J,bond}.$$

Notes:
◊ We may have very different numbers from these three approaches. Judgement calls/adjustments may be needed.
◊ Following the idea of CR from bond markets, a *country equity risk premium* (*CER*) can be easily derived for Country J:

$$CER_J = (k_M - k_f)_J - (k_M - k_f)_{US}.$$

◊ We construct a market risk premium for Country J based on USD rates. To convert this premium into a local currency premium, we can use IFE combined with relative PPP to estimate $E[e_f]$. That is, using the linearized version of both formulas, we get:

$$(k_M - k_f)_J \text{ (in local currency)} \approx (k_M - k_f)_J + (I_J - I_{US}).$$

Example: Suppose the limited returns history of Brazil's equity markets makes GE's risk manager uncomfortable. She wants to adjust $(k_M - k_f)_{Brazil}$ using different methods, using the U.S. market as a benchmark: the relative equity market approach and the mixed approach. GE uses the following data:

$(k_M - k_f)_{US}$ = **0.0382** (from Table 17.1)
$k_{f,US}$ = **4.50%**
σ_{US} = **15.01%**
σ_{Brazil} = 37.3% (based on past 15 years)
$\sigma_{Brazil,bond}$ = 23.1% (based on past 15 years)
CR_{Brazil} = **2.80%**
I_{Brazil} = 8%
I_{US} = 3%

◊ *Relative Equity Market Approach*:

$$(k_M - k_f)_{Brazil} = \mathbf{0.0382} + \mathbf{.028} * .373/.231 = \mathbf{0.093741}$$

$$\Rightarrow k_{e,Brazil} = k_f + \beta\,(k_M - k_f)_{Brazil} = \mathbf{.0450} + 1.1 * \mathbf{0.093741} = \mathbf{0.1481}.$$

If we want the ERP in local currency (BRL), then:

$$(k_M - k_f)_{Brazil} \text{ (in BRL)} \approx \mathbf{0.093741} + (0.08 - 0.03) = \mathbf{0.093741} + 0.05 = \mathbf{0.1437}$$

◊ *Mixed Approach*:

$$(k_M - k_f)_{Brazil} = \mathbf{0.0382} + \mathbf{.028} * .373/.231 = \mathbf{0.08341}$$

$$\Rightarrow k_{e,Brazil} = k_f + \beta\,(k_M - k_f)_{Brazil} = \mathbf{.0450} + 1.1 * \mathbf{0.08341} = \mathbf{0.1368}.$$

Note: We can calculate CER_{Brazil} from any of these approaches. For example, using the Mixed Approach:

$CER_{Brazil} =$ **0.08341** - **0.0382** = **0.04521** (in USD!) ¶

CER as a factor in the estimation of k_e:

Q: How sensitive are companies to CER? There are different ways to incorporate CER into k_e. (They are all CAPM extensions, delivering two-factor models.)

◊ *Beta as a Measure of Exposure*:

We assume that CER exposure is proportional to the β of the company/project. That is, the sensitivity to CER is treated in the same way as the sensitivity to market risk. (This is the implicit assumption of the CAPM used above). Then,

$$k_{e,J} = k_{f,J} + \beta\,(k_M - k_f)_J = k_{f,US} + \beta\,[(k_M - k_f)_{US} + CER_J].$$

◊ *Using different weights for CER Exposure ("lambda approach")*:

We can allow each project/company to have its own sensitivity to CER. This sensitivity is called lambda, λ. Similar to β, λ is scaled around 1 (λ=1, average exposure).

$$k_{e,J} = k_{f,US} + \beta\,(k_M - k_f)_{US} + \lambda\, CER_J.$$

There is no consensus on how to estimate λ. The easier way to do this: Estimate λ using the proportion of revenue generated by the company/project in the country relative to the rest of the companies in the country. (It is possible to adjust this estimate by where the production facilities are located, by a company's risk-management, etc.). A regression (say, returns against a CR indicator) can also be used to estimate λ.

◊ *Equal CER Exposure*:

A popular alternative method to estimate k_e is to estimate k_e as a U.S. company/project and, then, add CER. Very simple method that treats all companies/projects as equally exposed to CER:

$$k_{e,J} = k_{f,US} + \beta\,(k_M - k_f)_{US} + CER_J.$$

Example: Suppose that GE's risk manager wants to re-estimate k_e using the lambda approach. She uses the following additional data:
$k_{f,US}$ = **4.50%**
CER_{Brazil} = **0.04521** (using the Mixed Approach)
Revenue from Brazil: 50%
Exports contribution to Brazil's GDP: 13% $\Longrightarrow$ average revenue for a typical Brazilian firm: 87%

$\lambda_{GE\text{-}Brazil} = .50/.87 = 0.5747$

$k_{e,Brazil} = k_{f,US} + \beta\,((k_M - k_f)_{US} + \lambda_{GE\text{-}Brazil}\, CER_{Brazil}$
$= .0450 + 1.1 * (0.0382) + .5747 * (0.04521) = 0.1130$

If we want to express the cost of capital into BRL, we proceed as usual (linearized IFE+PPP):

$k_{e,Brazil}$ (in BRL) = **0.1130** + .05 = **0.1630** (**16.30%**). ¶

17.3 Determinants of the Cost of Capital for MNCs

Intuition: Economic factors that make the CFs of a firm more stable reduce k_c.
1) Size of firm (larger firms get better rates from creditors and have lower βs)
2) Access to international markets (better access, more chances of finding lower rates)
3) Diversification (more diversification, more stable CFs, lower rates. Also, βs closer to β_M)
4) Fixed costs (the higher the proportion of fixed costs, the higher the β)
5) Type of firm (cyclical companies have higher βs)
6) FX exposure (more exposure, less stable CFs, worse rates)
7) Exposure to CR (again, more exposure to CR, less stable CFs, worse rates).

Example: Calculating the Cost of Capital (Nov 2014)
General Electric (GE): Huge, internationally diversified company
Walt Disney (DIS): Large, moderate degree of international diversification
The GAP (GPS): Medium cap, low international diversification.

Data:
T = Medium-term, say 5 -years
US Treasuries (k_f): 1.70% (5-year T-bill rate, from Bloomberg)
S&P 500 return (k_M): 8.15% (39 years: 1976-2014)
tax rate (t): 27.9% (effective U.S. tax rate, according to World Bank)
Recall: $k_c = \frac{D}{D+E}\, k_d * (1-t) + \frac{E}{D+E} k_e$

	E	D	Rating	Spread	β	k_d	k_e	WACC
GE	109B	260B	AA-	87	1.58	2.57	11.89	**4.82**
DIS	46B	15B	A+	55	1.50	2.25	11.38	**8.98**
GPS	2.9B	1.4B	BBB-	154	1.31	3.24	10.15	**7.60**

For comparison, before the financial crisis, in Nov 2006, we got the following numbers:
US Treasuries (k_f): 4.25%
S&P 500 return (k_M): 9.02% (1976-2006)

tax rate (t): 25%

	E	D	Rating	Spread	β	k_d	k_e	WACC
GE	111B	410B	AAA	92	0.65	5.17	7.35	**4.62**
DIS	31B	13B	A-	140	0.93	5.65	8.69	**7.37**
GPS	5B	0.5B	BBB-	213	0.91	6.38	8.59	**8.24**

Note: k_d went down and βs increased from 2006 to 2014. We see simple results at work:

- ⋄ Lower interest rates ⟹ lower WACC
- ⋄ Higher betas ⟹ higher WACC. ¶

Example: Country risk matter.
According to The Economist (Sep 20, 2014), Western oil firms operating in Kurdish-run Iraq in mid-2014, after ISIS seized the city of Mosul, increased the assumed cost of capital from 12.5% to 15%. ¶

CHAPTER 17 – BRIEF ASSESMENT

1. Padres Co. wants to do an investment in the Dominican Republic (DR). Padres Co. uses the WACC to determine the cost of capital (and the CAPM to determine the cost of equity). Using the following information, set k_c.
Equity investment: DOP 200M (DOP = DR peso)
Debt issue: DOP 150M
DR tax rate = t = 25%
Cost of project = k_c = ?
k_f = 6.5%
Padres' spread over DR's k_f = 2.52%
$\beta_{\text{similar project-DR}} = 1.10$
Return of DR's stock market = 14% (k_M = 14%)

2. Suppose you do not trust the DR's k_M estimate. You decide to use an average of the estimates provided by the relative equity market approach and the mixed approach. You have the following data:
$(k_M - k_f)_{US} = 3.65\%$
$\sigma_{US} = 15.2\%$
$\sigma_{DR} = 42.5\%$
$\sigma_{DR,bond} = 28\%$
$CR_{DR} = 4.20\%$
$E[I_{DR}] = 4\%$
$E[I_{US}] = 2\%$

Compute the new estimate of k_c.

3. Now, Padres Co. wants to re-estimate k_e using the lambda approach. Padres Co. has the following additional data:
$k_{f,US} = 2.5\%$
Revenue from DR: 20%
Exports contribution to DR's GDP: 15%.

Using your results from exercise 2, compute the new estimate of k_e.

4. What is the effect on Padres Co.'s estimated DR's cost of capital under the following events?
(A) DR risk-free rate decreases?
(B) Padres Co.'s investment in DR becomes more diversified
(C) Padres Co.'s CFs become less predictable
(D) DR decides to decrease the corporate tax rate.

CHAPTER 17 - BONUS COVERAGE: Cost of Debt – GE Data (Nov 2014)

From Morningstar we can get Debt, Equity, bond yields & rating, and beta. For example: (http://quicktake.morningstar.com/StockNet/bonds.aspx?Symbol=GE&Country=usa):

General Electric Co GE | ★★★

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Morningstar Credit Rating	Amt Outstanding	Issuer Type	Issuer Domicile	Debt/Assets	Sector
AA-	$759.2 Bil	Corporate	United States	42.04 %	Industrials

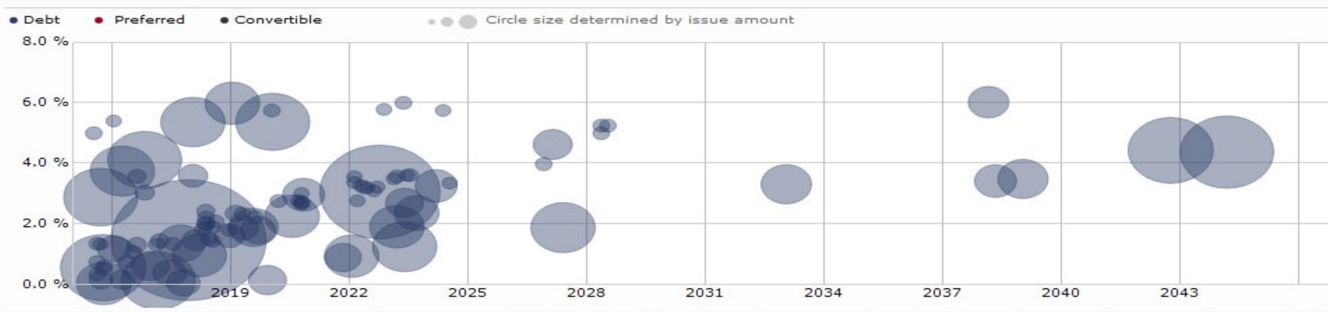
Capital Structure

Most Recent (Mar 2015) | **Historical**

Type	%	Amount
Debt	70.5	259.6 Bil
Preferred	---	---
Equity	29.5	108.6 Bil

Type	%	Amount
Debt	70.2	302.1 Bil
Preferred	---	---
Equity	29.8	128.2 Bil

Yield to Maturity

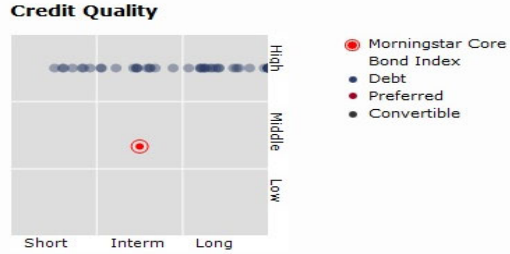


Name	Maturity Date	Amount $(Mil)	Credit Quality	Price	Coupon %	Coupon Type (Fixed/Floating)	Callable	Rule 144A	Yield to Maturity %
Ge Cap Europea 0.728%	08/08/2018	11,204.5	---	---	0.728	---	No	---	---
General Elec 5.25%	12/06/2017	4,000.0	---	109.1	5.250	Fixed	No	No	1.46
General Elec 2.7%	10/09/2022	3,000.0	---	97.7	2.700	Fixed	No	No	3.05
General Elec 4.5%	03/11/2044	2,250.0	---	102.1	4.500	Fixed	No	No	4.37
Ge Cap Retail Bk Draper Utah	03/07/2017	2,000.0	---	---	1.050	Fixed	No	No	---
General Elec 0.85%	10/09/2015	2,000.0	---	100.1	0.850	Fixed	No	No	0.56
Ge Cap Retail Bk Draper Utah	03/07/2019	2,000.0	---	---	1.950	Fixed	No	No	---
Ge Cap Bk Inc Retail	08/24/2016	2,000.0	---	---	1.350	Fixed	No	No	---
Ge Cap Retail Bk Draper Utah	03/08/2021	2,000.0	---	---	2.650	Fixed	No	No	---
Ge Cap Retail Bk Draper Utah	03/09/2020	2,000.0	---	---	2.300	Fixed	No	No	---

