Topic 13: foreign exchange markets

Introduction

It is useful to study foreign exchange (FX) markets for 3 reasons (at least):

1. It introduces the explicit purpose of international finance: to facilitate trade in goods and assets across countries and over time. There are different currencies and we need to see how monetary systems facilitate (or sometimes disrupts) these trades.

To put more perspective here, there are 2 fundamental purposes of exchange markets:

- To facilitate trade across countries => need to study exchange rates.
- To facilitate trade over time (borrowing and lending) => need to study foreign currency credit and debt instruments (and relationships between exchange rates and interest rates).

2. We study relationships among exchange rates based on actions of traders, investors, speculators, arbitragers, banks and central banks. This behavior is important in understanding exchange rates.

3. FX markets are important and enormous: current "turnover" is over $7 trillion per day.

FX market basics

The “FX market” is a collection of all supplies and demands for FX.

There is no single location (trade happens everywhere, including in Boulder banks) but there are several major centers: New York, Toronto, Chicago, San Francisco, Tokyo, Hong Kong, Singapore, Bombay, Zurich, Frankfurt, Paris, London.

All major currencies and most minor ones can be traded. There are advantages to centralized locations: agglomeration of skills, techniques, financial firms.

Note that paper currencies can be traded in FX market (mostly for tourism and illegal trade) but we are really talking about wire transfers, deposits, overnight loans between banks, etc.

And mostly these are done by major financial institutions.

Spot foreign exchange rates

Start with the spot FX market (trade for immediate delivery)

Facilitating international trade

Consider first how FX market facilitates regular trade. Define the exchange rate as the dollar price of a foreign currency ($ per unit).

Suppose that E = 0.008 $/¥ (= 125 ¥/$). This is the retail spot rate.

Imagine that a US auto company (Ford) contracts to buy a machine tool from a Japanese firm (Mitsubishi). The yen price is ¥1.5 million so Ford needs ¥1.5 m X (.008 $/Y) = $12,000. (US price is $12,000.)

If the contract is denominated in $, Ford pays $12,000, Mitsubishi converts it to ¥1.5m (to pay its workers and other costs in Japan).

If it is denominated in yen, Ford goes to its bank and buys ¥1.5 m for $12,000. It then pays Mitsubishi the ¥1.5m.

Spot FX rates

Either way, note that this US import is a supply of $ and a demand for ¥. And it requires an FX transaction.

Let this contract be in yen. Ford goes to Citi Bank, which removes from its account $12,000 and gives Ford a check or account of ¥1.5m. Ford sends this to Mitsubishi, which deposits in its account at a Tokyo bank.

Result: Ford gets its machine tool for $12,000, Mitsubishi gets ¥1.5 million. Citi Bank has reduced its liability by ¥1.5m, which now sits in an account in Tokyo. (In fact, both banks would charge a small fee to make these trades.)

Note: how would we account for this case in the US BOP?

- A debit of $12,000 in the CA (imports) and a credit of $12,000 in the FA (sold a US-owned asset to a Japanese firm).

Where does Citi Bank get yen? Many possible ways:

- Citi Bank could hold yen balances for transactions purposes (and for investments).
- Citi Bank has customers that export to Japan and they receive yen and deposit them in return for dollars.
- Citi Bank may also have to buy yen from other banks in the wholesale or interbank market (among major banks and brokers).

Spot FX rates

Let’s take this example another step. Suppose Citi Bank buys the ¥1.5 m from Sumitomo Bank (SB) for $12,000 (there would be a somewhat lower cost since wholesale currency prices are a bit lower). SB agrees because it has customers needing $ to import or buy dollar-based assets.

Now suppose a Japanese insurance company (Nippon Life, or NL) wants to buy a $12,000 computer from IBM (denominated in $) and it goes through SB at a cost of ¥1.5m. In the same way, the insurance company would get its computer and IBM would be paid in $.

The main point is that FX transactions facilitate (or “intermediate”) trade in goods and services.

