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Exchange Rate Terminology and Analytics

The level of and fluctuations in exchange rates have an important influence on firm performance. But the terminology and mechanisms by which shifts in exchange rate affect firms are not well understood. This note introduces the reader to the language, conventions, and basic analytics that are used to describe exchange rate fluctuations. It is organized into three sections:

- What is an exchange rate?;
- Measuring currency appreciation and depreciation; and
- Nominal and "real" exchange rates (with examples).

What is an Exchange Rate?

An exchange rate is the price of a currency measured in terms of another currency. That is, how much of one currency could you purchase with one unit of another currency. For example, in mid-February 2001, one US dollar could purchase 1.106 Euros, 9.68 Mexican pesos, or 0.6894 British punds. Each of these figures is the local currency *price* of one USD. **Table A** lists a sample of exchange rates from February 15, 2001:

Table A
Exchange Rates (Feb. 15, 2001)

Country	Currency per USD	USD per Currency	Country	Currency per USD	USD per Currency
Brazil	1.9890	0.5028	India	46.575	0.02147
Britain	0.6894	1.4505	Japan	115.44	0.00866
Canada	1.5298	0.6537	Kuwait	0.3064	3.2637
China	8.2772	0.1208	Mexico	9.6800	0.1033
Euro	1.1060	0.9042	Poland	4.1095	0.2433
Germany	2.1632	0.4623	Venezuela	703.25	0.001422

Source: The Wall Street Journal, Feb. 16, 2001, page C 13.

There are several points worth noting about how exchange rates are quoted. These are:

1. *Exchange rates are often, but not always, quoted as a ratio of local currency and U.S. dollars.* This convention comes from the dollar's widespread use as a unit of account in international trade and investment, and because of its role as a reserve currency for many central banks.

Professor Robert E. Kennedy prepared this note as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

There is nothing magical about dollar exchange rates; any currency can be quoted in terms of any other. This is common in the EU, where currencies are quoted relative to the German deutschemark or the Euro. Exchange rates between any two currencies can be calculated if their exchange rates in a common currency are known. For example, if we know the USD exchange rate of the Polish zloty (PZL) and the German deutschemark (GDM), the PZL–GDM exchange rate can be calculated as follows:

$$\frac{PZL}{GDM} = \frac{PZL/USD}{GDM/USD} = \frac{4.1095}{2.1632} = 1.8997\ PZL/GDM$$

2. *In most cases, exchange rates are quoted as a ratio greater than one.* This means that currencies with less purchasing power than one USD are quoted as currency per dollar (e.g. 1.53 Canadian dollars per USD or 115 Japanese yen per USD). Currencies that have more purchasing power than a dollar are often quoted as USD per local currency unit (e.g. 1.45 USD per British pound or 3.26 USD per Kuwaiti dinar).

   This is merely a convention. Switching from one unit to the other (e.g. from currency/USD to USD/currency) is done by taking the inverse of the relevant exchange rate. That is:

$$\frac{\text{USD}}{\text{Renminbi}} = \frac{1}{\text{Renminbi/USD}} = \frac{1}{8.2772} = 0.1208$$

   That is, one renminbi is equal to 12.08 cents and one dollar is equal to 8.2772 renminbi.

   When performing calculations involving exchange rates, it is important to ensure that you use the proper measure (USD per currency or currency per USD).

Measuring Currency Appreciation and Depreciation

Currencies often fluctuate in value. Such fluctuations are commonly referred to as either an *appreciation* (*revaluation*) and or a *depreciation* (*devaluation*). Because of differences in the ways that currencies are quoted, a devaluation might involve either an increase or decrease in the quoted exchange rate. When discussing changes in the value of a currency, it is best to think in terms of foreign currency per local currency unit (e.g. USD/British pound when measuring shifts in the value of the pound or French Francs/deutschemark when considering shifts in the DM).

Why? Because, as with other items, the item whose price/value is being measured appears in the denominator of the price ratio you use to measure its value. When we quote the price of a Snickers bar, we give the price in ¢/bar–say 50¢/bar. You could quote the price as two bars/dollar. If the price remained stable, little confusion would result. If, however, the exchange ratio changes to one bar per dollar, we would say the price of a Snickers bar has increased. This is intuitive when using the ¢/bar measure—it goes from 50¢/bar to 1--¢/bar. It is less intuitive when using the bar/$ measure. The exchange ratio goes from two bars/$ to one bar/$. The quoted exchange ratio declined, although the value of the Snickers bar increased. Therefore, it is generally easiest to perform calculations using an exchange ratio your object of interest in the denominator.

The same practice should be applied when measuring shifts in the value of a currency. The percentage change in the value of a currency should ***always*** be measured using foreign currency per local currency measures.

