December 13, 2006

The Balassa-Samuelson Relationship and the Renminbi

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The author would like to thank Maral Shamloo for efficient research assistance and the Kuwait Fund at Harvard University for support.

Introduction

When thinking about which way an exchange rate ought to move, we tend to think either completely inside the Balassa-Samuelson compartment, or completely outside of it. When we think outside of it, we recognize that the exchange rate can be temporarily pulled away from its long-run equilibrium value by such factors as discrete devaluations, fluctuations of larger anchor currencies, monetary expansion (including overshooting) and speculative bubbles.

When we think inside the Balassa-Samuelson theory, we usually tend to assume that the country lies right on the Balassa-Samuelson equilibrium relationship. This note will focus on China as an example of particular importance currently. If China is growing 7 per cent per year faster than its trading partners, it ought to experience a corresponding trend of appreciation. A common econometric estimate of the coefficient is .4 (e.g., Rogoff, 1996). The prediction would then be real appreciation of the yuan or

renminbi (RMB) at 2.8 per cent per year (.4*7%) But this leaves out the reality that, as strong as the relationship between income per capita and the real exchange rate is, any given country at any given time *is likely to lie rather far off the Balassa-Samuelson equilibrium line* – due again to such factors as discrete devaluations, fluctuations of larger anchor currencies, monetary expansion, and speculative bubbles. This paper finds econometrically a tendency for the real exchange rate to regress back to the equilibrium line, and estimates this tendency at very close to one half the gap per decade. This tendency can be as important a prediction of the Balassa-Samuelson theory as the prediction that the currency will move along the line if the country grows faster than its trading partners, even though the latter is typically the only effect that is noted in the literature.

To illustrate with round numbers, prices in China are about $1/10^{th}$ the level of prices in the US. Some of the gap can be explained by the fact that real incomes in China are about $1/8^{th}$ the level of the US – but not all. The RMB is still undervalued by about 40 %, judged relative to the Balassa Samuelson line. The estimate that one can expect about half of such gaps to be closed per decade implies real appreciation of 20% over the coming decade, or an average rate of 2% per year. This is almost as large as the conventional calculation along the lines that if Chinese growth remains 7 per cent above US growth, the predicted movement along the Balassa-Samuelson line is 2.8 per cent per year. One should add the two together to get an estimate of total future real appreciation of the RMB: about 4.8 per cent per year.

Purchasing Power Parity (PPP) is often calculated as a guide for what the exchange rate should be, for China as for other countries. The overwhelming majority are estimates of *relative* PPP, that is, based on price indices. They do not necessarily show the yuan to be strongly undervalued. But that may be because they use the past as the benchmark, and the yuan may have been undervalued in the past.[1]

Comparisons of price levels across countries are difficult, because such *absolute* PPP data are much less available than *relative* PPP data (for which one only needs price indices and exchange rates). But some data are available. As of 1990, China's price level was reported as only .119 of the US price level, according to the Penn World Tables, Mark 5.6.[2] That prices are lower in China is not in itself a surprise. Even if we thought that markets in internationally traded goods were perfectly integrated, there is no mechanism to arbitrage disparities in prices of nontraded goods. There is abundant empirical evidence, along both the cross-section and time-series dimensions, that prices of non-traded goods, and thereby of general price levels, rise with levels of productivity, real wages and real income. This robust empirical regularity, the Balassa-Samuelson effect, is most often explained by the assumption that productivity growth is more rapid in traded goods than non-traded goods.[3]

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[1] Bosworth (2004) takes an absolute PPP approach like the present paper. Ceglowski and Golub (2005) compare Chinese and international unit labor costs. Other studies attempting to estimate econometrically where the yuan exchange rate should be include Cheung, Chinn, and Fujii (2005) and Funke and Rahan (2005).

[2] China's prices showed up as the lowest of 31 countries; the next lowest was Bangladesh at .154. Summers and Heston (1991) describe the data. See Rogoff (1996, p. 659-660).

[3] Useful references include Balassa (1964), De Gregorio, Giovannini, and Wolf (1994) and Kravis and Lipsey (1988).

Estimation for 1990

The news is that China's prices have been, not just low, but well below the level that one would predict from the country's per capita income and the cross-country empirical relationship between the real exchange rate and real income. According to the same source, China's real per capita income in 1990 was .125 of the US level. Rogoff's (1996) regression estimates that for every 1 percent increase in a country's real per capita income (in a cross-section), its real exchange rate is stronger by 0.366 per cent. Notwithstanding the relatively good fit of this univariate regression (R^2=.42) there are some substantial outliers. China is one of them, though far from the most egregious.

