Exchange rate determination (Part I)

Readings

- Schmitt-Grohé et al. (2019) *International Macroeconomics*, Chapter 8
- Guest Lecture: Applied Economic Theory (Lars Christensen)
- Taylor, Alan M. and Mark P. Taylor, "The Purchasing Power Parity Debate," Journal of Economic Perspectives 18, Fall 2004, 135-158. DOI: 10.1257/089533004263274
- Handbook of International Economics (2014), Chapter 7, "International prices and exchange rates"

Learning objectives

- What are the determinants of the real exchange rate?
- Does the law of one price (LOOP) hold?
- Absolute vs. relative PPP . . .
  - short-run disturbances, long-run equilibrium
- Why does it fail?
  - Nontradables, trade barriers, home bias, and price indices

Contents:

The Law of One Price

applies to single perfectly substitutable good i only! The law of one price holds if $P_i = \mathcal{E} P_i^*$

$P_i =$ domestic currency price of good i

$P_i^* =$ foreign currency price of good i

$\mathcal{E} =$ nominal exchange rate, (domestic currency price for 1 unit of foreign currency)

- Why should it hold? arbitrage
- Does it hold? e.g., The Big Mac Index (good $i = BM$)

Construct a measure for the number of domestic Big Macs needed to buy one foreign Big Mac (e_{BM}) $\Rightarrow$ the BM real exchange rate (RER):[1]

$$e_{BM} = \frac{\mathcal{E} P_{BM}^*}{P_{BM}}$$

- $e_{BM} > 1$ (expensive), $e_{BM} < 1$ (cheap), $e_{BM} = 1$ (unity)

[1] S denotes the domestic currency price of one unit of foreign currency. e.g., if RSA is home country: R15:$1.

Examples of goods for which the LOOP holds:

- Gold
- Oil
- Wheat
- Luxury Consumer Goods (MontBlanc pens, Rolex watches, etc.)

Examples of goods for which the LOOP fails:

- Big Mac
- Housing
- Transportation
- Haircuts
- Restaurant Meals

Service jobs have typically been "protected" from globalization $\rightarrow$ (infinitely) high transaction costs . . .

How will "globotics" change the mobility and value of services? . . . labour tele-mobility . . . 3D-printing?

Reasons Why the LOOP May Fail . . .

- a good has non-traded inputs such as:
  - labour
  - rent
  - electricity
- government policies/regulations (taxes)
- barriers to trade (tariffs, quotas)
- pricing-to-market (pharmaceuticals)

Absolute Purchasing Power Parity (PPP)

For **absolute PPP** to hold requires that LOOP holds $\forall$ goods i in the (weighted) basket of consumption goods:

$$e = \frac{\mathcal{E}P^*}{P}, \quad \text{units} \Rightarrow \frac{\text{domestic baskets}}{\text{foreign baskets}}$$

where

$P =$ domestic currency price of a domestic *basket* of goods

$P^* =$ foreign currency price of a foreign *basket* of goods

$\mathcal{E} =$ nominal exchange rate (domestic currency price for 1 unit of foreign currency)

$e =$ *real* exchange rate

- $e = 1$, PPP holds.
- $e > 1$, home basket is *undervalued*, or foreign basket overvalued.
  - if $\Delta e > 0$, we say the RER *depreciates*
- $e < 1$, home basket is *overvalued*, or foreign basket undervalued.
  - if $\Delta e < 0$, we say the RER *appreciates*

Absolute Purchasing Power Parity (PPP)

To test PPP, we must measure P & P^* ...

- what are the issues with CPI?
  - index *not* levels[2]
  - basket of goods not comparable across countries
    - different items
    - different weights
  - tradables v. non-tradables
  - data collection ...

$\therefore$ even if the LOOP holds $\forall$ goods, PPP ($e = 1$) may not necessarily hold

[2] But still very useful to track *changes* in real ex rate over time.

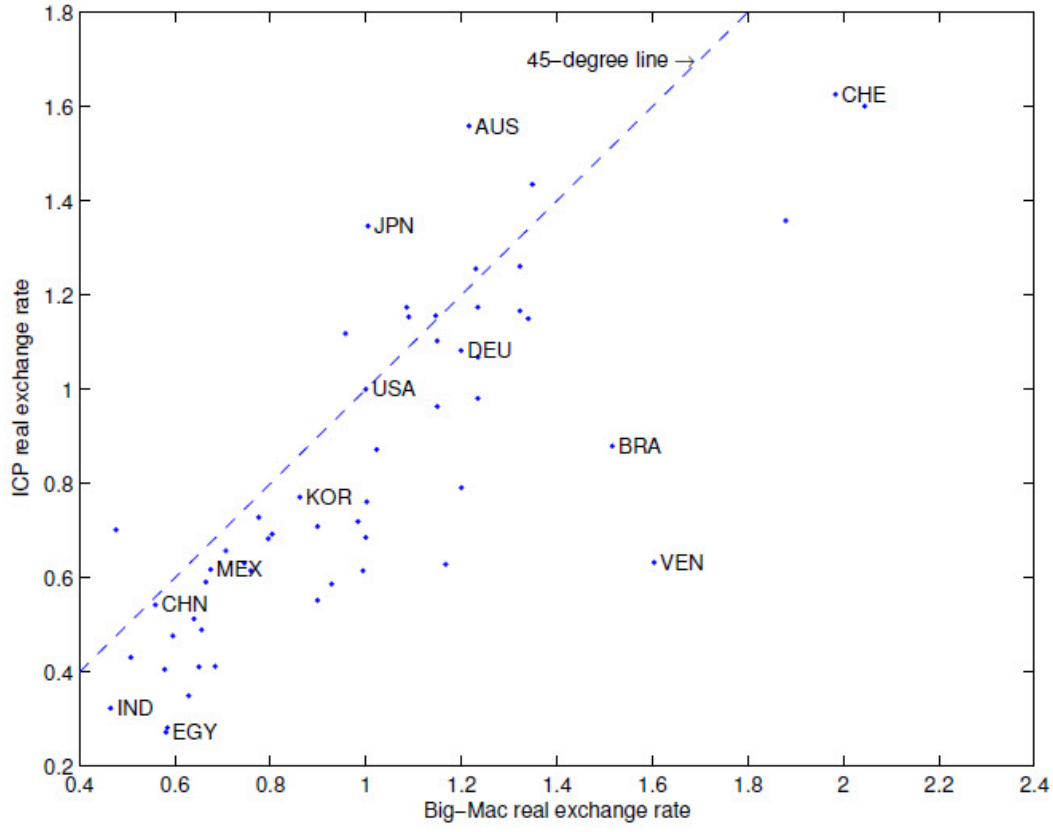
Deviations From Absolute PPP in Selected Countries: Evidence from the International Comparison Program

Country	e	$\mathcal{E}$	$\mathcal{E}^{PPP}$
Switzerland	1.63	1.13	0.69
Norway	1.60	0.18	0.11
Australia	1.56	1.03	0.66
Sweden	1.36	0.15	0.11
Japan	1.35	0.0125	0.00931
Canada	1.26	1.01	0.80
France	1.17	1.39	1.18
New Zealand	1.17	0.79	0.67
Belgium	1.17	1.39	1.19
Netherlands	1.16	1.39	1.20
Austria	1.15	1.39	1.20
Ireland	1.15	1.39	1.21
United Kingdom	1.12	1.60	1.43
Germany	1.08	1.39	1.28
Italy	1.07	1.39	1.30
United States	1	1	1
South Korea	0.7711	0.0009023	0.00117
China	0.54	0.15	0.29
Sierra Leone	0.36	0.000231	0.000644
Sri Lanka	0.35	0.01	0.03
Burundi	0.34	0.000793	0.00235
Gambia, The	0.34	0.03	0.10
Nepal	0.33	0.01	0.04
Madagascar	0.33	0.000494	0.00148
Tanzania	0.33	0.000636	0.00191
Cambodia	0.33	0.000246	0.000742
Uganda	0.33	0.000396	0.0012
Vietnam	0.33	4.88e-05	0.000149
India	0.32	0.02	0.07
Bangladesh	0.31	0.01	0.04
Ethiopia	0.29	0.06	0.20
Pakistan	0.28	0.01	0.04
Egypt	0.27	0.17	0.62

Source: Schmitt-Grohé et al. (2019), Table 8.2, p. 269.

