AN OVERVIEW OF ECONOMICS OF EXCHANGE RATES
A Non-technical Introduction

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1. The Big Picture:

Exchange Rate is a distillation of many economic and non-economic factors in one price. In the absence of government interventions, exchange rates are determined by a combination of economic, political, social and commercial factors which affect the demand and supply of a currency. In this sense, exchange rates are not any different from other commodity prices. As price controls or market interventions cause deviations from equilibrium prices in the context of commodities, government interventions also cause exchange rates to deviate from their fundamental equilibrium values that would otherwise prevail.

This lecture note focuses on exchange rates determined by demand and supply dynamics. In this context, it is plausible to classify factors affecting demand and supply for currencies in two broad groups:

- Demand and supply directly linked to commercial activity
- Demand and supply driven by expectations

Exchange rate demand and supply stemming from exports and Imports of goods and services as well as foreign direct investments fall into the first category. For instance, exports of goods and services from the US require payments in US dollars. Foreigners need to acquire US dollars to pay their suppliers in the US. This increases the demand for US dollars. Similarly, US imports require US residents to pay foreign suppliers in their own currency. This requires exchanging US dollars against foreign currencies which increases the supply of US dollars in the market. Consequently, increasing exports increase the demand for US dollars, and increasing imports increases US dollar supplies. If we assume for a moment that there are no other channels of demand and supply, an increase in US exports lead to an appreciation of US dollar ceteris paribus. Obviously, the multiplicity of channels of demand and supply and complex interaction among these factors suggests that the prediction of exchange rate changes is a complex business.

International portfolio investments and speculation fall into the second category. Investors in search of higher returns screen global markets constantly. Higher return prospects in a particular country provided that the investment environment is accommodating and there are no (or minimal) restrictions to capital flows, attract investments in a variety of financial instruments. These investments create demand for the recipient country's currency as foreigners acquire the currency to pay for the investments. To put it in another way, countries offering higher return opportunities experience capital inflows and an increase in demand for their currencies, which in turn leads to the appreciation of their currencies. In contrast, countries with poor return prospects experience capital outflows. These outflows increase the supply of the local currency and lead to depreciation. Investors monitor a host of economic indicators including macro, and microeconomic trends to anticipate changes in the prices of a variety of financial instruments, and take investment positions to exploit impending changes. Investors ultimately aim to earn returns that are consistent with the risks that they take and their actions are driven by fundamentals, rather than market timing or other skills that may lead to abnormally high returns.

Technically speculators make risky bets in the currency markets by using variety of instruments. Their actions are driven by expectations and market timing. The speculators provide liquidity in markets by taking positions on the opposite side of hedgers who are willing to transfer risks. When speculative positions are sizable, exchange rate adjustments are accelerated towards fundamental equilibrium.

There are two frequently heard arguments about speculators: The first argument is an accusation blaming speculators for destabilizing markets through their sizable trades. In other words, speculators force particularly undesired devaluations and cause economic havoc in financially turbulent times. While there is truth to this argument, speculators take sizable positions when there are unsustainable deviations from fundamental values. The second argument is that speculators play an important role in financial markets by providing liquidity and facilitating risk transfer as they are willing to bear undesired risks. This argument also suggests that their actions help exchange rates move toward fundamental equilibrium. Speculators take calculated risks and build up positions when they are convinced that counteracting forces are weak. For instance, they refrain from betting against Central banks with strong reserve positions.

The third group of traders in the currency markets, namely Arbitrageurs, take advantage of temporary price discrepancies. Since their activities require the mobilization of a substantial amount of capital, their trading activities change the demand and supply dynamics in very short time intervals. However, their trading activities do not cause substantial changes in currency markets.

It is very difficult to attribute trading activity into one particular group of players. However, it is clear that their actions collectively move exchange rates constantly in the markets.

It is fair to suggest that in the short run trading activity driven by expectations dominates the demand and supply dynamics and drives the exchange rates. Commercial transactions are consequences of longer-term decisions and are less influential in the short run.

Both types of transactions are affected by a host of economic, political and psychological factors. Most exchange rate models incorporate variables such as relative prices, relative GDP growth rate, relative income levels, relative productivity levels, relative interest rates, relative money supply, relative stock and bond yields which capture dynamics both in real sectors and financial sectors. Currency traders follow a range of news and data releases pertinent to these variables.

There are broadly three categories of **news** that shape the expectations in the FX markets:

- Scheduled Macro Data Announcements
- Non-Scheduled Macro Data Announcements
- Non-scheduled non-macro (non-fundamental) news

Table-1: Scheduled Macro Data Announcements in the US

Indicator	Reported as	Time
PPI	M/M% change	08:30 ET
CPI	M/M% change	08:30 ET
Feds Fund Rate	Change in % pts	14:15 ET
GDP(Advance Release)	% chance qoq	08:30ET
Industrial production	M/M% change	09:15 ET
Housing Starts	millions	08:30 ET
Monthly M3	Change $ (billion)	16:30 ET
Trade balance	USD (billion)	08:30 ET
Unemployment rate	Percent	08:30 ET
Non-farm payrolls	Thousands	08:30 ET
Retail sales	M/M% change	08:30 ET

Source: Source: Michael Rosenberg, "Exchange Rate Determination" McGraw Hill, 2003.
M/M % implies month to the month percentage change

These variables generally reflect the macroeconomic health of an economy and positive surprises are likely to increase demand for the currency and lead to an appreciation. Note that traders live with these figures, and teams supporting traders forecast these variables. Consequently what matters is the difference between the trader forecasts and the actual data. The larger the surprise, or the larger the difference between consensus forecasts and the actual figure, the larger the impact on the exchange rates.

Any other news that has an impact on monetary and fiscal fundamentals such as inflation, interest rates, central bank attitudes toward a tighter or looser monetary policy, government budget deficit and trade balance have an impact on exchange rates. While there may be no scheduled data releases on these issues, information provided by numerous government agencies, industry groups and think tanks continuously flow into the markets and cause changes in the exchange rates. The following table shows a subsample of such nonscheduled data releases and possible directional impact on exchange rates.

Table-2: Nonscheduled Data Items that affect exchange rates

Monetary Fundamentals	Fiscal Fundamentals	Growth & Unemployment	Exchange Rate Policy
Inflation (↑/↓)	Trade Balance (surplus/deficit)	Growth (+/-)	Intervention Signals
Interest Rates (↑/↓)	Fiscal position (good/bad)	Employment (↑/↓)	Joint Intervention Signals
Bias (T/L)		Housing (↑/↓)	Implicit Target
		Growth Gap (↑/↓)	Strong/Weak Currency Bias

Source: Michael Rosenberg, "Exchange Rate Determination" McGraw Hill, 2003.

