Handout #3
Exchange Rates
Introduction

An exchange rate, as previously presented in Handout #1, is the price of one currency in terms of a second that is determined by the familiar forces of demand and supply. Like the prices of other highly liquid assets (e.g., stocks and bonds), exchange rates fluctuate by the second in response to the ongoing shifts in demands and supplies. Whereas the trading of many stocks and bonds is limited to a particular stock or bond exchange (e.g., the New York Stock Exchange), there are several major foreign exchange markets around the world (e.g., New York, Frankfurt, Tokyo).

3.1 Exchange Rates and Arbitrage

If one finds that the ¥/$ exchange rate is 100 in the New York foreign exchange market, one would expect the same $ to prevail in all other foreign exchange markets around the world. To understand the financial reasoning behind this expectation, conduct the thought experiment of imagining that there was a second market where the exchange rate differed, e.g., assume that $/¥ = 110 in Tokyo. With the different $/¥’s at the different locations, a profit making opportunity exists, i.e., an arbitrage opportunity exists. Arbitrage is the purchase of something in one market and the immediate (if not simultaneous) resale of it in a different market where the price is higher. Given the above exchange rates in New York and Tokyo, arbitrage would take place in the form of buying ¥ with $’s in Tokyo, while selling ¥ for $’s in New York. I.E., $1 sold in Tokyo receives ¥110, which is then used to purchase $1.10’s in New York. Note the profit of 10 cents in this example was earned in a split-second. This kind of profit assures that arbitrage takes place anytime the exchange rate differs in different locations. Furthermore, the arbitrage activity will dependably drive exchange rates from different markets toward each other.

Continuing with the example, all those arbitrageurs selling $’s in Tokyo will cause the $/¥ to fall from 110, while all the buying of $’s in NY will push up $/¥ from its level of 100. As long as a difference between the two exchange rate exists, arbitrage will occur that causes the two rates to converge.

Arbitrage is a very strong, important, and predictable force in financial markets. Another consequence of arbitrage in currencies is cross-rate parity. Cross-rate parity exists when the exchange rate between currencies x and z, is equal to the product of the exchange rate between x and y and the exchange rate between y and z. For example, if $/£ = 210 and £/¥ = 0.50, then cross-rate parity would exist when $/¥ = ($/£)(£/¥) which in this case is 105. To demonstrate what would happen if cross-rate parity did not hold at a particular moment, assume that $/£ = 210 (in Tokyo), £/¥ = 0.5 (in New York), but $/¥ = 110 (in London). This combination of exchange rates presents a situation in which selling a $ in London buys ¥110, while selling a $ in NY buys 0.5£’s which, when sold in Tokyo only commands ¥105; cross rate parity does not hold as $/¥ > ($/£)(£/¥). This presents an arbitrage opportunity, where the arbitrage involves selling $ for ¥ in London since the $ sells for more ¥ in London than when exchanging $ for ¥ via the NY and Tokyo markets. Each $ sold in London receives ¥110, which are traded for £0.524 in Tokyo, which then buys $1.048 in NY, generating nearly a nickel profit on every dollar that starts this loop. Arbitrage of this nature where three markets are involved is called triangular arbitrage.

Note that the triangular arbitrage opportunity depends on cross-rate parity not holding, and, once again, the arbitrage activity provides the force that pushes the three exchange rates to values where cross-rate parity holds. Continuing with the above example where $/¥ > ($/£)(£/¥),
all the arbitrageurs selling $’s in London would make London’s $/¥ fall, the selling of ¥ in Tokyo would make ¥/£ rise, and the selling of £’s in New York’s would increase £/$, all of which would lead to cross-rate parity among the three currencies.

3.2 Other Exchange Rate Measures

The exchange rate that has been presented to this point (e) is the working exchange rate at which currencies are actually traded. Its full title is the nominal spot exchange rate, where “spot” indicates it is the prevailing rate at the moment when currencies are traded, and “nominal” means that it is not adjusted to account for the effects of inflation on the real purchasing power of either of the currencies. As a source of information on economic and financial activity, the nominal spot exchange rate (e) has two major weaknesses. The first is that any e tells the price a currency only in terms of one other currency, as opposed to how it is doing in general against all other currencies. The second is that, as just mentioned, it does not correct for the effects of inflation that can mask the true price incentives behind international trade or investment. Alternative exchange rate measures can be calculated that correct for these weaknesses.