Debt & Coverage Ratios

	Firm	Ind Avg	Rel to Industry
Debt/Assets	0.42	0.36	
Debt/Equity	2.39	0.98	
Current Assets/Current Liability	2.30	2.07	
EBITDA/Interest	3.04	---	
Debt/EBITDA	9.48	3.98	
Cashflow Ops/Total Debt	0.11	0.36	
			- Avg +

Credit Quality



CHAPTER 17 - BONUS COVERAGE: Cost of Debt (2011)

Intel Plans First Non-Convertible Bonds in 24 Years to Fund Stock Buybacks

By Sapna Maheshwari – (Bloomberg) - Sep 14, 2011 2:07 PM CT

Intel's USD 1.5 billion of five-year notes may yield 110 basis points more than similar-maturity Treasuries, the USD 2 billion of 10-year notes may pay a spread of 135 basis points and the USD 1.5 billion of 30-year bonds may offer 160 basis points more than benchmarks, said the person with knowledge of the transaction who declined to be identified because terms aren't set.

Intel is graded A1 by Moody's Investors Service and A+ by Standard & Poor's, Bloomberg data show.

The average A rated bond pays a 217 basis-point spread and the average AA graded company debenture offers a 187 basis-point spread, Bank of America Merrill Lynch index data show, indicating strong demand for Intel's offering.

CHAPTER 17 – BONUS: ISSUING BOND DEBT - GOOGLE

Google debuts in high-grade bond market with $3 billion deal

On Monday May 16, 2011, 1:04 pm EDT

BRADENTON/NEW YORK, May 16 (IFR) - Google Inc hit the U.S. bond market on Monday with its high grade market debut, announcing a $3 billion sale of 3-year, 5-year and 10-year notes that will take advantage of low borrowing rates.

Proceeds of the SEC-registered deal will be used to repay commercial paper and for general corporate purposes, the company said in a statement. Citigroup, Goldman Sachs and JP Morgan are joint lead managers on the deal, which garnered an Aa2 rating from Moody's Investors Service, the third-highest rating in the agency's scale.

Google is one of the few large-cap technology companies to actually have debt on its balance sheet -- albeit at about $2 billion of commercial paper, a tiny sum compared to its $169 billion market cap.

The company is the latest in a spate of new or rare technology company borrowers coming to the corporate bond market this year, as they look to take advantage of low interest rates and realize that having some debt makes sense.

"We are seeing some of the large cap tech companies deciding that having debt on the balance sheets is an appropriate way of having a capital structure and running a company, which is relatively new to them," said one banker.

"Generally most of these large cap tech companies have only used the debt markets to finance their acquisitions. They typically don't use the debt markets for anything else."

Now, with rates so low and their own industries having reached a level of maturity, many are using the debt markets as a way of returning value to shareholders, at a time when they have large levels of cash trapped overseas.

Microsoft, for instance, raised funds in the bond market in February in part to buy back shares, while Google is improving its debt profile by extending the maturity of its debt. Both have large levels of cash overseas.

Cisco Systems in March sold $4 billion of three-year fixed and floating rate notes and six-year bonds; eBay in October last year sold $1.5 billion of three, five and 10 year notes.

Google is planning to sell $1 billion of 3-year notes, that launched at 33 basis points over comparable Treasuries. The company will sell $1 billion of 5-year notes at 43 basis points over Treasuries and $1 billion of 10-year notes at 58 basis points over Treasuries. That compares with market "whispers" that put the 3-year in the mid 30s, the 5-year in the high 40s and the 10-year in the mid 60s. Pricing is expected later on Monday.

At the guidance stage, sources heard book size on the deal was already up to $8-$9 billion, with sources originally hearing there was little chance of an increase.

Google may grab the lowest coupon levels seen so far this year. The 2011 coupon to beat in 3-years is 1.25 percent, with both IBM and Colgate-Palmolive pricing deals with a 1.25 percent coupon. The 2011 coupon to beat in 5-years is 2.50 percent set by Microsoft on Feb 3. The 2011 coupon to beat in 10-years is 3.85 percent, set by Berkshire Hathaway's Pacificorp last week.

While at the lowest levels seen since December 2010, benchmark Treasury rates are still not in a spot which would allow any all-time low coupon records to be hit, with the all-time low coupon record in 3-years at 0.75 percent, in 5 years at 1.375 percent and in 10-years at 2.95 percent.

Google's strong debt protections measures are backed up by its almost $11 billion of operating profit and $7 billion of free cash flow for fiscal 2011, ended March, according to Moody's Senior Vice President Richard Lane. The company also has nearly $37 billion in cash balances, he said. "These strengths, combined with solid business execution, will drive strong profitability, significant free cash flow generation, and ample financial flexibility," Lane said.

However, the company is facing challenges from well-funded rivals, including Microsoft, rated Aaa, and Apple, which is not rated, along with private companies such as Facebook, he said. "An additional rating constraint considers the still developing nature of Internet technologies, usage, and behavioral patterns, all of which pose challenges to constantly invest and innovate," he said.

(Reporting by IFR senior analysts Andrea Johnson and Danielle Robinson; Additional reporting by Reuters reporter Jennifer Saba; Editing by Ciara Linnane.)

Chapter 18 - Long term financing – Part 1: Bonds

Review from Chapter 17
Cost of capital

$k_c = (D/V) * k_d * (1 - t) + (E/V) * k_e$

$V = E + D$

k_c = cost of capital = required rate of return = discount rate.

In this chapter we answer the following question: How do we determine the cost of debt? Or how do investment banks determine the price (coupon) of a bond?

We will focus on two long term financial instruments: bonds and swaps.

18.1 Bond Market

The bond market (debt, credit, or fixed income market) is the financial market where participants buy and sell debt securities, usually bonds. Governments and agencies, Corporations, Municipalities & individuals (mortgages) are the main participants.

Size of the world bond market (2022 debt outstanding): USD 133 trillion, or 140% of World GDP (size of world equity markets capitalization USD 95 trillion).

- U.S. bond market debt: USD 39 trillion (39%).
- European Union bond market debt: USD 28 trillion (28%).
- Japan bond market debt: USD 13 trillion (13%).
- China bond market debt: USD 12 trillion (12%).

Organization:

- Decentralized, OTC market, with brokers and dealers.
- Small issues may be traded in exchanges.
- Daily trading volume in the U.S.: USD 809 billion (in 2019)
- Government debt dominates the market (50% or more of market).
- Non-financial corporations make up 12% of market (61% by U.S. corporations).
- Used to indicate the shape of the yield curve.

Note: The bond market is a public debt market, strictly regulated by a local body –in the U.S., the S.E.C. There is a private debt market: bank debt, private placements, and special debt vehicles (in the U.S., the popular Rule 144A debt).

• The World Bond Market: Segments

- *Domestic*: A domestic firm issues local debt in local currency (80% of World Bond Mkt). For example, Apple, the U.S. tech giant, issues USD bonds in the U.S. market.
- *Foreign*: A foreign firm issues local debt in the local currency. Regulated like a domestic issue. For example, Apple issues AUD bonds in the Australian market.
- *Euro-yyy bond*: A firm issues debt in a currency (yyy), different than the local currency where the bond is issued/trades. Domestic investors (from the firm's home country) are not the target of the issue. For example, Apple issues EUR bonds in the U.K market.

The Foreign + Eurobond Markets form the International Bond Market (20% of World Bond Mkt).

According to Henderson et al. (2006), 20% of corporate bonds are issued in the international bond market (from 1990-2001, USD 4.2 trillion). BTW, it is a high number relative to the 6% of public equity offering issued by corporations outside the home country.

Main currencies in the International Market (in 2015): USD (47%), EUR (39% of issues), and GBP (7%). The majority of the issues are straight (fixed rate) bonds (78%).

• Eurobond Market

Characteristics:

- Unregulated
- Bearer bonds (you hold them, you own them)
- Good rated firms (say, AAA rated) or governments borrow in Eurobond market
- Fastest way to raise funds for reputable borrowers
- Very creative market, with lots of instruments (straight bonds, FRN, dual zero-coupon bonds, currency bonds, convertibles, bonds with warrants, etc.)
- Most common bonds: Straight bonds (market share around 70%)

Coupon payments for straight bonds are annual (YTM should be in p.a. basis).
Coupon payments for floating bonds are semi-annual (YTM should be in s.a. basis).

18.2 Brief Review

There is a huge variety of bonds, loosely divided in straight or fixed rate, floating rate, and equity-related. In the international bond market, the majority of the issues are straight (fixed rate) bonds, with 71% of the market, while floating rate bonds have 26% of the market.

1.A Straight or Fixed Income Bonds

A fixed income bond is a financial instrument with specific interest payments on specified dates over a period of years. On the last specified date, or *maturity*, the payment includes a repayment of principal. The interest rate or coupon is expressed as a percentage of the issue amount and is fixed at launch.

Example: Straight bond.

In January 2004, the Brazilian Companhia Vale do Rio Doce (CVRD) issued straight coupon Eurobonds, with the following terms:

Amount:	USD 500 million.
Maturity:	January 2034 (30 years).
Issue price:	100 (or 100%)
Coupon:	8.25% payable annually
YTM:	8.35% (Brazil's government bonds traded at YTM 9.02%)

Note: CVRD, which is the world's largest iron ore miner, was initially planning to sell USD 300 million worth of the bonds, but ended up placing USD 500 million thanks to strong demand that surpassed USD1 billion. ¶

1.B. Floating Rate Notes (FRNs)
FRNs are similar in structure to straight bonds but for the interest base and interest rate calculations. The coupon rate is reset at specified regular intervals, normally 3 months, 6 months, or one year. The coupon comprises a money market rate (e.g., LIBOR) plus a margin, which reflects the creditworthiness of the issuer.

Example: FRNs ("floaters").
In January 2004, Mexico issued a USD Eurobond, with the following terms:

Amount:	USD 1,000 million.
Maturity:	January 2009 (5 years).
Issue price:	99.965
Coupon:	6-mo LIBOR + 70 bps payable semiannually.

At the time the notes were offered, 6-mo LIBOR was 3.64 percent. So for the first six months Mexico paid an interest at an annual rate of 4.64% (=3.64% + .70%)

Afterward, at the end of each six-month period, the interest rates on the bonds are updated to reflect the current 6-mo LIBOR rate for dollars. ¶

2. Q: How are bonds priced?
Bonds typically trade in 1,000 increments of a given currency (say, USD or EUR) and are priced as a percentage of par values (100%). The price of a bond is determined by computing the NPV of all future cash flows generated by the bond discounted at an appropriate interest rate –i.e., YTM. There is a one-to-one relation between the price of a bond (P) and the YTM of a bond.

$P = C_1/(1+YTM) + C_2/(1+YTM)^2 + C_3/(1+YTM)^3 + ... + C_T/(1+YTM)^T$,

C_t = Cash flows the bond pays at time t. ($C_T = \text{coupon}_T + \text{Face Value}_T$)

Once you know the YTM, you know the price –given that you know the coupon payments.

Interesting mathematical fact: If C = YTM $\Rightarrow$ P = 100 (par or 100%)

Example: A straight Eurodollar bond matures in 1 year.
C = 10%
FV_1 = USD 100
P = 95 (USD 95).
YTM_{Bond} = ?

$$P = \frac{C + FV_1}{1 + YTM} \quad \Rightarrow \quad 95 = 110 / (1+YTM).$$

$$YTM = 110/95 - 1 \quad \Rightarrow \quad YTM = .1578947. ¶$$

18.3 Setting the YTM -i.e., the price- of a (Euro)bond

We have three main cases:
(1) Established company with a history of borrowing (say, GE, IBM);
(2) Established company with no history of borrowing (until 2010: MSFT, Google);
(3) New company.