While macroeconomic indicators and news associated with them are critically important , traders also keep track of additional indicators that inform them about their peers' perspectives and other factors that may potentially influence macroeconomic indicators. The table below provides a subsample of such indicators that are highly regarded by market participants. For instance, positions taken in the option markets provide insights about the collective opinion of the market.

Indicator	Variables to Watch
Options Market	Calls/Puts, Demand for Barrier Options, Open Interest, Volume
Technical Analysis	Momentum, Support
FX Market Characteristics	Volume, Order Flow (sell/buy trades), Volatility, Spreads
Sentiment	Positive/Negative
Private Sector Dynamics	Restructuring, Major Acquisitions, Government Involvement in Corporate Sector
Politics	Political Uncertainty, Political News

Source: Michael Rosenberg, “Exchange Rate Determination” McGraw Hill, 2003.

Market indicators such as trading volume, order flow (sell/buy trades), volatility implied in options prices (simply “implied volatility), bid and ask spreads in spot forward and derivative quotations, trader sentiments revealed by surveys are among such non-macroeconomic indicators observed by traders. These indicators typically influence traders’ short term views about the direction of exchange rates. Other micro factors such as major acquisitions, industry-wide restructuring efforts, government interventions in the corporate sector (such as bailouts, or introduction of new regulations with significant implications). In addition to the factors listed above, political news that has the potential to have economic repercussions are monitored in the currency markets .

2. **Exchange Rate Models**

Although exchange rates are notoriously complicated prices, a simple set of principles help us begin to capture this complexity. These economic principles that link exchange rates, price levels, and interest rates together are called “international parity conditions”. International parity conditions form the core of the financial theory that is unique to international finance. Broadly we will explore three such parity relationships:

- Purchasing Power Parity
- International Fisher Effect or Uncovered Interest Parity
- Interest Rate Parity

These three parity relationships goes long way to explain short, medium and long term changes in exchange rates, and they constitute invariable building blocks of complex forecasting models. While parity relationships were developed under simplifying assumptions, these assumptions do not undermine the fundamental insights they provide. In the following section these relationships are discussed in turn:

3. Purchasing Power Parity

3.1 Absolute Purchasing Power Parity

In its absolute form, Purchasing Power Parity simply states that bilateral exchange rates between two currencies should be equal to the ratio of price levels of comparable consumption baskets. This is motivated by a well-known economic principle called "law of one price." Under certain assumptions, the law of one price stipulates that prices of goods around the world should be equal to each other when measured in one common currency.

Law of one price is built on the following simplifying assumptions:

- Identical products, services or basket of such goods and services do exist in various national markets
- There are no restrictions on the cross-border transactions
- There are no transportation costs
- Information about goods and services prices are equally accessible globally
- There are no taxes or transaction costs

In the jargon of financial economics, these conditions imply the existence of perfect markets.

Law of one price stipulates that

$$P^{LC} = S_{LC/FC} \text{ x } P^{FC} \qquad (1)$$

Where P^{LC}= The price of goods or services in the local market

P^{FC}=The price of goods or services in a foreign market

$S_{LC/FC}$ = Exchange rate expressed as local currency units per unit of foreign currency

The above relationship implies that the exchange rate between local and foreign currency should be

$$S_{LC/FC} = P^{LC} / P^{FC}$$

In its absolute form, PPP implies that exchange rates simply reflect relative price levels at home and foreign markets. In the context of the absolute version of Purchasing Power Parity (or A.P.P.P.), any deviation from the parity leads to arbitrage and consequent elimination of deviations from equilibrium. We can illustrate this with a simple example:

Example:

Assume that a basket of tradable goods in the US cost USD 2,000,000. An identical basket of goods in the UK cost GBP 1,000,000. Under the assumptions, we listed above, these prices imply an equilibrium exchange rate of

$S_{USD\ per\ GBP} = P^{US} / P^{UK} = (2{,}000{,}000/1{,}000{,}000) = \$2$ per Pound

Let's assume for a moment that this condition is violated in the markets and the prevailing exchange rate in the market is only USD1 per GBP. What would happen if this were the case? We know that this deviation from the equilibrium value of $2 per Pound would create an arbitrage opportunity. Let's say you are the first smart person on earth to identify this opportunity and attempt to take advantage of it. You would do the following:

- Borrow quickly USD 1,000,000
- Use your dollars to purchase Pound at the rate of USD1 per Pound and get GBP 1,000,000
- Buy the basket of goods in the UK
- Bring them back to the US, and sell it for $2,000,000

This transaction would provide you a profit of $1,000,000 almost instantly. You would imagine that in a market where information becomes quickly available news will be heard all around, and many people will attempt to generate profits the same way you have generated profits. It is plausible to think that the chain of transactions involved in this process, i.e., borrowing dollars, buying pounds with US dollars, purchasing the tradable basket of goods, and importing them back to the US would lead to changes in respective prices! Let's for a moment assume that the prices of the basket of goods and the capacity to procure dollars do not change. If that is the case, we will see demand for pounds to increase the price of pounds in terms of the US dollars. Why? It is simply because pound dealers will notice the increase in demand for pounds, and will start to increase their asking price or the offer rate. Each incremental increase in the price of the pound will lead to less profitable arbitrage transactions. However, these transactions will continue until the last penny is exploited through the arbitrage process. The arbitrage will cease when the exchange rate reaches to USD 2 per Pound. The following table shows arbitrage profits at various levels of exchange rates:

Table-3: Arbitrage Profits vs. Exchange Rates

Exchange Rate	Price of the Basket in the US (USD)	Price of the Basket in the UK (GBP)	US Dollar Cost of Basket in the UK (USD)	Arbitrage Profit
1.0000	2,000,000	1,000,000	1,000,000	$1,000,000
1.2500	2,000,000	1,000,000	1,250,000	$750,000

1.5000	2,000,000	1,000,000	1,500,000	$500,000
1.7500	2,000,000	1,000,000	1,750,000	$250,000
1.9800	2,000,000	1,000,000	1,980,000	$20,000
2.0000	2,000,000	1,000,000	2,000,000	$0

The example above explains why exchange rates implied by the purchasing power parity should hold. While this relationship sounds theoretically solid, in light of the assumptions interjected in its construction may raise questions about its validity. The good news is that relaxation of these assumptions does not change the fundamental conclusion that exchange rates should reflect relative prices of tradable goods in respective economies. The exact relationship requires incorporation of transaction costs and adjustments for other market imperfections, but the simple relationship we described above remains to be a good approximation of the equilibrium exchange rates. Also, the arbitrage mechanism we described above is replaced by international trade, and although it works much smaller than the theoretical arbitrage, in the long run, it produces comparable results.