The Effective Exchange Rate ($\bar{e}$)

The Effective Exchange Rate ($\bar{e}$) is an index that reveals how the value of a currency changes over time – on average – compared to all other currencies. Calculating $\bar{e}$ requires specifying a base year (any year will do in this case) to serve as a reference point from which to gauge changes. The value of each exchange rate included in the country’s $\bar{e}$ is given in terms of its value compared to what it was in the base year. For example, if computing the $\bar{e}$ for the year 2003 when using 2000 as the base year, the ratio of $e_{2003}/e_{2000}$ is an important building block. If $e_{¥/S} = 88$ in 2003, when $e_{¥/S} = 80$ in 2000, then the ratio would equal 1.10, which indicates that the $ has appreciated by 10% since the base year (i.e., is 110% of its base year value). If the comparable ratio of £/$ exchange rates equaled 0.94, this reveals that the $ was worth 94% of its base year value against the £, or, in other words, the $ has depreciated by 6% between 2000 and 2003.

But to take a simple average of these ratios would generate a value that would be uninformative if not misleading. As an example, say that we wanted to know how the $ was doing on average versus just two currencies: the Canadian dollar ($C$) and Thailand’s bhat. If the $ appreciated by 10% since the base year against the $C$ (its ratio was 1.10) while also appreciating by 2% against the bhat (with a ratio of 1.02), then taking a simple average of these ratios would be 1.06, indicating that the $ appreciating by 6% on average against these two currencies. But given that the US has much more international activity with Canada than Thailand, the $’s appreciation against the $C$ is more important to the US economy and, therefore, should carry more weight than the change in the bhat/$ exchange rate when calculating this kind of measure.

Instead of being a simple average, the $\bar{e}$ is a weighted average where the weight assigned to the change in each exchange rate is determined by the importance of that country to the domestic country’s economy. A common way to assign these weights is to use the share of the country’s entire international trade that is conducted with that particular country. For example, when computing the $’s $\bar{e}$ for a particular year of interest ($\bar{e}_{¥/S}$), the weight associated with the appreciation/depreciation of the $ against each currency is the sum of US exports to and imports from that country, divided by the total volume of US exports plus imports. For example, the weight on the percentage change in the value of the $ relative to the $C$ is computed as
Due to the construction of these weights, it is necessarily the case that the weights for all a country’s trading partners sum up exactly to one. Once the weights are computed, the effective exchange rate for a particular year of interest (Y1) is calculated as

\[ \hat{e}_{Y1} = \sum w_i \times e_{Y1} / e_{BY} \text{ for all trading partner countries i} \] (3.1)

If, continuing with the above example, the US only traded with Canada and Thailand, in which 90% of US trade was with Canada \( (w^C = 0.9) \) and the remaining 10% with Thailand \( (w^T = 0.10) \). The effective exchange rate would be

\[ \hat{e}_{Y1} = (w^C = 0.9) \times 1.10 + (w^T = 0.10) \times 1.02 = 1.092 \] (3.2)

Thus, the effective exchange rate in this case indicates that the $ has appreciated by 9.2% on average against (in this case) its two trading partners currencies since the base year. Table 3.1 provides other sample numbers and provides the associated \( \hat{e} \)'s.

Consider another case in which the \( \hat{e} \) for a particular currency was computed to be 1.70. This would relate that the currency was worth 70% more, on average against its trading partners’ currencies, than it was in the base year. If the \( \hat{e} \) the following year was 1.87, then the \%\( \Delta \hat{e} \) indicates the currency appreciated by 10% on average against its trading partners during the year.

**Real exchange rates (\( e \))**

When it comes to CA activity, it is not the value of one currency in terms of a second that matters, it is the value of one country’s goods in terms of the other country’s goods. For example, it is the relative price of foreign goods compared to domestic goods that determines whether one wants to buy the import instead of a domestic good, and whether foreigners choose to buy the domestic export or their good. But the relative price of the different countries’ goods depends on the prices in the two countries as well as \( e \).