1. Established company with history of borrowing

Example: IBM wants to borrow USD 100M in the next 10 days ⇒Eurobonds
YTM_{IBM}=?
- Look at competitors (by industry and credit rating).
- Look at secondary market (the best way).

IBM has outstanding bonds trading in the secondary market. $YTM_{IBM\text{-outsanding}} = 5.45\%$
Then, $YTM_{IBM\text{-new debt}} = 5.45\%$. ¶

2. Established company with no history of borrowing
- Analyze the company.
- Look at competitors and industry benchmarks ⇒ set a range, say YTM ∈ [2.55%, 4.10%].
- Based on your analysis, pick a YTM in the range.

3. New company

Now, if a MNC is new to the Eurobond market, setting the YTM is more complicated.
- Look at competitors and industry benchmarks.
- Analyze the new company (or new industry, if needed) and potential market.
- Determine potential demand. Book building for the new bond (phone calls, lots of research).

The YTM is determined by:

$$YTM = \text{Base Rate } (k_f) + \text{Spread (Risk of Company)}$$

k_f = risk free rate = government bond (of similar maturity)
Spread = Risk of company = this is what the investment bank has to determine (in bps)

In general, the spread is related to a risk rating (S&P, Moody's). If a company is in a given risk category, there's a corresponding risk spread.

Example: Space Tourism (or an internet company in 1994, or railroads in the 1800s!)
New company, no similar borrower in the market.
The investment banker determines that the YTM spread is in the range 140 bps to 210 bps over U.S. Treasuries (k_f).
Aggressive spread: 140bps (⇒ risk of not selling enough bonds –i.e., overpricing risk).
Conservative spread: 210 bps (⇒ risk of overselling bond issue –i.e., underpricing risk!).
The investment banker decides on setting the Yield spread at 145 bps.

The lead manager is able to formulate a pricing scheme:

U.S. Treasury: 5.915% s.a. (semiannual)
ST spread: 1.45% s.a.
ST yield: 7.365% s.a. ($\Rightarrow$ p.a. = $(1 + 0.07365/2)^2 - 1$)

<u>Technical detail</u>:
Straight Eurobonds pay annual coupons. $YTM_{ST} = (1 + 0.07365/2)^2 = 7.501\%$ p.a. (annual)
At inception, the bond sells at par $\Rightarrow$ P = 100 (if P=100 $\Rightarrow$ C=YTM).
Then, C_{ST} = YTM = 7.50 %. ¶

CHAPTER 18 – BONUS: ISSUING BOND DEBT - PETROBRAS

Brazil's Petrobras breaks drought in LatAm market

Reuters January 9, 2017
By Paul Kilby

NEW YORK, Jan 9 (IFR) - Brazil's Petrobras opened the Latin American primary markets on Monday with the region's first cross-border bond sale of the year.

Petrobras is approaching investors with five and 10-year bonds to finance an up to US$2bn tender as part of the debt-laden company's efforts to term out upcoming maturities.

At initial price thoughts of 6.5% area on the five-year and 7.75% area on the 10, bankers are calculating starting new issue premiums at anywhere between 50bp and 75bp.

That calculation depends in part on how much weight to give the high dollar price on the existing 8.375% 2021s and 8.75% 2026s, which according to one banker were trading last week around 109 and 110.50, or yields of 5.95% and 7.18%.

"The dollar price is worth something but not worth 25bp," said one, arguing that investors like Petrobras bonds for their high liquidity.

"Liquidity means more than the high dollar price."

But other market participants disagreed. "I would say that fair value is close to 5.75% on the five year," another banker said. "The high dollar price matters a lot for this."

Either way, Petrobras is starting with a generous premium to get investors on board, much as Mexican state-controlled oil company Pemex did in December, when it amassed an over USD 30bn order book after initially offering lavish NICs.

"Petrobras isn't in a position these days where it can skin every last basis point on their deals," said the first banker.

The company has been struggling to regain its footing following a corruption scandal that has had a broad impact on Brazil's political and business classes.

New management has been shedding assets and undergoing liability management exercise in an effort to deleverage and improve the company's credit standing.

While Petrobras fell short of its 2015-2016 divestment target to raise USD 15.1bn, investors largely feel the company is heading in the right direction, and it is still seen as cheap to the sovereign.

In the tender, Petrobras is targeting USD-denominated 3% 2019s, floating-rate 2019s, 7.875% 2019s, 5.75% 2020s, 4.875% 2020s and floating-rate 2020s.

If holders tender by the early bird date of January 23, they will receive a purchase price of 100.625, 101.625, 110.50, 104.875, 102.75 and 101.625, respectively.

Petrobras is also offering to buy back euro-denominated 3.25% 2019s at 105.125 if holders tender by the early bird date.

The bond is set to price on Monday. Bradesco, Citigroup, HSBC, Itau and Morgan Stanley are acting as leads. Expected ratings on the SEC-registered notes are B2/B+ (stable/negative).

(Reporting by Paul Kilby; Editing by Marc Carnegie)

CHAPTER 18 - BONUS COVERAGE: BOND SPREADS (2014)

REUTERS CORPORATE BOND SPREAD TABLES

Reuters Corporate Spreads for Industrials - 03/28/2014							
Rating	**1 yr**	**2 yr**	**3 yr**	**5 yr**	**7 yr**	**10 yr**	**30 yr**
Aaa/AAA	5	8	12	18	28	42	65
Aa1/AA+	10	18	25	34	42	54	77
Aa2/AA	14	29	38	50	57	65	89
Aa3/AA-	19	34	43	54	61	69	92
A1/A+	23	39	47	58	65	72	95
A2/A	24	39	49	61	69	77	103
A3/A-	32	49	59	72	80	89	117
Baa1/BBB+	38	61	75	92	103	115	151
Baa2/BBB	47	75	89	107	119	132	170
Baa3/BBB-	83	108	122	140	152	165	204
Ba1/BB+	157	182	198	217	232	248	286
Ba2/BB	231	256	274	295	312	330	367
Ba3/BB-	305	330	350	372	392	413	449
B1/B+	378	404	426	450	472	495	530
B2/B	452	478	502	527	552	578	612
B3/B-	526	552	578	604	632	660	693
Caa/CCC+	600	626	653	682	712	743	775
US Treasuries	0.13	0.45	0.93	1.74	2.31	2.73	3.55

Spread values represent basis points (bps) over a US Treasury security of the same maturity, or the closest matching maturity.

CHAPTER 18 - BONUS: BOND MATH -Bond Prices and Yields

Before reviewing the basics of bond mathematics, we will introduce some notation:

P = current market value of a bond = present value of the bond.
FV = face value or future value at a certain date, usually maturity.
r = internal rate of return (yield-to-maturity) of a bond.
T = number of years to final maturity.
C = coupon rate of the bond.

A.1. Yield-to-maturity

The theoretical value of a bond is determined by computing the present value of all future cash flows generated by the bond discounted at an appropriate interest rate. Conversely, one may calculate the internal rate of return, or *yield-to-maturity* (YTM), of a bond on the basis of its current market price and its promised payments. The YTM is also referred as yield. The YTM measures the expected total return on the overall investment. No other financial instrument has such an easily observed or intuitively understandable expected return.

Example: A straight Eurodollar bond has a coupon payment of 5%. The market price of the Eurodollar bond is P = 103.91. Maturity is one year from now. The Eurodollar bond has a yield-to-maturity r, given by

$$P = \frac{C + FV_1}{1+r} \quad \Rightarrow \quad 103.91 = 100 / (1+r).$$

Hence,

$$103.91(1 + r) = 105 \;\Rightarrow\; (1 + r)=105/103.91 \;\Rightarrow\; r = .0104898. \P$$

Similarly, one may compute the yield-to-maturity of zero-coupon bonds maturing in T years using the formula:

$$P = \frac{FV_T}{(1 + r)^T},$$

where r is expressed as a yearly interest rate. The term $1/(1+r)^T$ is the discount factor for year T. The YTM is defined as the interest rate at which P dollars should be invested in order to realize F_T dollars T years from now:

$$P(1 + r)^T = FV_T.$$

Example: A two-year zero-coupon Eurodollar bond paying FV_2 = USD 100 is currently selling at a price P = USD 85.20, has a YTM, r, given by

$$85.20 = 100/(1 + r)^2, \quad \Rightarrow \qquad r = (100/85.20)^{1/2} - 1 \;\Rightarrow\; r = 0.08338. \P$$

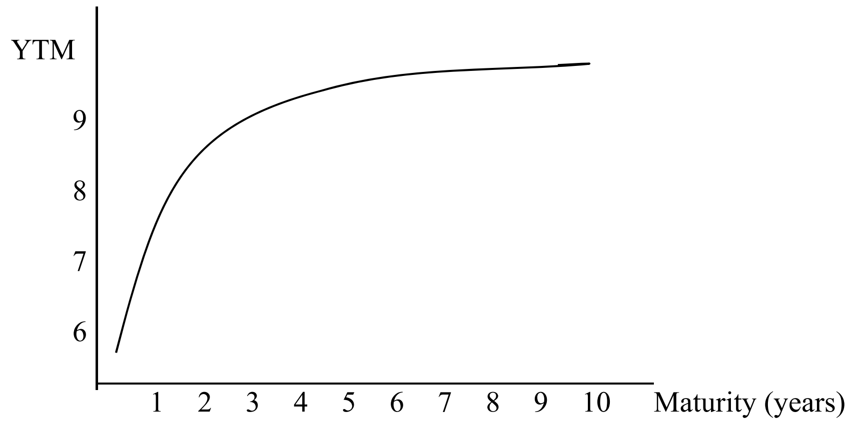
The YTM should not be confused with the *current yield* or *dividend yield*. The current yield on a bond is the ratio of the coupon bond to its current price.

Example: A bond with a price of 90 and a coupon of 10 percent has a current yield of:
10/90 = .1111 = 11.11%. ¶

A.2. Yield curves

Similar bonds -i.e., bonds with similar characteristics: risks, coupons, maturities- should have the same return. Suppose we have bonds with similar characteristics but with the only exception of maturity. Graphing the yields to maturity on similar bonds with different maturities allows us to draw a *yield curve*. As illustrated below in Figure 18.1, the YTM of two zero-coupon bonds in the same currency but with different maturities is usually different.

Figure 18.1: Example of a Yield Curve from zero-coupon bonds



The yield curve shows the YTM computed on a given date as a function of the maturity of the bonds. Therefore, the graph should have on the horizontal or x-axis years to maturity and on the vertical or y-axis the YTM. It provides an estimate of the current *term structure* of interest rates. To be meaningful a yield curve must be drawn from bonds with identical characteristics, except for their maturity. In the graph, two zero-coupon bonds are represented as two points on the yield curve.

A yield curve is a best fit average of the individual yields, so the individual bond yields may well lie above or below the line when it is drawn. This gives an indication as to whether a particular bond has a relatively high or low yield in relation to its market. Points above the curve may be considered as high-yielding (*cheap*), and those below as low-yielding (*dear*).

The normal slope of the curve when the market is in equilibrium is positive, that is, yields rise as maturity lengthens. Under these conditions, investors are receiving higher remuneration for forgoing immediate consumption and for the increased risks associated with longer-term investments.

The slope of the curve is important: the curve becomes steeper when the market expects a general rise in interest rates, and therefore traders sell longer dated bonds, forcing the price down and the yield up.

A flat curve arises when investors are indifferent to maturity risk, that is, short-term and long-term interest rates are very similar.

An uncommon yield curve arises where the yield curve has one or more humps of relative high yields, with lower yields on either side. Usually, there is a technical explanation for such a curve, such as oversupply of issues in a particular maturity band, for example a major issue by a government.

The so-called Treasury yield curve is constructed from on-the-run Treasury issues. These are the most recently auctioned Treasury securities: 3-month, 6-month, 1-year, 2-year, 4-year, 5-year, 10-year, and 30-year.

The first three issues are Treasury bills, which are issued at discount and pay no coupon. That is, these Treasury bills are zero-coupon securities. In contrast, the five other issues are coupon bonds. In fact, there are no zero-coupon securities issued by the U.S. Department of the Treasury with a maturity greater than one year. Consequently, the Treasury yield curve is a combination of zero-coupon securities and coupon securities.

