Foreign Exchange Markets

1. Terminology

The vocabulary used in the foreign exchange markets can get confusing. To avoid this confusion we will start with a basic definition. Exchange rate is defined as "units of local/domestic currency per foreign currency". The terms "domestic" and "local" are used interchangeably, both imply home country currency. In the language of the currency markets the term "base currency" is the most commonly used term to refer foreign currency. Several terms are used to refer "local/domestic currency". One such term is "terms currency". Other terms such as "counter currency" or "back currency" are also used to imply domestic currency. In this course the terms "base currency" and "terms currency" will be used to refer to foreign and domestic currencies respectively.

In international foreign exchange markets exchange rates are quoted (or expressed) in a particular structure. In exchange rate quotes three letter "ISO codes" are used to identify each currency[1]. For instance USD, EUR and JPY are the codes used to identify U.S. dollar, Euro and Japanese Yen respectively. In foreign exchange trading systems the symbol of a base currency is followed by "/", the symbol of terms currency and the units. Units are always in terms currency. A simple example will clarify quotations:

Table-1: Frequently traded currency pairs, ISO codes and terms used by traders

ISO Codes	Currency Pair	Trading Term	Base Currency	Terms Curency
EUR/USD	Euro/U.S. dollar	Euro	EUR	USD
GBP/USD	British pound/U.S. dollar	Cable or sterling	GBP	USD
USD/JPY	U.S. dollar/Japanese yen	Dollar yen	USD	JPY
USD/CHF	U.S. dollar/Swiss franc	Dollar Swiss	USD	CHF
USD/CAD	U.S. dollar/Canadian dollar	Dollar Canada	USD	CAD
AUD/USD	Australian dollar/U.S. dollar	Aussie dollar or Aussie	AUD	USD
EUR/GBP	Euro/British pound	Euro sterling	EUR	GBP
EUR/JPY	Euro/Japanese yen	Euro yen	EUR	JPY
EUR/CHF	Euro/Swiss franc	Euro Swiss	EUR	CHF
GBP/JPY	British pound/Japanese yen	Sterling yen	GBP	JPY

Source: Peter Rosenstreicht, (2010) "Forex Revolution: An Insider's Guide to the Real World of FX Trading, FT Prentice Hall,

Example:

Let's read translate the expression EUR/USD 1.3785 into plain English. In this expression the symbol of Euro (EUR) is followed by "/", symbol of dollar (USD) and units of USD. This quotation implies that 1 Euro is worth 1.3785 US dollars. In this expression, 1 unit of EUR is expressed in 1.3785 units of USD.

---

[1] You can find ISO codes for currencies in the following link http://www.currency-iso.org/iso_index/iso_tables/iso_tables_a1.htm

Accordingly, in this example "EUR" is the "base currency" and "USD" is the "terms currency". To put it another way, Euro is the foreign currency and USD is the domestic or local currency.

To further confirm our understanding of the terminology let's check the following example:

USD/JPY 85.20

How do we translate this quote? In this case 1 unit of USD is worth JPY85.20. This expression implies that USD is the base currency (foreign) and JPY is the terms currency (domestic).

US dollar is the most frequently traded in the global currency markets and therefore in most currency quotations US dollar is the base currency. In other words, most currencies are commonly expressed in the amount it would take to buy 1 USD. For example, the JPY is often listed as a number such as USD/JPY 85.20, which means that it takes JPY 85.20 to buy 1 USD. The USD is the base currency, and JPY is the terms currency. This is referred to as "European terms". In other words, when the USD is the base currency in a currency quotation, the quotation is called "European Terms Quotation". However, this is not a universal rule, and there are currency expressions where base currency is not the USD. There are handful of currencies that are quoted as "base currencies" against USD. These currencies are the Euro, the British Pound, the Australian dollar and the New Zealand dollar. These quotations, where USD is the terms currency, are referred to as "American Terms Quotation".

Example: American Terms Quotation

American Terms imply that the quotation is expressed in the number units of the U.S. dollars per unit of another currency.