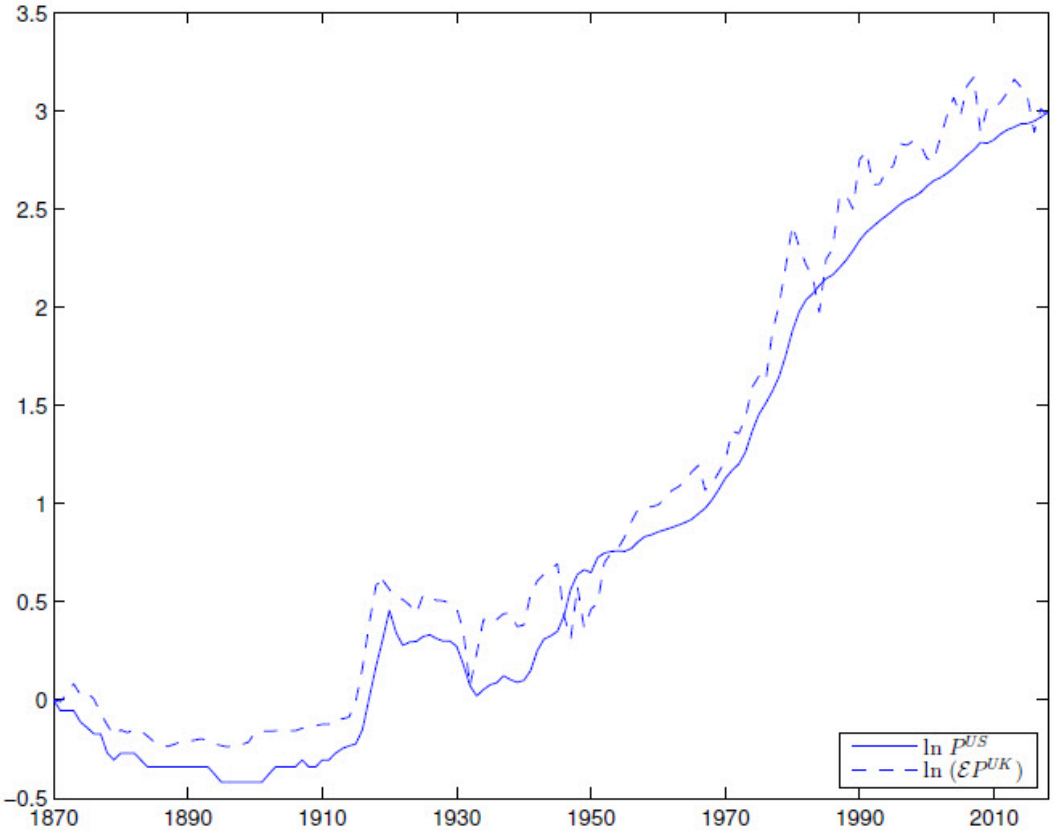
e.g.: a basket of goods that cost \$100 in the U.S only cost \$54 in China.

Figure 8.2: Comparing the ICP and Big-Mac Real Exchange Rates in 2011



Notes. The figure plots the ICP real exchange rate against the Big-Mac real exchange rate for 57 countries in 2011. The figure shows that the Big-Mac real exchange rate is highly correlated with the ICP counterpart. This suggests that the Big Mac real exchange rate is a good measure of how expensive different countries are relative to one another. Selected country names are indicated using ISO abbreviations. Source: See notes to tables 8.1 and 8.2.

Figure 8.4: U.S. and U.K. Consumer Price Indices in Dollars: 1870-2018



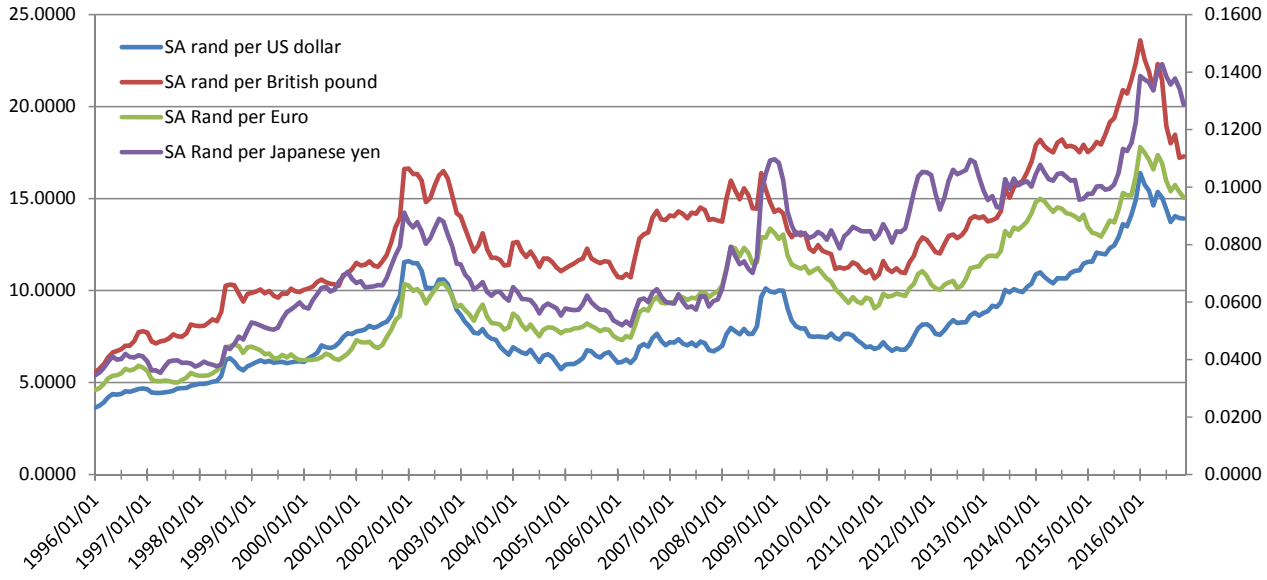
Notes. Both price indices are normalized to 1 in 1870 and are expressed in logarithms. The fact that the two lines keep close to each other over 148 years suggests that relative PPP holds in the long run. Data Source: Until 2013, Òscar Jordà, Moritz Schularick, and Alan M. Taylor. 2017. "Macrofinancial History and the New Business Cycle Facts," in NBER Macroeconomics Annual 2016, Volume 31, edited by Martin Eichenbaum and Jonathan A. Parker. Chicago: University of Chicago Press. After 2013, IFS, FRED, and U.K. Office of National Statistics.

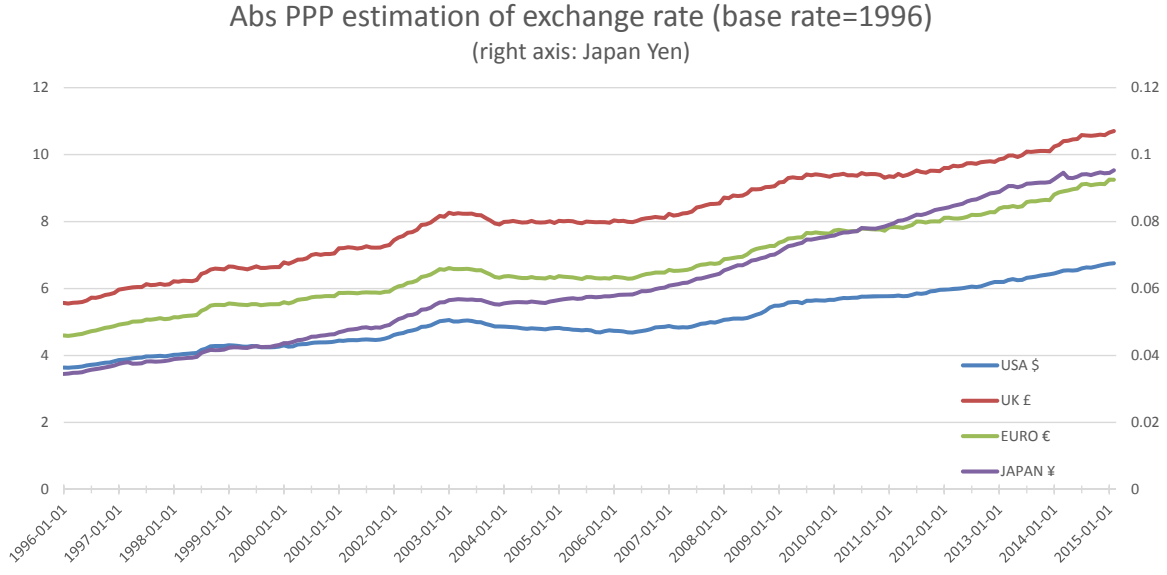
PPP puzzles: Short-Run Disturbances, Long-Run Equilibrium