There are, in fact, zero-coupon Treasury securities with a maturity greater than one year that are created by government dealer firms. These securities are called *stripped Treasury securities*. All stripped Treasury securities are created by dealer firms under a Treasury Department program called STRIP (Separate Trading of Registered Interest and Principal Securities).

A.3. Valuing a bond with coupons

The theoretical value of a bond with coupons may be considered the present value of a stream of cash flows (coupons and principal payments). The cash flows occur at different times and they should be discounted at the interest rate corresponding to their date of disbursement. In essence, a coupon-paying bond is a combination of bonds with different maturities.

Example: A five-year EUR 1,000 bond with an annual coupon of EUR 80 is a combination of five bonds. Each bond has a nominal value of EUR 80 and a maturity of one to five years, and a bond with a nominal value of EUR 1,000 and a maturity of five-years. ¶

The YTM, r, of a T-year coupon-paying bond is given by

$$P = C_1/(1+r) + C_2/(1+r)^2 + C_3/(1+r)^3 + ... + C_T/(1+r)^T,$$

where C_i is the coupon payment, including final reimbursement, at date i=T.

♦ **Price of a bond = f(Coupon, YTM, T)**

The formula for the price of a bond shows that the bond's price is a function of the maturity of the coupon rate and of the YTM. Other factors being constant, the higher the coupon rate, the higher the value of the bond. Other factors being constant, the higher the YTM, the lower the price of the bond. ♦

Coupons may be paid semiannually or quarterly, and a valuation may be made at any time during the coupon period. This calls for the more general valuation formula to determine YTM:

$$P = C_1\, t_1/(1+p)^{t1} + C_2\, t_2/(1+p)^{t2} + C_3\, t_3/(1+p)^{t3} + ... + C_T\, t_T/(1+p)^{tT},$$

where p is the daily yield, i.e., $(1+p)^{365} = (1+r)$, and t_1, t_2,.., t_T are the dates on which the cash flows occur, expressed in number of days from the current date. Cash flows include all payments.

The majority of U.S. domestic bonds pay interest twice a year. In this case, the above formula simplifies to:

$$P = C_1/(1+r/2)^1 + C_2/(1+r/2)^2 + C_3/(1+r/2)^3 + ... + C_T/(1+r/2)^T,$$

where r is the annual YTM of the bond.

Example: Annual v. Semiannual coupon bonds
A. Annual coupon bond.

An 8% annual coupon bond with a face value of USD 1,000 and with 5 years remaining to maturity has a YTM of 10%, the current price P is:

$P = 80/(1.10) + 80/(1.10)^2 + 80/(1.10)^3 + 80/(1.10)^4 + 1{,}080/(1.10)^5 = 924.18$ (or 92.418%)

Note: the YTM of 10% is higher than the current yield of USD 80/USD 924.18 = 8.66%.

B. Semiannual coupon bond.
An 8% semi-annual coupon bond with a face value of USD 1,000 and with 5 years remaining to maturity has a YTM of 10%, the current price P is:

$$P = 40/(1.05) + 40/(1.05)^2 + 40/(1.05)^3 + 40/(1.05)^4 + 40/(1.05)^5 + 40/(1.05)^6 + \\ + 40/(1.05)^7 + 40/(1.05)^8 + 40/(1.05)^9 + 1040/(1.05)^{10} = 922.78.$$

Note: The YTM on the semiannual coupon bond is higher than the YTM on the annual bond. The annualized YTM on the semiannual yield is $(1 + .10/2)^2 - 1 = .1025$, or 10.25%. ¶

A.4. Implied forward exchange rates

How do we compare exchange rate movements and YTM differentials? A higher yield in one currency is often compensated, ex post, by a depreciation in this currency, and in turn, an offsetting currency loss on the bond. It is important to know how much currency movement will exactly compensate the yield differential.

Consider a one-year T-bill with an interest rate $r_{d,1}$ in domestic currency, and $r_{f,1}$ in foreign currency. The current exchange rate is S_t, expressed as the domestic currency value of one unit of a foreign currency. Using the IRPT (interest rate parity theorem), derived in Chapter 7, it is possible to calculate the forward exchange rate, $F_{t,1}$ that makes an investor indifferent between the two investments:

$$1 + r_{d,1} = (1 + r_{f,1})\ F_{t,1}/S_t.$$

The implied offsetting currency depreciation is given by

$$\Delta S_1 = p = (F_{t,1} - S_t)/S_t = (r_{d,1} - r_{f,1})/(1 + r_{f,1}).$$

You should notice that the implied offsetting change in S_t was called, in Chapter 7, foreign currency premium (p).

Example: The USD one-year interest rate is $r_{d,1}$=5.468%, the EUR interest rate is $r_{f,1}$=4.120%, and the exchange rate is S_t=1.10 USD/EUR. The forward exchange rate is equal to:

$F_{t,1} = S_t\,(1+r_{d,1})/(1 + r_{f,1})$ = 1.10 USD/EUR (1.05468)/(1.0412) = 1.1142 USD/EUR.

The foreign currency premium (or implied offsetting currency movement) is therefore equal to:

$\Delta S_1 = p = (1.1142 - 1.10)/(1.10) = 0.01295$ (or 1.295%).

Thus, a 1.295% appreciation of the EUR will exactly compensate the yield advantage of the USD investment.¶

Similarly, we can calculate implied forward exchange rates on two-year zero-coupon bonds as well as on bonds of longer maturity.

The implied forward exchange rate for a t-year bond is given by:

$F_{t,T}/S_t = [(1 + r_{d,T})/(1 + r_{f,T})]^T$.

The implied currency appreciation or depreciation over the t-year period is equal to

$\Delta S_T = [(1 + r_{d,T})/(1 + r_{f,T})]^T - 1$.

Example: We are given two hypothetical term structures (five first years). Suppose that S_0= 1.10 USD/EUR. With this information we calculate the implied forward exchange rates in Table 18.1

Table 18.1: Implied Forward Exchange Rates and Currency Depreciation

Maturity (T)	1	2	3	4	5
EUR Yield (%)	4.120	4.322	4.544	4.678	4.792
USD Yield (%)	5.468	5.618	5.645	5.658	5.850
$F_{t,T}$ (USD/EUR)	1.1142	1.1275	1.1351	1.1418	1.1567
ΔS_T (%)	1.295	2.500	3.193	3.798	5.151

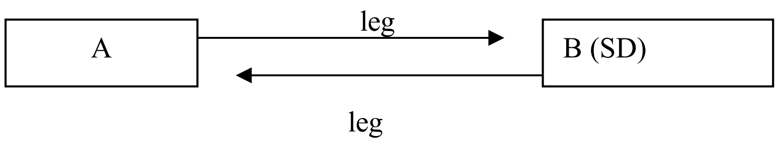
For the above calculations, we assume that the yield curves are for zero-coupon bonds. The formulas are slightly more complicated if we use yield curves for coupon bonds, because we must assume that the coupons are reinvested each year or semester until final maturity.

Chapter 18 - Long term financing – Part 2: Swaps

This chapter introduces a new debt instrument, a swap, which is very flexible and allows companies to change the profile of CFs.

<u>Definition</u>: Swap
A *swap* represents a periodic exchange of CFs between 2 parties. In general, one of the parties is a swap dealer (in general, a bank). Each payment to the counterparty is called a "leg."

Typical exchange of CFs between 2 counterparties:



A usual swap contract has to specify:
◊ Frequency of the payments (f)
◊ Duration of the swap (T)
◊ How the legs (payments) are calculated. (In general, one leg is a *fixed* payment and the other leg is a *floating* (market price) payment. The fixed payment is based on a fixed rate called the *coupon* of the swap).

There are different types of swaps. They differ in how the payments (legs) are indexed. For example, if the legs are denominated in different currencies: currency swap.

• Market Organization
- Most swaps are tailor-made contracts.
  ◊ Swaps trade in an OTC type environment.
  ◊ Swap specialists fill the role of broker and/or market maker.
  ◊ Brokers/market makers are usually large banks.
  ◊ Prices are quoted with respect to a standard, or generic, swap.
  ◊ Reference interest rates are *inter banking offered rates* (IBOR): USD LIBOR, JPY LIBOR, Euribor (EUR IBOR), etc. Since 2018, the Fed has been publishing a new reference rate, the *Secured Overnight Financing Rate (SOFR),* based on Treasury repo rates, to replace LIBOR.

- *All-in-cost*: price of the swap (quoted as the rate the fixed-rate side will pay to the floating-rate side)

- It is quoted on a semiannual basis (s.a.):
  ◊ absolute level ("9% fixed against six-month *LIBOR flat*")

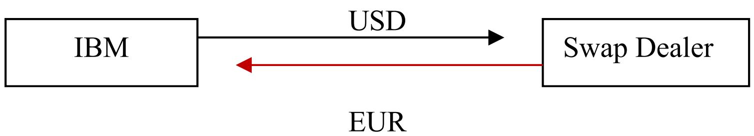
  ◊ bp spread over the U.S. Treasury yield curve ("the Treasury yield + 57 bps against 6-mo *LIBOR flat*," where "LIBOR flat" = LIBOR is quoted without a premium or discount).

- It is a big market, with a USD 425 trillion of outstanding notional amounts (in December 2014).

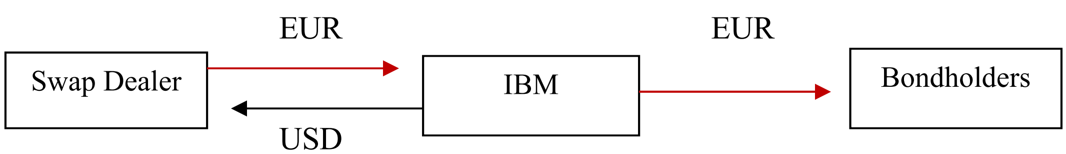
• Q: Why use a swap?
A: To change the profile of cash flows.

Example: IBM pays bondholders of a Eurobond in EUR

Situation: Payments in EUR. IBM wants to pay in USD
Solution: A currency swap



Net result: IBM pays USD:



• Swap Dealers
The SD is an intermediary, usually a large financial institution. They make a living of the bid-ask spread, usually paid as a premium/discount over one of the legs. Usually, SDs attempt to match the sides –i.e., find a counterparty to any swap they enter (with opposite direction). In the previous example:

Thus, the SD does not face interest rate/currency risk. It only faces credit risk (this is why, only companies with good reputations enter into the swap market).

If a swap dealer matches the two sides of a swap is called *back-to-back transaction* (or "*matched book*" transaction). But, if a counterparty to a swap cannot be quickly found, the SD enters a swap and then hedges the interest rate risk using interest rate derivatives, while waiting for a counter party to appear. This practice is called *warehousing* swaps.

In practice it is difficult to find a perfect counterparty to a swap, with the same amounts and maturity needs. In this case, the swap dealer also faces *mismatch risk.* SDs also warehouse the unhedged portions of swaps.

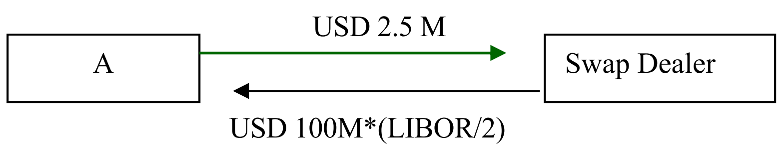
18.4 Five Types of Swaps

• *Interest rate swap (Plain vanilla)*

One party (A) pays a fixed interest rate. The other (B) pays a floating market rate. The floating interest rate is set every period according to market conditions. Usually, one of the parties is a bank (SD).

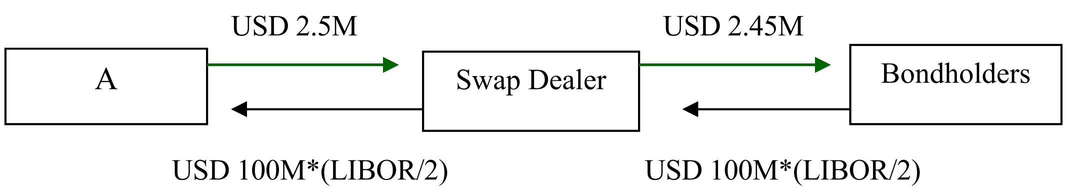
Example: A pays 5% to swap dealer; SD pays floating rate (LIBOR) to A.
Frequency = f: Semi-Annual (s.a.)
Duration = T: 4 years
Notional Principal: USD 100M
Legs = Fixed: 5%; Variable: 6-mo LIBOR.