In practice, the precision of APPP depends on:

- The degree of trade liberalization
- The extent of Transaction Costs
- Substitutability of Consumption Baskets
- Informational Asymmetry

If the imports and exports are restricted, transaction costs are high, the goods baskets are not comparable, information is not available about the price of comparable baskets, we should expect deviations from APPP.

Simple Example: Using APPP to Set the Exchange Rate between USD and GBP

We survey prices of basket of tradable goods in the UK and the US. Let say our findings indicate the following:

Price (UK-Basket)=GBP 2,345,000

Price (US-Basket)=USD 3,780,000

According to APPP the GBP/USD rate (i.e. dollars per pound) should be:

$S_{\$/£}=P_{\$}/P_{£}$ =(3,780,000/2,345,000)=$1.6119 per pound

As this example shows, local currency value of the designated basket is higher in the US as compared to the UK. That sets the value of Pound at 1.6119, well above 1. Note that the parity does not say much about the strengths of Pound or USD, it just reflects the relative price levels.

While APPP defines fundamental bilateral exchange rates in terms of relative prices of identical goods baskets, more importantly, it emphasizes that even if the relationship does not hold at present, in the long-run, exchange rates should move to reflect the relative price levels of an identical basket of goods between two countries.

Absolute Purchasing Power Parity and Big Mac Currencies

Big Mac Index is a lightly modeled gauge of "correct" exchange rates based on the theory of purchasing-power parity. However, the basket of tradable goods consists of only a single item, a Big Mac hamburger, produced in nearly 120 countries. In the context of the Big Mac Index, the fair-value benchmark or equilibrium value for a currency is the exchange rate that equalizes the cost of burgers in the US and elsewhere. The equilibrium exchange rates or "Purchasing Power Parity Implied Exchange Rates" are calculated by using relative prices of Big Mac burgers in various countries and in the US. For instance, if Big Mac is sold at 5.90 Brazilian Real in Brazil and 3.06 US dollars in the US, fair value (or PPPIER) of the US dollar in terms of Brazilian Real is calculated as:

$$S_{BRL/USD} = \frac{BRL5.90}{USD3.06} = USD/BRL1.93$$

At that time the actual spot exchange rate observed in the currency markets is USD/BRL2.47. In other words, each USD is traded against BRL2.47 in the market. The theoretical rate implied by Purchasing Power Parity or the fair value of USD is far below the exchange rate prevailing in the market. In other words, in currency markets, Brazilians pay more for 1 US dollar than the price Purchasing Power Parity suggests. In other words, Brazilians pay 2.47 Real per US dollar rather than the theoretical rate of BRL1.93. This leads us to the conclusion that the market price of the US dollar for Brazilians is too high which makes the US dollar overvalued from the Brazilian perspective. At the same time, the respective theoretical and market rates indicate that the Brazilian currency is undervalued against the US dollar.

Big Mac Price in Local Currency	Actual Exchange Rate (April 2005)	Big Mac Prices in USD	PPP Implied Exchange Rate	under (-) / over (+)
3.06	----	3.06	1	
4.75	2.9	1.64	1.55	-46.50%
5.9	2.47	2.39	1.93	-21.90%
1,500	594	2.53	490	-17.50%
28	10.84	2.58	9.15	-15.60%

Source: The Economist, April 17, 2005, Print Edition.

You may argue that fair value estimates based on Big Mac prices cannot possibly be serious exercise. While you have a point, this simple adaptation makes a case for PPP surprisingly clear. The point here is to use relative prices to get a theoretical exchange rate. Economists are capable of compiling sophisticated price indices to get better estimates of theoretical prices. But in the end, they use the same approach to get to the theoretical rates.

Another important point in the above table is the last column where you see under or overvaluation of the currency. In the Brazilian Real example implied PPP or fair value of the US dollar from the Brazilian perspective was calculated as BRL1.93 per USD. However, the prevailing market price of the US dollar is 2.47 BRL. As it is indicated above, Brazilians pay more than the theoretical rate per USD. This makes USD overvalued or BRL undervalued. The extent of undervaluation of the local currency (in this example BRL) can be calculated as follows:

LC % under(-) /over (+) valuation=(PPPIER-Actual Spot Rate)/Actual Spot Rate

=1.93-2.47/2.47=-21.9%

Note that this formula is used to calculate the under or overvaluation of the local currency. In order to calculate under or overvaluation of foreign currency the following formula is used:

FC % under(-) /over (+) valuation=(Actual Spot Rate-PPPIER)/PPPIER

In this example, USD is the foreign currency. By using the formula above we can calculate USD overvaluation as:

FC % under(-) /over (+) valuation=(Actual Spot Rate-PPPIER)/PPPIER

=2.47-1.93/1.93=+27.97%

The US dollar is 27.93% overvalued against Brazilian Real.

3.2 Relative Purchasing Power Parity

In its relative form, PPP tells us that given an equilibrium spot rate of S_t at T=t , next period exchange rate S_{t+1} can be inferred from relative expected inflation rates at home and abroad for the period (t, t+1)

$$S_{t+1} = S_t \times \frac{(1+\pi_d)}{(1+\pi_f)} \qquad (2)$$

Where i_d=domestic inflation forecast from t to t+1 and i_f= domestic inflation forecast from t to t+1. The key idea here is that the exchange rates are a function of relative expected inflation rates in respective countries. We can alternatively state the relationship between exchange rates and relative inflation rates as follows:

$$\frac{S_{t+1} - S_t}{S_t} = \frac{(\pi_d - \pi_f)}{(1+\pi_f)} \qquad (3)$$

Given an equilibrium exchange rate S_t at T=t, percentage change in the value of the foreign currency should be equal to expected inflation rate differentials of two countries during period t, t+1.

