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International Finance (Econ 421)

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Handout #7: The Real Exchange Rate

1. Introduction

Absolute PPP does not hold in the real world, and relative PPP seems to hold only in the long run. It is therefore useful to develop a concept that measures by how much economies deviate from absolute and relative PPP. The real exchange rate does just that.

This handout defines the real exchange rate, explores its determinants, and then connects it to our model of nominal exchange rate determination. We will see that under the assumption of sticky prices the real exchange rate behaves just like the nominal one, as a result we will focus on long run effects. Specifically, we will see how changes in demand and supply conditions across countries affect the long run real exchange rate and this, in turn, affects the nominal rate. This analysis will help us to better understand how expectations are formed, and hence affect our short run analysis as well.

2. The Real Exchange Rate

The real exchange rate is the relative price of some fixed baskets across countries.[1] In other words, it is the price of the foreign basket in terms of domestic baskets.

Using our standard notations let P denote the price, in domestic currency, of a fixed basket of goods and services in the home country, and let P^* denote the price, in foreign currency, of a fixed basket in a foreign country.[2] Finally, let E denote the nominal exchange rate between the home and foreign currencies. The real exchange rate, q, is given by:

$$\mathbf{q} = \boldsymbol{EP^*/P} \qquad \textbf{(1)}$$

[1] By "fixed" we mean that the basket does not change over time. It should be noted, however, that the baskets of goods and services we consume and produce do change over time. For example, many communication services we consume today did not exist, or at least were not widely used, 15 or 20 years ago (cell phones and internet).

[2] The baskets in the two countries do not have to be the same.

Notice that the units of the real exchange rate are ***domestic baskets per foreign basket***. This can be easily seen by carefully manipulating the units on the right hand side. Suppose, for example, that we are interested in the American-European real exchange rate.[3] In that case E is measured in dollars per euro, *$/€*, and P^* is measured by € per European basket; hence, EP^* is in $ / European basket. Finally, the denominator, P, is in $ per American basket; therefore dividing $ / European basket by $ / American basket, we get American basket / European basket.

Similarly to the nominal exchange rate, we refer to fluctuations in the real exchange rate as ***real appreciations*** and ***real depreciations***. A real appreciation of the domestic currency is an increase in its ***foreign purchasing power*** relative to its ***domestic purchasing power***. This is reflected by a fall in q since a lower q simply implies that the foreign basket is now cheaper relative to the domestic basket. By the same token, a real depreciation of the domestic currency is a fall in its ***foreign purchasing power*** relative to its ***domestic purchasing power***. This is reflected by an increase in q since a higher q implies that the foreign basket is now more expensive relative to the domestic basket.

Finally, notice that if the baskets in the two countries are identical, then absolute PPP suggest that the real exchange rate must always equal 1. Under relative PPP the real exchange rate might deviate from 1; however, it must stay fixed since EP^* moves in fixed proportions to P. Taking relative PPP as a long run equilibrium condition implies that the real exchange rate must be constant in the long run. Notice that any deviation from relative PPP would be captured by fluctuations in the real exchange rate; hence q can be viewed as a measure of how far the economies deviate from their long run equilibrium.

2.1. International Comparison: Purchasing Power Adjustments

One important role of real exchange rates is that they allow us to compare appropriately the standard of living in different countries. For example, consider the comparison between the GDP per capita in the US to that of India. In 2004 GDP per capita in the US was approximately $40,000 while in India it was $630 (see Table 1).

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[3] It is common to refer q in terms of currencies – the dollar-euro real exchange rate, for example. However, this practice might be a bit misleading since q is not measured by $/€.

Table 1: GDP per Capita – An International Comparison (2004 Figures)[1]

	Currency	GDP	Ex. Rate	GDP	Population	GDP per Capita		RER[2]
		Millions of NC	NC/$	Millions of $	Millions	Nominal $	PPP $	
Argentina	Peso	447,307	2.92	153,014	38.4	3,988	12,400	0.32
Brazil	Real	1,766,620	2.93	603,948	183.9	3,284	8,100	0.41
Chad	African Franc	2,083,000	528.29	3,943	9.4	417	1,600	0.26
France	Euro	1,648,400	0.81	2,046,774	60.3	33,968	28,700	1.18
India	Indian Rupee	31,055,100	45.32	685,293	1087.1	630	3,100	0.20
Israel	New Israeli Sheqel	523,851	4.48	116,879	6.6	17,708	20,800	0.85
Italy	Euro	1,351,330	0.81	1,677,910	58.0	28,913	27,700	1.04
Japan	Yen	505,185,000	108.19	4,669,295	127.9	36,501	29,400	1.24
Luxembourg	Euro	25,664	0.81	31,866	0.5	69,423	58,900	1.18
Niger	African Franc	1,601,000	528.29	3,031	13.5	225	900	0.25
US	Dollar	11,734,300	1.00	11,734,300	295.4	39,722	40,100	0.99
Venezuela	Bolivar	206,125,000	1891.33	108,984	26.3	4,147	5,800	0.71