Table 1 reports a re-running of the Rogoff regression for 1990 (with data from the year 2000 Penn World Table). The estimate is a highly significant .317: every one percent increase in income is associated with a real appreciation of .317 percent. We confirm that China is an outlier: apparently undervalued by 42 % in logarithmic terms, or by 34% in absolute terms.[4]

Table 1: Estimation of Balassa Samuelson Relationship for 1990

```
Number of obs =     118
F(  1,   116) =   55.3          Root MSE      =  .506
R-squared     =  0.323          Adj R-squared =  0.317
------------------------------------------------------
     q 1990  |      Coef.   Std. Err.      t
-------------+----------------------------------------
    y 90     |   .317     .043            7.44
    constant |  -3.399    .362            -9.39
------------------------------------------------------
```

Data Definitions:
Q≡ RER ≡ Real Exchange Rate is obtained by dividing *Price Level of Gross Domestic Product* for each country by that of the US.
q ≡ LogRER ≡ Log of Real Exchange Rate
rgdpch ≡ Real GDP per capita (Constant price: Chain series)
y ≡Loginc ≡ Log of real GDP per capita

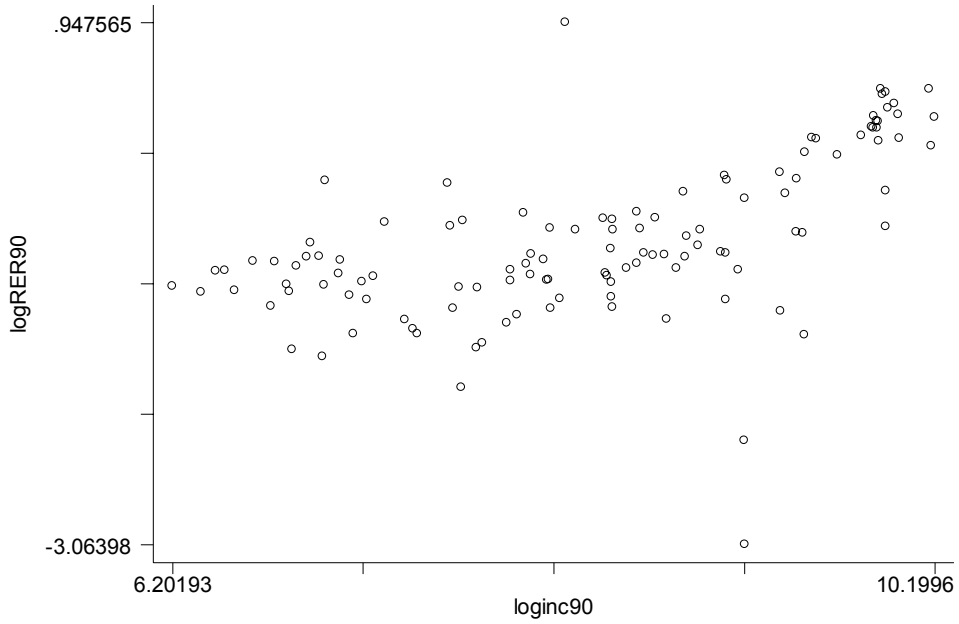
[4] The word "undervaluation" or "overvaluation" has no single agreed upon definition among economists. But the renminbi seems now to qualify for most of the various possible definitions of undervalued. E.g. Frankel (2006).

Source: Heston, Summers and Aten (2002).

The regression of the log real exchange rate against the log of real income per capita was based on 1990 data for 118 countries, for RER and Real GDP per capita yields:

$$q_{1900} = -3.40 + 0.317\ y$$

The coefficient on the log of per capita income is statistically significant, and similar to others' estimates.



The residual for each country was calculated and this value for China is - 42%:

In log form, $(q-\hat{q})_{90} = -0.422,$ or in levels, $Q_{1990} / \hat{Q}_{1990} = 0.656$.

In other words, the real exchange rate was 66% of its predicted value by the regression.

Few economists would seriously recommend a revaluation over a short period of time of the yuan on the order of magnitude suggested by this interpretation of the Balassa-Samuelson equation. In the first place, a sudden revaluation of the currency of

this magnitude would be disruptive.[5] In the second place, other considerations matter in addition to the Balassa-Samuelson regression, including current monetary conditions. In the third place, one would first have to investigate the reliability of the Chinese price data. It is possible that the numbers in the Penn World Table have been extrapolated extensively from a slender base.[6] The possibility of measurement errors in the level and growth of real GDP has also been widely discussed.

Nevertheless, the numbers are suggestive of a disequilibrium that in the very long run may have to be corrected one way or another. Even if the adjustment is drawn out over a long period of time, to correct the disparity with no change in the nominal exchange rate would imply substantial inflation, not desirable as a long-term trend. Thus the Balassa-Samuelson calculation seems another reason to plan on a transition to a more flexible exchange rate regime.

The yuan appreciated in real terms during the course of the 1990s. In nominal terms, the currency depreciated substantially, particularly in 1994 when the official rate was unified with the already-depreciated parallel rate, as reported in Table 1 of the Data Appendix. In 2000 the nominal exchange rate was 8.28 (the level at which it has been pegged since 1998), as compared to an official rate of 4.78 in 1990. But the cumulation of inflation during the 1990s has been greater than the depreciation, implying a real

[5] It is hard to think of precedents of discrete upward revaluation of this magnitude. Perhaps the closest parallel is the 16% revaluation of the Japanese yen in 1971. Eichengreen and Hatase (2005) argue from that experience that a gradual increase in flexibility would be better for China today than a sudden large adjustment. But McKinnon (2006) argues from the Japanese precedent that a predictable path of currency appreciation for China could put it into an undesirable low-interest-rate trap.