> GBP/USD 1.7500
> 1.7500 U.S. Dollar = 1 GBP (base currency)
> 1.7500 USD per GBP

Currencies quoted in American Terms:

EUR	Euro	Euro zone
GBP	Pound	UK
AUD	Dollar	Austr.
NZD	Dollar	NZ

Example: European Terms Quotation

European Terms imply that the quotation is expressed in the number units of foreign currency per U.S. dollar

> USD/CAD 1.1500
> 1.1500 CAD = 1 U.S. dollar (base currency)
> 1.1500 Canadian dollars per U.S. dollar

Currencies quoted in European Terms:

CAD	Dollar	Canada
DKK	Kroner	Denmark
SEK	Kroner	Sweden
HKD	Dollar	HK
MXN	Peso	Mexico
JPY	Yen	Japan

When an exchange rate in a given country indicates the number of local currencies for one unit of foreign currency, the quotation is referred to as "Direct Quotation". This quotation method is almost universal with the exception of UK and the Commonwealth currencies.

When one unit of local currency is expressed in terms of foreign currency, the quotation is referred to as "Indirect Quotation" or "Continental Quotation" which is used by only a small group of countries such as UK, Australia and New Zealand.

Cross Rates

In the jargon of foreign exchange markets, a cross rate is a currency pair that doesn't involve the USD or the EUR, such as GBP/JPY[2]. A relatively new term that imply currency pairs involving euro such as EUR/JPY or GBP/EUR are called "euro crosses". Since practically all currencies can be traded against each other, there are hundreds of exchange rate pairs that are not quoted against USD or EUR. Some of them involved emerging market currencies and they are referred to as "exotic" currency pairs.

A widely observed convention in currency markets is to express one unit of a "strong currency" ("strong" only refers the parity relationship, not the relative economic strength of the currency or the economy) in terms of a "weaker currency". For instance, when the euro introduced in January 1999, its parity against US dollar was set at USD1.18 per EUR. Since it took more units of USD to purchase 1 unit of the euro, the euro was established as base currency, and the euro was quoted in international currency markets as EUR/USD 1.18.

Two Way Quotations: Bid and Offer Rates

In foreign exchange markets exchange rates are expressed in bid and offer (ask) terms. A dealer quotes the price that he/she is willing to purchase and sell the base currency. Bid price shows the price (in terms currency) dealer is willing to pay for one unit of base currency. "Offer" price shows the price (in terms currency) dealer is asking for one unit of base currency.

Example: EUR/USD

EUR/USD 1.3785-1.3790
Base currency= Euro
Terms Currency: USD

Bid price= 1.3785 (dealer is willing to pay $1.3785 per unit of euro)
Ask (offer) price= 1.3790 (dealer is willing to sell 1 unit of euro at $1.3790)

As the quotation indicates, dealer is ready to buy Euros at $1.3785 and ready to sell at $1.3790.

If we assume that you are a currency trader and see this quotation in your screen. Let say, you would like to buy 1 million Euros. If you execute the trade at this quote, you will pay the dealer $1,379,000 and receive 1,000,000 Euros in exchange.

Let's also assume that another trader is willing to sell 1 million Euros to the dealer at $1.3785. The dealer pays $1,378,500 and receives 1 million Euros.

When these two transactions are combined, it is easy to see that the dealer made a profit of $500.

This is how foreign exchange dealers make their profits. They buy at a lower price and sell at a higher price. In the jargon of foreign exchange markets, the difference between bid and offer rates is referred to as

---

[2] Peter Rosenstreicht, (2010) "Forex Revolution: An Insider's Guide to the Real World of FX Trading, FT Prentice Hall,

"Spread". In this particular case spread is equal to $0.0005. The difference between bid and offer rates is in the fourth decimal. In most cases exchange rates are expressed up to fourth decimal. If an exchange rate is expressed in fourth decimal, one unit of the fourth decimal is referred to as 1 pip. In the above example, the bid-ask spread is 5 pips.

Spread = | 1.3785 - 1.3790 | = 0.0005 or 5 pips
Pip value= $0.0001

Example: EUR/JPY

EUR/JPY 117.95/118.00
Base currency= EUR   Terms Currency: JPY
Bid price= 117.95; Ask price= 118.00
When selling Euros, 1 Euro = JPY117.95; when buying Euros, JPY118.00 = 1 Euro.

