Note: I am using old solutions, but no harm done, since they illustrate the logic correctly.

A course on Open Economy Macroeconomics, Aalto University SB Spring ~~2017~~ 2019 Problem set 2, Solutions

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Exercise 1 *Find recent bid-ask quotes (e.g. http://www.oanda.com/convert/classic) for the dollar rates for Euro andYen, and also find the cross rate between Euro and Yen. Suppose you sell \$1 and buy Euros, then you sell the proceeds to buy Yen, and finally you sell the proceeds of that sale to buy back dollars. Do you end up with more or less than the \$1 you started out with?*

Solution 2 *Wednesday 16.03.2017 10:05 average bid and ask rates from OANDA, see the table below. So you start with selling* \$1 *for* 0.93975 *euros (bid rate for buying euros). Next, by selling your euros for yens you obtain* $122.20 \times 0.93975 = Y114.83745$. *Finally, you sell your yens for US dollars at* 0.00871 *per Y which gives you* $114.83745 \times 0.00871 = \$1,0002342$. *So, you end up with slightly more than* \$1.

Market Rates for \$, € and JPY on Wednesday 16.03.2016 at 14:05 (OANDA)

	Bid	Ask
\$ vs €	0.93975	0.93986
€ vs Y	122.20	122.22
Y vs \$	0.00871	0.00871

Exercise 3 *Economists would expect the rate of return in Ex1 to be quite small. Explain why? (Hint: think what would happen if there were a big return?)*

Solution 4 *In Ex1 you actually win roughly* 0.02%. *Why? Although* ***arbitrage*** *takes care of the fact that the* ***bid-ask spreads*** *are very small given that* ***transactions costs*** *are very small, the euro seems to relatively weak against the USD: by buying Y via € you get* $Y114,83745$, *whereas if you would have bought Y directly with your \$1 you would have obtained* $Y114.84$. *In general if the bid-ask spreads are large (,while transaction costs low), you would expect large gains from arbitrage and, hence, a quick response from agents participating in currency markets to exploit the implied profit opportunities.*

Q3

	2006	2007	2008	2009
US Dollar	1	1	1	1
JPN Yen JPY	116.05	130.615	113.3	102.31
NA Rupiah IDR	2363	5535	8005	7050

Exercise 5 *Refer to the above table. a) Suppose you are manager of an Indonesian company that borrowed the equivalent of US$1,000,000 in Yen from a Japanese bank at the beginning of 2006. That amount is immediately converted into Rupiah for operations in your Indonesian factory. How much Rupiah do you now have for operations? b) If you were to pay back the Japanese bank at the beginning of 2007, how much Rupiah does you company have to pay for the full principal borrowed in 2007? What about in 2008? And in 2009? c) If you were manager of an Indonesian company that exported goods to America, how would these exchange rate movements have affected the dollar sales price of your goods?*

Solution 6 *Use the above table* ***Q3****. a) US$1,000,000 buys JPY116,050,000 in 2006. Using the implied cross-rate, the NA Rupiah price of Yen in 2006 is JPY1=IDR20.362*[1]*, so the Yen loan buys IDR2,363,010,000*[2]*. b) In 2007 the Indonesian Rupiah has depreciated against the Yen from IDR20.362 per Yen in 2006 to IDR42.376 per Yen in 2007*[3]*, so to pay back the full principal of the JPY116,050,000 loan you need to come up with IDR4,917,734,800. In 2008 the Rupiah has further depreciated against the Yen to IDR70,653 per Yen while*[4] *in 2009 it has strenghened (from 2008) against the Yen to IDR68.908 per Yen,*[5] *so you would need to raise IDR8,199,396,700 in 2008 and IDR7,996,773,400 in 2009 to pay the full principal borrowed in 2006. c) What happens to the US$ price of your exports,* ***depends also on what happens to the domestic (ie. Rupiah) price of exports****. It is conceivable that you could raise this price, but* ***for simplicity assume that the Rupiah price of your company's exports remains constant throughout the years****. Then the effect of the exchange rate movements on the path of the dollar sales price of the company's products can be read off from the path of the dollar value of the Rupiah (e.g. US$ price of NA Rupiah):*

	2006	2007	2008	2009
IDR	1	1	1	1
US$ per 1000 IDR	0.4232	0.1807	0.1249	0.1418

Hence, the dollar price of exports falls in the three first years (2006-2008), whereas it increases in 2009.

