

Topic 16: exchange rates in the long run and PPP

Introduction

The basic question here is what determines movements in flexible exchange rates over longer periods, say a few years or a decade?

What it comes down to is an assumption that *exchange rates ultimately have to adjust to reflect the underlying competitiveness of economies.*

The basic intuition: Let's suppose the US and Canada have a flexible exchange rate, which may move up and down a lot over months or a year or 2. But over a longer period, what would we expect to move the exchange rate between them?

Suppose over 5 years the US rate of price inflation is 5% per year and the Canadian rate is 7% per year.

This means, other things equal, that Canadian goods and services are getting more expensive every year compared to US prices. In turn, people would buy fewer Canadian g&s and buy more US g&s.

That would tend to depreciate the Canadian \$ and appreciate the US \$ because it would imply a (tendency toward) a Canadian BOP deficit and a US BOP surplus.

So our basic story will be this: countries with higher (lower) inflation over time will see their currencies depreciate (appreciate). Will consider some evidence of this later.

Introduction to price indexes

To understand this idea (and related ideas) we have to understand how to compare prices and inflation across countries. We will start with price levels (indexes) and then move on to inflation rates.

First, consider how expensive each country is in terms of prices, living costs, real wages, and so on.

Start with the basics: how do we compare price levels across countries? We can first consider how much it costs to live in various places.

Let P^{US} be the annual cost to an average household of consuming a basket of goods and services in the US, a measure of the cost of living.

This basket would include the cost of a given amount of food of various types, rent or housing costs, medical care, commuting costs, gasoline, entertainment, etc.

One obvious example is the computation of what we call the “poverty line”, which is the income needed for a household of four people to purchase a given combination of goods that will keep the family fed and healthy. Currently in the US the poverty line is around \$27,500.

But we focus here on the cost of living for the average or median household.

Price indexes

This basket P^{US} is computed from dollar prices.

Let P^{UK} be the annual cost for the *same basket of goods and services* in the UK, a measure of the cost of living there. This is computed using pound (£) prices.

Then we can define the *relative cost of living* between these countries as

$$R = P^{US}/EP^{UK}, \text{ where } E \text{ is the market spot exchange rate } (\$/\pounds).$$

EP^{UK} is a measure of the UK cost of living expressed in dollars.

Then R is a comparison of the cost of living for the same basket of goods and services in US versus UK.

Example: Let $P^{US} = \$60,000$ (cost of basket); $P^{UK} = \pounds45,000$; $E = 1.5\$/\pounds$. Then the relative cost of living is $R = \$60,000/(\pounds45,000 * 1.5\$/\pounds) = 60,000/67,500 = 0.89$. This means it's 11% cheaper to live in the US than in the UK.

Price indexes

Note that we can use similar calculations to compute how much a given basket of inputs (labor, capital prices, intermediate inputs like chemicals and machinery) costs in one country versus another, converted to the same currency.

In this case R would be a measure of *relative competitiveness* in trade for 2 (or many) countries.

For example, central banks and economists spend a lot of time calculating how much the average wage in manufacturing is in one country versus another. Then $R = W^{\text{US}}/EW^{\text{UK}}$ would be a measure of how expensive US labor is in manufacturing relative to the UK.

Now if R rises we say the relative costs of the US go up. For example, if R rises from 0.89 to 0.95, US prices and costs have gone up 6 percentage points relative to UK prices and costs.

Economists often refer to an increase in R as being equivalent to a *real appreciation* of the \$ (and real depreciation of the £) because an appreciation of the dollar would also raise American prices as the British see them. A fall in R would be a *real depreciation* of the \$.

That is, a *real appreciation* of the \$ (higher R) means the US becomes more expensive relative to the UK. A *real depreciation* of the \$ (lower R) means the US becomes cheaper relative to the UK.

Changes in R

What determines these changes? Just look at the expression for R: $R = P^{US}/EP^{UK}$. Then

- P^{US} rises (because of rising prices of goods and services in the basket) => R rises (higher US costs).
- P^{UK} falls => R rises (lower UK costs).
- E falls (appreciation of \$ or depreciation of the £ in the spot market) => R rises (higher US costs).

R (the relative cost of living or relative price indexes) is the *key* international price for measuring cost of living, competitiveness in wages, etc. We need to take a closer look at the relationships here and try to understand why they are important.

Simplest concept: the law of one price

An initial concept is the law of one price (LOOP).

Consider a single good (C) that is traded internationally and is homogeneous and of identical quality (e.g., chemicals, corn, etc.) The *law of one price* says that they should have the same price when expressed in the same currency.

$$P_C^{US} = EP_C^{UK}$$

But that implies $R_C = P_C^{US}/EP_C^{UK} = 1$.