Empirical work that focuses on the path of real exchange rates must grapple with three key factors:

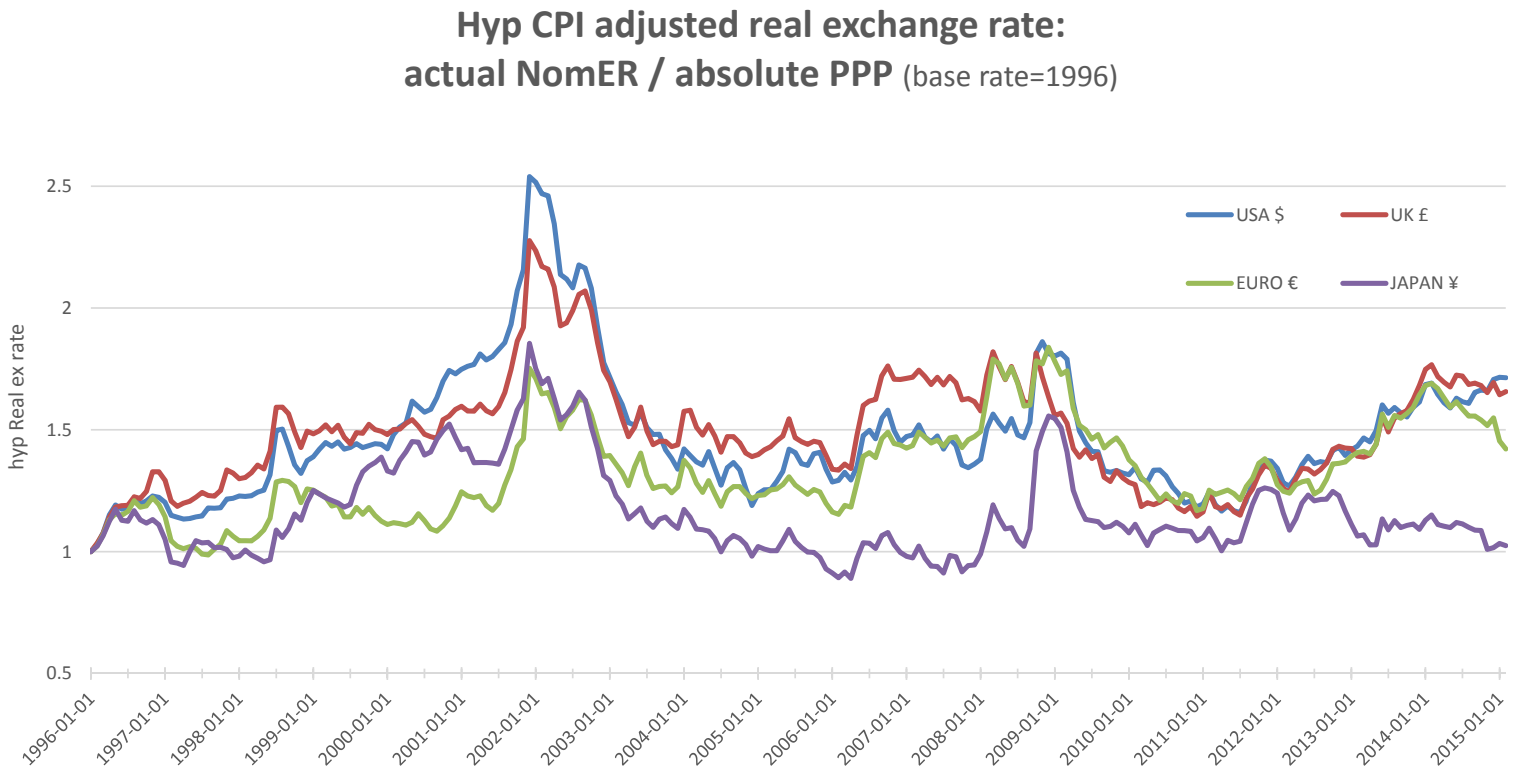
- the reversion speed;
- the volatility of the disturbance term; and
- the long-run, or equilibrium, level of the real exchange rate

Deviations from absolute PPP: South Africa



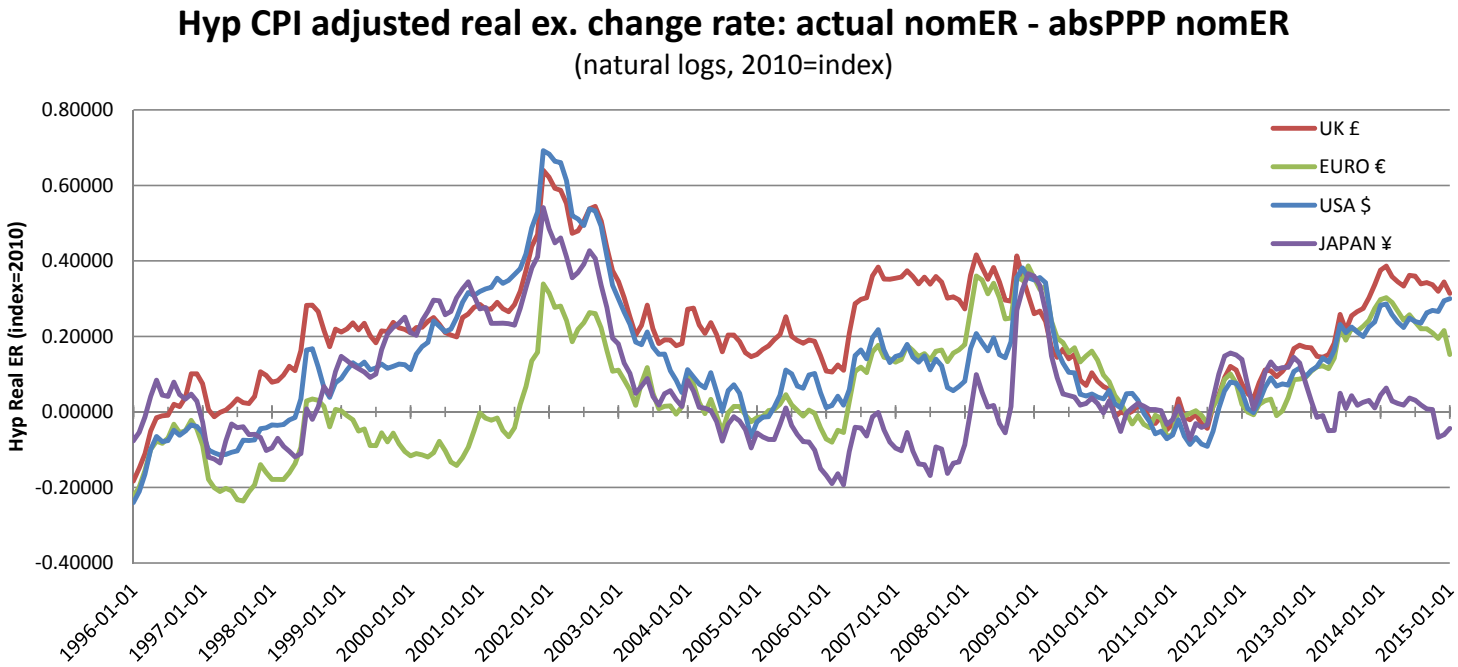


Deviations from absolute PPP: South Africa



From previous slide: series in top panel divided by series in bottom panel. $e^{R/\$} > 1$ implies home basket is *undervalued*.