Note here that IBM wanted to sell a computer and Ford wanted to buy a machine tool. These wants are not consistent within the economy. But more opportunities exist across borders and the FX market makes this possible.

Current data: 11/23/2018; 4:30 PM EST (wholesale [interbank] rates)

	AUD	CAD	CHF	CNY	EUR	GBP	JPY	SGD	USD
AUD	1	0.955353	0.720214	5.020632	0.636135	0.563062	81.582448	0.993479	0.722909
CAD	1.046733	1	0.753872	5.255263	0.665863	0.589376	85.395069	1.039908	0.756693
CHF	1.388476	1.326485	1	6.971028	0.883258	0.781799	113.275290	1.379422	1.003742
CNY	0.199178	0.190285	0.143451	1	0.126704	0.112150	16.249438	0.197879	0.143988
EUR	1.571994	1.501810	1.132172	7.892405	1	0.885131	128.247146	1.561744	1.136409
GBP	1.776003	1.696710	1.279102	8.916655	1.129777	1	144.890638	1.764422	1.283888
JPY	0.012258	0.011710	0.008828	0.061541	0.007797	0.006902	1	0.012178	0.008861
SGD	1.006563	0.961624	0.724941	5.053584	0.640310	0.566758	82.117909	1	0.727654
USD	1.383300	1.321540	0.996272	6.945040	0.879965	0.778884	112.853000	1.374280	1

Read these as the price of the row currency in terms of each column currency. Are these consistent?
Consider 1$ = 0.778884 GBP. But 1/0.778884 = 1.283888 so yes. https://www.ratesfx.com/rates/crossrates.html

Spot arbitrage

What makes exchange rates consistent across markets?

- How do we know the $/¥ rate in London is the same as in New York or Tokyo (or Toronto, etc.)? (Note they may not be during the time one is closed.)
- The answer is FX arbitrage, serving the important function of preventing differences in currency rates.

Arbitrage is the activity of simultaneously buying low and selling high to make a riskless profit. (I'm going to define it here as riskless, but advanced financial instruments do carry risk for arbitragers.)

Arbitrage equalizes prices of any homogeneous commodity across locations. This is efficient because it eliminates the need to market participants to search for the best price.

Foreign currencies are the ultimate homogeneous good so we should expect arbitrage to ensure the equality of prices, except for minor transactions costs. This should happen instantaneously due to software programs always looking for differences to arbitrate.

Spot arbitrage

Spatial arbitrage is obvious. This ensures that rates in 2 (multiple) locations are the same.

Let a NY bank sell ¥ for 0.008$/¥ and a Tokyo bank sell yen for 0.0083$/¥ at the same time.

- Arbitragers recognize that the yen is cheaper in NY.
- So they could take $1m, buy ¥ in NY to get $1m/(0.008$/¥) = ¥125m.
- *At the same time* take those yen (digitally) to Tokyo and buy dollars, getting ¥125m * (0.0083)$/¥ = $1,037,500. This is a riskless profit of $37,500 per $1m. (Or equally a profit of 0.0003$/¥ traded.)

What would be the effects on exchange rates?

- The rate $/¥ would rise in NY (depreciate $, appreciate ¥); and
- The rate $/¥ would fall in Tokyo (depreciate ¥, appreciate $);
- This would happen to achieve equality, say at 0.0082 $/¥. (Again, there would be very small differences due to the transaction costs involved.)
- Then no more arbitrage is possible. (We call an equilibrium a "no arbitrage" condition; here that's just $/¥ is the same in both Tokyo and NY.)

Spot arbitrage

Triangular arbitrage is more subtle. This ensures consistency of cross exchange rates in a single location Then combining this with spatial arbitrage we would have consistent cross exchange rates in multiple locations.

Suppose we have these spot exchange rates in New York:

$E_{\$/C\$} = 0.75$ \$/C\$ $E_{£/C\$} = 0.6$ £/C\$ $E_{\$/£} = 1.3$ \$/₤

Note than in New York there are 2 ways to compute the £/C\$ spot rate.