In some cases like the Japanese Yen quotations against USD and EUR, exchange rate is expressed in two decimals. In these quotations 1 pip is one unit in the second decimal. For example, the spread in the above quote is 5 pips, and pip value is JPY 0.01.

Spread = | 117.95 - 118.00 | = 0.05 or 5 pips
Pip value= JPY0.01

Example: GBP/USD
GBP/USD 1.7400-1.7410
Base currency= GBP Terms Currency : USD
Bid price= 1.7400; Ask price= 1.7410
When selling Pound, 1 Pound = USD$1.7400; when buying Pound, USD$1.7410 = 1 Pound.
Spread = | 1.7400 - 1.7410 | = 0.001 or 10pips
Pip value=$0.0001

2. Calculating Changes in Exchange Rates

Communication in foreign exchange markets often involve changes in exchange rates. We use the terms "appreciation", "depreciation", "revaluation" or "devaluation" very frequently to refer to the changes in exchange rates. The terms "appreciation" and "depreciation" imply changes in the values of currencies whose value is determined by markets, namely freely floating and managed floating currencies. When the value of the currency is determined by the government interventions, we use the terms "revaluation" or "devaluation" to refer to the increases and decreases in value.

Calculation of the changes in exchange rates requires identification of "base" and "terms" currencies. Let's illustrate this through an example:

Let's assume that the Brazilian Real exchange rates changed from USD/BRL3.2020 to USD/BRL3.1606 over a two week period. First, we would like to calculate the change in the value of USD.

The exchange rate quotation above implies that USD is the foreign/base currency and BRL is the domestic/terms currency. In other words, exchange rate expresses 1 unit of USD (foreign currency) in units of BRL (domestic currency). If we use our initial definition of exchange rate as:

S= # of local/domestic currency units per unit of foreign currency

We can calculate the change in the value of base (or foreign) currency USD as:

% Change in Foreign (Base) Currency=$\dfrac{S_1 - S_0}{S_0}$

In contrast percentage change in the local or terms currency can be calculated as:

% Change in Local (terms) Currency=$\dfrac{S_0 - S_1}{S_1}$

In both cases where S_0=value of the base currency at t=0 ; S_1= value of he base currency at t=1

A) Since USD is the base/foreign currency, the change in the value of base currency can be calculated as:

% Change in FC $= \dfrac{S_1 - S_0}{S_0}$

S_0=3.2020 S_1=3.1606

% Change in USD $= \dfrac{3.1606 - 3.2020}{3.2020} = -1.293\%$

Dollar depreciated by 1.293% against BRL.

B) Calculate the change in the value of BRL (local currency)
S_0=3.2020 S_1=3.1606

% Change in TC $= \dfrac{S_0 - S_1}{S_1}$

% Change in BRL $= \dfrac{3.2020 - 3.1606}{3.1606} = +1.309\%$

BRL appreciated by 1.309%. Note that change in USD and change in BRL are not merely same figures with different signs. In other words, changes in exchange rates are not symmetrical. This asymmetry is referred to as "Singer Paradox".

Exchange Rate Expressions in Textbooks

Most introductory international finance textbooks use a different convention to express exchange rates. For instance in market convention we could express 1 unit of dollars in JPY term as follows:

USD/JPY 85

In textbooks you are likely to see an expression like the following to imply the same:

¥85/$

Note that in this case Yen (local currency) symbol preceded the units (terms) of the currency which was followed by a "/" and the dollar (foreign currency. Unfortunately, textbook expressions are out of touch, and do not reflect the conventions used in the global currency markets.

Example: Understanding Two Way FX Quotations

Your company is an exporter of digital network equipment to Germany. Due to competition, you accept to bill your customer in Euros. Your customer wired Euro 10,000,000 into your London bank account. Your shopping among 31 banks revealed the following Euro quotes:

Bank	Bid	Ask
Barclays:	EUR/USD1.3310	EUR/USD1.3320
Citibank:	EUR/USD1.3317	EUR/USD1.3319
JPM Chase	EUR/USD1.3316	EUR/USD1.3321

Example: Which quote would yield the highest amount of US dollars for you?