Relative purchasing power parity describes the dynamics of the changes in exchange rates. In order to preserve equilibrium value, an exchange rate is expected to change to offset inflation rate differentials. Consequently, the expected change in the exchange is roughly equal to the difference between local and foreign inflation rates[1].

Note that equation (2) shows the expected future spot rate of 1 unit of foreign currency in terms of local currency. Equation (3) shows the expected change in foreign currency given the local and foreign inflation rates.

How can we express the expected change in the value of the local currency? The expected change in the value of the local currency is given as follows:

$$\frac{S_t - S_{t+1}}{S_{t-1}} = \frac{(\pi_f - \pi_d)}{(1+\pi_d)} \qquad (4)$$

Example:

As of April 2010, the exchange rate between the Brazilian real and U.S. dollar was USD/BRL 1.70 (alternatively R1.70/$). The U.S. and Brazilian inflation rates between April 2010 and April 2011 were 2 % and 20 %, respectively.

A US importer imports electrical equipment from a Brazilian company. Annual purchases are around $100,000 or BRL170,000 per annum

a). Assuming that the Brazilian manufacturers cost increases from BRL170,000 to 204,000 and exchange rate remains at BRL1.70, what happens to the imports from Brazil?

Answer:

Since the Brazilian cost increases are passed through to the US importer, US importer's cost of equipment purchases increases from 100K to 120K. This would urge the US company to look for new suppliers.

b) Based on this information what would be your PPP forecast for the exchange rate in April 2011?

Answer:

Relative version of the PPP implies that April 2011 exchange rate should be:

[1] Note the use of term "approximate" here. It is approximate because denominator has been ignored for simplicity.

$$S_{April\,2011} = 1.70 \times \frac{(1\ +0.2)}{(1+\ 0.02)} = 2.00$$

In other words, the exchange rate to be consistent with PPP, it should change from 1.70 BRL per US dollar to 2.00 BRL per US dollar. This implies an expected change in the USD equal to:

$$\frac{S_{t+1} - S_t}{S_t} = \frac{(\pi_d - \pi_f)}{(1+\pi_f)} = \frac{(0.2 - 0.02)}{(1+0.02)} = +17.65\%$$

c) If the exchange rate in April 2011 were 2.00 and the Brazilian Electrical machines were sold at BRL204,000, how would US importer react?

Answer:

USD Cost=204,000/2=102,000

Note that if this were the case, the cost of the machine would increase by only as much as the US inflation rate of 2%. At this price, Brazilian exporter would preserve its competitiveness, and most likely continue to sell to its US customer. Since the real or inflation-adjusted price for the US importer would not change, this would not require any change the US importer's procurement strategy.

d) Assume that the actual exchange rate observed as of April 16th 2011 is USD/BRL 1.5778 (note that this is the average of the bid and offer rates or a mid-rate). What is the implication of this on the Brazilian exporter?

Answer:

At this exchange rate Brazilian exporter will most likely lose its customers in the US as its products will become too expensive for the US importers.

USD Cost @ 1.5778 → 204,000/1.5778=129,293; this implies almost 30% increase in the USD costs.

e. Is BRL under or overvalued as of April 16^{th} at 1.5778? What is the extent of under or overvaluation?

Answer:
BRL is grossly overvalued at 1.5778 as the PPP implied rate is 2.00. The extent of over or undervaluation of Brazilian Real given as:

% under(-) /over (+) valuation=(PPPIER-Actual Spot Rate)/Actual Spot Rate

=2.000-1.5778/1.5778 = + 26.75%

Note that we used this formula because BRL is the local currency.

A Brief Review of Currency Under or Overvaluation:

In practice, spot rates often deviate from their PPP implied levels. When exchange rate deviates from its PPP implied level, it is referred to be either over or undervalued. We use the following rule to determine which is the case:

1) If the actual spot rate is above PPP implied rate, the exchange rate (of the LC) is undervalued.

2) If the actual spot rate is below PPP implied rate, the exchange rate (of the LC) is overvalued.

The extent of under or overvaluation can be determined by using the following formulas:

$$\text{Under/OverValuationof LC}=\frac{\text{PPP Implied Rate-Actual Rate}}{\text{Actual Rate}}$$

$$\text{Under/OverValuation of FC}=\frac{\text{Actual Rate-PPP Implied Rate}}{\text{PPP Implied Rate}}$$

Analysis of the Example

The example we reviewed above indicates that given relative inflation levels in the US and Brazil, the fair value of USD/BRL is around USD/BRL as of April 2011. However, it seems to be that the market if defying PPP and, the USD is traded against BRL as low as 1.5778.

Let's examine the medium to long term implications of this deviation from PPP:

First, Brazilian exporters will lose their clients in the US and possibly other markets because of escalating prices. In other words, Brazilian exporters become progressively less competitive internationally.

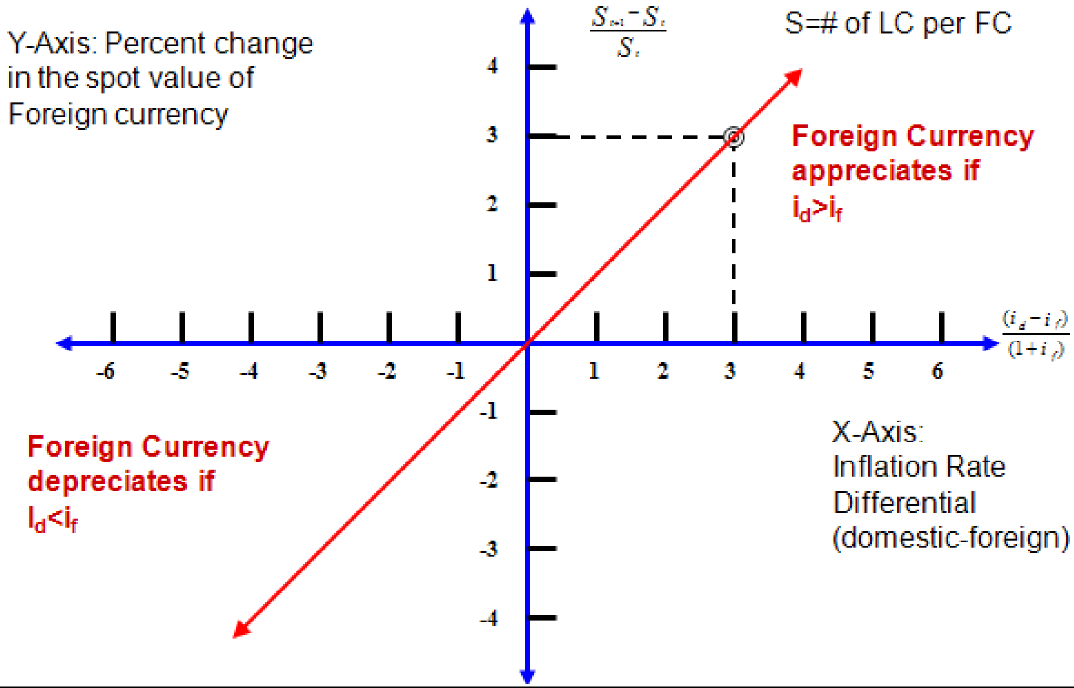
Second, as their currency appreciates, foreign goods will look cheaper, and imports will surge.