[1] $\$1 = Y116.05$ and $\$1 = R2363$, hence $1Y = \frac{2363}{116.05} = R20.362$.
[2] $Y116,050,00 \cdot 20.362(R/Y) = R2,363,010,00$
[3] $R42.376 = \frac{5535}{130.615}$
[4] $R70.653 = \frac{8005}{113.3}$
[5] $R68.908 = \frac{7050}{102.31}$

Exercise 7 *Suppose that during the period 2006-2009 the annual rate of consumer price inflation in Japan was zero and in the USA and Indonesia, resp., 1%, 1.5%, 3% and 0% and 5%, 7%, 10% and 5%. Assume further the price level in the US, Japan and Indonesia in 2005 was, resp., 110, 104 and 140. (This means that relative to the base 2000, for example, consumer prices in the US, Japan and Indonesia were 10, 4 and 40 percent higher in 2005).Take US as the home country and use the above table to compute the 2005-09 real exchange rate of the US $ relative to JPN Yen and Indonesian Rupiah assuming that* ***relative to 2006*** *the nominal USD exchange rate in 2005 was 5 % weaker against both the Yen and Rupiah. Compute also the change in the US real exchange rates vis-á-vis the Yen and Rupiah during the time period 2006-09.*

Solution 8 *Note first that the nominal exchange rate for the USD in 2005 was 5% weaker against both the JPY and NA Rupiah relative to 2006. Now, the exact numbers you get from your calculations depends on how you interpret this. The problem is that percentages are not symmetric and depend on the base. Looking from the US exporter's side, natural interpretation would be to say that each dollar of the price of his/her export good bought 5% less JPYs in 2005 than in 2006 so that you should then calculate the 2005 JPY price of the USD as* $0.95 \cdot 116.05 = 110.2475$. *This is the assumption below. But, from the perspective of the Japanese exporter, you could think that each Y of the price of his/her export good bought 5% more USDs than in 2006 so that you should then calculate the 2005 USD price of the JPY as* $1.05 \cdot (1/116.05) = 0.00905$. *I really do not think there is an absolutely right way of proceeding.*[6] *So, start by the definition of the real exchange rate (Domestic economy = USA)*

$$\begin{aligned} Q &= \textit{real exchange rate} = \frac{\textit{Domestic currency value of the foreign price level}}{\textit{Domestic price level}} \\ &= \frac{\textit{Nominal exchange rate} \times \textit{Foreign price level}}{\textit{Domestic price level}} \\ &= \frac{S \times P^f}{P} \end{aligned}$$

So, taking into account the 2005 nominal exchange rate S_{2005} *for the USD*[7]*, we have*

	2005	2006	2007	2008	2009
US$ price of JPY	0.0091	$\frac{1}{116.05}$=0.0086	0.0077	0.0088	0.0098
US$ price of IDR (per R1000)	0.4455	0.4232	0.1807	0.1249	0.1418

Now, we can calculate the real exchange rates

[6] I had an informative exchange of emails with one of you on this.

[7] In 2005 $\$1 = 0,95 \cdot 116.05 = Y110,2475$ and $\$1 = 0,95 \cdot 2393 = IDR2244,85$. Take the inverse of these figures and you end up in the second column of the table.

Real exchange rate	2005	2006	2007	2008	2009
US vs JPY	$\frac{0.0091\times104}{110}=0.0086$	$\frac{0.0086\times104}{111.1}=0.0081$	0.0071	0.0078	0.0088
US vs IDR $\frac{1}{1000}\times$	$\frac{0.4455\times140}{110}=0.567$	$\frac{0.4232\times147}{111.1}=0.5599$	0.2520	0.1861	0.2219

The factor $\frac{1}{1000}\times$ *in the US vs IDR comes from the fact that the US$ price of NA rupiah is expressed as the amount of dollars you can buy with* 1000 *rupiah. Next, you can calculate the percentage changes in the real exchange rates. For that you can use the exact formula*

$$100\times\frac{\textit{Period t real exchange rate - Period t-1 real exchange rate}}{\textit{Period t-1 real exchange rate}}$$

or the logaritmic approximation

$100\times[$*Log of period t real exchange rate - Log of period t-1 real exchange rate*$]$

The first one gives you

Change Q	2005→2006	2006 → 2007	2007 → 2008	2008 → 2009
US vs JPY	$100\times\frac{0.0081-0.0086}{0.0086}=-5.8\%$	-12.3%	9.8%	12.8%
US vs IDR	$100\times\frac{0.4455-0.567}{0.567}=-21.4\%$	-56.8%	-26.15%	19.2%

Note that you do not need the factor $\frac{1}{1000}\times$ *any more as it appears both in the numerator and denominator. You can alternatively use logs to compute the real exchange rates and their changes. Denoting logarithmic variables by small letter, ie.* $x=\ln(X)$*, we have that the log of the real exchange rate* q *in year* t *is*[8]

$$q_t=p_t^f+s_t-p_t$$

Here: p^f *is the consumer price level in either Japan or Indonesia*[9]*,* s *is the nominal exchange rate (US$ price of Yen or Rupiah) and* p *is the US consumer price level. Annual rates of changes are now*

$$\Delta q_t=\ln(q_t)-\ln(q_{t-1})=\Delta p_t^f+\Delta s_t-\Delta p_t$$

Now to calculate the logs, you just consult you pocket calculator or computer to have eg. for US vs JPY from 2005 to 2006: the left hand side is