Suppose Siemens receives the following quotes for JPY and TWD.
        EUR/JPY 132.30-132.80
        EUR/TWD 40.50-40.90
How many EUR will Siemens receive from its sales of TWD 50,000,000?
How many EUR will Siemens receive from the sale of JPY 10 billion?
How many TWD Siemens will receive for EUR5, 000,000?

Example: Spot Trading

An FX dealer in New York posts following quotes in a trading platform.

USD/CAD 1.4314-1.4390
GBP/USD 1.5210-1.5240
USD/CHF 1.2450-1.2480

You see these rates in your trading screen and would like to do the following:

1. You want to exchange your Canadian dollars into US dollar. How much CAD do you have to pay for USD 1,000,000?
2. You have USDs and want to buy GBP1,000,000. How much USD will you have to pay?
3. You have GBP1,000,000 and you want to buy USD. How much USD you get in exchange for GBP 1m?
4. You have USD1,000,000, and want to buy GBP. How much GBP should you receive in exchange for USD1,000,000?
5. You want to sell CHF1,500,000. How much USD should you receive?
6. You have CAD and want to buy CHF. How much CAD should you pay for each CHF?

Answers:

1. The quote tells you that the dealer is willing to sell USD at CAD 1.4390. To get 1,000,000 USD, you have to trade at the offer rate because you are buying USD, the base currency. You will pay 1.4930 x 1,000,000 = CAD1,439,000 and receive $1,000,000. This example can be used to make a generalization. When a trader faces a dealer, trader buys the base currency at the offer rate, and sells the base currency at the bid rate.

2. The GBP/USD quote tells you that the dealer buys GBP at $1.5210 and sells GBP at $1.5240. You have USD and want to buy GBP 1,000,000. Since you are buying the base currency, you have to trade at the offer rate!
You will pay 1,000,000 x 1.5240=$1,524,000 and receive GBP 1,000,000.

3. You have GBP 1,000,000. The quote tells you that for every GBP 1, dealer pays $1.5210. To convert pounds into USD you have trade at the bid rate. You will get 1,000,000 x $1.5210=USD1,521,000

4. The quote tells you trade at the offer rate to buy the base currency. For every $1.5240, you will receive GBP1. For 1,000,000 USD you receive USD1,000,000/1.5240=GBP656,168

5. Here the language of the question can get confusing. Stay focused and re-read the question. Selling CHF means buying USD. This means that you will buy USD by using your Swiss Francs. Since USD is the base currency you will trade at the offer rate. For every 1.2480 Swiss Franc (CHF) you will receive USD1. For 1,500,000 CHF, you will receive 1,500,000/1.2480=USD1,201,923

6. This is tricky! The dealer did not post any cross rate between CAD and CHF. However, this transaction can still be executed in two steps. In each step we trade one currency against USD.

First, you pay CAD 1.4390 get 1 USD (use USD/CAD quotation)
Second, you pay 1 USD get CHF1.2450 (use USD/CHF quotation)

Since you received 1.2450 CHF for 1.4390, your cost of buying 1 CHF is 1.4390/1.2450=CAD 1.1558. In other words, you ended up paying CAD1. 1558 for each Swiss Franc.

3. **Arbitrage:**

Merriam Webster dictionary defines arbitrage as "nearly simultaneous purchase and sale of securities or foreign exchange in different markets in order to profit from price discrepancies". The key determinant of arbitrage is the ability to generate positive returns without taking any risk. Simultaneous buying and selling ensures that there is no capital at risk, and profits are locked in at the time trade is initiated. Locked in arbitrage profits are collected at some time in the future. Arbitrage plays a crucial role in financial markets and make sure that prices return to equilibrium.

In foreign exchange markets information travels fast and it is incorporated into exchange rates very quickly. However, in this enormous $4tr market, price formation process is intermittently disrupted and temporary price discrepancies across markets do occur. Geographic price discrepancies are typically so small and short lasting that transaction costs do not allow market participants to take advantage of them. In rare instances these discrepancies create profitable trading opportunities. Once market participants identify these opportunities, they mobilize large sums of capital to buy and sell the same currency simultaneously in different markets. As a result of this massive trading activity where traders buy low and sell high, discrepancies fade away quickly and disappear.