Third, the declining exports will mean lower demand for BRL, and the increasing imports will mean a surge in the supply of BRL. When these forces gather momentum, BRL will move from 1.5778 towards 2.000; eventually, at some point, Brazilian exports will be restored, and imports will decline.

Fourth, while the theoretical presentation of PPP implies that the inflation differentials are quickly incorporated into the exchange rates, in reality exchange rates deviate from PPP implied rates for a prolonged period of time for various reasons and, converge to their theoretical (fair) values over the medium to long run.

The cycles of overvaluation and undervaluation may last as long as 2-3 years in emerging economies and, 5 to 7 years in developed economies. While corrections in developed economies are usually smooth, emerging economies may see abrupt changes at the peak of overvaluation.

Chart-1: Purchasing Power Parity Line



Source: Author

The red diagonal linear line in the chart shows the Purchasing Parity line. When exchange rate changes are consistent with PPP, we expect to see percentage exchange rate changes on the line. Given domestic and foreign inflation rates, if the exchange rate change is above the line, the local currency is undervalued. If the exchange rate change is below the line, the exchange rate is overvalued.

4. Fisher Effect or Fisher Relation

Fisher effect describes a relationship among nominal risk free interest rates, inflation and real interest rates.

i=Nominal risk-free interest rate (i in the textbook)

r*=Real interest rate

π=expected inflation

According to Fisher Effect, these three variables are connected by the following relationship:

$$i = r^* + \pi + r^* \times \pi$$

The expression above is derived from the following definition of nominal interest rates:

$$(1+i) = (1+r^*) \times (1+\pi)$$

This simple relationship indicates that nominal risk-free interest rates are composed of real interest rates and inflation expectations or inflation premiums. In other words, nominal rates are determined by real interest rates and expected inflation rates.

When an average investor invests in a risk-free investment instrument such as a treasury bill, investor at least expects to preserve his or her future consumption power. This requires compensation for expected inflation. This drive to preserve consumption power explains why "I" or inflation premium is part of the Fisher equation. Would preserving consumption power be sufficient? Probably not! Since the investor in question postpones its consumption to the future, he/she may also expect to increase his/her consumption power in real terms. This expectation explains why "r" is the part of the equation. When we define the relationship as follows

$$(1+i) = (1+r^*) \times (1+\pi)$$

a third term enters into the picture which is what we call the "cross term" which is a product of r and i. Since this term is usually small when inflation expectations and real rates are small, most sources describe the Fisher relationship by ignoring the cross term. If we ignore the cross term the relationship changes from a price form to an approximate form:

$$i = r^* + \pi + r^* \times \pi \rightarrow i = r^* + \pi$$

Note that r*+π is only an approximation and it is acceptable when r and π are both small. Unless you are told otherwise, I would recommend you to stick with the accurate version.

Fisher Effect or Fisher relationship allows us to determine the third variable if we know any of the two variables out of three. In other words, we can determine what the nominal risk-free rate should be if we are given the real rate and inflation rate. Alternatively, you can calculate real interest rates if you are given estimates of inflation premium and nominal risk-free interest rates. A simple example may help you to understand this better:

Example

1 year US T-Bill rate is 5%. Expected inflation for the year is 1.8%. What should be the real interest rate in the US?

Answer:

If we use the Fisher Relationship given as (1+R)=(1+r)x(1+i) and plug in the known variables, we can solve it for "real interest rate." Note that Treasure Bill yield represents nominal risk-free interest rate R=5%; inflation expectation "i" is 1.8% and real interest rate can be calculated as:

$r^*=[(1+i)/(1+\pi)]-1=[(1.05)/(1.018)]-1=3.1\%$

We should emphasize an important observation here: Out of the three variables we used above only one of them, i.e., the nominal risk-free interest rate is directly observable. Inflation premium is an expectation that is implied in Treasury Inflation Protected Securities (TIPS)[2]. Real interest rates are implied in nominal risk-free interest rates.

Fisher Effect indicates that nominal risk-free interest rates across the world would differ simply because inflation expectations and real interest rates would differ. As we well know, inflation expectations are shaped by fiscal and monetary policies followed by the governments and they are influenced by domestic priorities, economic philosophies, etc. In other words, it is clear that inflation rates and future inflation expectations vary across countries. It is possible to make a similar argument about real interest rates. Depending on domestic supply and demand for capital, real rates may vary. For instance, it is plausible to think that in a country with abundant savings and relatively weak demand for investments, real compensation for savings to be low. In contrast, insufficient domestic capital accumulation and substantial need for capital investments suggest higher expected real compensation for savings. If countries are segregated, these differences will persist and real interest rates would be different across countries. However, we know that this is not the case in reality. Capital is mobile and moves around the world. If we take an extreme position and assume full mobility of capital, how would our previous conclusion about real interest rates

[2] Treasury Inflation-Protected Securities, or TIPS, provide protection against inflation. The principal of a TIPS increases with inflation and decreases with deflation, as measured by the Consumer Price Index. When a TIPS matures, you are paid the adjusted principal or original principal, whichever is greater. By comparing prices of TIPS and equal maturity Treasury yields, we can derive market's expectation of inflation for a given investment horizon.

change? Under the assumption of full capital mobility, and perfect markets we would expect the differences in real interest rates across the world to disappear. This will happen through an arbitrage mechanism that we explored in the context of purchasing power parity. In this case, arbitrage will take place in capital markets, and capital will move from low real interest rate countries towards high real interest rate countries. In the process, capital shortage in low real interest rate markets will push the real rates up, and abundance of capital in high real interest rate markets will push the real interest rates down. Consequently, real interest rates will converge. Therefore, under perfect capital mobility it is plausible to assume that that real interest rates across the countries are equal to each other. More specifically we can assume that

$$r_d^* = r_f^*$$

The above condition holds under perfect capital mobility and efficient market assumptions. If real interest rates deviate from equality, arbitrage should enforce the real interest rates to converge and eventually be equal.