[1] Data source: GDP in national currency, exchange rates, and population figures are from the International Financial Statistics. GDP per capita adjusted to PPP is from the CIA World FactBook. GDP in dollars and the real exchange rate are based on self calculation.

[2] Notice that the real exchange rate for the US is not 1 due to the use of different data sources.

The figure for India was calculated by converting the rupee value into dollars using the average spot exchange rate. However, is that the right comparison? There is no doubt that on average Americans are richer than Indians, but is the standard of living in the US really 63 (= 40,000/630) times greater than in India?

The problem with the calculation we have just made is that it does not take into account differences in purchasing power in the two countries. It has long been recognized that poor countries have lower price levels; that is, a dollar in India, for example, can buy more goods and services than in the US. Therefore, if the Indian dollar-income is 63 times lower than the American one, it does not mean that the standard of living in India is 63 times lower than in the US.

In order for the comparison to be meaningful we must adjust the GDP figures to the purchasing power of the dollar in the two countries. We do that by using the real exchange rate. For example, suppose that we find that prices in the US are twice as high as in India; then the Indian *nominal* GDP per capita figure should be doubled before we make any comparison to the US. In other words, we have to multiply the Indian figure by the (Indian) real exchange rate, which is exactly the price of American basket in terms of Indian basket.

Table 1 compares GDP per capita across different countries. Notice that richer countries tend to have a higher real exchange rate; that is a higher dollar price level relative to the US, while poorer countries have lower price level. As a result, after adjusting to PPP the difference in standard of living across countries, although substantial, is smaller than what the spot exchange rate might suggest. Specifically, for the US-India case, the price level in the US is five times higher than in India (q = 0.2), and hence after adjusting to PPP, we find that Indians are on average 13 (= 40,100/3,100) times poorer than Americans, not 63.

2.2. The Balassa–Samuelson Theory: Why Prices Are Higher in Rich Countries?

Table 1 indicates that the American real exchange rate against rich countries tends to be higher relative to its value against poor countries. In other words, the price level in rich countries is higher than the price level in poor countries. The Balassa–Samuelson theory provides an explanation to this phenomenon.

Any economy can be divided into two sectors: tradable and non-tradable. The Ballasa–Samuelson theory makes three assumptions about the relationship between these sectors across countries: (1) in the tradable sector workers in rich countries are more productive relative to workers in poor countries; (2) in the non-tradable sector there is no significant difference in productivity between rich and poor countries; and (3) absolute PPP holds in the tradable sector.

Before analyzing the implications of these assumptions, we need to evaluate their validity. It seems reasonable to assume that rich countries have access to better technologies; as a result workers in these countries are probably more productive. However, why is this difference relevant only to the tradable sector? The reason is that the tradable sector produces manufactured goods for which technology can play an important role, while the non-tradable sector, on the other hand, mainly produces services. Production technologies for many services do not change much over time and are typically similar across countries. For example, technology of haircuts has not changed much over the years and barbers everywhere still use a comb and a pair of scissors to cut hair. Other professions that may also illustrate this point include waiters, bus drivers, mailmen, and teachers to name a few.

The discussion above motivates the first two assumptions, but what about the third assumption regarding absolute PPP? We know that absolute PPP does not hold in the data, but recall that much of the explanation for its failure is based on the existence of non-tradable goods, or non-tradable components in tradable goods. It is therefore reasonable to assume that absolute PPP is at least more relevant for tradables than to non-tradables.

Assuming the Balassa–Samuelson assumptions have some validity, we are ready to discuss their implications for price differences across countries.