Direct spot rate = $E_{£/C\$} = 0.6$

Cross spot rate = $(E_{\$/C\$}) / (E_{\$/£}) = (0.75)/(1.3) = 0.577$

This is the *cross exchange rate* in New York between pounds and C\$.

We see that C\$ are expensive (in terms of £) using the direct rate but cheap using the cross rate.

- Let arbitragers use ₤1m to buy (₤1m)* 1.3 \$/£ = \$1.3 m in NY and also sell \$ to buy \$1.3m/0.75 \$/C\$ = C\$1.7333 m.
- At the same time sell those C\$ to buy (C\$ 1.7333m)*(0.6 £/C\$) = £1.03998 m in New York.
- This is a riskless profit of £39,980₤ per 1m₤ arbitraged.

Spot arbitrage

Effects on exchange rates.

As before the effects will be to drive these rates together.

- $E_{\$/£}$ would fall because arbitragers sell £ to buy \$ (\$ appreciates).
- $E_{\$/C\$}$ would rise because arbitragers sell \$ to buy C\$ (\$ depreciates).
- $E_{£/C\$}$ would fall because arbitragers buy £ with C\$ (£ appreciates).

What would consistent cross rates be?

$E_{\$/C\$}$ = 0.768 \$/C\$ $E_{£/C\$}$ = 0.595£/C\$ $E_{\$/£}$ = 1.29 \$/£

(Exercise: show that these rates generate consistent cross-rates.)

Again, this happens within any one market and across all markets. All of this happens instantaneously with sophisticated computer software so we should never expect to see differences in cross rates.

Were the cross exchange rates in the earlier table consistent? We had $E_{\$/C\$}$ = 0.756693; $E_{£/C\$}$ = 0.589376; $E_{\$/£}$ = 1.283888. Then the cross rate for £/C\$ = (0.756693/1.283888) = 0.589376.

IT'S NOT MAGIC; IT'S ARBITRAGE.

Forward exchange rates

What may be a new concept for you is *forward arbitrage*, which links currency markets over time.

To understand this we need to understand the idea of a *forward exchange rate*. These are exchange rates known today for currency amounts delivered in the future. In the forward exchange market people sign contracts today to deliver currencies in the future at specific times: 30 days, 60, 90, 180 days in the future. But they do so at a price (exchange rate) decided today in the forward market. There is no risk involved; all prices are known now.

Why is there a forward market?

Most international trade (and many asset) transactions happen under contracts signed over a period of time: 30, 60, 90, 180 days or up to a year. But think of the risk involved with the exchange rate:

- Imagine a US firm signs a contract now to accept and pay for imported machinery in 90 days. In the intervening period the firm would sell some of its goods, hoping to make enough revenues to pay for the imports in 90 days (plus a profit).
- The foreign exporter would sign the contract now, produce the machinery over 90 days and hope the agreed sales price covers his costs. These traders could just wait and see what the spot rate is in 90 days.
- A problem arises with flexible exchange rates. They fluctuate over any period, making both parties subject to *exchange rate risk*. There is a possibility of adverse movements in spot rates that lower profits (or cause losses).
- This truly is risk because the exchange rate could also move in your favor, raising profits.

Forward exchange rates

Risk-loving firms might accept the risk (and just wait for the spot rate in 90 days) but most trading firms prefer to hedge or eliminate ("cover") this risk. They can do this by using the forward market and agreeing now to trade at the current forward exchange rate.

Definition: To "hedge" is to eliminate exchange rate risk through buying or selling forward contracts.

Example: Suppose Liquor Mart decides to buy 1000 cases of Heineken from the Netherlands, with delivery in 90 days. The euro cost is €5,000. Let current spot E = 1.2 $/€. If that doesn't change then the dollar cost is $6,000 in 90 days.

If the dollar depreciates (Euro rises) to 1.3 $/€ over 90 days then the dollar cost rises to $6,500, implying an exchange rate loss of $500. But if it appreciates (Euro falls) to 1.1 $/€ then the dollar cost falls to $5,500, implying an ER gain of $500.