To demonstrate, assume the price of a generic US good is $2 \( (P_{US} = \$2) \), the price of a generic Japanese good is ¥400 \( (P_J = ¥400) \), and \( e_{YS} = 100 \). The opportunity cost of purchasing the US good \( (\$2) \) is the Japanese goods that the $2 could afford. Given that the $2 could buy ¥200, which buys half a Japanese good, the opportunity cost of purchasing a US good is half a Japanese good. It is this tradeoff that determines how much exporting and importing occurs between the US and Japan. Changes in the opportunity cost can occur due to changes in \( P_{US} \), \( P_J \), and/or \( e \). For example, say that \( P_{US} \) increases to $3 while \( P_J \) and \( e \) remain the same. The $3 could buy ¥300, which could purchase ¾ of a Japanese good, so, the opportunity cost of purchasing the US good is now ¾ of a Japanese good. With this increase in the value of US goods versus Japanese goods, the US would be more inclined to import Japanese goods (since they can now get more Japanese goods for their US goods), just as Japan would tend to import fewer US goods.

Because it is the relative value of goods and not the exchange rate that is important to the determination of CA activity, a measure capturing that information is desirable. The real exchange rate (which will be represented by the symbol \( e \), as opposed to the symbol \( e \)) is just such a measure that tracks the relative prices by adjusting the nominal exchange rate for past inflations in the two countries. A base year (any year) is picked whose price levels and the corresponding purchasing power of the respective currencies are identified as reference values. The real exchange rate at a given moment (or year) is the value of the nominal exchange rate at that moment adjusted for the changes in price levels of the two currencies’ since the base year:

\[ e_{FOR/DOM} = e_{FOR/DOM} \times CPI_{DOM} \times 1/CPI_{FOR} \] (3.3)
where the three factors on the right hand side of Equation 3.1 incorporate the effects of the nominal exchange rate, domestic prices, and foreign prices, respectively, on $e_{FOR/DOM}$. Equation 3.3 is equivalent to

$$\%\Delta e_{FOR/DOM} = \%\Delta e_{FOR/DOM} + \%\Delta CPI_{DOM} - \%\Delta CPI_{FOR}$$  \hspace{1cm} (3.4)

where the symbol “$\Delta$” in front of a variable represents the change in that variable.

To stress how $e$ is more relevant to understanding CA activity than $e$, consider the effects of inflation in the US economy on the $\$$ market (See Figure 3.1). The higher US prices would cause the demand for US goods, and therefore the demand for $\$$, to fall. They would also cause foreign goods to look relatively less expensive to US consumers, who would supply more $\$$ in the foreign exchange to buy imports. As Figure 3.1 shows, these two effects from inflation would cause $e$ to fall. In fact, as will be shown later, there are good reasons to expect an inflation of $X\%$ in the US (i.e., $\%\Delta CPI_{DOM} = X\%$) to cause $e$ to fall by $X\%$. If this were to occur, the relative price between US and the foreign goods would remain unchanged since the increase in the US price would be just offset by the fall in $e$ (see Equation 3.3 or 3.4). For instance, although the price of US goods have risen by $10\%$, $\$$ are now $10\%$ less expensive to buy with foreign currency, so the amount of foreign currency a foreign buyer needs to purchase the US good does not change. Without a change in the relative prices, one would not expect export or import flows to be affected.

The above examples have shown that $e$ can change when $e$ does not, and that $e$ can remain stable as $e$ changes. It is just as easily shown that $e$ and $e$ can move in opposite directions. Having said that, for the rest of this course there will be other presentations and examples where it will be claimed that, for example, a rise in $e$ will decrease exports and increase imports. Such statements will be implicitly assuming that prices in the two countries are not changing (at least, initially) to offset the effect and, therefore, the noted change in $e$ equals the change in $e$.

Table 3.1 also provides CPI information that allows computing several $e$’s.

**Real Effective Exchange Rates ($\bar{e}$)**

The effective exchange rate’s solution to the “just one other currency” problem and the real exchange rate’s correction for changing prices can be employed simultaneously to generate the **real effective exchange rate** ($\bar{e}$). The first step in generating the $\bar{e}$ for a particular year (or moment) is to compute the real exchange rates with all the country’s trading partners for that year. Then those real exchange rates are used to construct the real effective exchange rate in precisely the same way that nominal exchange rates are used to construct the effective exchange rate.

$$\bar{e}_{Yt} = \Sigma w_i \times e_{i,Yt}/e_{i,BY} \text{ for all countries } i$$  \hspace{1cm} (3.5)

Table 3.1 also provides computed real effective exchange rates for the US for several years.