Example: let the price of 1 kg of chemicals = \$20 in the US and £14 in the UK, $E = 1.5 \text{ \$/£}$.

Then $EP_C^{UK} = 1.5 * 14 = \$21$. Chemicals are more expensive in the UK. If we believe in perfect and costless movement of goods, people would buy C in US and export them to the UK. Then the price would rise in the US and fall in the UK (and we might also see the exchange rate fall (\$ appreciation) due to purchases in the US). This continues until equality.

For example, let the US price rise to \$20.15 and British price fall to £13.43. Then the LOOP would hold since $\$20.15 = 1.5 * 13.43$.

LOOP

What must be true for LOOP to hold?

1. Homogeneous goods (identical in quality) and highly tradable.
2. No trade barriers or transport costs (including on inputs).
3. International firms with market power cannot “segment markets” through price discrimination and controls preventing goods from being exported from high-priced markets to low-priced markets.

What kinds of goods are homogeneous? This is debatable but we usually think of primary commodities (oil, minerals, gold, agricultural crops) and simple manufactures, such as toys and clothing. These goods do not need to be differentiated very much and so have similar characteristics and prices.

But goods that are highly differentiated in quality or branding would not be homogeneous. Cars, sophisticated machinery, cell phones, and so on are not likely to fit the LOOP. This is even more the case because they are produced by large firms with market power (GM, VW, Toyota, General Electric, Apple, Samsung, etc.).

Finally, services are generally not traded (though there are major exceptions). So would we expect the prices of haircuts to be the same? Suppose price of a haircut in US is \$20 and in Mexico is 150 Pesos (Ps). Let $E = 0.067$ \$/Ps (which is 15 Ps/\$). Then the dollar price of a haircut in Mexico is $150 * .067 = \$10.05$, which is much cheaper than in the US. But Americans don't flock to Mexico for haircuts because the cost of the trip isn't worth it.

Purchasing power parity exchange rates

Now we will move to a more general and powerful concept: the PPP exchange rate.

The idea here is to calculate the (unobserved) exchange rate that would make living costs (or costs of a good) equal in two countries. Go back to our definition of R:

$R = P^{US}/EP^{UK}$. The PPP rate would be determined by setting $R = 1$ (equalized costs of living). Then

$E_{PPP} = P^{US}/P^{UK}$, just the ratio of the basket costs. In our example above,

$E_{PPP} = \$60,000/£45,000 = 1.333$. If that were the market spot rate (it isn't) then living costs would be the same in US and UK.

Let's compare: the spot $E = 1.5$ but PPP rate = 1.333 (a cheaper pound and more expensive dollar). That means that the market spot rate on the pound is *overvalued* relative to its PPP rate.

Consider again the Mexican haircut. The market spot rate is $E = .067$ \$/Ps but (at least for haircuts) the $E_{PPP} = \$20/150Ps = 0.1333$ \$/Ps, a more expensive peso. This tells us that the peso is *undervalued* compared to PPP.

This means that haircuts are really cheap at the market exchange rate compared to the "equal price" or PPP rate. (If an American could buy a Mexican haircut for 150 Pesos but had to use the PPP exchange rate of 0.133 \$/Ps the cost would be $150 * 0.1333 = \$19.995$ (essentially \$20).

PPP

In general, it's true that services in poor countries (low-wage countries) are much cheaper than in rich countries when converted at the market exchange rate. Why is this?

- Wages are low so we expect lower costs of non-traded goods, such as services.
- Land prices, rents, etc. tend to be lower as well than in rich cities. So that also reduces the relative prices of services.
- Much of the service economy is in the informal sector and may not even be measured in the official income statistics.

Why PPP rates are very useful to understand

A really interesting question is just how to think about the true sizes (GDP, GNI) or living standards (GNI per capita) of different countries when we take account of the fact that prices of goods and (especially) services really are not the same when converted at market spot rates.

We often hear about countries with “extreme poverty”, where the average person lives on \$2 per day or less.

- No doubt that level of income is extremely low and the associated living conditions are awful.
- But this is not the same as \$2 of income in a rich country like the US. Because of cheap services people in poor countries can buy more with their incomes than the same income can buy in the US or Europe or Japan.
- PPP exchange rates are designed to figure out what a “true” comparison is.

PPP

What this means is that it makes sense at times to convert each country's total GNI or GDP at their PPP rates rather than market rates to see what the effective living standards really are.

Computing these rates is an industry in itself for economists (who go out and survey actual prices in all countries). (There is a massive project funded by the UN and the World Bank called the "International Comparisons Project" that pays for this work.)