Consider producers in the tradable sector in rich and poor countries. Profit maximization dictates:

$$W^R = P_T \times MPL_T^R \qquad , \qquad W^P = P_T \times MPL_T^P$$

where W is the wage rate, and MPL is the marginal product of labor. The superscripts R and P indicate country group – rich and poor. P_T is the price of tradables (common to poor and rich countries as implied by absolute PPP). By assumption, workers in the tradable sector in rich countries are more productive relative to workers in poor countries, that is $MPL_T^R > MPL_T^P$; and since both countries face the same price, P_T, wages in rich countries are higher relative to poor countries: $W^R > W^P$.

Now consider firms in the non-tradable sector. Profit maximization implies:

$$W^R = P_N^R \times MPL_N \qquad , \qquad W^P = P_N^P \times MPL_N$$

where the subscript N indicates the non-tradable sector. Since we assume no productivity differences across countries in the non-tradable sector, we removed the country index from MPL. Also notice that within each country wage rates must be the same across sectors, otherwise workers will move to the better paying sector until wages equate. Since $W^R > W^P$, we can conclude that the price of non-tradables in rich countries must be greater than their price in poor countries, that is $P_N^R > P_N^P$.

It should be noted that since every tradable good has some non-tradable component in it, non-tradables constitute a large share of the economy. In fact, some researchers argue that non-tradables account for 75 to 85 percent of the economy.[4] With such a large share of non-tradables, the Balassa–Samuelson theory is well suited for explaining price differences across countries.

3. Determinants of the Real Exchange Rate

3.1. The Short Run

By definition, the real exchange rate depends on prices at home and abroad and on the nominal exchange rate – see equation (1). Since we assume that in the short run prices are sticky, the real exchange rate must follow very closely the behavior of the nominal exchange rate. Therefore, the short run analysis we have conducted so far for the nominal exchange rate also holds for the real rate.

[4] See Burstein, A., Eichenbaum, M., and Rebelo, S, 2005. "Large Devaluations and the Real Exchange Rate." Journal of Political Economy 113 (4), pp. 742-784.

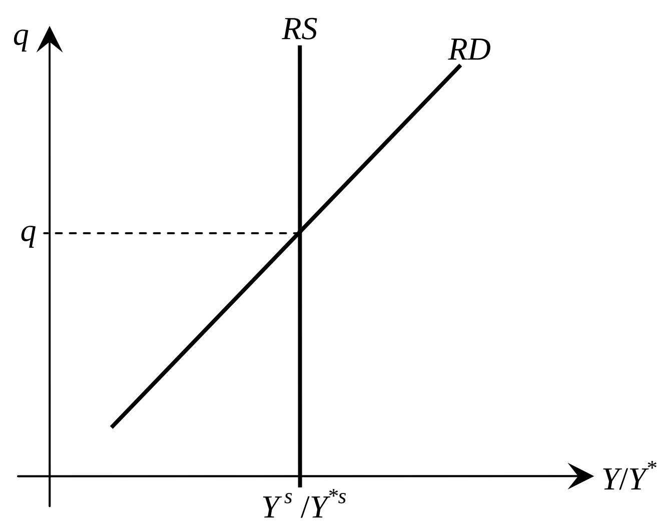
3.2. The Long Run

In the long run prices adjust and therefore the behavior of the real exchange rate can significantly deviate from that of the nominal rate. It should come at no surprise that, just like any other relative price, the real exchange rate is determined by relative demand and supply.

Figure 1 illustrates how relative demand and supply determine the real exchange rate. As is the case of any demand function the higher the price the lower demand is. In our case an *increase* in the relative price of home goods is captured by a *fall* in q; therefore the lower q the lower is the relative demand for home goods. As a result the relative demand schedule in Figure 1, *RD*, is *upward* sloping.

Long run supply is determined by supply of production factors and technology. These are unaffected by the real exchange rate. As a result, relative supply, *RS*, is vertical and does not change with q. The appendix of this handout presents data for the US that further motivate this assumption.

Figure 1: Long Run Relative Demand and Supply



Using Figure 1, it is easy to analyze the effects of movements in relative demand and supply on the real exchange rate. Notice, however, that since this is a long run analysis we assume that changes are permanent.

A permanent increase in relative demand toward home goods: An increase in relative demand for home goods creates excess demand at the ongoing real exchange rate. As a result, the price of home goods must increase relative to foreign goods in order to clear the markets. Notice that an ***increase*** in the relative price of home goods is reflected by a ***fall*** in the real exchange rate.

It is easy to see this effect using Figure 1. An increase in relative demand for home goods shifts the *RD* schedule outward (to the right). As a result, the equilibrium real exchange rate, *q*, falls.