**3.3 The Two Main Exchange Rate Policies: Fixed and Flexible Exchange Rates**

It has not been uncommon for governments to impose a specific exchange rate with a particular foreign currency. Because an exchange rate is determined by the forces of demand and supply in the foreign exchange market, such a policy requires the monetary authority to be ready to participate (or “intervene”) in that foreign exchange market: It needs to buy the foreign currency (with newly minted $\$$’s) as needed to prevent $e$ from rising above the designated rate, and it needs to sell foreign currency (and purchase $\$$’s) when the $\$$ would otherwise fall below
the rate. Because the policy keeps the exchange rate from deviating from the designated rate, it is referred to as a fixed exchange rate or pegged exchange rate policy. To the extent that people believe the government is committed to a fixed exchange rate, it reduces uncertainty about what the future exchange rate will be, i.e., it reduces exchange rate risk.

Figure 3.2 illustrates the case when the demand and supply for currencies by private individuals would generate an exchange rate below that fixed/pegged by the monetary authority. In this case, there is an excess supply of domestic currency in the foreign exchange market at the pegged rate that the monetary authority, if it is to uphold the policy, needs to buy. Purchasing its own currency requires selling foreign currency and, therefore, a fixed exchange rate policy requires the monetary authority to have available reserves of the foreign currency. The KFA Gov account discussed in Handout #1 is where all changes in the foreign reserve holdings by the monetary authority are reported. In this case, since the foreign reserves are being depleted, the KFA Gov is in surplus and, given the BOP constraint, the BOP (or ORTB) is in deficit. It is also possible for a monetary authority to fix its € below what the foreign exchange market would generate. In this case the monetary authority keeps the value of its currency down by selling it in exchange for the foreign currency, which it adds to its foreign reserves. This brings about a deficit in the country’s KFA Gov account and a surplus in its BOP.

It is also possible to peg a currency to a currency basket (a.k.a., a composite). As a simple example, assume the value of a hypothetical currency (the mooal) is fixed to a basket composed of 0.50 US dollars and 0.20 euros. The value of a mooal in terms of just $’s or just €’s depends on the €/$ exchange rate. When $e_{€/$} = 0.80 the mooal is worth $0.75 (i.e., the $0.50 plus the $ value of the €0.20, which would be $0.25). A mooal would also be valued at €0.60 (i.e., the €0.20 plus the € value of the $0.50, which is €0.40). A policy of fixing the mooal to this particular two-currency basket requires either honoring the $/mooal exchange rate of 0.75, or honoring the €/mooal exchange rate of 0.60. The presence of cross rate parity assures that honoring either of these effectively honors the other.

Now, if the €/$ exchange rate fell to 0.50, then the value of the mooal would change to $0.90 (the $0.50 plus the dollar value of €0.20, which is now $0.40) or €0.45 (the €0.20 plus the euro value of $0.50 which has fallen to €0.25). Maintaining the composite would now involve honoring either e$_{$/mooal} = 0.90 and/or the e$_{€/mooal} = 0.45$. Not surprisingly, the above depreciation of the $ relative to the € causes the $ value of the mooal to rise (from $0.75 to $0.90) since the € share of the basket is now worth more in terms of $’s. Similarly, the € value of the mooal falls (from €0.60 to €0.45) because the $ component of the basket is now worth fewer €’s. But note that while the depreciation of the $ by roughly 60% against the euro (i.e., e$_{euro/$}$ falling from 0.8 to 0.5), the mooal depreciated against the € by only 25% (i.e., the value of the mooal fell from €0.60 to €0.45): By pegging the mooal to a basket of currencies, the influence of a change in the value of any one exchange rate in the basket is dampened. After all, if the mooal had been simply fixed completely to the $, then a 60% depreciation of the $ against the € would have brought about a 60% depreciation of the mooal against the € as well.

Countries around the world that fix their currencies to a basket include Bangladesh and Morocco. China switched from fixing its currency to the $ to a basket as of July 2005. The exact composition of China’s basket and how it changes has not been disclosed by the Chinese government. Although it is evident that the $ has continued to represent a large fraction of the basket, it would seem that the $’s share of the basket has been slowly falling under the new policy.
Countries that permit their exchange rates to change with market forces without intervening in the foreign exchange markets are said to have a **floating** or **flexible exchange rate** policy. These countries typically have no activity in their $KFA_{GOV}$ account and, therefore, do not experience either a surplus or deficit in their BOP.