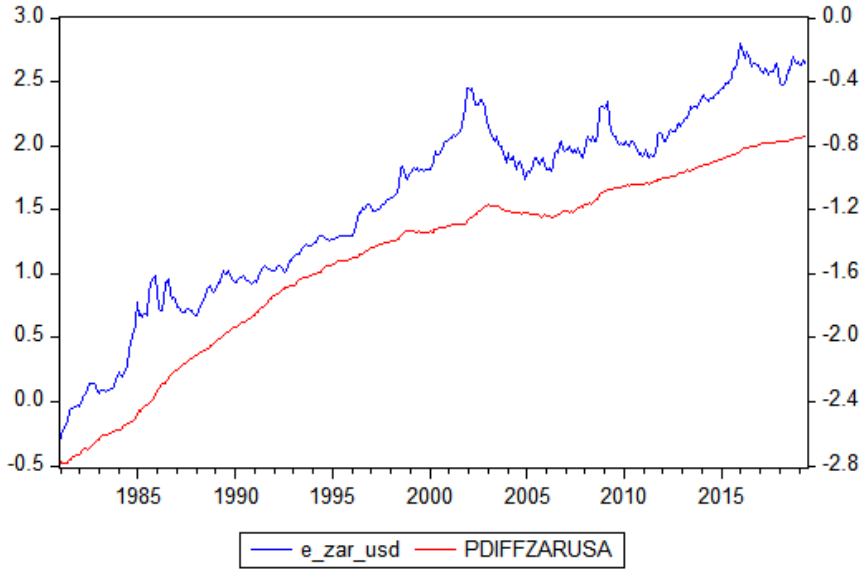
Log-deviations from absolute PPP: South Africa

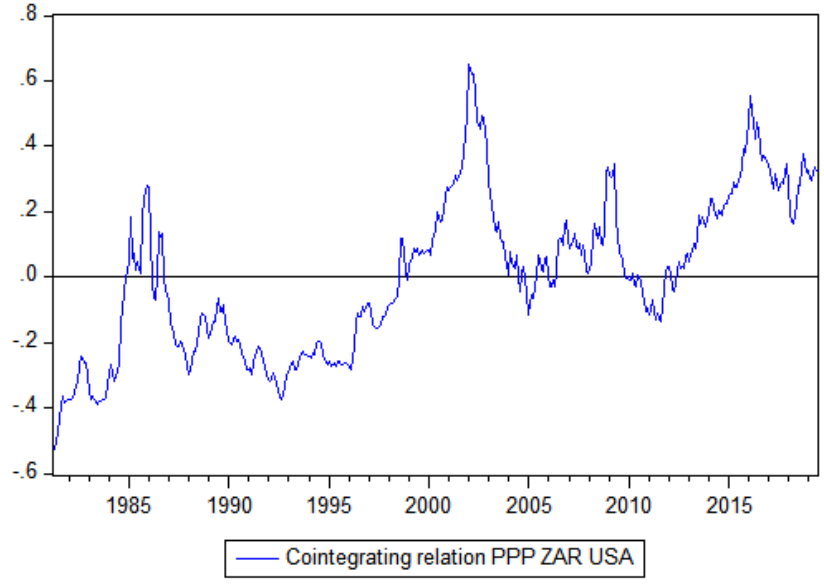


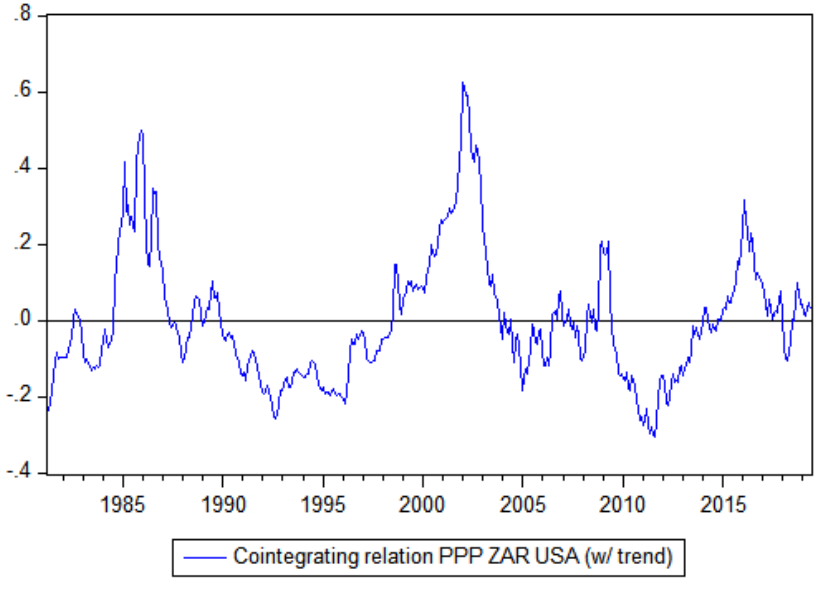
Strong co-movement vis-à-vis advanced economies: UK, Euro, USA, Japan

Persistent deviations from zero ($ln(e^{R/*}) > 0$) implies . . .

- home basket is *undervalued*, or foreign basket overvalued. $\Delta e^{R/*} > 0$ real depreciation
- hypothetical real ZARUSD: 33.36% $(2010/12 \rightarrow 2015/03)$





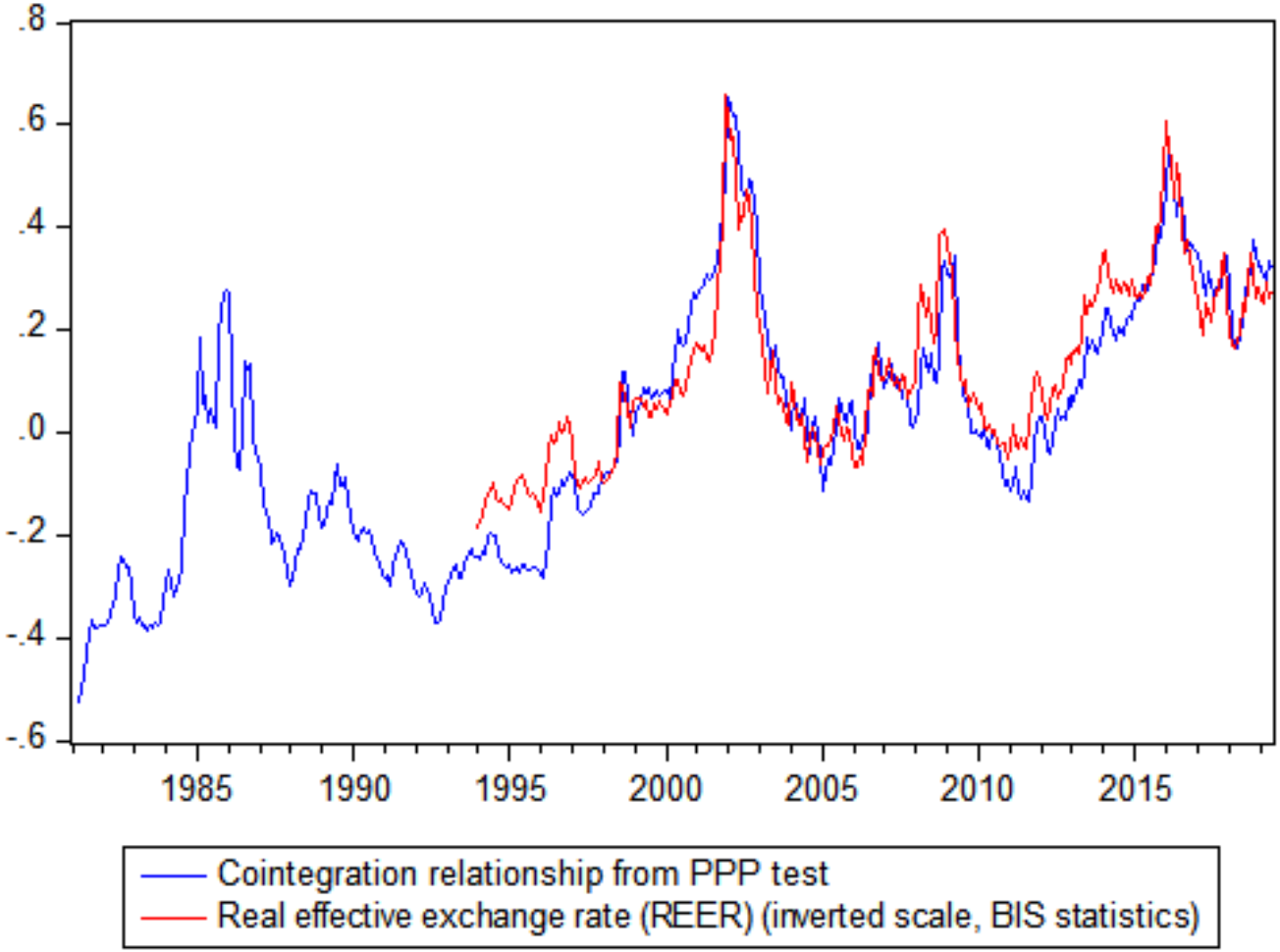


$$\ln(e_t^{R/*}) = \ln(\mathcal{E}_t) - \ln(P_t/P_t^*)$$

The cointegration hypothesis of PPP can be stated as:

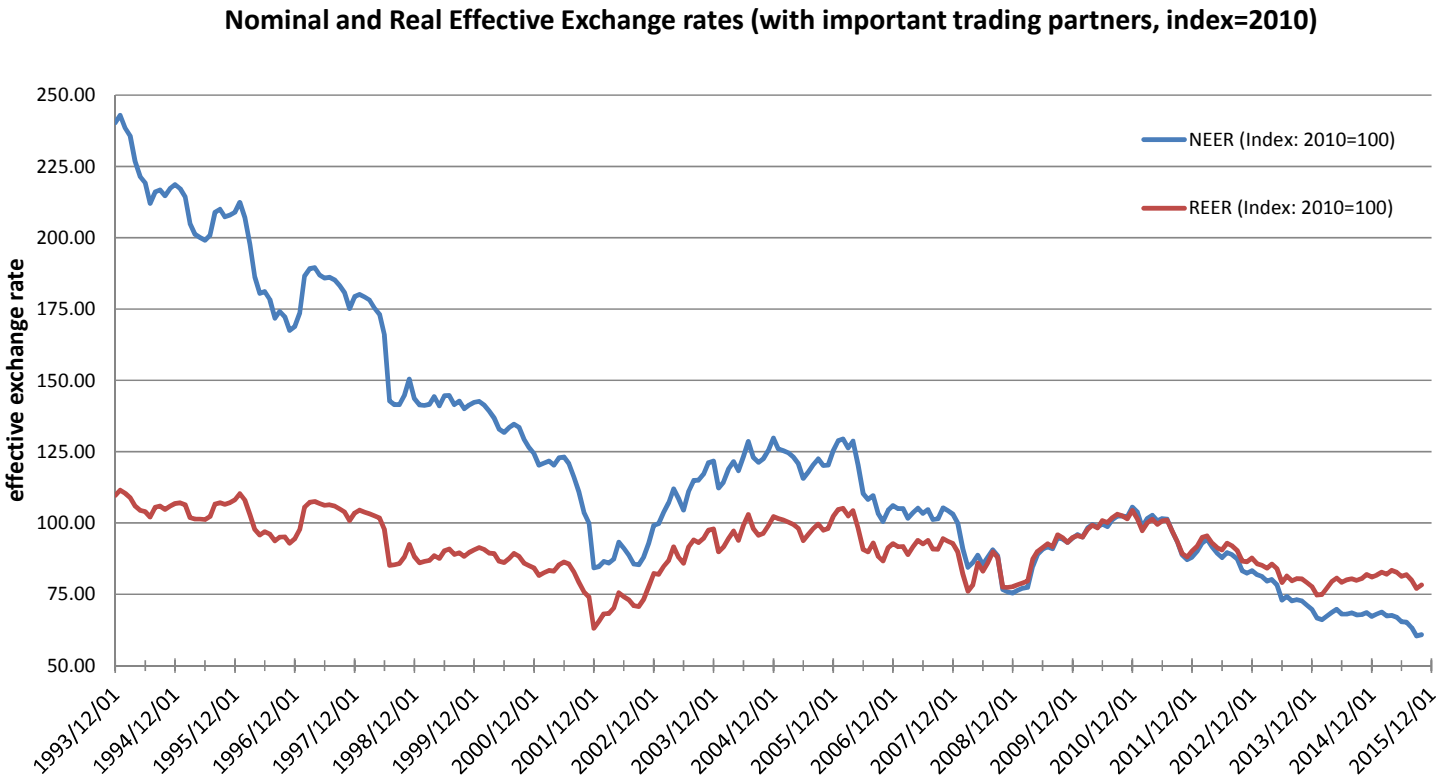
$$\begin{bmatrix} 1 & -1 & 1 \end{bmatrix} \begin{bmatrix} \ln(\mathcal{E}_t) \\ \ln(P_t) \\ \ln(P_t^*) \end{bmatrix} = \ln(e_t^{R/*}) \sim \mathcal{I}(0)$$

Left panel removes trend from conintegrating relationship to make the long run stationary (i.e., RER has a depreciation trend . . . see REER in next slide.



The real exchange rate is not constant. Absolute PPP therefore does not hold. We could argue (as above) that PPP is stationary (mean reverting) around a long run trend in the real rate. But the literature is inconclusive on this . . .

NEER & REER

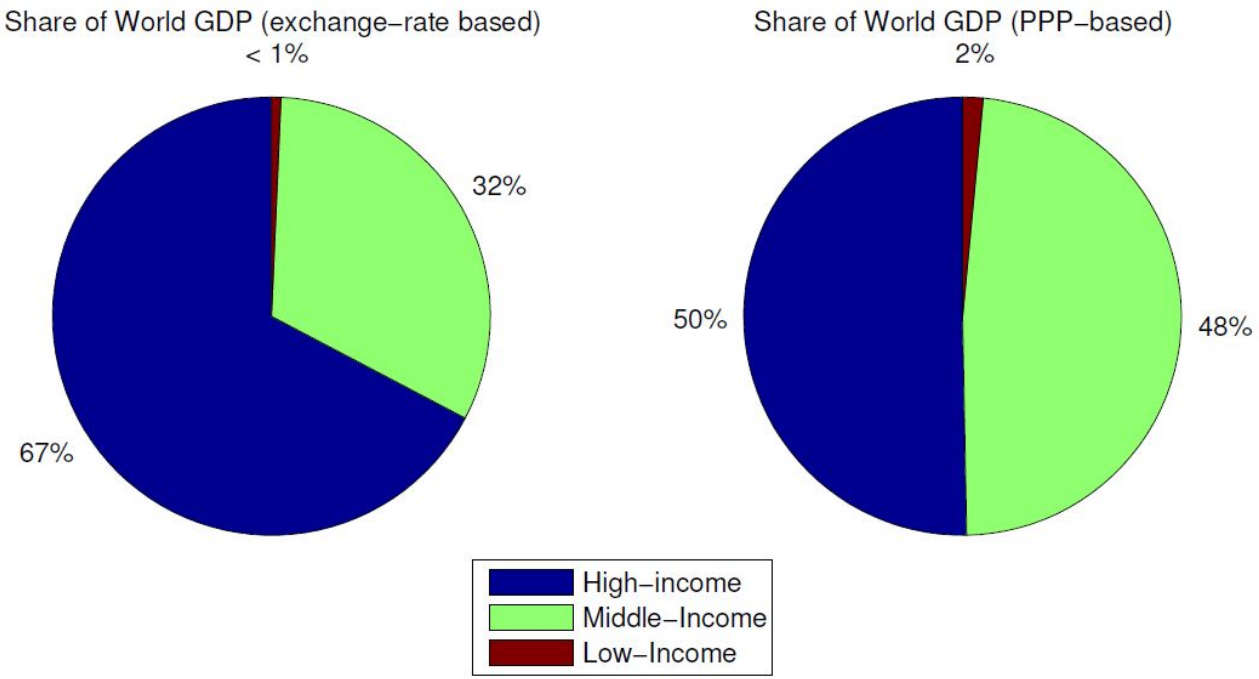


Index values (left axis): down means depreciation of the rand against trading partner currencies.

Depreciation of REER from 2010/12 $\rightarrow$ 2015/03: 21.4% (2015/10: 25%).

Can we explain this trend? (next session)

Application: PPP exchange rates and . . .