While this conclusion will be used to derive new parity relationship, in plain English it means that under perfect capital mobility and efficient markets assumptions, observed differences in nominal interest rates

5. International Fisher Effect or Uncovered Interest Parity

In the asset market approach, each currency is viewed as an investable asset. This approach works with the following assumptions:

- Markets are Efficient
- Foreign and Domestic Assets are perfect substitutes (you prefer the one that offers higher return)

Let's start with the assumption that there are foreign and domestic risk-free assets! The "Efficient Market Hypothesis" suggests that assets with equal risk, should offer equal returns when returns are measured in a common currency (you should remember this phrase from low of one price!) In other words, foreign risk free investments should offer returns that are equal to domestic risk free returns when returns are calculated in domestic currency terms!

For instance, an American investor should earn the same dollar returns on its Euro-denominated risk-free investments as he/she would earn from a US Treasury investment when returns are calculated in USD. This follows that dollar return on Euro risk-free bond investment:

$$i_{\$}^{€} = (1 + i_{€}) \times \left(\frac{S_1}{S_0}\right) - 1$$

where S=dollars per euro and S_1/S_0=(1+%change in Euro)

EMH stipulate that $$i_{\$}^{€} = (1+i_{€})\times\left(\frac{S_1}{S_0}\right) - 1 = i_{\$}$$

At the time of investment, all variables but S_1 is unknown. This suggests that according to EMH, there is only one justified expected future spot rate S_1, and this can be derived from the above condition.

$$i_{\$}^{€} = (1+i_{€})\times\left(\frac{S_1}{S_0}\right) - 1 = i_{\$} \rightarrow (1+i_{€})\times\left(\frac{S_1}{S_0}\right) = (1+i_{\$}) \rightarrow S_1 = S_0 \times \frac{(1+i_{\$})}{(1+i_{€})}$$

Note that the only exchange rate that would not violate EMH is S_1 which is given as:

$$S_1 = S_0 \times \frac{(1+i_d)}{(1+i_f)}$$

Note that the subscript for dollar and Euro was replaced with d and f which respectively represent domestic and foreign. Let's illustrate the concept by using an example:

Example:

Assume that following one-year risk-free interest rates and spot rate prevails in the market at time t=0. What is your best estimate of S_1 based on IFE?

$i_{\$}$= 5%
$i_{€}$=10%
S_0=1.4
S_1=?

<u>Answer:</u>

The question practically asks us to identify the expected future spot rate that would equate the returns in USD and EUR risk-free investments over a year period.

$$S_{t+1} = S_t \times \frac{(1+i_d)}{(1+i_f)} = 1.4 \times \frac{(1+0.05)}{(1+0.1)} = 1.3364$$

<u>Analysis:</u>

Given the current spot rate of \$1.4000 per Euro and risk free interest rates at time T=t, the exchange rate 1.3364 (the expected spot rate at time T= t+1) makes risk free returns in the US and Eurozone equal.

Proof:

Dollar Return from Eurozone risk-free investment:

$$i_{\$}^{€} = (1+i_{€}) \times \left(\frac{S_1}{S_0}\right) - 1 = i_{\$} \rightarrow (1+0.1) \times \left(\frac{1.3664}{1.4000}\right) - 1 = 5\% = i_{\$}$$

This is exactly the same return we would earn by investing in the US risk-free asset!

An additional Insight:

We can view an American investor's investment in a risk-free asset in Europe in two pieces:

1) An investment into Euro-denominated risk-free asset that would yield a return of $i_{€}$
2) An investment in Euro that would yield a return of S_1-S_0/S_0

Dollar returns will be determined by a combination of these two returns, i.e. return on Euro risk-free asset will be:

$$i_{\$}^{€} = [(1+\text{Euro Return}) \times (1+\%\Delta \text{ in Euro})]\text{-}1\text{=}(1+i_{€}) \times \left(\frac{S_1}{S_0}\right) - 1$$

Deriving IFE from PPP and Fisher Effect:

The expected future spot rate is given as: $S_1 = S_0 \times \frac{(1+\pi_d)}{(1+\pi_f)}$

Domestic and foreign risk-free nominal interest rates are given as follows:

$$(1+i_d) = (1+r_d^*) \times (1+\pi_d)$$

$$(1+i_f) = (1+r_f^*) \times (1+\pi_f)$$

We can express the gross inflation rates in the domestic and foreign markets in the following form:

$$(1+\pi_d) = \frac{(1+i_d)}{(1+r_d^*)} \quad \text{and} \quad (1+\pi_f) = \frac{(1+i_f)}{(1+r_f^*)}$$

Using the above, we ca re-write the RPPP equation as follows:

$$S_1 = S_0 \times \frac{(1+\pi_d)}{(1+\pi_f)} = S_0 \times \frac{\left(\frac{(1+i_d)}{(1+r_d^*)}\right)}{\left(\frac{(1+i_f)}{(1+r_f^*)}\right)}$$

We argued that under full capital mobility $r_d^* = r_f^*$, accordingly in the above equation gross real interest rates are canceled and the equation can be written as:

$$S_1 = S_0 \times \frac{(1+i_d)}{(1+i_f)}$$

This the same equation we derived under the EMH assumptions with asset pricing approach.

Summary

Under certain assumptions, IFE offers a predictive tool to forecast future exchange rates based on current exchange rate, domestic and foreign nominal risk-free interest rates! By inputting nominal and foreign risk-free rates with respective maturities, forecasts of future expected exchange rates are obtained. The IFE implies that a high-interest rate currency depreciates against a lower interest rate currency in the future.

The model below is used to forecast exchange rate at t+1, when we are at time t. Inputs for the model are current exchange rate S_t, domestic risk-free interest rate i_d at time t with maturity t+1 and foreign risk-free interest rate i_f at time t with maturity t+1:

$$S_{t+1} = S_t \times \frac{(1+i_d)}{(1+i_f)}$$

Two simple variants of this model give us expected changes in foreign and domestic currency:

1) Restated IFE: Expected Change in Foreign or Base Currency:

$$\frac{S_{t+1} - S_t}{S_t} = \frac{(i_d - i_f)}{(1+i_f)}$$

2) Restated IFE: Expected Change in Domestic or Terms Currency:

$$\frac{S_t - S_{t+1}}{S_{t+1}} = \frac{(i_f - i_d)}{(1+i_d)}$$

Does IFE Hold in Practice?