The World Bank now calculates these PPP rates, all scaled to the US dollar. That is, they ask ***"what exchange rate would give the local currency the same purchasing power in a country as the dollar does in the US?"*** These PPP rates are sometimes referred to as ***"international dollars"***.

Some data are on the next page.

Listed next are some market spot rates (yearly averages), GNIs (gross national income) at market rates, PPP rates, and GNIs at PPP rates in 2016 (source: World Bank, World Development Indicators, online).

Country	Market spot (currency/\$)	Market GNI (\$b)	Market GNI per person (\$)	PPP rate (currency/\$)	PPP GNI (\$b)	PPP GNI per person (\$)	Market rate over or under
Tanzania (T shilling)	2,177	49	900	721	148	2,718	undervalued
Egypt (Eg. Pounds)	10.03	326	3,410	3.22	1,051	10,994	undervalued
Vietnam (Dong)	21,935	195	2,060	7,486	571	6,032	undervalued
China (RMB)	6.64	11,374	8,250	3.54	21,324	16,948	undervalued
Mexico (Peso)	18.66	1,154	9,040	9.84	2,189	17,147	undervalued
S. Korea (Won)	1,160	1,414	27,600	875.5	1,874	36,579	undervalued
Japan (Yen)	109	4,817	37,930	94.9	5,529	43,540	undervalued
Germany (Euro)	1.11	3,625	43,940	0.982	4,098	49,673	undervalued
Switzerland (CHF)	0.99	680	81,240	1.261	534	63,797	overvalued
Norway (Krone)	8.40	431	82,390	11.17	324	61,936	overvalued
USA	1.00	18,357	56,810	1.00	18,969	58,700	na

Here is how the World Bank computes this. The first 3 columns are given by (official) market exchange rates. Column 1 is the exchange rate itself (note carefully that it is in local currency units per \$ so it is 1/E in our notation. Then E would be the reciprocal of these figures.) Column 2 is GNI evaluated at that rate (and what you would see if you just looked up international income figures). Column 3 is GNI divided by population to get GNI per capita, our standard measure of income based on the market exchange rate. Tanzania is very poor, for sure.

Notice an immediate problem with using market exchange rates: the dollar value of GNI and GNI per capita fluctuate with the market rate. For example, in Egypt the market exchange rate is 10.03 E£/\$ and the \$ value of GNI is \$326b. This means that the local currency value of GNI is $326 \times 10.03 = 3,270$ b E£. Now suppose the Egyptian currency appreciates to 8 E£/\$. We would compute that the dollar value of GNI is now $3270/8 = \$409$ billion. Entirely because of the exchange rate change, measured Egyptian GNI went up by 25%! And so would measured GNI per capita.

Back to PPP:

Since the market exchange rates are defined as $1/E$, we can see (using our notation) that the *relative price* R in Tanzania is $R = P^{US}/[(1/2,177) \times P^T]$; in Egypt it would be $R = P^{US}/[(1/10.03) \times P^E]$; and so on. So these figures essentially tell us what it would cost in these countries to consume the US basket and using market exchange rates.

To get the “PPP rate” the World Bank pays people to go out and compute the prices in local currency of a fixed basket of goods and services, which they then compare to the cost of that basket in the US (in dollars). Then they divide the US basket price by the local currency basket price (ignoring the market exchange rate), which generates the PPP currency rates in column 4. In other words, these are the exchange rates at which R would be equal to one in each country. (US and local baskets would cost the same at these (unobserved) PPP exchange rates.)

The World Bank does not publish its basket prices, but you can infer from the first row that its procedure raises the PPP-based total GNI in Tanzania from \$49 billion to \$148 billion. That is, at US prices, Tanzania’s GNI is worth $148/49 = 3.02$ times what the market-based GNI is. In turn, the PPP exchange rate (local currency per \$) becomes $(1/E)/3.02 = 2177/3.02 = 721$.

PPP Summary

To describe this again, in Tanzania the spot rate was 2,177 shillings/\$ (this is the reciprocal of how we have been defining the spot rate, as \$/currency). At that exchange rate total GNI was \$49 billion and GNI per person was \$900.

Tanzania is very poor; if you divide \$900 by 365 days this would give you a market-rate income of \$2.47 per day.

But because services are so cheap the apparent purchasing power of a Tanzanian (compared to a resident of the US) is a total GNI of \$148 billion and GNI per person of \$2,740. In that sense people in Tanzania are about 3 times higher in average incomes than the market figures would suggest.