Appreciation A currency is said to "appreciate" (or be revalued) when it increases in value. This means that it can be used to purchase more foreign currency units or goods. Such a shift has the effect of making foreign produced goods and services appear cheaper. For example:

- If the exchange rate for British pounds changes from 1.45 USD/£ to 1.60 USD/£ , it would have appreciated. That is, it takes more dollars to purchase a pound. This appreciation makes U.S.-produced goods and services appear to be less expensive to potential buyers holding British pounds. Before the revaluation, a British firm with £1 million could purchase USD 1.45 million worth of goods. After the revaluation, it could afford more U.S. goods (USD 1.60 million). Alternatively, purchasing USD 1.45 million of goods would cost only £906,000 after the appreciation.

- A shift in the yen–dollar rate from 115 to 90 yen/dollar is also an appreciation because. the convention is to quote the yen/USD rate. This change is an appreciation because one yen buys more dollars after the revaluation than before ($0.0087 before vs. $0.011 after). A firm with one million yen could afford to purchase goods worth about USD 8700 before the shift, but could purchase more than USD 11,000 of goods after the shift.

Devaluation A currency is said to be "devalued" (alternatively, "depreciated" or "lower") if it declines in value. This has the effect of making foreign produced goods and services appear more expensive; a given quantity of local currency can purchase fewer foreign currency units or goods. Staying with the examples from above, if the USD/£ rate went from 1.45 to 1.33, the pound would have lost purchasing power relative to the dollar and USD denominated goods and services would appear more expensive to people holding pounds. A change in the yen–USD rate from 115 to 150 would also be a devaluation.

Measuring Appreciation and Depreciation

Currency fluctuations are commonly discussed in percentage terms; but the figures cited can be confusing. Consider the value of the Polish zloty. At year-end 1988, the exchange rate was 502 zloty per dollar. In January 1990, the rate was fixed at 9,500 PZL/USD. The zloty was worth much less, but how much less? We could calculate the percentage change in the PZL/USD rate (1792%) and cite this as the magnitude of the devaluation. In fact, this is often done in news accounts, but it is misleading and can lead to incorrect calculations.

The proper method is to convert to USD/PZL figures and then calculate the shift in value. Before the devaluation, the zloty was worth about $0.001992 (1/502). Afterward it was worth about $0.000105 (1/9500). This means that the zloty lost 94.7% of its value, and thus went through a 94.7% devaluation.

A related, and very important point, is that percentage changes in the value of a currency are multiplicative, not additive. This means that a devaluation followed by an equal percentage appreciation does not leave the value of the currency back at the starting point. Consider a shift in the Mexican peso/USD exchange rate.

Q1: If the peso/USD rate goes from 4 to 8, what has happened to the value of the peso?	A1: It experienced a 50% devaluation, from 25¢/peso to 12.5¢/peso.
Q2: How would you describe the movement of the USD?	A2: It appreciated by 100% against the peso, from 4 peso/USD to 8 peso/USD.
Q3: How much would the peso have to appreciate to get back to its original level?	A3: It would have to appreciate by 100%, from 12.5¢/peso to 25¢/peso. A 50% appreciation would leave it at only 18.75¢, or 75% of its original level.

Nominal and "Real" Exchange Rates

A final important concept is the distinction between nominal exchange rates and "real" exchange rates. A nominal exchange rate is the rate at which you can exchange one currency for another. Nominal rates are quoted in the paper and posted at foreign exchange kiosks. "Real" exchange rates are, in fact, much more important for businesses operating across borders. They provide an inflation-adjusted measure of a currency's purchasing power.

Why adjust for inflation? Because both inflation and nominal exchange rate movements affect a firm's cost position relative to international rivals. The real exchange rate is a method for measuring the combined effect of these two factors. While the real exchange rate is not widely reported, it is a vitally important concept to understand.

Consider the following scenario involving two Coca Cola bottling plants, one located in Germany and the other in Poland. Each plant incurs local currency costs and attempts to sell in both countries.[1] The desired gross margin is 20% of sales (or 25% over production costs).

The Base Case

Exchange rate: 2 PZL/DM		German Plant:	Polish Plant:
	Cost/can	1 DM	2 PZL (= 1 DM)
	Price/can	1.25 DM	2.5 PZL (= 1.25 DM)

With an exchange rate of 2 PZL/DM, neither firm has a cost advantage over the other, and each will likely focus on capturing sales in its home market.

Variation 1: A 20% Nominal Zloty Appreciation

A 20% nominal zloty appreciation means that the value of a zloty rises from 0.5 DM/PZL to 0.6 DM/PZL. Alternatively, the PZL/DM rate drops from 2.0 to 1.67. This shift changes the competitive dynamic between the two firms.

Exchange rate: 1.67 PZL/DM		German Plant:	Polish Plant:
	Cost/can	1 DM	2 PZL (= 1.2 DM)
	Price/can	1.25 DM (= 2.09 PZL)	???

The zloty appreciation creates a significant cost disadvantage for the Polish plant—its costs remain at 2 PZL/can, but this is now 20% higher than its German rival's costs when measured in DM. The German plant is now well positioned to sell Coke in Poland.