Whereas defining fixed exchange rates is straightforward, the decision by a government to adopt such a policy is involved and complicated. The pros and cons of a fixed exchange rate policy versus a flexible exchange rate policy will be addressed in detail in Handouts 9 and 10.

**Interesting Historical Note:**

Fixing the value of a paper currency in terms of some other money was originally undertaken hundreds of years ago by banks promising to redeem gold for their currency at any time at an established rate of exchange. In other words, these banks pegged their currencies to gold. Currencies that are backed by gold in this way are said to belong to the **gold standard**. The convenience of paper currencies compared with dealing with actual gold gave banks an incentive to issue currencies. The value of each currency varied with the reputed dependability of the issuing bank to exchange it for gold.

The days of the gold standard have passed (for reasons discussed in Handouts 10 and 11), and the currencies of the world are no longer backed by monetary authorities promising to redeem gold (or any other commodity) for them. Instead, each of the currencies of the world is now a **fiat currency**, whose value is asserted by government fiat in the form of proclaiming it to be “legal tender,” rather than having its value sustained by it being reliably convertible into a given amount of gold or other commodity.

Much more will be said about the gold standard in Handouts 10 and 11 along with discussions of why one fiat currency might be pegged to another fiat currency.

**Key Terms**

- arbitrage
- cross-rate parity
- currency basket (or composite)
- effective exchange rate ($\tilde{e}$)
- exchange rate risk
- fiat currency
- fixed (or pegged) exchange rate policy
- flexible (or floating) exchange rate policy
- gold standard
- Nominal exchange rate ($e$)
- real effective exchange rate ($\tilde{e}$)
- real exchange rate ($\bar{e}$)
- spot exchange rate ($e$)
- triangular arbitrage
Assume there are 3 countries: A, B, C, each with its own currency (a, b, c), and that all of A’s trade is with B and C. Given these values:

<table>
<thead>
<tr>
<th>Year</th>
<th>e_{b/a}</th>
<th>e_{c/a}</th>
<th>CPI_A</th>
<th>CPI_B</th>
<th>CPI_C</th>
<th>X_{A→B}</th>
<th>M_{A→B}</th>
<th>X_{A→C}</th>
<th>M_{A→C}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>5</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>80</td>
<td>60</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>2000</td>
<td>8</td>
<td>140</td>
<td>140</td>
<td>180</td>
<td>90</td>
<td>80</td>
<td>60</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>2001</td>
<td>9</td>
<td>130</td>
<td>120</td>
<td>180</td>
<td>105</td>
<td>80</td>
<td>60</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

All of the following exchange rates treat A as the domestic country and employ 1990 as the base year.

\[
\tilde{e}_{1990} = 1.000 \\
\tilde{e}_{2000} = 1.540 \quad \text{\left(=\left(0.7\right)(1.6)+\left(0.3\right)(1.4)\right)} \\
\tilde{e}_{2001} = 1.650 \quad \text{(}w_B = 0.70 \text{ and } w_C = 0.30) \\
\]


\[
e_{b/a-1990} = e_{b/a-1990} = 5 \\
e_{b/a-2000} = 4.706 \quad \text{\left(=8(100/170)\right)} \\
e_{b/a-2001} = 6.000 \\
\]

NOTE: Currency a depreciated in real terms by 5.88% against b between 1990 and 2000. It appreciated by 27.5% between 2000 and 2001.

\[
e_{c/a-1990} = e_{c/a-1990} = 100 \\
e_{c/a-2000} = 147.368 \\
e_{c/a-2001} = 148.571 \quad \text{\left(=130(120/105)\right)} \\
\]

NOTE: Currency a appreciated in real terms by 47.37% against c between the base year and 2000. It appreciated by 0.82% between 2000 and 2001.

\[
\tilde{e}_{1990} = 1.00 \\\n\tilde{e}_{2000} = 1.101 \quad \text{\left(=\left(0.7\right)(0.941)+\left(0.3\right)(1.474)\right)} \\
\tilde{e}_{2001} = 1.286 \\
\]

Figure 3.1

Figure 3.2
DOMESTIC CURRENCY

Domestic currency purchased using foreign reserves out of GOV vault