Consider this table:

90-day Liquor Mart contract for €5,000 of Heineken

SPOT RATE NOW	$ COST	SPOT IN 90	$ COST	LM GAIN OR LOSS
1.2 $/€	$6,000	1.3	$6,500	$500 loss
		1.1	$5,500	$500 gain

Note this risk applies only to Liquor Mart since the contract is in Euros. Heineken sees no risk.

Currency denomination

This example points to a big issue in international business: the *currency denomination* of trade contracts.

- If a contract is in your currency you see no risk but you do if it’s in the other country’s currency.
- Most US export contracts (80%) are in $ and most EU export contracts (70-75%) are in Euros so exporting firms in those places face relatively little currency risk.
- But importers in each place do since they have to pay the other currency.
- Some firms may choose to denominate their exports in a foreign currency (e.g. $) to accept the risk themselves as a matter of competitiveness (Japanese firms often do this; around 50% of their exports to the US are in $).
- And firms in developing countries face a double problem: both their imports and exports are generally in $ or Euro terms or some other major currency (e.g., Yen or Chinese Yuan). This should give you one good reason why many DCs choose to fix their exchange rates to the currency of their major trading partner.

Hedging exchange-rate risk

Back to our example now. LM has what we would call an open liability in Euros, so it is exposed to risk. How could this be hedged?

1. Bargain over the currency denomination. LM might ask for the contract to be in $ but this is unlikely since Heineken would have the greater bargaining power. There might be some kind of sharing but that is unlikely since a contract with 2 currencies is awkward.

2. Adjust retail selling prices. If LM sees the exchange rate go to 1.30 (bad news) it could raise its price in its store(s) to cover the higher costs.

- The problem is that it faces local competition from other liquor stores and other beer brands and doing this might cost it some market share. That just means that sales would be risky rather than the exchange rate, so it merely shifts the type of risk.

3.Hedge through spot purchases. LM could buy €5,000 today in the spot market for $6,000 and keep the euros, facing no risk.

- But it wouldn't just sit on the euros, it would invest them for 90 days in a euro-based asset at a known interest rate.
- Let $i_{€}^{90}$ = 0.005 (this would translate to an annual interest rate of .02, or 2 percent). Then LM would have (€5,000)*(1.005) = €5,025 in 90 days. It then pays its €5,000 contract, gets the beer, and has €25 of interest returns left over.

Forward hedging

4. Hedge through forward market purchases. This is what the forward market is for. Traders in forward markets agree today to buy or sell foreign currency in the future at a price known today.

Let's go through this idea. An agreement to exchange currencies today (spot) is different from one to exchange them in 90 days (forward) so they would bear different prices today.

That is, spot rates are given by the supply and demand for currencies in spot markets but forward rates are given by S and D for forward currencies (30, 60 days, etc.)

So $E \neq F_{30} \neq F_{60} \neq F_{90} \neq F_{180}$

If $F > E$ we say the foreign currency is at a *forward premium*. As we will see this means people expect the foreign currency to rise in value over time, so we have to pay a premium for it now.

If $F < E$ it is at a *forward discount* and people expect the foreign currency to fall in value over time.

Some actual forward rates: 11/27 5:22 pm EST

E = \$/€ spot = 1.1295.

F_{30} = \$/€ 30 forward = 1.1323 ($F_{30} > E$ so there is a 30-day forward premium on euro)

F_{60} = \$/€ 60 forward = 1.1357 (bigger 60 day premium)

F_{90} = \$/€ 90 forward = 1.1388 (even bigger 90 day premium)

What is the forward premium over 30 days on the euro? It's the percentage difference between forward rate and spot rate:

$f_{30} = (1.1323 – 1.1295)/1.1295 = 0.0025$ (0.25%).

All of this suggests market participants expect the Euro to appreciate relative to the dollar over 30, 60, and 90 days. We'll come back to that theory next.

Forward hedging

Back to the hedging story. Recall in our example that spot E = 1.2 $/€ and the contract comes due in 90 days.