$$100\times[\ln(0.0081)-\ln(0.0086)]=100\times[-4.8159-(-4.75599)]=-5.99\%$$

[8] Note that for two positive variables X and Y we have $\ln(X\cdot Y)=\ln(X)+\ln(Y)$, $\ln\left(\frac{X}{Y}\right)=\ln(X)-\ln(Y)$ and $\ln(X^a)=a\ln(X)$, where a is a real number. Note further that if X is the value of a stochastic process/time series at time t, so that we should write X_t, and Y denotes that value of the stochastic process/time series at time t-1, ie. $Y=X_{t-1}$, the $\ln\left(\frac{X_t}{X_{t-1}}\right)=\ln(X_t)-\ln(X_{t-1})$. This log-change is above denoted by Δ, ie. $\Delta\ln(X_t)=\Delta x_t=\ln(X_t)-\ln(X_{t-1})$. Finally, the fact that this log-change describes rate of change comes from the fact that (for small changes) $\Delta\ln(X_t)=\frac{X_t-X_{t-1}}{X_{t-1}}=\frac{\Delta X_t}{X_{t-1}}$

[9] The question referred to Indian Rupiah, but it should be **Indonesian** Rupiah IDR.

This figure is somewhat different to what we have using the exact formula, ie. −5.8%. The reason is, first, that the nominal depreciation of the USD between 2005 and 2006 is about 5% which is not a small number. So the (natural) log-approximation is not the precise. On the other hand, using the right hand side of the above equation we have, eg. USD against JPY

$$0\% + (-5.651) - 0.9955\% = -6.6465\%$$

Hence, approximation errors accumulate. You can continue calculating the rest of the real depreciation following the exact formula given above or using the approximate ones. Now, use the table Q4 below (, which uses logs). From 2005 onwards, the dollar strenghened in real terms against the JPYin 2006 and 2007 (5.99% and 13.3%) and then depreciated in 2008 and 2009 (9.4% and 12% respectively). Thirdly, the dollar strenghened in real terms against the IDR in 2006, 2007 and 2008 (21.4%, 79.8% and 30.3% respectively) and depreciated in 2009 (17.6%). The lessons we can draw from this example is that the volatility of the nominal exchange rate explains most of the volatility in real exchange rates.

Q4a

	2006	2007	2008	2009
US Inflation %	1	1.5	3	0
JPN Inflation %	0	0	0	0
Indonesia Inflation %	5	7	10	5
Depreciation vs JPY %	-5,65[10]	-11,8	14.2	10.2
Depreciation vs IDR%	-5,14	-85.1	-36.9	12.7
Real Depreciation vs Yen %	-5.99	-13.3[11]	9.4	12.0
Real Depreciation vs Rupiah %	-21.4	-79.8	-30.3	17.6
Real Exchange Rate vs Yen $\frac{1}{100}\times$	0.81	0.71	0.78	0.88
Real Exchange Rate vs Rupiah $\frac{1}{1000}\times$	0.4455	0.2520	0.1861	0.2219

Q4b Price level

[10] Note that we are using natural logs to compute the rate of depreciation. Eg. for JPY in 2006: $\ln(0.0086) - \ln(0.0091) = -0.0565$ or -5.65%. The more exact figure would be $\frac{0.0086-0.0091}{0.0091} = -0.0549$ or 5,49 %

[11] Using more precise notation we have eg. for the US $ vis-a-vis JPY in 2007, we have

$$\begin{aligned} \Delta q_{2007}^{US,JPN} &= \ln Q_{2007}^{US,JPN} - \ln Q_{2006}^{US,JPN} \\ &= \Delta p_{2007}^{JPN} + \Delta s_{2007} - \Delta p_{2007}^{US} \end{aligned}$$

where Δs_{2007} refers to the change in the US$ price of the Yen from 2006 to 2007, ie. nominal depreciation of the Yen against the US dollar. From the table: JPN inflation in 2007 is zero ($\Delta p_{2007}^{JPN} = 0$), US inflation in 2007 is 1.5% ($\Delta p_{2007}^{US} = 0.015$) and the rate of depreciation of the JPY is 11.8% ($\Delta s_{2007} = -0.118$). Hence

$$\Delta q_{2007}^{US,JPN} = 0 - 0.118 - 0.015 = -0.133$$

or 13.3% real **appreciation** vis-a-vis Yen

Price level	2005	2006	2007	2008	2009
US	110	111.1[12]	112.8	116.1	116.1
Japan	104	104	104	104	104
Indonesia	140	147	157.3	173.0	181.7

[12] Take e.g. the US, where the inflation rate is 1% between 2005 and 2006, the 2006 level is obtained by multiplying the 2005 price by the gross inflation rate from 2005 to 2006, ie. $1 + 0.01$. Hence the 2006 price level is $110 \cdot 1.01 = 111.1$.