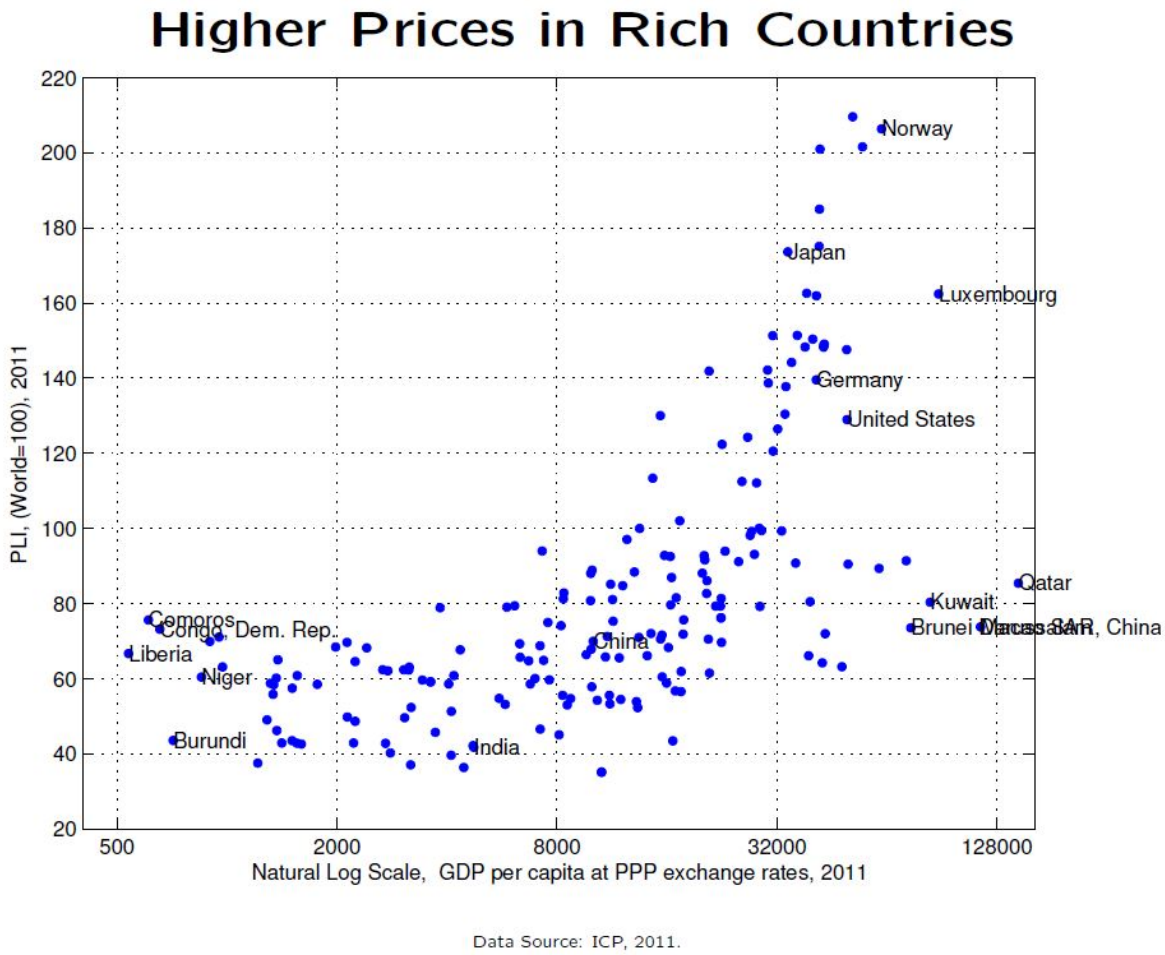


The income categories are as follows: low income—per capita gross national income (GNI) less than $1,025 (32 countries); middle income—per capita GNI from $1,026 to $12,475 (84 countries); and high income—per capita GNI greater than $12,475 (56 countries).

GDP (PPP-based)		GDP ($-based)	Economy
Rank	World Share	World Share	
1	17.1	22.1	United States
2	14.9	10.4	China
3	6.4	2.7	India
4	4.8	8.4	Japan
5	3.7	5.2	Germany

Data Source: Table 7.1 of “Purchasing Power Parities and Real Expenditures of World Economies, Summary of Results and Findings of the 2011 International Comparison Program.”

Application: PPP exchange rates and . . .



Country	Per Capita US$	GDP PPP
United States	49 782	49 782
India	1 533	4 735
US/India	32	11

$1 533 can buy 3 times as many goods in India (at Indian prices) than it can in the U.S. at U.S. prices.

Relative purchasing power parity (PPP)

- Most studies of PPP $\therefore$ focus on *changes* in RER over time:

  $ln(e) = ln(\mathcal{E}_t) + ln(P_t^*) - ln(P_t) \Rightarrow$ take difference:

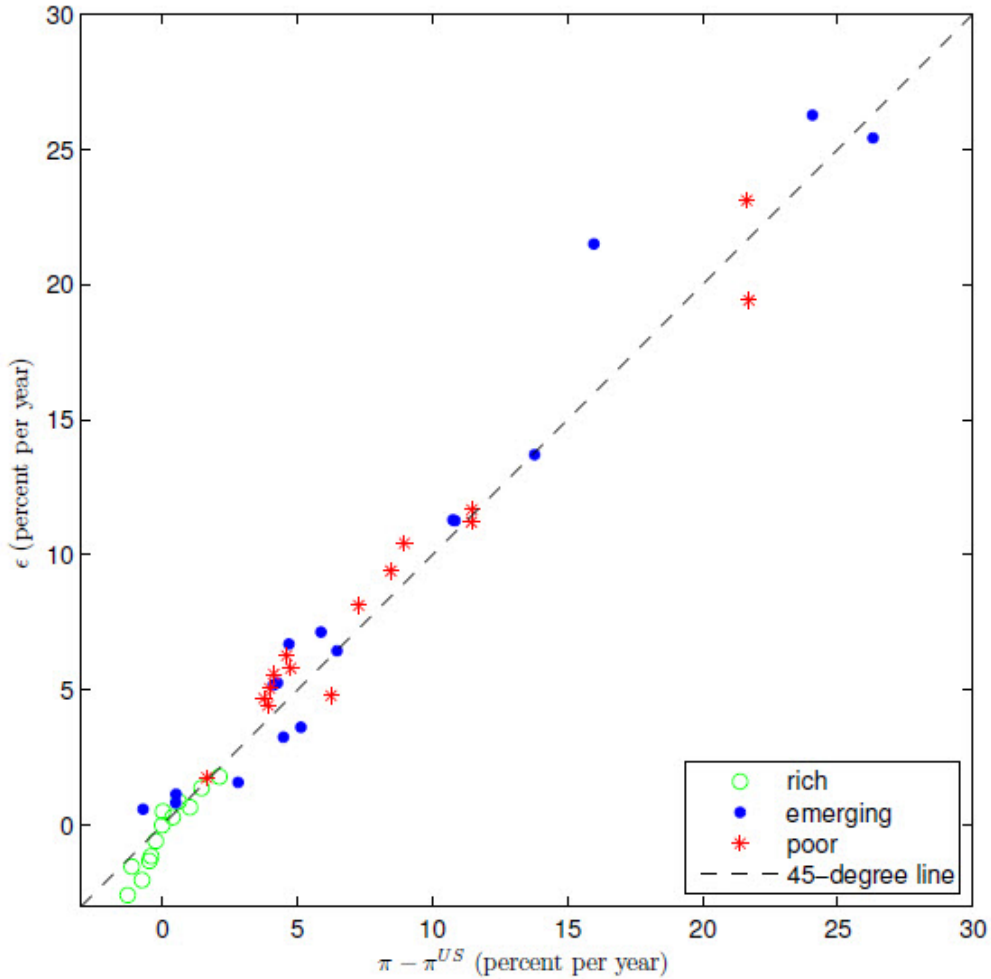
  $$\text{Rel PPP} : \%\Delta e = \%\Delta \mathcal{E}_t - (\pi_t - \pi_t^*)$$