Foreign exchange market participants screen markets for arbitrage opportunities and mobilize dedicated funds to take advantage of temporary deviations. There are two widely recognized arbitrage opportunities in foreign exchange markets:

1) Geographic Arbitrage
2) Triangular Arbitrage

Geographic Arbitrage

Geographic Arbitrage opportunities emerge rarely, disappear quickly, and offer small returns for traders. Let's explore the concept with a simple illustration:

Assume that dealers in London and Tokyo flash the following USD/CHF rates:

London Dealer: USD/CHF 1.7640-1.7600
Tokyo Dealer : USD/CHF 1.7665-1.7700

Arbitrage desk in Capital Partners, a hedge fund, sees the opportunity and executes the following trade simultaneously:

Buy USD100,000,000 in London @1.7600, pay   CHF176,000,000; trade settles in 2 business days
Sell USD 100,000,000 in Tokyo @1.7665, receive CHF 176,650,000 trade settles in 2 business days

In 2 days when funds are settled, net amount captured by Capital Partners is

CHF 176,650,000-176,000,000=CHF650,000

Capital Partners generated CHF650,000 profit for every USD100m mobilized.

Triangular Arbitrage

While dollar is on one side of the trade in 88% of the global foreign exchange transactions, some dealing banks in foreign exchange markets specialize in making a direct market between non-dollar currencies. They price these rates at a narrower bid-ask spread than the cross-rate spread. While the cross rate quotations impose a discipline on these dealers, on occasion their direct quotes may not be consistent with cross-exchange rates. This creates a triangular arbitrage profit opportunity. Triangular arbitrage is defined as the process of exploiting the discrepancies between direct non-dollar rates and the dollar based cross-rates. Triangular arbitrage requires three trading steps. Arbitrage trader trades out of a currency and returns back to the same currency after taking intermediate trades. An arbitrage trader identifies the triangular arbitrage opportunity by comparing direct non-dollar quotes with cross rates calculated from dollar based quotes. The following simple example illustrates the concept of triangular arbitrage:
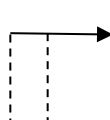
Example:

Assume that dealers in New York, London and Frankfurt provide the following quotes:

New York/Citibank Quote: EUR/USD 0.9045
London/Barclays Quote: GBP/USD1.4443
Frankfurt/Dresdner Quote: GBP/EUR 1.6200

We have two dollar based quotes and a direct quote between Pound and Euro. In order to check if there are any profitable arbitrage opportunities, we need to compare the euro cross with direct quote of GBP/EUR.

Euro Cross Rate (tradable in London and New York):
(GBP/USD1.4443)/(EUR/USD0.9045)= GBP/EUR 1.5968

⟶ Direct Quote of € against £
   GBP/EUR1.6200 (tradable in Frankfurt)

This discrepancy offers a profitable arbitrage opportunity: We can buy GBP with Euro through cross rate and sell it at direct rate!! Note that cross rate allows us to purchase pound at EUR1.5968, simultaneously sell pound at the direct rate of 1.62. If we assume to start with a hypothetical EUR1,000,000:

1. Sell EUR1,000,000 at $0.9045, get USD 904,500
2. Sell $904,500 @1.4443 → get GBP626,254
3. Sell GBP626,254 @1.62, get €1,014,532

Net Profit: €1,014,532-1,000,000= €14,532 per 1m € recycled!

Triangular Arbitrage with Bid and Ask Rates

When bid and ask rates are involved cross rate calculations are considerably more complicated. An initial challenge is to calculate the cross rates when exchange rates are quoted with bid and ask rates. Cross rates are either calculated by dividing one currency pair to another or by simply multiplying two currency pairs.