The key message of the IFE is that higher interest rate currencies depreciate. This assertion is because of the simple conclusion that higher interest rates imply higher inflation rates under the assumption of equal real interest rates. If "equal real interest rates" assumption is violated, IFE loses validity and collapses as a predictive model. Empirical evidence suggests that IFE does not hold for highly traded currency pairs such as EUR/USD and USD/JPY. Indeed just the opposite is observed for such currency pairs, and higher interest rate currencies appreciate. A deeper look at these cases suggests that inflation premiums in these countries are close to each other and the nominal interest rate differentials are attributed to real interest rate differentials.

In contrast, IFE holds for emerging market currencies and some currency pairs that do not include US dollars. In these cases, nominal interest rate differentials are attributed to inflation rate differentials and risk premiums associated with government debt. Accordingly, higher nominal interest rate currencies depreciate.

As it was briefly mentioned above, one reason why IFE does not hold in practice is that real interest rates are not equal across countries! If that is the case, higher nominal rates may imply higher real interest rates. Higher real interest rates attract capital inflows and lead to the appreciation of the currency.

6. Interest Rate Parity

The forward rate is an exchange rate quoted for settlement at some future date. A forward contract states the exchange rate at which a foreign currency will be bought or sold forward at a specific date in the future.

Interest Rate Parity model establishes a strong linkage among spot rates, forward rates, and relative interest rates and it indicates that they are linked together by the following relationship where S_t is the spot rate at time t, $F_{t,t+1}$ is the forward rate at time t with maturity t+1, i_d and i_f are the domestic and foreign nominal interest rates from t to t+1

$$F_{t,t+1} = S_t \times \frac{(1+i_d)}{(1+i_f)}$$

Note that in the IRP, $F_{t,t+1}$ is the forward rate or forward price that can be transacted at time t, with a maturity of t+1. Since all variables in the model are observed at time t, it is a relationship that is enforced by arbitrage. In that sense, forward rate is not a mere forecast; it is a relationship that has to hold! If this relationship does not hold, arbitrage activity forces the relationship to hold!

Let's illustrate the concept with a simple example: Suppose we have the following information:

Spot Rate: USD/IDR 7,500 (7,500 IDR per USD)

Forward Rate: IDR 10,000 /USD

$$i_{USD} = 5.00\%$$
$$i_{IND} = 40.00\%$$

Given the data, does Interest Parity Hold? To answer the question, we need to check if the quoted forward rate is consistent with IRP:

One year theoretical forward rate established by IRP is given as:

$$F_{t,t+1} = S_t \times \frac{(1+i_d)}{(1+i_f)} = 7,500 \times \frac{(1+0.4)}{(1+0.05)} = 10,000$$

This theoretical rate is consistent with the one-year forward rate in the market which is trading at USD/IDR 10,000.

What does this mean besides the validation of the relationship just explored? This means that a US investor would earn 5% "dollar return" on T-Bill investments, whether the investment is in the US T-bills or Indonesian T-Bills! In other words, the forward rate quoted in the market is consistent with IRP, returns measured in a common currency are equalized. To put it another way, forward rate acts as a return equalizer. Let's see this first hand by following up the above example:

Assuming that we can invest both in the US and Indonesian T-Bills, we will explore each in turn with a $1 million available to us to invest in either market:

<u>A: Investment in US T-Bills:</u>

Step-1: Invest $1,000,000 in US T-bills

Step-2: 1 year later you will have: $1,000,000(1+0.05)

=$1,050,000 or 5% return on investment

B: Investment in Indonesian T-Bills

Step-1: Buy spot IDR at 7,500 → 1,000,000 x 7,500 =IDR 7,500,000,000

Step-2: Invest IDR 7,500,000,000@40% → get 10,500,000,000

Step-3: Sell IDR proceeds forward to get back to USD @IDR10,000/$

10,500,000,000 /10,000 =$1,050,000

Step-4: Calculate Return in USD =($1,050,000/1,000,000)-1

= 5% return in USD

We can also calculate the dollar return on Indonesian T-Bill investment as follows:

$$i_{\$}^{IND} = (1+i_{IND})\times\frac{S}{F}-1 \rightarrow i_{\$}^{IND} = (1+0.4)\times\frac{7,500}{10,000}-1 = 5\%$$

Although Indonesian T-bills offer 40% return versus 5% return offered by US T-bills, when we calculate returns in USD, our dollar returns turned out to be exactly 5% as we would earn in the US.

The IRP indicates that the percentage spread between the forward rate and the spot rate within the investment horizon should equalize the returns earned from investments in two equal risk assets. For instance, in this example, US investor, who earned 35% extra return on Indonesian T-bills, lost this extra return when he/she converted IDR proceeds back to USD. In other words (F-S/S), USD forward premium is such that, our investment in Indonesian T-bills earns 5% return in dollar terms. This is an equilibrium condition, and it is consistent with the efficient markets argument suggesting that equal risk investments should provide equal returns when measured in a common currency!

Let's consider the same example with slightly different data:

Spot Rate: USD/IDR7500

Forward Rate:USD/ IDR 8,000

R_{USD}: 5%

R_{IDR} :40%

Theoretical forward rate:

$$F_{t,t+1} = S_t \times \frac{(1+i_d)}{(1+i_f)} = 7,500\times\frac{(1+0.4)}{(1+0.05)} = 10,000$$

One year forward contract trades in the market at USD/IND8,000. In this case, Parity does not hold! What is the implication of the deviation from IRP or theoretical forward rate? This deviation means that dollar return on US T-Bill and Indonesian T-Bill investments will not be equal anymore! Let see this by following up the example:

Suppose we can borrow up to $1,000,000 at 5% interest:

Step-1: Borrow 1,000,000 for one year at 5% → Payback $1,050,000

Step-2: Exchange $1,000,000 into IR7,500 → IDR 7,500,000,000

Step-3 : Invest IDR7,500,000,000 @40% → get 7,500,000,000 x (1+0.4)

=IDR10,500,000,000

Step-4: Sell expected proceeds forward @IDR8,000

USD Proceeds from forward sale in one year=10,500,000,000/8,000=1,312,500

USD Gross Return: (1,312,500/1,000,000)-1=31.25%

Step-5: Pay principal and interest in USD 1,050,000,

net profit = 1,312,500-1,050,000=262,500

Note that the profit $262,500 is locked in at T=0, at the maturity, after all, trades settled, $262,500 was collected. Anybody with access to loans and Indonesian money and currency markets can generate net arbitrage profit of $262,500. What happens if many banks and hedge funds spot this opportunity and pour money into this trade to make profits?