  - Does relative PPP hold?
  - Relative PPP holds when $\%\Delta(e) = 0$

    $$\%\Delta \mathcal{E}_t = \pi_t - \pi_t^*$$

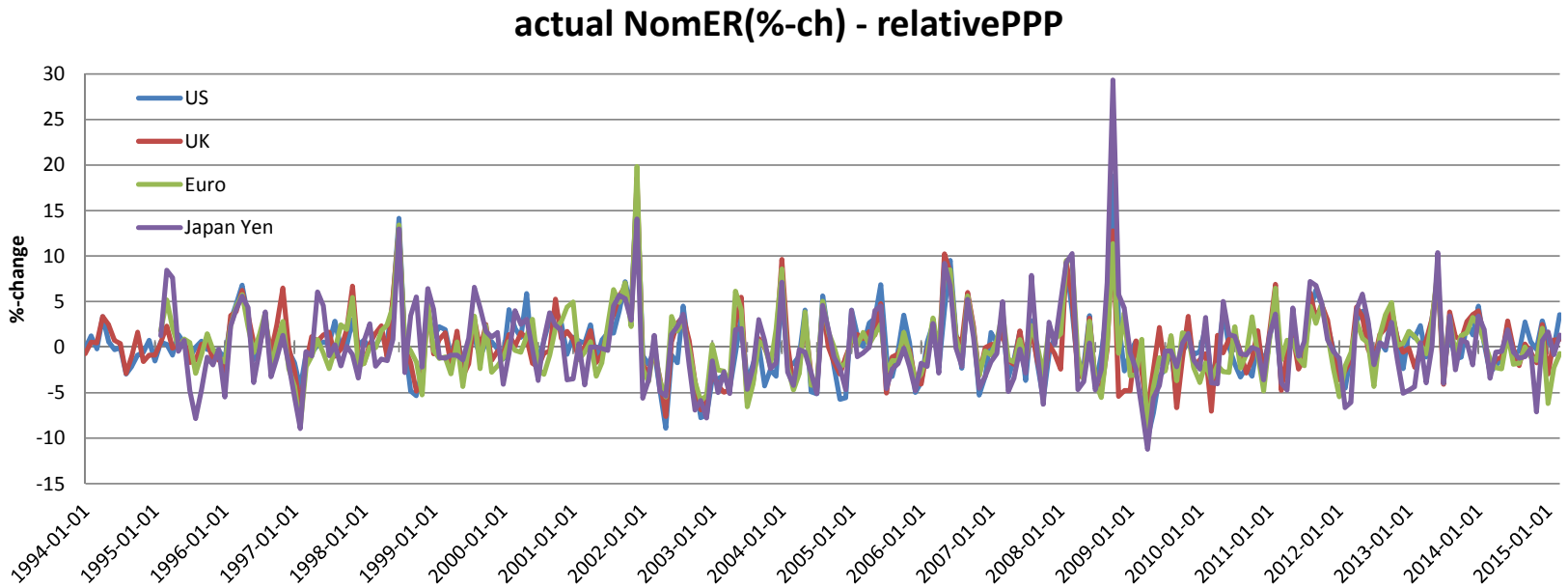
  - Short-run vs Long-run?

Figure 8.5: Inflation Differentials and Depreciation Rates, 1960 to 2017 Averages



Notes. Each marker represents a country. There are 45 countries in total; 13 rich, 17 emerging, and 15 poor. For a given country, ϵ denotes the average depreciation rate against the U.S. dollar and π denotes the average inflation rate. The variable π^{US} denotes the average U.S. inflation rate. The observations line up close to the 45-degree line, indicating that relative PPP holds well in the long run.

Log-deviations from relative PPP: South africa



Short run? Long run? (Taylor and Taylor, 2004)

Suggests that relative PPP holds in the long run: implies that over a long horizon, the difference between cumulative domestic inflation and cumulative foreign inflation equals the cumulative depreciation of the domestic currency. Formally:

$$\pi^* - \pi = -\%\Delta\mathcal{E} \ .$$

avg.$\%\Delta e^{R/*}$: \$0.31; £0.27; €0.21; ¥0.08.

Large & persistent deviations do occur in the short-run . . . why?

Why PPP fails: long-run movements of the real exchange rate

Table on slide 10 showed that consumption goods in India were 3 times cheaper than the U.S. in 2011.

- Why didn't the U.S. just import all of India's consumption goods??!

The Balassa-Samuelson hypothesis (next Session) is appropriate to study *long-run* deviations from PPP because factors of production (labour, technology, capital) change slowly over time. More on the long-run in the next session ...

Why PPP fails: short-run exchange rate disturbances

Combination of monetary policy & price stickiness (Flood and Rose, 1995; Benigno, 2004; Engel, 2012)

- nominal exchange rates move substantially and goods prices do not
- real and nominal exchange rate volatilities in the short term are correlated almost one for one
- law of one price (LOOP) for traded goods is often violated
- price stickiness w/ non-traded sector, small monetary shocks can generate high levels of exchange rate volatility

There are numerous other propositions . . . e.g.: Obstfeld and Rogoff (2000); Corsetti (2016); Horioka & Ford (2017)

Nontradable goods and deviations from Abs PPP

- Not all goods are tradable . . . why?
  - transportation costs are too large to be profitable . . . e.g. . . .
  - nontradeables typically more than 50% of a country's output . . . why is this important?[3]
  - Price of nontradables determined entirely by domestic factors: ∴ LOOP should not hold ∴ systematic deviations from PPP

$$P_T = \mathcal{E}P_T^* \quad ; \quad P_N \neq \mathcal{E}P_N^*; \tag{1}$$

$$P = \phi(P_T, P_N) \quad ; \quad P^* = \phi(P_T^*, P_N^*)\ , \tag{2}$$

where the function $\phi(.,.)$ is increasing in P_T & P_N and homogeneous of degree one.[4]

[3] Hint: CPI $\rightarrow$ average price level in the economy

[4] $\phi(\lambda P_T, \lambda P_N) = \lambda\phi(P_T, P_N)\ \forall\ \lambda > 1$. (See p. 296)

Nontradable goods and deviations from Abs PPP, cont.

1. $\therefore$ the real exchange rate, e, can be written as:[5]

$$e = \frac{\phi(1, P_N^*/P_T^*)}{\phi(1, P_N/P_T)} \tag{3}$$

   - e $\therefore$ depends on the *ratio of nontraded to traded prices in both countries*.[6]

2. $e > 1$ implies . . .
   - $P_N^*/P_T^* > P_N/P_T$
   - The real exchange rate is greater than one $\Rightarrow$ the consumption basket is more expensive abroad than at home.

3. Persistent failure (divergence) of abs PPP occurs when $e_t \neq 1$ for $t = 1, 2, 3...n$. e.g., e can increase over time if:
   (a) the price ratio abroad increases more over time than at home; or,
   (b) P_N rises more slowly than P_T (or decreases), *ceteris paribus*.

[5] note assumption on ϕ on previous slide.

[6] i.e.,: the relative price of nontradables in terms of tradables *across countries*

Trade barriers and real exchange rates

Another possible reason for why the real exchange rate (e) varies a lot in short-run are trade barriers . . .

- For simplicity $\Rightarrow$ assume all (exportable and importable) goods are tradable. Under no trade barriers (i.e., PPP holds) we can re-write $e = \mathcal{E}P^*/P$ as[7]

$$e = \frac{\mathcal{E}\phi(P_X^*, P_M^*)}{\phi(P_X, P_M)} = \frac{\phi(\mathcal{E}P_X^*, \mathcal{E}P_M^*)}{\phi(P_X, P_M)} = \frac{\phi(P_X, P_M)}{\phi(P_X, P_M)} = 1 \tag{4}$$

  Now: impose a tariff $(\tau > 0)$ on domestic imports:

$$e = \frac{\mathcal{E}\phi(P_X^*, P_M^*)}{\phi(P_X, P_M)} = \frac{\phi(\mathcal{E}P_X^*, \mathcal{E}P_M^*)}{\phi(\mathcal{E}P_X^*, (1+\tau)\mathcal{E}P_M^*)} < 1 \tag{5}$$

- An import tariff τ, imposed by the domestic economy, leads to an appreciation of the RER $\rightarrow$ makes the domestic consumption basket more expensive.