A) If the cross rate is obtained by dividing one currency pair into the other one:

Cross Bid Rate is calculated by dividing bid of the nominator pair into the offer of the denominator pair
Cross Offer Rate is calculated by dividing the offer of the nominator pair into the bid of the denominator pair
Can you get the cross rate by multiplying one currency pair with the other? If yes then

B) If the cross rate is obtained by multiplying two currency pairs:

Cross Bid Rate is calculated by multiplying bid of the first pair by the bid of the second pair
Cross Offer Rate is calculated by multiplying offer of the first pair by the offer of the second pair

Example: CAD/JPY Cross Rate

Use the following USD based quotes to calculate CAD/JPY Cross Rate:
USD/JPY   105.50-106.10
USD/CAD   1.2840-1.2850
Solution: To get CAD/JPY rate you need to divide USD/JPY rate to USD/CAD rate. In other words CAD/JPY= (USD/JPY)/(USD/CAD)

If we follow the rule described in (A):
Bid Rate of CAD/JPY is= Bid of the nominator (USD/JPY) / Offer of the denominator (USD/CAD)= 105.50/1.2850=82.10
Offer Rate= Offer of the nominator (USD/JPY) / Bid of the denominator (USD/CAD)=106.10/1.2840=82.63
Cross Rate: CAD/JPY 82.10-82.63

An intuitive explanation

Bid side of the CAD/JPY implies that we deliver CAD to the dealer and dealer pays us JPY. In other words, we buy JPY with CAD.
To purchase JPY with CAD, first we need to convert CAD into USD.
It takes CAD1.2850 to purchase 1 USD.
If we deliver 1 USD to the dealer we get JPY 105.50

In other words for every 1.2850 CAD we receive 105.50 JPY or for each CAD we get 105.5/1.2850=JPY 82.10

Offer Side
The offer side of the CAD/JPY implies that we pay JPY to get CAD. In other words we buy the base currency.
We pay JPY106.10 to get 1 USD
We pay 1 USD and get CAD 1.2480
For each (106.10/1.2480)=82.63 JPY we get 1 CAD.

Example: EUR/CAD Cross rate:

Using the following rates, calculate EUR/CAD cross rate:
EUR/USD 1.2310-1.2315
USD/CAD 1.2840-1.2850
Calculate EUR/CAD Cross Rate:
(EUR/USD) x (USD/CAD)=EUR/CAD or our answer to first statement is "NO". Our answer to second statement is "YES". Follow the rule stated in 2:
Cross-Bid Rate= Bid x Bid= 1.2310 x 1.2840=1.5806
Cross-Offer Rate= Offer x Offer=1.2315 x 1.2850=1.5825
Hence EUR/CAD 1.806-1.5825

Example: Triangular Arbitrage with Bid and Offer Rates:

Suppose the following rates appear in your trading screen:

EUR/USD 1.3520 -1.3525
USD/TRY 1.5890-1.5940
EUR/TRY 2.1390-2.1433

Is there an arbitrage opportunity?

1. Cross Rate and Arbitrage Check
The cross rate: EUR/TRY
We can calculate the cross rate EUR/TRY from USD based quoted:
(EUR/USD)x(USD/TRY)=EUR/TRY
In this case since the cross rate is obtained through multiplication we should multiply bid of the first rate with bid of the second rate (and offer to offer to calculate the offer rate of the cross:
Bid Rate=1.3520 x 1.5890=2.1483
Offer Rate=1.3535 x 1.5940=2.1559

Bid Rate=1.3520 x 1.5890=2.1483
Offer Rate=1.3535 x 1.5940=2.1559

As these rate diverge from the direct quote of EUR/TRY 2.1390 -2.1433, there is an arbitrage opportunity. One can purchase the Euros directly at 2.1433, and sell indirectly at 2.1483. The steps in the arbitrage are the following:

Assume TRY100m is utilized to execute the arbitrage:

1. Use TRY100 m to purchase EUR spot:
TRY100,000,000 /2.1433=EUR46,657,024

2. Buy USD at 1.3520
EUR46,657,024 x 1.3520=$63,080,297

3.Sell USD at 1.5890 against TRY
=$63,080,297x1.5890=TRY100,234,591

Arbitrage Profit: TRY 234,591
The dollar equivalent can be calculated by using USD/TRY rate of 1.5890 → TRY 234,591/1.5890=$147,634