1) Demand for IDR leads to an appreciation of IDR (less IDR per dollars are received)

2) Theoretically dollar borrowing rate should go up, and IDR treasury rate should come down. But these are unlikely to happen in practice as these trades will be too small for the size of the market!

3) Increasing forward sales of IDR depreciates the forward rate, and investors receive fewer dollars at the end of the year.

All three changes collectively reduce the arbitrage profits, and some point no more gains are left.

The transactions described above is referred to as "Covered Interest Arbitrage." The term covered implies that by entering into a forward contract, interest rate advantage is preserved or "covered." If a forward contract were not entered at time T=0, the arbitrage would be "uncovered," and Indonesian Rupee proceeds would be converted into USD at the spot rate prevailing at time T=1.

Although technically this does not qualify for arbitrage simply because of the assumed currency risk, such trades are referred to as "Uncovered Interest Arbitrage."

Summary:

In international money and currency markets, the interest rate differential between two currencies approximately equals the percentage spread between forward and spot rates. If this is not the case, traders have an opportunity to earn arbitrage profits.

How Covered Interest Arbitrage Opportunities are Identified:

How do we identify Covered Interest Arbitrage opportunities? It is simple, all we have to do to check if the IRP holds. A more practical way to check the IRP requires a simple variation of the model. We can re-write the IRP condition as:

$$\frac{F_{t,t+1} - S_t}{S_t} \times \frac{360}{d} = \frac{(i_d - i_f)}{(1 + i_f)}$$

This relationship is a different expression or formulation of the same relationship we mentioned above. The left-hand side of the equation shows the expected percentage change in the exchange rate in annualized terms[3]. This also implies the gain or loss encountered when foreign currency is bought at the spot and sold at forward. This percentage spread between spot and forward rate is referred to as "forward premium" or "forward discount."

If the forward rate of the foreign currency is higher than the spot rate, purchasing the foreign currency at the spot rate and, selling it at the forward rate generates a loss in local currency terms. This suggests a forward premium for the foreign currency and a forward discount for the local currency.

If the forward rate of the foreign currency is smaller than spot, buying the foreign currency spot and selling it forward generates a gain. This is called "forward discount" of the foreign currency and, the "forward premium" of the local currency.

The right-hand side in the equation shows the net interest rate differential. When interest rate parity holds, investing in a higher nominal interest rate currency does not provide any advantage over investing in lower interest rate currency, because any differential interest rate earned in higher interest rate currency is lost because of an equal forward discount of the higher interest rate currency. However, when the interest rate parity does not hold, one can generate arbitrage profits.

An example may further clarify the discussion:

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[3] This is also referred to as forward premium or discount with proper time adjustment.

Example:

Suppose you can borrow \$2m or JPY220.4m. Given the following data, explore if IRP holds and determine if there is a profitable covered interest arbitrage opportunity.

Assumptions	Value	Yen Equivalent
Arbitrage funds available	\$2,000,000	JPY 220,400,000
Spot rate (USD/JPY)	110.20	
180-day forward rate (USD/JPY)	109.80	
180-day U.S. dollar interest rate	3.000%	
180-day Japanese yen interest rate	1.800%	

Let's check the IRP condition first:

$$\frac{F_{t,t+1} - S_t}{S_t} \times \frac{360}{d} = \frac{(i_d - i_f)}{(1 + i_f)}$$

Left-hand side gives us the premium or discount of the foreign currency. In the example, foreign currency is USD because we express 1 unit of USD in terms of JPY.

$$\frac{109.8 - 110.20}{110.20} \times \frac{360}{180} = -0.0072 \neq \frac{0.018 - 0.03}{(1 + 0.03)} = -1.16\%$$

Left-hand side indicates that USD has [(109.8-110.20)/110.20]x(360/180)=-0.7259% forward discount. This means that if you borrow JPY, buy USD, and sell dollars forward, you incur a 0.72% loss. On the other hand, the right-hand side of the equation shows that the net interest rate differential is 1.16% in favor of USD. These observations indicate that IRP does not hold, and there is an arbitrage opportunity. Now, how can we take advantage of this deviation?

Obviously, USD offers a higher return as compared to JPY. The key issue is whether by investing in USD can we keep the interest rate advantage after accounting for a round-trip transaction from

JPY to USD and back to JPY. The forward discount we calculated above suggests that we will lose about 0.73% in this roundtrip transaction. However, interest rate differential that we calculated suggests that we can generate a 1.16% net interest rate benefit after accounting for JPY borrowing costs. With this, we can conclude that borrowing in JPY and investing in USD would provide arbitrage profits. If the USD discount were larger and, it exceeded 1.16% net interest rate advantage, this would not be possible!

Now let's review the steps of the arbitrage:

1. Borrow JPY 220,400,000 due in 180 days
   220,400,000*[(1+(0.018)*(180/360))][4]=222,383,600

2. Buy USD 2,000,000 at 110.20

3. Invest USD @ 3% for 180 days 2,000,000 [1+(0.03*(180/360))]=2,030,000

4. Sell Proceeds forward at T=0 @109.80 to get
   2,030,000*JPY109.80=JPY222,894,000

5. Payback JPY principle and interest: 222,383,600

6. Net Profit: JPY222,894,000-222,383,600=JPY510,400

Note that in this transaction, return on USD investment in JPY terms is:

$$i_{JPY} = (1 + i_{USD}) \times \left(\frac{F}{S}\right) - 1$$

$$i_{JPY} = \left(1 + 0.03 \times \frac{180}{360}\right) \times \left(\frac{109.80}{110.20}\right) - 1 = 1.13\%$$

This is higher than the cost of borrowing for 180 days, which is 1.8 x (180/360)=0.9%. The difference explains the net arbitrage profit of JPY510,400 . If the forward discount on USD were higher, this arbitrage profit could not be generated!

[4] Please note that we adjusted the interest rate for 180 days. Interest rates are quoted in annualized terms, and we need to make adjustments for shorter or longer periods by using the factor (d/360) where d indicates maturity in days.