Why do we say the Tanzanian shilling is undervalued? KEEP IN MIND THAT THIS IS A COMPARISON TO THE PPP EXCHANGE RATE ONLY. Because the market rate of 2,177 TS/\$ is cheaper than the PPP rate of 721 TS/\$.

The other PPP rates are computed in the same way.

PPP summary: other observations

China's GNI at market rates was \$11.37 trillion but at PPP rates was \$21.32 trillion, actually larger than the US economy. *In 2014 China passed the US in total GNI (and GDP) at PPP exchange rates.*

Switzerland and Norway have high incomes at market rates (over \$80,000 per capita). But because of high service prices (due to high land costs, high taxes, regulations, etc.) their purchasing power is much lower. The "real" (PPP adjusted) living standard in Switzerland is \$63,797. Again, the way to think about that is that a Swiss person consuming in Switzerland has the same real income as an American who has \$63,797 but consumes in the US.

Since the US is the comparison country its income is the same in either computation.

Now look at the last column. "Undervalued" means that the market spot price of the local currency is low compared to the PPP price. That is, a dollar bought 2,177 Shillings in 2016 on the market but would only be worth 721 Shillings if the PPP rate actually existed in the market (it doesn't). China's market rate was 6.64 RMB/\$ (0.15 \$/RMB) but its PPP rate was 3.54 RMB/\$ (0.28 \$/RMB). So the RMB (the yuan) was undervalued in the PPP sense by about 47% (computed as $(3.54-6.64)/6.64 = -0.467$).

"Overvalued" means just the opposite. In Norway the market rate was 8.40 Krone/\$ (0.119 \$/Krone) but the PPP rate was 11.17 Krone/\$ (0.09 \$/CHF).

As you can see, lower-income economies tend to have undervalued market rates and higher-income economies tend to have overvalued market rates. This basically reflects the low wages and costs in the former and high wages and costs in the latter.

PPP: the Big Mac Index

Another way to see all of this is rather fun. The idea here is to look up the Big Mac index (most recently in the January 2018 *The Economist* magazine). The Big Mac is interesting in this context because it is a homogeneous good. But it's also not traded across locations and local rents and wages are quite different. *The Economist* calculates this index for 56 countries.

First let's go through one example then show a few other countries.

China (Beijing McDonald's) Big Mac data.

- Local price = 20.4 RMB for a Big Mac.
- Market exchange rate = 6.43 RMB/\$ (= 0.156 \$/RMB).
- Market dollar price = $20.4/6.43 = \$3.17$. (This is what you would pay in dollars by exchanging dollars for RMB in the spot market.)
- US market dollar price = \$5.28 (what you would pay at an average US McDonald's).

Then the implied PPP exchange rate = $20.4\text{RMB}/\$5.28 = 3.86 \text{ RMB}/\$$ (= 0.259 \$/RMB). Keep in mind that this is the exchange rate that would equalize the prices in US and Beijing (but it doesn't exist).

So in this sense the RMB is undervalued, by quite a bit. How much? $(3.86 - 6.43)/(6.43) = -40\%$.

Here are a few other interesting countries:

	LC BM price	US\$ price	US BM price	Market spot rate	PPP BM rate	Over or undervalued
Argentina (pesos)	75 P	\$3.96	\$5.28	18.94 P/\$	14.21 P/\$	under
Hong Kong (HK \$)	20.5 HK\$	\$2.62	\$5.28	7.82 HK\$/\$	3.88 HK\$/\$	under
Egypt (Eg£)	34.21 Eg£/\$)	\$1.93	\$5.28	17.70 Eg£/\$	6.48 Eg£/\$	under
Mexico (pesos)	48 P	\$2.57	\$5.28	18.66 P/\$	9.09 P/\$	under
Russia (Rouble)	130 Rb	\$2.29	\$5.28	56.75Rb/\$	24.62 Rb/\$	under
Norway (NK/\$)	49 NK	\$6.24	\$5.28	7.85 NK/\$	9.28 NK/\$	over
Switzerland (CHF/\$)	6.5 CHF	\$6.77	\$5.28	0.96 CHF/\$	1.23 CHF/\$	over

Again, how these are computed: The LC price (column 1) is data; so are the US BM price (column 3) and the market spot rate (column 4). Then the US\$ price (column 2) is the LC BM price divided by the spot rate (column 1/column 4). The PPP BM rate is the LC price (column 1) divided by the US BM price (\$5.28). [AGAIN, BECAUSE THESE EXCHANGE RATES ARE LC/\$ WE HAVE TO TAKE THE RECIPROCAL OF OUR EARLIER EQUATION ($E_{PPP} = P^{US}/P^{LOCAL}$) AS THE PPP RATE DEFINED IN LC/\$.]