Let F_{90} = 1.25. Note this forward premium on the euro is ((1.25 – 1.2)/1.2)*100 is 4.2%.

Here, the forward cost *today* of getting €5,000 in 90 days is 5,000*1.25 = $6,250. Liquor Mart would agree to this price now but pay it later at this known $ price. There is NO RISK.

Is this smart? If the dollar depreciates (or appreciates less than 4.2%) over 90 days, then yes. If it appreciates by more than 4.2%, then no. But if LM is risk-averse it would be willing to pay this premium to avoid the risk.

Clicker question

Suppose the current spot rate on the British pound is $E = 1.25$ \$/£ and the current 30-day forward exchange rate is $F_{30} = 1.22$ \$/£. Then

A. The £ is trading at a forward premium.

B. The £ is trading at a forward discount.

C. The \$ is trading at a forward premium.

D. The \$ is trading at a forward discount.

E. Both B. and C.

Forward arbitrage

Let's now put structure on this idea of what's smart or not and link exchange rates to interest rates.

Let E = spot rate ($/€). F = forward rate for 90 days. $i_\$$ = US interest rate for 90 days. $i_€$ = Euro interest rate for 90 days.

Remember that spot, forward, and interest transactions are risk-free because prices are quoted (known) now. But future spot rates are not known and are therefore a source of risk.

Consider the act of *forward arbitrage*, which is simultaneously operating in (1) spot market; (2) forward market; and (3) both investment markets to establish equalized returns on US and euro assets. What does this mean?

Suppose that a US investor has $1m and is looking for the highest risk-free $ return. She has 2 options:

1.Invest for 90 days at the US interest rate. Then the proceeds = ($1m)*(1 + $i_\$$) and return = ($1m)*$i_\$$.

Example: let $i_\$$ = 0.005 (0.5%, which is annualized interest rate of 0.005*4 = 0.02 (2%). Then

Proceeds = $1,005,000 Return = $5,000 (0.50%)

Forward arbitrage

2. Invest in the EU, say in Germany. This involves 3 risk-free steps:

- Buy € in the spot market now. € received = ($1m)*(1/E).
- Invest the € received at the German (EU) rate. Proceeds = ($1m)*(1/E)*(1 + $i_€$).
- Agree today to sell these euro proceeds forward at rate F (known today).

Doing all this generates $ proceeds = ($1m)*(1/E)*(1 + $i_€$)*F in 90 days.

Example Let E = 1.2 $/€; $i_\$$ = 0.005, $i_€$ = 0.002, F = 1.22$/€. What do we get?

- Buy Spot € and get ($1m)*(1/1.2) = €0.8333m.
- Invest the euros in Germany => (€0.8333m)*(1.002) = €0.835m.
- Sell these euros in the forward market for dollars => dollar proceeds = (€0.835m)*(1.22) = $1.0187m. Return = $18,700 (1.87%).

Recap: US return (just the US interest rate) = 0.50%.

Euro return (working through spot rate, euro interest rate, and forward rate) = 1.87%.

Forward arbitrage

Here, despite having a lower interest rate, Germany (EU) is the better risk-free investment. How can we compare this to see why?

Forward premium on euro (f) = (1.22 – 1.20)/(1.20) = 0.0167 (1.67%).

So the combined return on the euro investment is $i_{€}$ + f = 0.002 + 0.0167 = 0.0187 (1.87%).

Clearly 1.87% is much higher than the US return of 0.5%. What would happen? US investors would arbitrage by buying euro investments. This would mean:

Selling $ spot and buying euro spot => spot rate rises, say to 1.210.

Buying German investments => $i_{€}$ would fall (and $i_{\$}$ would rise as investment leaves US but ignore that). So let's suppose $i_{₵}$ falls to 0.001 (which is 0.1% for 90 days).

Selling euro forward => forward rate falls, say to 1.215. Then forward premium is f = (1.215-1.210)/1.210 = 0.004 (0.4%).

Now we have US direct return is still 0.005 (0.5%).