A permanent increase in relative supply of home goods: An increase in relative supply of home goods creates excess supply at the ongoing real exchange rate. As a result, the relative price of home goods must fall in order to clear the markets. Notice that a ***fall*** in the relative price of home goods is reflected by an ***increase*** in the real exchange rate.

Again, it is easy to see this effect using Figure 1. An increase in relative supply of home goods shifts the *RS* schedule outward (to the right). As a result, the equilibrium real exchange rate, *q*, increases.

4. Real and Nominal Exchange Rates in the Long Run

The analysis above suggests that, depending on relative demand and supply conditions, the real exchange rate may change in the long run. The definition of the real exchange rate, equation (1), links the nominal exchange rate to the real rate. Putting the two observations together implies that changes in the long run real exchange rate may affect the long run nominal exchange rate.

The real exchange rate depends on prices; however, these are determined by equilibrium in the money markets and our long run relationships as we discussed in the previous handout. From that discussion, recall that prices react to changes in output since $P = M^s/L(R,Y)$. In the long run output supply is inelastic as it is determined by supply of production factors and technology.[5] We can therefore conclude that changes in relative demand do not affect long run output, and hence do not affect prices. Changes in supply conditions, on the other hand, affect the long run price level by altering money demand.

[5] This is exactly why the relative supply curve, *RS*, in Figure 1 is vertical.

Before analyzing the effects of relative demand and supply on the nominal exchange rate, it is useful write the nominal exchange rate as a function of the price levels and the real exchange rate. This is achieved simply by rearranging equation (1):

$$E = q \cdot P/P^* \quad \textbf{(2)}$$

A permanent increase in relative demand toward home goods: An increase in relative demand for home goods leads to a real appreciation of the domestic currency (a fall in q); and as we have just discussed, the long run price levels do not change (since outputs do not change). Using equation (2) we can now conclude that the nominal exchange rate must appreciate (E falls) by the same proportion as q.

That is, an increase in relative demand toward home goods leads to a long run appreciation and therefore also to a fall in the expected exchange rate, E^e.

A permanent increase in relative supply of home goods: A permanent increase in relative supply of home goods has two opposite effects. First, it causes the real exchange rate to depreciate in the long run, and hence the nominal exchange rate tends to depreciate as well. Second, this change affects relative output in the long run which may result in a pressure for nominal appreciation.

To see the second effect, let's assume for simplicity that foreign output, Y^*, is fixed, but domestic output, Y, have increased. Since $P = M^s/L(R,Y)$, a higher output leads to a lower price level, which in turn puts pressure on the nominal exchange rate to appreciate.

We therefore conclude that the effect of a permanent increase in relative supply on the nominal exchange rate is ambiguous. If the effect of the real exchange rate dominates, then the nominal exchange rate depreciates in the long run; and if the effect of the price level dominates, then the nominal exchange rate appreciates in the long run.

5. Appendix: The US GDP in the Long Run

This handout assumes that GDP is constant in the long run. We now attempt to motivate this assumption by examining data on US GDP over a long period of time.

The graph below depicts the US GDP (in base 10 logs) during the last 200 years (1790-2004).[6] The main feature of the graph is that it follows very closely a linear line. This means that for the last 200 years GDP in the US have grown at roughly a constant rate.[7]

Of course, there are some fluctuations (business cycles), but it seems that GDP always goes back to its trend. Most apparent deviation from the trend is the great depression in the early 1930s, which followed by a recovery driven by War World II.

The use of base 10 logs allows us to compare the levels of GDP in different points in time. In the early 1800s log(GDP) was around 1 and by year 2000 it has reached a level of 4. This means that within 200 years the US economy have grown by a factor 1000(!).[8] This growth is driven by both population growth and technological innovations.

The message of this graph is that GDP seems to have a ***deterministic*** trend. As a result many dynamic models analyze ***stationary*** economies; that is, economies that do not grow in the long run. After these models are solved, we can always recover the actual level by adding back the trend. In our model of exchange rate determination we take a similar approach as we assume that the long run level of output is fixed. Adding growth to the model is not going to change any of our results, as long as the home and foreign countries grow in the long run at the same rate. For sake of simplicity we abstract from growth.