Now you can see why it's so cheap to eat in Argentina, HK and Russia but REALLY EXPENSIVE in Norway and Switzerland.

This kind of calculation is pretty cool and you can do studies like this on your own when you travel; pick an interesting product to compare prices.

Absolute versus relative PPP

We've implicitly defined *absolute PPP* above as the exchange rate that makes living costs equal between countries:

$$E_{PPP} = P^{US}/P^{UK} \text{ (or } R = 1\text{)}.$$

Is it likely that exchange rates would actually move to this level?

No because of so many non-traded goods and differences in local costs, taxes, rents, etc. That is, we just don't expect absolute PPP to hold and the costs of buying goods really does differ across countries for long periods of time. So do differences in wages and other costs. Put another way, some countries have higher price *levels* than others due to these factors. (So do cities: think about costs in New York City versus Pueblo Colorado.)

But perhaps we should expect some tendency toward *relative PPP*.

This is the idea that over a long period, market exchange rates must move in the direction of differences in inflation rates. That is, a country with high inflation should see a depreciating currency and a country with a low inflation should see an appreciating currency. Why? Inflation makes your products less competitive and reduces the demand for your currency. So if one country experiences higher inflation than another the first one will see its currency drop in value to restore its competitiveness in trade.

Absolute versus relative PPP

How do we define the idea of relative PPP (RPPP)? First, it's not reasonable to think the ratio of living costs equals 1 (absolute PPP). But the ratio might tend toward a given constant:

$P^{US}/EP^{UK} = \theta$. If $\theta > 1$ the US is more expensive but if $\theta < 1$ the UK is more expensive.

Then RPP involves % changes in the exchange rate to keep θ constant. Rewrite the equation as

$P^{US} = EP^{UK}\theta$. Then $(\% \Delta P^{US}) = (\% \Delta E) + (\% \Delta P^{UK}) + (\% \Delta \theta)$ (This is a property of percentages, or really of logarithms.)

But by assumption in RPPP, $(\% \Delta \theta) = 0$. So we have

$$(\% \Delta P^{US}) - (\% \Delta P^{UK}) = (\% \Delta E) .$$

In words, the difference between US inflation and UK inflation will equal the percentage depreciation or appreciation of the £ relative to the \$.

Relative PPP (RPPP)

Then the proposition of RPPP is simply that the market spot rate adjusts over time to equal differences in relative inflation rates.

(Usually we think in terms of consumer price indexes here).

Let's take an example, using US and Canada. Let $P^{US} = \$115,000$ and $P^C = C\$100,000$ and $E = 0.95$ $\$/C\%$ (price of C\$). Then $P^{US}/EP^{C\$} = \$115,000/(0.95 * C\$100,000) = 1.21 = \theta$. That is, it is currently 21% more expensive to live in the US and this ratio should stay fairly constant over time.

RPPP says that The market exchange rate will adjust (say over 1-2 years or longer) with differences in inflation rates to keep this relative cost stable.

So let $(\% \Delta P^{US}) = 3\%$ and $(\% \Delta P^C) = 5\%$. The US CPI goes up 3% and the Canadian CPI goes up 5%. Then RPPP would mean

$$3\% - 5\% = (\% \Delta E) = -2\%.$$

That is, faster Canadian inflation should make the C\$ *depreciate* over time, in this case by 2%. If so, the new exchange rate would be $E = 0.95 * (1 - 0.02) = 0.95 * 0.98 = 0.93$ $\$/C\%$.

Relative PPP (RPPP)

Does this depreciation maintain the same relative living costs? With inflation we have new cost bundles: $P^{US'} = \$115,000(1.03) = \$118,450$ and $P^{C'} = C\$100,000(1.05) = C\$105,000$. Then $\$118,450 / (0.93 * C\$105,000) = 1.21$.

The relative costs of living are sustained (it's still 21% more expensive in the US).

Again, the *idea* behind RPPP is that in the long run E must adjust to reflect changes in the differences in inflation rates.

How true is this? In fact for the major industrialized countries it does seem to hold reasonably well over a 3-5 year horizon, sometimes quicker than that. But as you can guess there are large short-run (daily or monthly) variations around any such trends because in the short run exchange rates really are a part of asset prices as we discussed in prior notes.

IMPORTANCE: RPPP IS OUR BASIC THEORY OF WHAT DETERMINES EXCHANGE-RATE CHANGES IN THE LONG RUN. IT IS THE BEST PREDICTOR WE HAVE OF HOW EXCHANGE RATES WILL MOVE OVER A PERIOD OF SEVERAL YEARS.