Every 6 months, A pays USD 2.5M and receives 6-mo LIBOR.



Today, suppose 6-mo LIBOR = 6%. In 6 months, SD pays USD 3M. Net difference is USD 0.5M. Only the net payment will be exchanged. ¶

<u>Note</u>: Recall the SD is an intermediary. The SD will try to find a counterparty to the swap, but with opposite direction. For example:



In this situation, the SD does not face interest rate risk. It only faces credit. ¶

<u>Day count convention (on short-term rates)</u>: In the example, the first floating payment is listed as 6%. But, since it is a money market rate, the 6-month LIBOR should be quoted on an actual/360 basis. Assuming 183 days between payments the actual payment should be

USD 100M x (0.06) x (183/360) = USD 3.05M

The fixed-rate side is also adjusted. Payments may not be equal at each date.

Remark: In interest rate swaps, the notional principals are never exchanged (only the net changes hands).

A popular variation to the plain vanilla swap is the *basis swap*, where the two legs are indexed to floating interest rates. For example, Party A pays 6-mo LIBOR, while the SD pays 12-mo LIBOR.

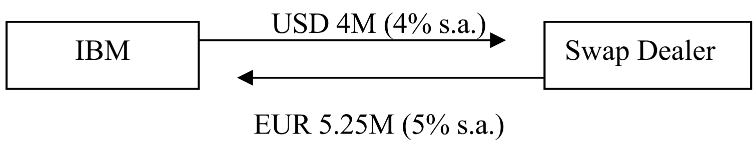
• *Currency Swaps (also called Cross-Currency Swaps,* XCCY)

Both legs are denominated in different currencies. There are different possibilities here:

1. Fixed-Fixed

   Example: IBM pays 4% in USD and receives 5% in EUR.
   f = Semi-Annual
   T = 3 years
   Notional Principals: USD 200M, EUR 210M
   Legs = Fixed USD: 4%; Fixed EUR: 5.25%.

   Every 6 months, IBM pays USD 4M and receives EUR 5.25M



2. Fixed-Floating (also called *Circus swap*)

   Example: IBM pays LIBOR in USD and receives 5% in EUR. ¶

3. Floating-Floating (also called *XCCY basis swap,* if initial exchange of notionals occurs)

   Example: IBM pays LIBOR in USD and receives LIBOR in EUR. ¶

   The difference between the two floating rates in a currency swap is called the *basis swap spread*. The USD LIBOR is usually one of the rates. It is quoted USD LIBOR vs. FC LIBOR $\pm$ spread or *premium* (positive or negative).

   If the XCCY spread is negative, banks are willing to receive lower interest rate payments on funds lent in non-USD currencies, in exchange for USD. The XCCY spread is taken as an indicator of funding conditions.

Note: Unlike interest rate swaps, in currency swaps the notional principal can be exchanged. This makes a currency swap more like an exchange of bonds.

Example: Back to the IBM USD/EUR fixed-for-fixed swap. The swap involves three sets of cash flows:

At inception, IBM receives USD 200 million and the swap dealer receives EUR 210 million:

Then, there are the semi-annual interest payments:

Finally, at the end of the swap, the principals are repaid:

Notes: Since at the end both parties are simply returning the notional principals they exchanged at inception, the exchange rate at the end is the same as the initial rate. There is no FX risk involved in the repayments of principals. ¶

• ***Commodity Swap***

One party (A) pays a fixed commodity price. The other (B) pays a variable commodity price.

Example: Coffee Commodity Swap

Situation: Maxwell House (MH) buys 100M lbs of coffee every 6 months. MH receives 100M lbs of coffee and pays the market price for the coffee. MH decides to use a swap to fix the price of coffee.

Terms: MH pays a fixed price and receives from a SD a variable market price.

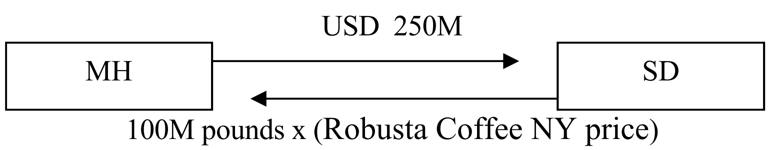
f = Semi-Annual

T = 5 years

Notional Principal = 100M lbs of coffee

Legs = Fixed: 2.5 USD/lb; Variable: Robusta Coffee NY cash price.

Every 6 month, MH pays USD 250M to the SD and receives market price*100M lbs.



Suppose Robusta Coffee NY price = 2.2 USD/lb. MH pays: USD 30M (net). ¶

• ***Equity Swaps***

One party (A) pays a fixed amount, usually calculated as a fixed interest rate. The other (B) pays a variable amount based on the performance of an equity index –S&P 500 or Nikkei 225.

Example: A Mutual Fund pays LIBOR in GBP and receives the returns of the FTSE 100 (in GBP).

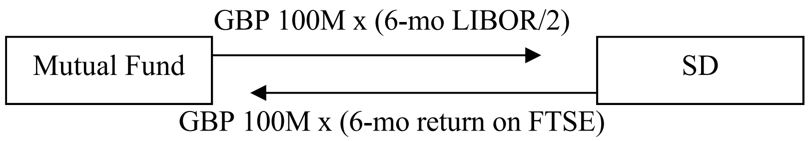
f = Semi-Annual

T = 3 years

Notional Principals: GBP 100M

Legs = Floating Rate: 6-mo LIBOR; Equity Variable: 6-mo return on FTSE.

Every 6 months, the Mutual Fund pays a fixed amount (GBP 100M x 6-mo LIBOR/2) and receives a floating amount (GBP 100M x 6-mo return on the FTSE 100).



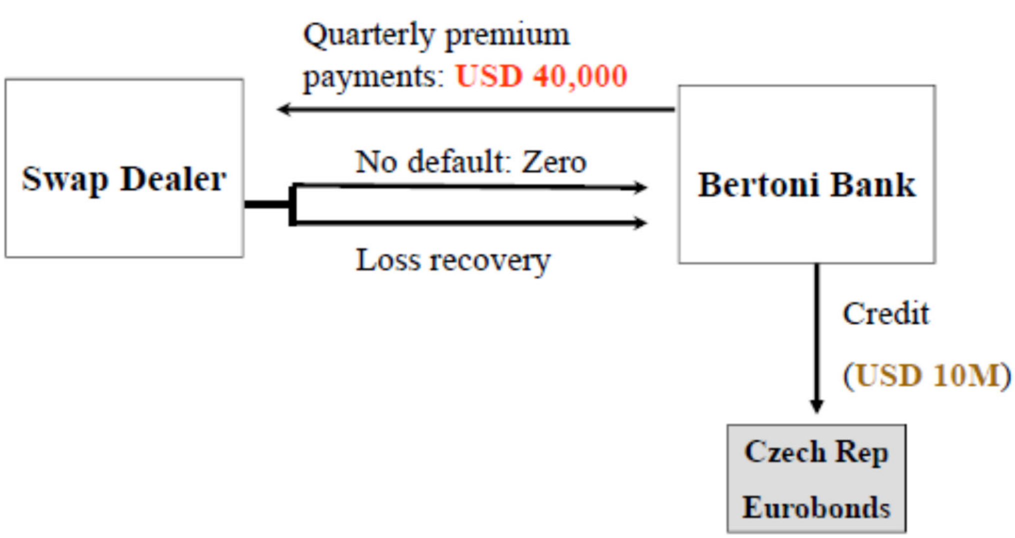
If the return on the FTSE is negative, the Mutual Fund pays the SD. ¶

• ***Credit Default Swaps*** **(CDS)**
One party (A) buys protection against specific risks associated with credit events –i.e., defaults, bankruptcy or credit rating downgrades. It is said that Party A buys a CDS or protection –i.e., "sells" risk or "short credit exposure- and the counterparty, usually a Swap Dealer, sells a CDS or protection –i.e., "buys" risk or credit exposure.

Cash flows:
- The protection buyer pays a periodic fee (the *spread*) to the protection seller.
- The protection seller pays a set amount if there is a credit event (usually, default).

Example: Bertoni Bank buys protection against a Czech Republic default on bonds.
f = Quarterly
T = 5 years
Notional Principal: **USD 10M** (same amount as Czech Republic bonds holdings)
Credit Event: Default
Spread (or **Premium**) = **160 bps**.

Diagram of CFs:



Payment calculation: (**0.0160** / 4) * **USD 10M** = USD 40,000 *(every quarter as a premium for protection against company default).* ¶

Remark: In the example above, the spread reflects the likelihood of a Czech Republic default. In Chapter 17 we mentioned that CDS spreads are a very good indicator of country risk.

- **Market size per segment: Outstanding amount & Market Value (in June 2019)**
  - Interest rate swap: USD 389.3 trillion & USD 7.8 trillion.
  - Currency swaps: USD 26.4 trillion & USD 1.1 trillion.
  - Equity swaps & Forwards: USD 3.1 trillion & USD 0.2 trillion.
  - Commodity swaps & Forwards: USD 1.5 trillion & 0.3 trillion.
  - Credit default swaps: USD 7.8 trillion & 0.2 trillion.

18.5 Valuation of a Swap

The value of a swap is equal to the difference of the NPV of the CFs exchanged.

V = Value of Swap = NPV(Receivables) – NPV(Payables) (denominated in same currency)

At inception (T=0), the value of a swap to both parties should be 0 (or very close to 0). This would be a "*fair*" valuation. But, as time goes by, interest rates and exchange rates will change and, thus, V will change too.

Example: IBM's fixed-fixed currency swap.
Value of Swap(IBM) = V_{IBM} = NPV(Receivables in EUR)*(S_t) – NPV(Payables in USD)

Situation: 2 years have passed. Payments left = 2 (T=1 year)
f : Semi-Annual
T: 1 year
Notional Principals: USD 200M, EUR 210M
Coupons: 4% USD (USD 4M), 5% EUR (EUR 5.25M)
S_t = 1.05 USD/EUR
Discount rates: In USD: 6 mo= 5%, 1 yr=5.1%
In EUR: 6 mo= 6%, 1 yr=6.2%
Notional principals are repaid at the end of swap.

$$V_{IBM} = [\text{EUR } 5.25\text{M}/(1.03) + \text{EUR } 215.25\text{M}/(1.031)^2]*1.05 \text{ USD/EUR} - [\text{USD } 4\text{M}/(1.025) + \text{USD } 204\text{M}/(1.0255)^2] = \text{USD } 20{,}094{,}054$$

If IBM wants to liquidate the swap, IBM has to receive USD 20,094,054 to sell the swap.¶

Note**:** You can think of currency swaps as a collection of forward currency contracts. IBM exchanges USD 4M for EUR 5.25M for 2 years ⇒ implicit S_t = .762 USD/EUR.
At T=3, IBM exchanges USD 204M for EUR 215.25 M ⇒ implicit S_3 = .94 USD/EUR.

• **Remark:** ***Credit Risk***
Credit risk in the swap market: Potential loss to a counterparty of the present value of a swap position if the swap party defaults.

IBM has credit risk exposure from the currency swap only in years when the value of swap is positive (in this example, always). In the previous example, if S_t = 0.95 USD/EUR then,

V_{IBM} (1st-year) = [EUR 5.25M/(1.03)*.95 USD/EUR] - [USD 4M/(1.025)] = USD .94M
V_{IBM} (2nd-year) = USD -1.61M. $\Rightarrow$ SD would face credit risk in year 2.

A CDS can be used to deal with this risk.

Chapter 18 - Long term financing – Part 2: Swaps (continuation)

Review from Chapter 18 – Part 2: Swaps
- Four types of swaps, similar in structure, but different in how the legs are indexed.
    1. Interest Rate Swap
    2. Currency Swap
    3. Equity Swap
    4. Commodity Swap.

- Value of Swap: NPV(Receivables) – NPV(Payables)

Q: Why does the value of the currency swap change?
A: The value is a function of the coupons and the exchange rate. When these variables change, the value of the swap also changes.

For example, going back to the IBM currency swap, the value is a function of the exchange rate (USD/EUR), and interest rates (i_{EUR} and i_{USD}):

$V_{IBM} = f(\text{coupon}_{EUR}, \text{coupon}_{USD}, S_t, i_{EUR}, i_{USD}, T)$

Only the exchange rate and interest rates constantly and randomly change.