CONVERSELY: trade liberalization (i.e., $\tau \rightarrow 0$) $\Rightarrow \uparrow$ relative price of exports over imports goods $\therefore e$ should rise (i.e., depreciate) $\Rightarrow$ e.g., China from 1998 to 2005 (joins WTO '01)

[7] We assume again that $\phi(.,.)$ is homogeneous of degree one

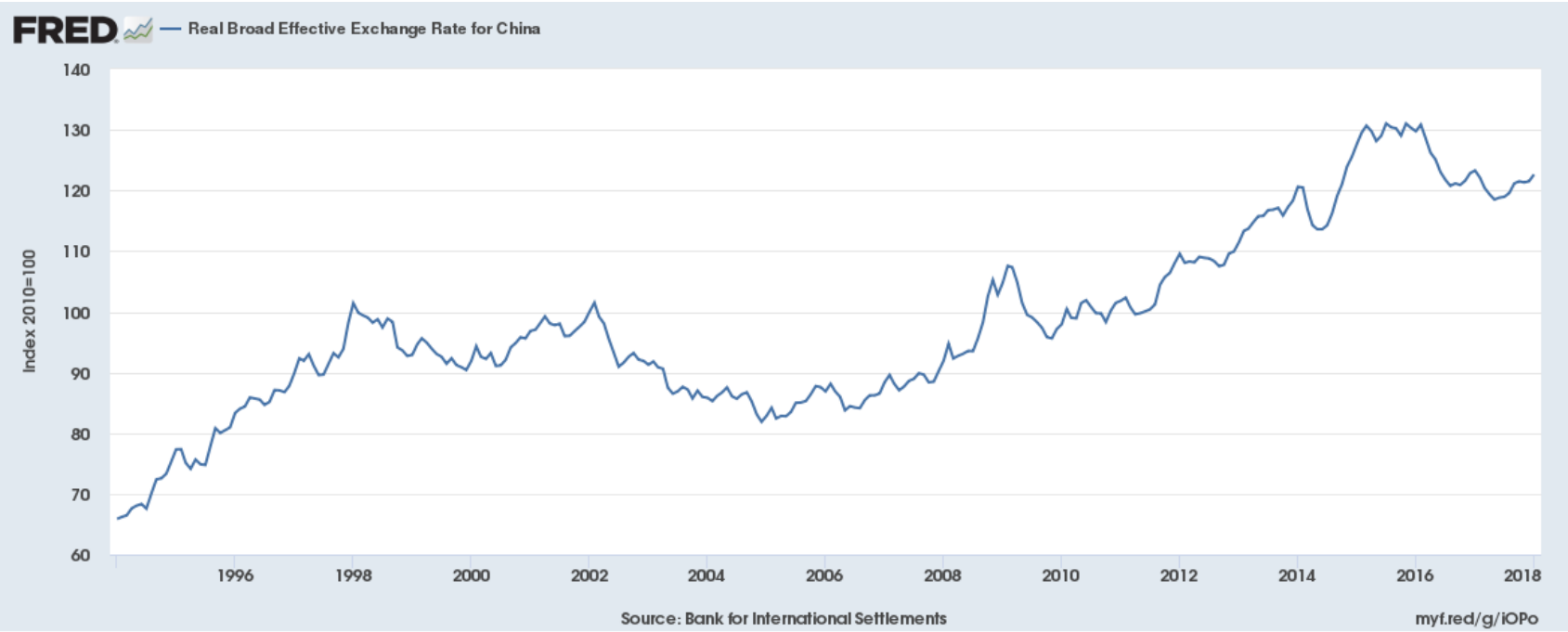


Figure: China: Real Broad Effective Exchange Rate (index=2010)

up (down) = appreciation (depreciation)

Balassa-Samuelson effect (Chapter 9.4) from 1998 to 2005 . . .

What happened thereafter . . . ?

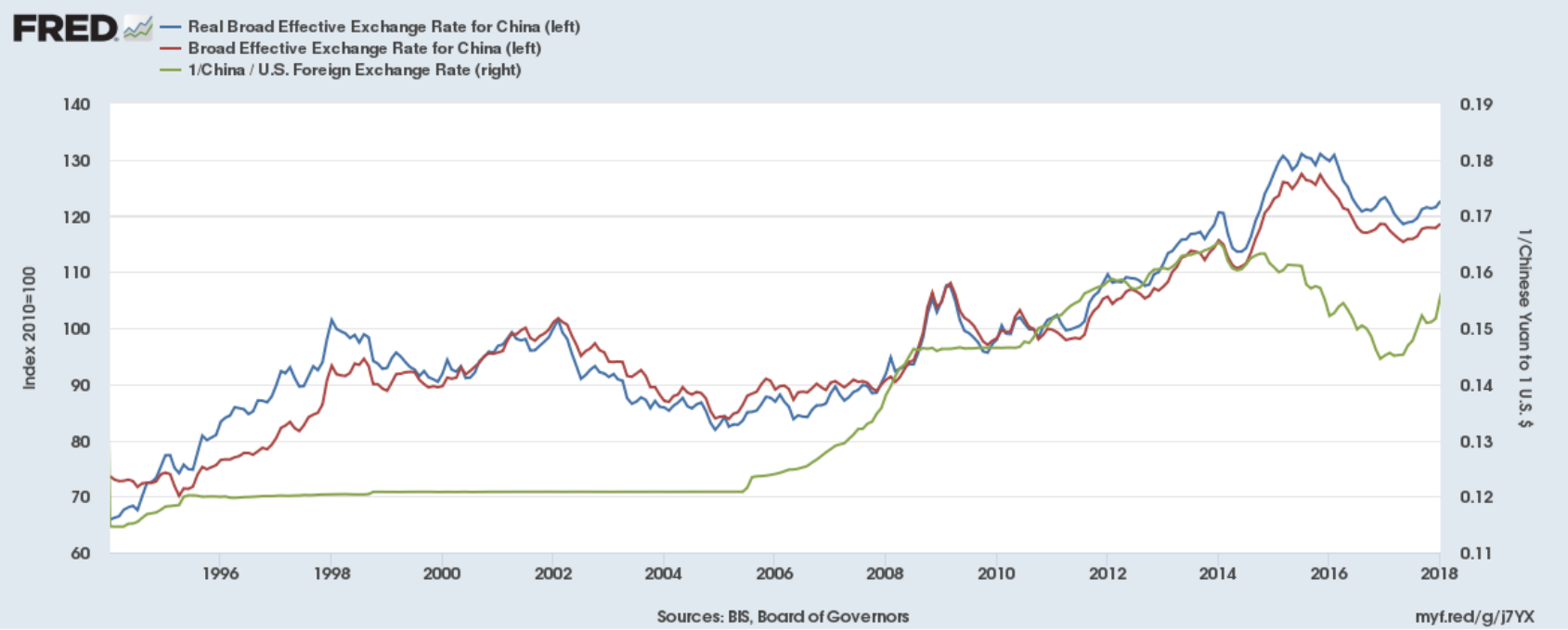


Figure: China: Real Broad Effective Exchange Rate (index=2010)

up (down) = appreciation (depreciation)

Something happened after June 2005 . . .

Something happened after January 2014 . . .

Eswar Prasad on Chinese Monetary Policy - Past & Present

Figure: Changes in China's FX reserves due to valuation changes vs flows

Home bias and the real exchange rate

Assumes that the weights with which a particular good enters in the consumption basket is different across countries.

- e.g., tastes or preferences for locally produced goods . . . boerewors vs frankfurter?

Assume boerewors and frankfurters are freely traded so that their LOOPs hold:

$$P_b = \mathcal{E} P_b^* \; ; \quad P_f = \mathcal{E} P_f^* \; .$$

Assume the following price index weighting functions for SA and Germany:

$$P = \phi(P_b, P_f) = (P_b)^{\gamma}(P_f)^{1-\gamma} \; ; \quad P^* = \phi(P_b^*, P_f^*) = (P_b^*)^{\gamma^*}(P_f^*)^{1-\gamma^*} \; .$$

The real exchange rate can then be written as:

$$e = \frac{\mathcal{E} P^*}{P} = \left(\frac{P_f}{P_b}\right)^{\gamma-\gamma^*}$$

Because SA has a larger preference for boerewors ($\gamma > \gamma^*$) an increase in the price of boerie causes a real appreciation of the rand (a fall in E). i.e., the SA consumption basket becomes relatively more expensive.

Microfoundations of price indices

Read: Section 8.9, pp. 302-307.

Understanding how to get to the end result is important:

$$\gamma = \frac{P_T C_T}{P_T C_T + P_N C_N} \tag{6}$$

The example shows that knowing how much individuals spend on each category of goods ($P_T C_T, P_N C_N$) allows us to obtain the correct weights (γ) of each individual price in the aggregate price index P.

Statistical agencies use information from surveys asking individuals about their expenditure behaviour to construct price indices.

References

Schmitt-Grohé, S., Uribe, M., Woodford, M., 2019. International Macroeconomics. Columbia University. URL: http://www.columbia.edu/~mu2166/UIM/suw.pdf.

Taylor, A.M., Taylor, M.P., 2004. The purchasing power parity debate. Journal of Economic Perspectives 18, 135–158.