When viewed in zloty terms, the price of German–produced Coke is only 2.09 PZL. The Polish firm is faced with a choice of either cutting its prices (and profit margins) to compete or losing sales to the German firm.

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[1] I use Coca Cola as an illustration because the product is sold around the world with very little customization for local markets. In reality, Coca Cola bottling plants are allowed to sell only in a designated geographic region, which is almost always within one country.

Variation 2: 20% Inflation in Poland; No Change in the Nominal Exchange Rate

Now consider a second scenario. Assume the exchange rate is once again 2.0 PZL/DM, but that Poland has experienced 20% inflation during a period when Germany had no inflation. The competitive positions of the two firms has again shifted.

Exchange rate: 2 PZL/DM		German Plant:	Polish Plant:
	Cost/can	1 DM	2.4 PZL (= 1.2 DM)
	Price/can	1.25 DM (= 2.5 ZPL)	???

The Polish plant's costs have increased by 20%, to 2.4 PZL per can. With the nominal exchange rate stable, the Polish firm again has a cost disadvantage. In fact, the effect is exactly the same as with the nominal appreciation. The Polish plant's production costs are 20% higher than the German firm's costs. As with the currency appreciation, the Polish firm must either reduce margins or risk losing volume.

Variation 3: 20% Inflation in Poland with an Offsetting Nominal Devaluation

Now consider a situation with both inflation and an offsetting devaluation—in this case 25% Polish inflation offset by a 20% zloty devaluation. (Note that a 20% devaluation offsets 25% inflation). Inflation raises the Polish plant's costs from 2.0 to 2.5 PZL/can. The 20% devaluation means that the DM/PZL exchange rate goes from 0.5 to 0.4, and the PZL/DM rate goes from 2.0 to 2.5.

Exchange rate: 2.5 PZL/DM		German Plant:	Polish Plant:
	Cost/can	1 DM	2.5 PZL (= 1 DM)
	Price/can	1.25 DM	3.12 PZL (=1.25 DM)

With local inflation and an offsetting devaluation, there is no competitive effect. When measured in either DM or PZL, Polish and German costs are equal and neither firm has a cost advantage. This means that the *real exchange rate* is unchanged.

Calculating the Real Exchange Rate

The real exchange rate measures how inflation and nominal shifts in a currency's value affect firms' competitive position. The real exchange rate is generally quoted as an index number, relative to some base year which is set at 100.

As we have seen above, both nominal appreciation and domestic inflation raise the *real* of a currency. These factors make it more difficult for domestic firms to compete for sales, both at home and abroad. Nominal devaluation and deflation (which is rare) lower the value of a currency, making it easier for domestic firms to compete at home and abroad.

The formula for calculating the real exchange rate for country X relative to country Y involves the following steps:

1. Start with the RER index for time (T-1). If this is the first year, set RER_{t-1} to 100.

2. Multiply by the ratio of the countries' inflation rates. Higher inflation in country X raises the real exchange rate by the ratio of (1 + the inflation rates). When inflation in country Y exceeds that in country X, the RER is lowered.

3. Multiply by the change in the nominal value of the currencies. A nominal appreciation raises the real exchange rate while a nominal depreciation lowers it.

$$\mathrm{RER}_{x,t} = \mathrm{RER}_{x,(t-1)} * \frac{(1+\mathrm{infl}_x)}{(1+\mathrm{infl}_y)} * \left[\frac{\mathrm{ExRate}(y/x)_t}{\mathrm{ExRate}(y/x)_{t-1}} \right]$$

Three examples illustrate how, even with nominal exchange rate volatility, the real exchange rate can remain unchanged, rise, or fall.

Example 1: Assume Polish inflation of 25%–compared with 0% in Germany–and that nominal devaluation of the zloty is 20%:

$$\mathrm{RER}_{P,1} = RER_{p,0} * \frac{(1.25)}{(1.0)} * \frac{(0.4)}{(0.5)} = 100 * 1.25 * 0.8 = 100$$

As was illustrated with variation three above, the real exchange rate is unchanged, at an indexed value of 100.

Example 2: Assume that Polish inflation is 50%–compared with 0% in Germany–and that nominal devaluation is 20%:

$$\mathrm{RER}_{P,1} = RER_{p,0} * \frac{(1.5)}{(1.0)} * \frac{(0.4)}{(0.5)} = 100 * 1.5 * 0.8 = 120$$

The real exchange rate has risen by 20%, from 100 to 120.

Example 3: Assume that Polish inflation is 10%–compared with 0% in Germany–and that nominal devaluation is 20%

$$\mathrm{RER}_{P,1} = RER_{p,0} * \frac{(1.1)}{(1.0)} * \frac{(0.4)}{(0.5)} = 100 * 1.1 * 0.8 = 88$$

The real exchange rate has fallen by 12%, from 100 to 88.