Comparative statics-V_{IBM} (IBM pays USD, receives EUR):

If S_t falls (USD appreciates) $\Rightarrow V_{IBM}$ falls.
If i_{USD} falls $\Rightarrow V_{IBM}$ falls
If i_{EUR} goes up $\Rightarrow V_{IBM}$ falls.

The opposite happens for the Swap Dealer.

Note: You can think of currency swaps as a collection of forward currency contracts. IBM exchanges USD 4M for EUR 5.25M for 2 years $\Rightarrow$ implicit S_t = .762 USD/EUR
At T=3, IBM exchanges USD 204M for EUR 215.25M $\Rightarrow$ implicit S_3 = .94 USD/EUR

18.5.1 Decomposition into Forward Contracts

We can decompose the currency swap into a series of forward contracts. Then, we can value the currency swap as the sum of the values of the series of forward contracts.

Example: IBM entered into a 3-year currency swap, which has one year left. The swap terms, current exchange rate and discount rates are given below:

T: 1 year
Notional Principals: USD 200M, EUR 210M
Coupons: 4% USD (USD 4M), 5% EUR (EUR 5.25M)
$\mathbf{S_t}$ = 1.05 USD/EUR
Discount rates: In USD: 6 mo = 5%, 1 yr = 5.1%
In EUR: 6 mo = 6%, 1 yr = 6.2%

Then, the swap sets the following implicit forward FX rates:

2 semi-annual exchanges: EUR 5.25M = USD 4M $\Rightarrow S_{t+j}$= .762 USD/EUR

At maturity, final exchange: EUR 210M = USD 200M $\Rightarrow S_2$ = .9524 USD/EUR. ¶

• Each of the currency exchanges in a swap represents an implicit (swap) forward contract. We can value the implicit swap forward rate relative to the forward rate determined by IRPT, $F_{t,T}$.:

$$\mathbf{F_{t,Tj}} = S_t\,(1 + i_{d,Tj} \times T_j/360)/(1 + i_{f,Tj} \times T_j/360).$$

Suppose in the swap, we are long the FC (say, IBM is long EUR). Then, the PV, using i_d as the discount rate, of each annual payment j is:

$$(\mathbf{F_{t,j}} - \text{Swap forward rate at time j}) \times \text{Amount of FC}/(1+i_d)^j$$

Example (continuation): We calculate IBM's value of the exchange of principals at T=1 year ($\text{Value}_{IBM,Principal}$).
$\mathbf{F_{t,T=12\text{-}mo}}$ = 1.05 USD/EUR * $(1+.051/2)^2/(1+.062)^2$ = **1.038827 USD/EUR**
Swap forward rate = USD 200M/EUR 210M = **0.952381 USD/EUR.**

$\text{Value}_{IBM,Principals}$ = (**1.038827 USD/EUR** – **0.952381 USD/EUR**) * EUR 210M /$(1 + .051/2)^2$ =
= **USD 17.2621M**

IBM would be willing to sell the exchange of principals for **USD 17.2621M**.

Note: We can do the same for each exchange of CFs. ¶

• Alternatively, we can value the CFs in terms of forward DC.

Notation:
T_j: time of the jth settlement date
i_{Tj}: interest rate (appropriate to discount the CFs) applicable to time T_j
$F_{t,Tj}$: forward exchange rate applicable to time T_j.

• IBM's NPV of the forward contract corresponding to the exchange of payments at T_j:

$$(\text{EUR } 5.25\text{M} \times F_{t,Tj} - \text{USD } 4\text{M})/(1+i_{USD,Tj})^{Tj}$$

• Similarly, IBM's NPV of the forward contract corresponding to the exchange of principals at T (maturity):

$$(\text{EUR } 215.25\text{M} \times F_{t,T} - \text{USD } 204\text{M})/(1+i_{USD,T})^{T}.$$

$\Rightarrow$ The value of a currency swap can be calculated from the term structure of forward rates and the term structure of domestic interest rates (yield curve).

Example (continuation): Reconsider IBM's example with two payments left. Using IRPT, the 6-mo, and 12-mo forward exchange rates are:

$F_{t,6\text{-}mo}$ = 1.05 USD/EUR x (1+.05/2) /(1+.06/2) = **1.0449029 USD/EUR**
$F_{t,12\text{-}mo}$ = 1.05 USD/EUR x $(1+.051/2)^2/(1+.062/2)^2$ = **1.038827 USD/EUR**

• The exchange of interest payments involves receiving EUR 5.25M and paying USD 4M. Thus, the values of the CFs in terms of forward USD are (in millions):

(EUR 5.25 x **1.0449029 USD/EUR** - USD 4)/(1+.05/2) = **USD 1.4495027**
(EUR 5.25 x **1.038827 USD/EUR** - USD 4)/$(1+.051/2)^2$ = **USD 1.3824395**

• Final exchange of principals: IBM receives EUR 210M and pays USD 200M. The value of the forward contract is (in millions):

(EUR 210 x **1.038827 USD/EUR** – USD 200)/$(1+.051/2)^2$ = **USD 17.262119**

• The total value of the swap (in USD M) is:

1.4495027 + **1.3824395** + **17.262119** = **20.094061** (check value from last class!)

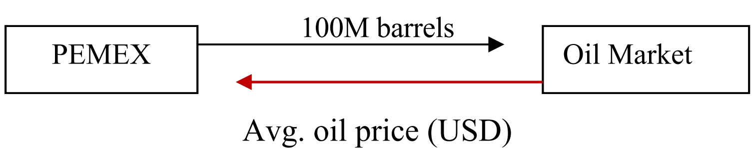
⇒ IBM would be willing to sell this swap for **USD 20,094,061**. ¶

18.6 Financial Engineering

Financial engineers combine different financial instruments to solve problems for firms. In this section, we present one example of combination of swaps. We combine swaps to deal with a typical situation for non-US commodity markets participants: Commodity prices are set in USD.

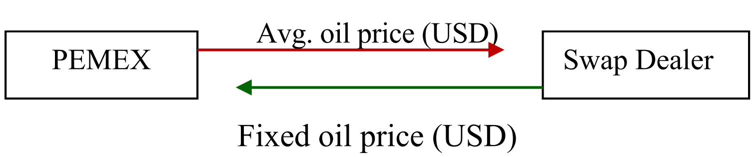
Problem: Two sources of uncertainty: commodity price risk and FX risk.
Solution: Use swaps to fix the price of the commodity in terms of the domestic currency.

Example: Mexican Oil Producer – PEMEX (Petróleos Mexicanos)
Pemex sells 100M barrels every six months in the Oil Market.

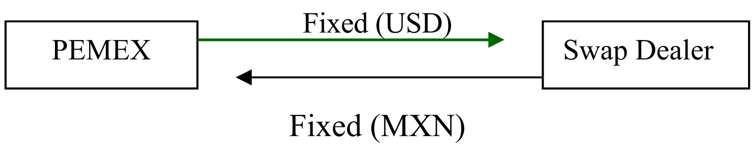


The price for oil is set in USD. Not in MXN. This creates transaction/economic exposure.

1. **Commodity price risk** – use a commodity swap



2. **Exchange rate risk** – use a currency swap



With two swaps, PEMEX has fixed the price of oil in terms of MXN.

Swap Details

◊ <u>Commodity swap</u>

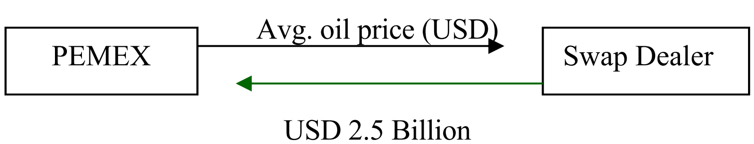
Dealer pays 25 USD/barrel against market price for 2 years.
Notional = 100M Barrels
Duration: 2 years
Frequency: semiannual

◊ <u>Currency swap (fixed by fixed)</u>

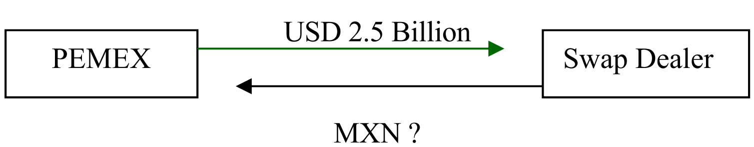
SD pays 6.5% in MXN against 5% in USD.
$S_t = .105$ USD/MXN
$i_{USD} = 5\%$
$i_{MEX} = 6.5\%$
Duration: 2 years
Frequency: semiannual

* We need to find out the fixed price of oil in terms of MXN

1. **Commodity Swap** (Notional = 100M Barrels)



2. **Currency Swap**



Calculations for the SD MXN payments:
(1) Need to determine the Notionals of Swap

Notional of USD part = USD 2.5B/.025 = USD 100B

(2) Determine MXN payment. (Recall that at inception the Value of the Swap is zero.)
NPV (USD payments) = USD 100B
NPV (MXN payments) = USD100B/.105 USD/MXN = MXN 952.38B

$\Rightarrow$ SD's MXN payment = MXN 952.38B (.0325) = MXN 30.952381B

Note: The price of oil in MXN for 2 years has been fixed:

P_t = MXN 30,9524M/100M barrels = 309.52 MXN/Barrel. ¶

CHAPTER 18 – BRIEF ASSESMENT

1. Green Lion, an Irish design company, wants to refinance debt amounting to USD 200 million. An investment bank suggests issuing a straight bond, with annual coupon payments. The investment bank has the following data available:

Irish government bond yields: 4-year 5.75 % (p.a.)
U.S. Treasury government bond yield: 4-year 1.85 % (s.a.)
German government bond yield: 4-year 2.25 % (s.a.)
Green Lion Euro-Eur bond yield (outstanding debt): German government bonds + 345 bps (s.a.)

Given the current tight market conditions, an investment bank suggests: a 5-year full-coupon USD Eurobond and an issue price of 100% (P=100).

(A) Following usual market practices, set the coupon and the yield of the new Green Lion bond.
(B) A year from now, there is a big debt crisis in Europe. What would the effect of this crisis be on the value of the bond? Briefly explain your logic.
(C) Two years from now, the Irish government has a budget surplus. What would the effect of this budget surplus be on the value of the bond? Briefly explain your logic.
(D) Three years from now, Green Lion wants to buy back the bond. If the yield to maturity for similar bonds is 8% and S_t = 1.20 USD/EUR, how much does Green Lion have to pay (in EUR) for the bond buyback?

2. The annual Chinese yuan (CNY) interest rate is 5% (s.a.), while the annual USD interest rate is 1% (s.a.). Padres Co., a U.S. firm, entered into a currency swap with a swap dealer, where Padres pays 3% semi-annually in USD and receives 4% semi-annually in CNY. The notional principals in the two currencies are USD 6 million and CNY 26 million. The swap will last for another two years. The exchange rate is 0.16 USD/CNY. For simplicity, assume the term structure in Chinese and in the U.S. is flat.

A. Draw a diagram showing the semi-annual swap cash flows (in CNY and in USD).
B. Value this currency swap for Padres Co.
C. A year from now, the exchange rate is 0.13 USD/CNY. Assuming that nothing else has changed, use the forward contract decomposition approach to calculate the new value of the swap for Padres Co.

3. Metales Inc, a Mexican company, imports 100 tons of copper per quarter. The company wants to set the price of copper in terms of MXN. Combine swaps to achieve this goal. Draw a diagram.

Chapter 20 – Short-term Financing

• Sources of short-term financing
  - Commercial Paper/Bank Notes
  - Bank Debt
    Cost of debt: call a bank. Example for a US MNC ⇒ $i_{USD} = 5\%$
    Banks set cost of borrowing: Base Rate + Spread (reflecting risk)

• MNCs can borrow anywhere. If an MNC borrows abroad faces FX Risk (needs to pay attention to $e_{f,t}$).

• Determination of the Cost of Borrowing
For a US MNC, the effective borrowing cost (in USD) has two elements:
  - Cost of borrowing = quoted interest rate = i
  - But, when borrowing abroad, borrowers should also consider $e_{f,t}$.
    ⇒ We are back to IFE.

For a US MNC, the *effective borrowing* cost (in USD):
$$R_{b,FC} \text{ (in USD)} = (1+ i_{FC} * T/360)(1+ e_{f,t}) - 1$$

As we know, $e_{f,t}$ is unknown and difficult to forecast. Let's assume we know/estimate $E[e_f]$. Then, $R_{b,FC}$ (in USD) is an expectation, the *expected* effective borrowing cost ⇒ $E[R_{b,FC}]$.