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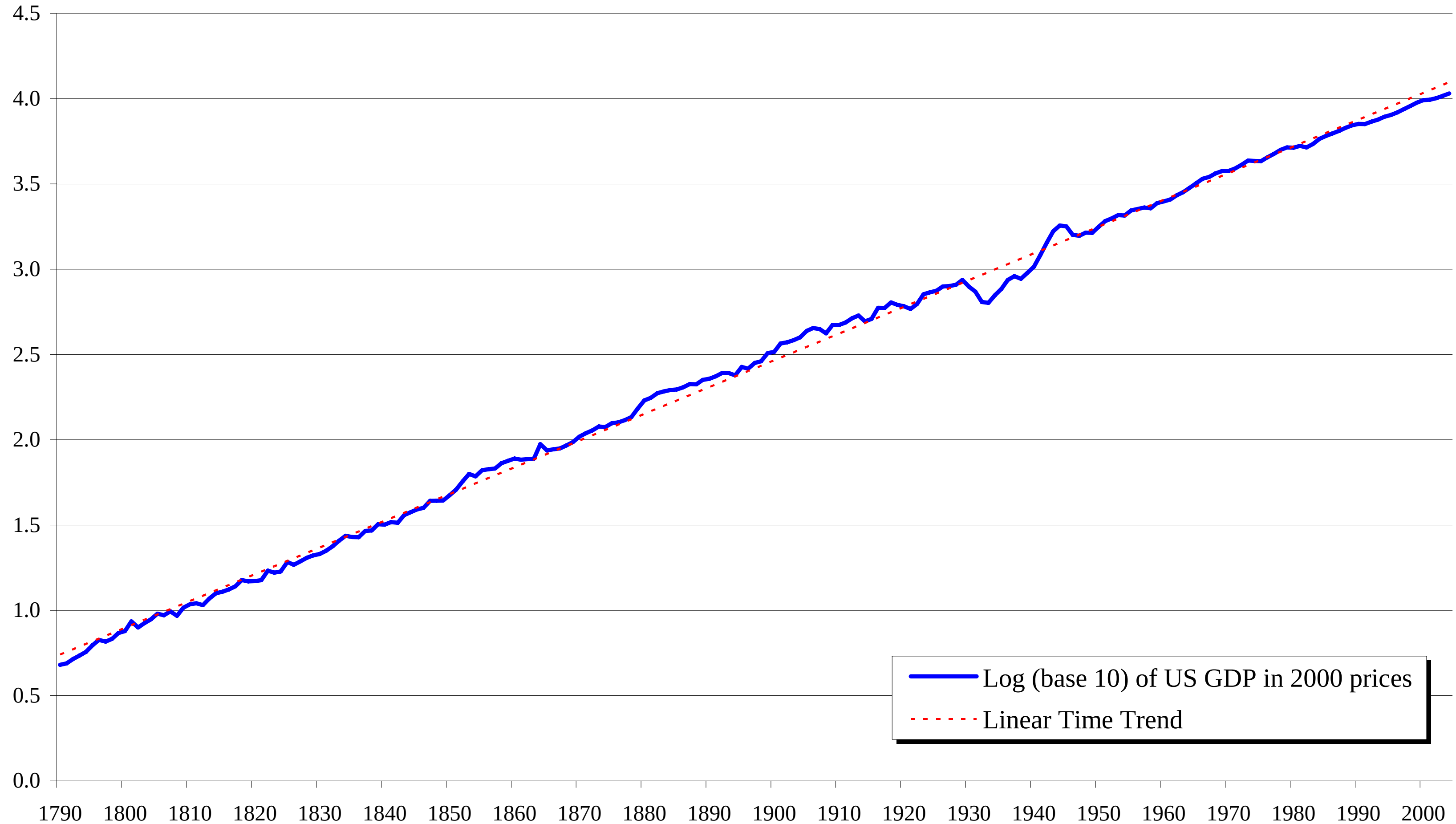
[6] Taking logs of base 10 gives a convenient interpretation for the relative levels: an increase in one unit in log(GDP), say from 3 to 4, represents growth of a factor of 10.

[7] Recall that when we take logs using the natural base, *e*, the slope has the interpretation of growth rate. In this case since we use base 10 the slope is the growth rate divided by ln(10). Nevertheless, a constant slope, i.e. a linear line, implies a constant growth rate.

[8] The calculation is $10^{4-1}=10^3=1000$.

US Real GDP (In Logs - base 10), 1790-2004*



* Data Source: Louis D. Johnston and Samuel H. Williamson, "The Annual Real and Nominal GDP for the United States, 1790 - Present." Economic History Services, October 2005, URL: http://www.eh.net/hmit/gdp/