But the EU total return is now 0.001 + 0.004 = 0.005 (0.5%).

Forward arbitrage

We can see that forward arbitrage would bring these two returns together. So what is the mathematical condition?

It's simply the ***covered interest parity*** condition (CIP):

$$i_{\$} = i_{€} + (F – E)/E = i_{€} + f$$

In words, the interest rate of the home country must equal the interest rate of the foreign country plus the forward premium or discount on the foreign currency. The left side is the return in dollars on US assets and the right side is the return in dollars in euro assets, both completely risk free.

Going back to our actual data for he forward rate on the euro (from current market):

E = \$/€ spot = 1.1295; F = \$/€ 90 forward = 1.1388 => f = (1.1388 – 1.1295)/1.1295 = 0.0082 (or 0.82%)

It should then be that the 90 day interest rates should follow: $i_{\$} = i_{€} + f$

Since f > 0 (premium on euro) it must be that the US interest rate is higher than the euro interest rate by 0.0082 over 90 days. (Actually this is a poor example because there is no single "euro" rate, it depends on a weighted average of all the countries using the euro.)

But let's check the data. On 11/27 the US 90-day Treasury yield = 0.0061 (annualized rate = 0.0061*4 = 0.0244; 2.46%). The German 90-day government bond yields was -0.0019 (annualized rate = -0.0076). CIP suggests that:

0.0061 = -0.0019 + f => f = 0.0080. Very close to the actual forward premium on the euro.

Forward arbitrage

What about the Canadian dollar?

E in \$/C\$ = 0.7540

$F_{90} = 0.7554 \Rightarrow f_{90} = (0.7554 – 0.7540)/0.7540 = 0.0019$ (0.19%) forward premium on C\$.

Then we should have $i_{\$} = i_{C\$} + f_{90}$.

We saw that $i_{\$} = 0.0061$. From the data at last auction $i_{C\$} = 0.0043$ (= 0.0174 or 1.74% annual).

So = $i_{C\$} + f_{90} = .0043 + .0019 = 0.0062$, virtually the same as 0.0061. Again, CIP fits very closely.

CIP: important implications

Note that the theory of CIP relies on there being *perfect financial-capital mobility* between countries. This may not be true, especially for developing countries with controls on inflows and outflows of capital.

But suppose it is true. Then we can observe that:

1. Interest rates and exchange rates are closely linked across countries.

2. Central banks can use interest rate policy to affect exchange rates and vice-versa. It's not possible to run an independent interest-rate target without affecting exchange rates.

3. A country with a fixed exchange rate but very high financial-capital mobility is tying its interest rate to the foreign interest rate.

- Consider a developing country with a fixed exchange rate (e.g., Barbados, which sets 1B$ = $0.50 or 1$ = 2B$). Because there can be no change in the exchange rate, there would be no forward market or forward rates. In that case, f = 0 by definition and we must have:

$i_{\$} = i_{B\$}$ pretty much all the time if Barbados is open to financial flows.

By using this fixed rate policy Barbados cannot set its own interest rate and therefore has no independent monetary policy.

CIP: important implications

More on the Barbados story:

Corollary: suppose for some reason Barbados decided to set a lower interest rate than the US one but was committed to sustaining the fixed exchange rate and maintaining free capital mobility.

Then when Barbados tries to lower its interest rate (by expanding its money supply) there would be heavy outflows of Barbados dollars to the US to take advantage of this, putting upward pressure on $i_{B\$}$. This would continue until these interest rates equalized again.

Alternatively if Barbados attempts to keep a lower interest rate, there would be major financial outflows and great pressure on the B$ to depreciate. To keep the exchange rate fixed the CB of Barbados would have to buy B$ (and sell $), causing a quick depletion of its FX reserves. This is not sustainable so the central bank would have to just let the interest rate in Barbados return to equaling the US interest rate.

Final concept to consider from chapter 12: there are other ways to arbitrage and/or speculate in foreign markets, using instruments called options, futures, swaps and other derivatives. That's too advanced to spend time on so we'll ignore them.