20.1 MNCs: Evaluation of Borrowing Choices

MNCs can borrow in almost all countries. Q: Where should a MNC borrow? Where it is cheaper. MNCs will compare effective borrowing costs (translated to the domestic currency of the MNC, say USD).

Example: BHP Billiton, Australia's mining giant, can borrow at home or abroad, say China.
Data:
$i_{AUD} = 7\%$
$i_{CNY} = 10\%$
$E[e_{f,t}] = -1\%$ (CNY expected to depreciate 1% against AUD next quarter)
T = 90 day loan (T/360 = 90/360 = 1/4)

$R_{b,AUD} = i_{AUD} = 7\% * 90/360 = .0175$ (or 1.75%)
$E[R_{b,CNY} \text{ (AUD)}] = (1+ i_{CNY}*90/360) * (1 + E[e_{f,t}]) - 1 = (1 + .1/4)*(1 - .01) = .01475$ (1.475%)
⇒ BHP should borrow abroad –i.e., in CNY. It faces a lower expected borrowing cost. ¶

MNCs can borrow anywhere. MNCs can also have portfolios of borrowings.
Why? For diversification purposes: It reduces the risk of interest rates increasing in one place (revolving credit).

Example: Petrobras choices: Home (Brazil) or Abroad (single currency or portfolio of currencies)
Data:

$i_{BRL} = 9.1\%$
$i_{NZD} = 9\%$ $E[e_{f,t}] = 2\%$
$i_{JPY} = 2\%$ $E[e_{f,t}] = 6.8\%$
Portfolio: w_{JPY}=.8, w_{NZD}=.2
For simplicity assume T=1 year ($\Rightarrow$ T/360=1).

Where should Petrobras borrow?
1. Home: $R_{BRL} = 9.1\%$
2. New Zealand: $E[R_{NZD}] = 11.18\%$
3. Japan: $E[R_{JPY}] = 8.936\%$
4. Portfolio: $E[R_{Port}] = .80*(8.936) + .20*(11.18) = 9.3848\%$
$\Rightarrow$ Petrobras should borrow in Japan. ¶

Problem: We have assumed that we know the expected change in S_t -i.e., $E[e_{f,t}]$. But, we have not said anything about the precision of the expectation, that is, we have ignored the FX risk of each currency. In general, we work with a probability distribution. It gives us an idea of risk, since we will see a realization from the distribution, not the expectation.

Example: Now, we introduce probability distributions for e_f.
Data:
$i_{BRL} = 9.1\%$
$i_{NZD} = 9\%$
$i_{JPY} = 2\%$

NZD

$e_{f,t+90}$	Probability	R_{NZD}
.01	.5	(1 + .09) * (1.01) – 1 = 10.09%
.03	.5	(1 + .09) * (1.03) – 1 = 12.27%

JPY

$e_{f,t+90}$	Probability	R_{JPY}
.02	.4	(1 + .02) * (1.02) – 1 = 4.04%
.10	.6	(1 + .02) * (1.10) – 1 = 12.2%

Where should Petrobras borrow?
1 Home: $R_{b,BRL} = 9\%$
2. NZ : $E[R_{b,NZD}] = .5*(.1009) + .5*(.1227) = 11.18\%$
3. Japan: $E[R_{b,JPY}] = .4*(.0404) + .6*(.122) = 8.936\%$

NZD $e_{f,t+90}$	JPY $e_{f,t+90}$	Joint Prob(Ind)	Effective borrowing cost (BRL)
.01	.02	.5*.4=.2	.8*(.0404) +.2*(.1009) = .0525
.01	.10	.5*.6=.3	.8*(.1227) +.2*(.1009) = .1178
.03	.02	.5*.4=.2	.8*(.0404) +.2*(.1227) = .0566
.03	.10	.5*.6=.3	.8*(.122) +.2*(.1227) = .1221
			$\Rightarrow$ $E[R_{b,port}]$= .09379

Now, it is likely Petrobras will borrow in Brazil; but not so clear, preferences matter. ¶

Note: We have paid no attention to the variability of interest rates. Variability in borrowing costs was only introduced through the distribution of $e_{f,t}$. But interest rates do change and it may be very important to an MNC. For example, if an MNC selects a revolving credit line, it should consider the variability of the rates. In this chapter, we are considering this exercise as a one shot game.

Chapter 21 – Short-term Investing

The usual instruments for short-term investments are:
- Bank deposits & CDs
- Short-term bills/paper/notes

Idea: MNCs with excess cash for a short term period (7 days, 15 days, a month)
MNCs will try to invest in the country that offers the highest return, once exchange rate effects are considered. We are back to the context of the IFE.

MNCs have many choices for investing

- Home $\Rightarrow$ return(USD) = deposit interest rate (US)
- Abroad
  - Single country $\Rightarrow$ return (GBP) = deposit rate (UK)
  - Portfolio of currencies $\Rightarrow$ return (portfolio)

Exactly like in Chapter 20, when investing abroad, MNCs should also consider e_f. Since we do not know e_f, we work with $E[e_{f,t}]$. That is, for a US MNC, the (expected) *effective yield/return* (in USD) is:

$$E[R^{USD}_{FC}] = (1+ R_{FC} * T/360)\,(1 + E[e_{f,t}]) - 1 \qquad \text{(yield in DC=USD).}$$

21.1 MNCs: Evaluation of Investing Choices

Similar idea to Chapter 20: MNCs will maximize rates of return. Again, we will pay no attention to the variability of returns. This chapter ignores the risk/return relation.

Example: MSFT can invest at home, the U.K., and Mexico It has excess cash for 30 days
Data:
$R_{USD} = 6\%$
$R_{GBP} = 5\%$ $\quad E[e_{f,t}] = 0.7\%$
$R_{MXP} = 12\%$ $\quad E[e_{f,t}] = -1\%$
$T = 1$ month $\Rightarrow T/360=1/12$.
MSFT will translate the foreign return into an effective USD return, R^{USD}_{FC}.

1. Home

$$R_{USD} = .06 * 30/360 = .06/12 = 0.005 \text{ (or } 0.50\%)$$

2. Abroad

UK: $E[R_{GBP}^{USD}] = (1 + .05/12) * (1 - .007)-1 = .011196$ (or 1.12%)
Mexico: $E[R_{MXP}^{USD}] = (1 + .12/12) * (1 - .01) -1 = -.0001$ (or -0.01%)

In terms of expected returns, MSFT should invest in the U.K. ¶

• Using the distribution of e_f (realistic case)
We assume we know $E[e_f]$. The precision of $E[e_{f,t}]$ is given by the distribution of e_f. This distribution will tell us something about the risk.

Example: IBM has excess cash for 1 year (T/360=1)
Data:
$R_{USD} = 4\%$
$R_{GBP} = 5\%$
$R_{EUR} = 3\%$

$e_{f,t,}$ Distribution		Prob
GBP	-.04	.5
	0	.5
EUR	.01	.3
	.05	.7

1. Home
$R^{IBM}_{USD} = 4\%$

2. Abroad (GBP)

Distribution	Prob	R^{USD}_{GBP}
-.04	.5	(1 + .05) * (1 - .04) – 1 = .008
0.00	.5	(1 + .05) * (1 + 0) – 1 = .05

$E[R^{USD}_{GBP}] = .029$

3. Abroad (EUR)

Distribution	Prob	R^{USD}_{EUR}
.01	.3	(1 + .03) * (1 + .01) – 1 = .0403
.05	.7	(1 + .03) * (1 + .05) – 1 = .0815

$E[R^{USD}_{EUR}] = .043*(.30) + .0815*(.70) = 6.914\%$

4. Abroad (Portfolio: w_{GBP}=.4 & w_{EUR}=.6) – Assume independence between GBP and EUR.

Distribution		Prob	R^{USD}_{Port}
GBP	EUR		
-.04	.01	.15	.4*(.008) + .6*(.0403) = .02738
-.04	.05	.35	.4*(.008) + .6*(.0815) = .05210
0.0	.01	.15	.4*(.05) + .6*(.0403) = .04410
0.0	.05	.35	.4*(.05) + .6*(.0815) = .06890

$E[R^{USD}_{POR}] = 0.053084$

The portfolio somewhat reduces the risk (a more compact distribution), relative to the two individual abroad choices. But, it still looks better to invest in EUR. ¶

CHAPTERS 20 & 21 – BRIEF ASSESMENT

1. Cammy Co., a U.S. firm, needs funding for the next 90 days. It's planning to borrow 80% from a Swiss bank and the remaining 20% from a Brazilian bank. The forecasts of the appreciation (against the USD) of the Swiss franc (CHF) and the Brazilian real (BRL) for the next three months are as follows:

Currency	Possible e_f	Probability
CHF	0%	.50
CHF	2%	.50
BRL	4%	.80
BRL	8%	.20

The three-month borrowing rates are: 2% in CHF, 6% in BRL, and 2% in USD. Calculate the effective cost of funds of the overall portfolio. Would you advise Cammy Corp. to borrow abroad or at home? (Justify your answer, considering borrowing in CHF deposit only, BRL only, in the above mentioned 80-20 portfolio of currencies, and in USD only.)

2. Baggy Co., a U.S. firm, has excess cash for the next 30 days. It can invest 60% from a Swedish bank and the remaining 40% from a Dominican Republic bank. The forecasts of the appreciation (against the USD) of the Swedish kroner (SEK) and the Dominican peso (DOP) for the next month are as follows:

Currency	Possible e_f	Probability
SEK	-1%	.30
SEK	0%	.70
DOP	1%	.60
DOP	2%	.40

The 1-mo deposit rates are:1% in SEK, 7% in DOP, and 2% in USD. Calculate the effective yield of the overall portfolio. Would you advise Baggy Corp. to deposit abroad or at home? (Justify your answer, considering placing the excess funds in SEK deposit only, DOP only, in the above mentioned 60-40 portfolio, and in USD only.)

BONUS COVERAGE: Eurocurrency Futures

● Eurocurrency time deposit
Euro-zzz: The currency of denomination of the zzz financial instrument is not the official currency of the country where the zzz instrument is traded.

Example: a Mexican firm deposits USD not in the U.S. but with a bank outside the U.S., for example in Mexico or in Switzerland. This deposit qualifies as a Eurodollar deposit. ¶

Rate paid on Eurocurrency deposits: London Interbank Offered Rate (LIBOR).

• Eurodeposits tend to be short-term: 1 or 7 days; or 1, 3, or 6 months.
Typical Eurodeposit instruments:

Time deposit: non-negotiable, registered instrument, fixed maturity.
Certificate of deposit: negotiable and often bearer.

Note I: Eurocurrency deposits are direct obligations of the commercial banks accepting the deposits and are not guaranteed by any government. Although they represent low-risk investments, Eurodollar deposits are not risk-free

Note II: Eurodeposits serve as a benchmark interest rate for international corporate funding.

• Eurocurrency time deposits are the underlying asset in Eurodollar currency futures.

A. Eurocurrency futures contract
A Eurocurrency futures contract calls for the delivery of a 3-mo Eurocurrency time deposit at a given interest rate (LIBOR).

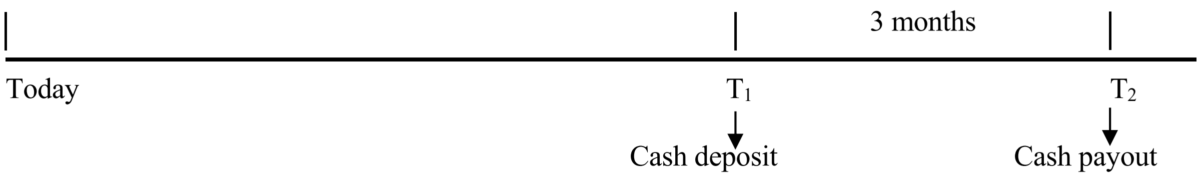
A trader can go long (a promise to make a future 3-mo deposit) securing a yield for a future 3-mo deposit.
A trader can go short (a promise to take a future 3-mo. loan) securing a borrowing rate for a future 3-mo loan.

The *Eurodollar futures* contract should reflect the market expectation for the future value of LIBOR for a 3-mo deposit.

• Q: How does a Eurocurrency futures work?
A: Think of a futures contract on a time deposit (TD), where the expiration day, T_1, of the futures precedes the maturity date T_2 of the TD.

Typically, T_2-T_1: 3-months.

Such a futures contract locks you in a 3-mo. interest rate at time T_1.



Example: In June you agree to buy in mid-Sep a TD that expires in mid-Dec.
Value of the TD (you receive in mid-Dec) = USD 100.
Price you pay in mid-Sep = USD 99.

⇒ 3-mo return on mid-Dec (100-99)/99 = 1.01% (or 4.04% annually.)

• Eurocurrency futures work in the same way as the TD futures:
"A Eurocurrency futures represents a futures contract on a Eurocurrency TD having a principal value of USD 1,000,000 with a 3-mo maturity."

- Eurocurrency futures are traded at exchanges around the world.
  Each market has its own reset rate: LIBOR, PIBOR, FIBOR, etc.

- Eurodollar futures price is based on 3-mo. LIBOR.

- Eurodollar deposits have a face value of USD 1,000,000.

- Delivery dates: March, June, September and December.
  Delivery is only "in cash," -i.e., no physical delivery:

"Eurocurrency futures are cash settled on the last day of trading based to the British Banker's Association Interest Settlement Rate."

- The (forward) interest rate on a 3-mo. CD is quoted at an annual rate.
  Eurocurrency futures price is quoted as:
  100 - (the interest rate of a 3-mo. euro-USD deposit for forward delivery).

Example: if the interest rate on the forward 3-mo. deposit is 6.43%, the Eurocurrency futures price is 93.57. ¶

Note: If interest rates go up, the Eurocurrency futures price goes down, the short side gains.

• Minimum Tick: USD 25.
  Since the face value of the Eurodollar contract is USD 1,000,000
  ⇒ one basis point has a value of USD 100 for a 360-day deposit.
  For a three-month deposit, the value of one basis point is USD 25.

Example: Eurodollar futures$_{\text{Nov 20}}$: 93.57
Eurodollar futures$_{\text{Nov 21}}$: 93.55

⇒ Short side gains USD 50 = 2 x USD 25. ¶

• Q: How is the future 3-mo. LIBOR calculate?
A: Eurodollar futures reflect market expectations of forward 3-month rates. An implied forward rate indicates approximately where short-term rates may be expected to be sometime in the future.

Example: 3-month LIBOR spot rate = 5.4400%
6-month LIBOR spot rate = 5.8763%
3-month forward rate = f = ?

$(1 + .058763 \times 182/360) = (1 + .0544 \times 91/360) \times (1 + f \times 91/360)$

$1.029708/ (1.013751) = 1.015740 = (1 + f \times 91/360) \quad \Rightarrow f = 0.062270 \ (6.227\%)$

Example: The WSJ on October 24, 1994 quotes the following Eurodollar contracts:

EURODOLLAR (CME) - $ 1 million; pts of 100%

	Open	High	Low	Settle	Chg	Yield Settle	Yield Chg	Open Interest
Dec	94.00	94.03	93.97	94.00	....	6.00	....	447,913
Mr95	93.56	93.60	93.53	93.57	+ .01	6.43	- .01	402,624
June	93.11	93.15	93.07	93.12	+ .01	6.88	- .01	302,119
Sept	92.77	92.80	92.73	92.77	....	7.23	....	243,103
Dec	92.45	92.49	92.42	92.46	....	7.54	....	176,045
Mr96	92.38	92.41	92.34	92.38	....	7.62	....	152,827
June	92.26	92.28	92.24	92.25	- .01	7.75	+ .01	124,984
Sept	92.16	92.18	92.12	92.15	- .01	7.85	+ .01	117,214
Dec	92.04	92.06	92.01	92.03	- .01	7.97	+ .01	95,555
Mr97	92.05	92.06	92.01	92.04	- .01	7.96	+ .01	83,127
June	91.98	92.01	91.95	91.97	- .01	8.03	+ .01	69.593
Sept	91.92	91.94	91.89	91.91	- .01	8.09	+ .01	55,103
Dec	91.81	91.82	91.77	91.79	- .01	8.21	+ .01	53,103
Mr98	91.83	91.84	91.79	91.81	- .01	8.19	+ .01	43,738
June	91.77	91.78	91.73	91.75	- .01	8.25	+ .01	37,785
Sept	91.71	91.73	91.67	91.69	- .01	8.31	+ .01	26,751
Dec	91.60	91.61	91.56	91.58	- .01	8.42	+ .01	24,137
Mr99	91.62	91.63	91.58	91.60	- .01	8.40	+ .01	21,890
June	91.56	91.57	91.52	91.54	- .01	8.46	+ .01	15,989
Sept	91.50	91.51	91.46	91.48	- .01	8.52	+ .01	10,263
Dec	91.40	91.41	91.36	91.37	- .01	8.63	+ .01	7,354
Mr00	91.44	91.44	91.40	91.41	- .01	8.59	+ .01	7,536
June	91.39	91.40	91.35	91.36	- .01	8.64	+ .01	4,971
Sept	91.34	91.35	91.30	91.31	- .01	8.69	+ .01	7,691
Dec	91.23	91.24	91.19	91.21	....	8.79	....	6,897
Mr01	91.28	91.28	91.24	91.26	....	8.74	....	7,312
June	91.24	91.24	91.20	91.22	....	8.78	....	5,582
Sept	91.21	91.20	91.17	91.19	....	8.81	....	5,040
Dec	....	....	....	91.09	....	8.91	....	3,845
Mr02	91.13	91.13	91.13	91.14	....	8.86	....	2,689
June	....	....	....	91.10	....	8.90	....	2,704
Sept	91.06	91.06	91.06	91.08	....	8.92	....	2,016
Dec	90.97	90.97	90.97	91.00	....	9.00	....	1,341
Mr03	91.01	91.03	91.01	91.04	....	8.96	....	1,589
June	90.97	90.97	90.97	91.00	....	9.00	....	1,367
Sept	90.85	90.98	90.95	90.98	....	9.02	....	1,354
Dec	90.85	90.88	90.85	90.89	- .01	9.11	+ .01	1,227

Est vol 437,328; vol Thur 615,913; open int 2,576,727. +17,451.

A.1 <u>Terminology</u>

Amount: A Eurodollar futures contract involves a face amount of USD 1 million. To hedge USD 10 million, we need 10 futures contracts.

Duration: Duration measures the time at which cash flows take place.
• For money market instruments, CFs generally take place at the maturity of the instrument.

A 6-mo. deposit has approximately twice the duration of a 3-mo. deposit.
$\Rightarrow$ Value of 1 bp for 6-mo. is approximately USD 50.

Hedge a USD 1 million six-month deposit beginning in March with:
(1) 2 March Eurodollar futures (*stack hedge*).
(2) 1 March Eurodollar futures and 1 June Eurodollar futures (*strip hedge*).

Slope: Eurodollar contracts may be used to hedge other interest rate assets and liabilities. The rates on these instruments are not expected to change 1-for-1 with Eurodollar interest rates.

• Let f be the interest rate in an Eurodollar futures contract, then

slope = Δ underlying interest rate / Δ f. (think of *delta* = change)

• If the rate of change of T-bill rates with respect to Eurodollar rates is .9 (slope = .9), then we only need nine Eurodollar futures to hedge USD 10 million of three-month T-bill.

• F_A: face amount of the underlying asset to be hedged
D_A: duration of the underlying asset to be hedged.
n: number n of Eurodollar futures needed to hedge underlying position

$$n = (F_A/1{,}000{,}000) \times (D_A/90) \times \text{slope}.$$

Example: To hedge USD 10 million of 270-day commercial paper with a slope of .935 would require approximately twenty-eight contracts.

Margin: Eurodollar futures require an initial margin. In September, this was typically USD 800 per contract; maintenance margin was USD 600.

● Q: Who uses Eurocurrency futures?
A: Speculators and Hedgers.

• Hedging
Short-term interest rates futures can be used to hedge interest rate risk:

- You can lock future investment yields (Long Hedge).
- You can lock future borrowing costs (Short Hedge)

A.2 Eurodollar Strip Yield Curve and the IMM Swap
• Successive Eurodollar futures give rise to a strip yield curve.

March future involves a 3-mo. rate: begins in March and ends in June.

June future involves a 3-mo. rate: begins in June and ends in September.
→ This strip yield curve is called *Eurostrip*.

Note: If we compound the interest rates for four successive Eurodollar futures contracts, we define a one-year rate implied from four 3-mo. rates.

• A *CME swap* involves a trade whereby one party receives one-year fixed interest and makes floating payments of the three-months LIBOR.

CME swap payments dates: same as Eurodollar futures expiration dates.

Example: On August 15, a trader does a Sep-Sep swap.
Floating-rate payer makes payments on the third Wed. in Dec, and on the third Wed. of the following Mar, June, and Sep.

Fixed-rate payer makes a single payment on the third Wed. in Sep. ¶

Note: Arbitrage ensures that the one-year fixed rate of interest in the CME swap is similar to the one-year rate constructed from the Eurostrip.

Application: Pricing Short-Dated Swaps
• Swap coupons are routinely priced off the Eurostrip.

Key to pricing swaps: The swap coupon is set to equate the present values of the fixed-rate side and the floating-rate side of the swap. Eurodollar futures contracts allow you to do that.

• The estimation of the fair mid-rate is complicated a bit by:
(a) the convention is to quote swap coupons for generic swaps on a semiannual bond basis, and
(b) the floating side, if pegged to LIBOR, is usually quoted money market basis (for consistency, we will assume that the swap coupon is quoted bond basis).

Notation: If the swap is to have a tenor of m months (m/12 years) and is to be priced off 3-mo Eurodollar futures, then pricing will require n sequential futures series, where n=m/3 or equivalently, m=3n.

Example: If the swap is a six-month swap (m=6), then we will need two future Eurodollar contracts.

• Procedure to price a swap coupon involves three steps:

i. Calculate the implied effective annual LIBOR for the full duration (full-tenor) of the swap from the Eurodollar strip.

$$r_{0,3n} = \prod_{t=1}^{n} [1 + r_{3(t-1),3t} \frac{A(t)}{360}]^{\tau} - 1, \qquad \tau = 360/\Sigma A(t)$$

ii. Convert the full-tenor LIBOR, which is quoted on money market basis, to its fixed-rate equivalent $FRE_{0,3n}$, which is stated as an annual effective annual rate (annual bond basis).

$FRE_{0,3n} = r_{0,3n} \times (365/360)$.

iii. Restate the fixed-rate equivalent on the same payment frequency as the floating side of the swap. The result is the swap coupon SC. This adjustment is given by

$SC = [(1 + FRE_{0,3n})^{1/k} - 1] \times k$, $\qquad$ k = frequency of payments.

Example: It's October 24, 1994. Housemann Bank wants to price a one-year fixed-for-floating interest rate swap against 3-mo LIBOR starting on December 94.

Fixed rate will be paid quarterly (quoted quarterly bond basis).

TABLE 21.A
Eurodollar Futures, Settlement Prices (October 24, 1994)

	Price	Implied 3-mo. LIBOR	Notation	Number of Days Covered
Dec 94	94.00	6.00	0 x 3	90
Mar 95	93.57	6.43	3 x 6	92
Jun 95	93.12	6.88	6 x 9	92
Sep 95	92.77	7.23	9 x 12	91
Dec 95	92.46	7.56	12 x 15	91

Housemann Bank wants to find the fixed rate that has the same present value as four successive 3-mo. LIBOR payments.

(1) Calculate implied LIBOR rate using (i).
Swap is for twelve months, n=4.

$f_{0,12} = [(1+.06x(90/360)) \times (1+.0643x(92/360)) \times (1+.0688x(92/360))x(1+.0723x(91/360))]^{360/365} - 1 ==$ .06760814 (money market basis).

(2) Convert this money market rate to its effective equivalent stated on an annual bond basis.

$FRE_{0,12} = .06760814 \times (365/360) = .068547144$.

(3) Coupon payments are quarterly, k=4. Restate this effective annual rate on an equivalent quarterly bond basis.

$SC = [(1.068547144)^{1/4} - 1] \times 4 = .0668524$ (quarterly bond basis)

→ The swap coupon mid-rate is 6.68524%. ¶

Example: Go back to the previous Example. .
Now, Housemann Bank wants to price a one-year swap with semiannual fixed-rate payments against 6-month LIBOR.

The swap coupon mid-rate is calculated to be:

SC = $[(1.068547144)^{1/2} - 1] \times 2 = .06741108$ (semiannual bond basis). ¶

Note: A dealer can quote swaps having tenors out to the limit of the liquidity of Eurodollar futures on any payment frequency desired.