[6] As a rough check MacPPP suggests that Chinese prices are about .56 of US prices. Parsley and Wei (2004).

appreciation.[7] China has also experienced rapid growth in real income, as reported in Data Appendix Table 1. Thus the real exchange rate predicted by the Balassa-Samuelson equation has changed. The gap between the current real exchange rate and the level predicted by Rogoff's equation appears to have been (very roughly) as big at the end of the decade as it was at the beginning.

Estimation for 2000

We can do better at updating the calculation than simple extrapolation. The Penn World Tables, Version 6.1, report absolute PPP data for 2000. China's absolute price level in 2000 was .23, relative to the U.S., and its real income per capita was $3747.3, which was .11 relative to the US.

Table 2 reports a new regression for the year 2000 on a cross-section of 118 countries. The regression yields a highly significant coefficient of 0.382 on the log of relative income. In other words, every one percent increase in real per capita income is associated with 0.38 percent in real appreciation. The price level (relative to the United States) that is predicted for China by the equation is 0.362 (derived from -1.015 in logs). China's actual price level is 0.231 relative to the US (derived from -1.464 in logs). The residual of the log was -0.448. In other words the regression suggests that the yuan was undervalued by 44.8 % in logarithmic terms (36.1% undervalued in absolute terms) in 2000.

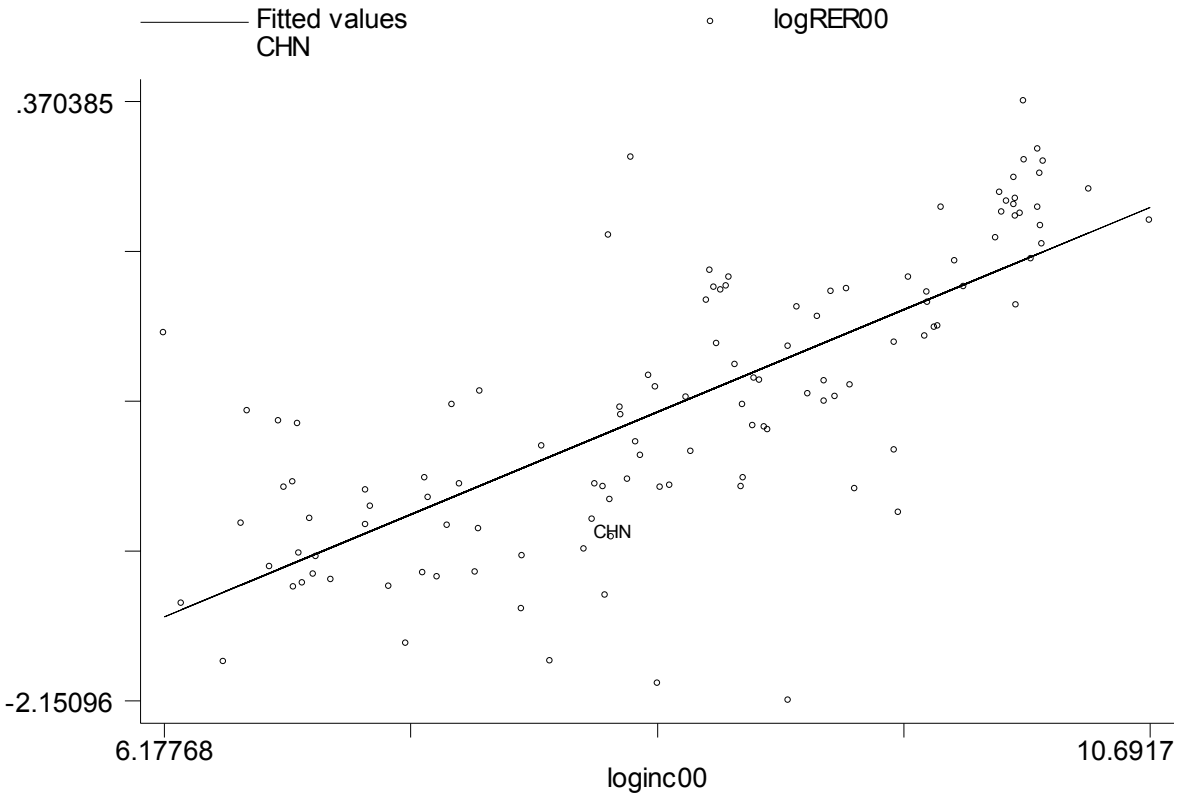
[7] If the base is the real exchange rate in the 1990 Penn World Tables, adding the cumulative changes in price levels and the exchange rate from 1990 to 2002 produces an estimate that China's prices are now up to .181 of US prices: He (2004). But it makes more sense to work off of the 2000 PWT.

We again ran the regression q vs. y for 118 countries, based on their year 2000 data for RER and Real GDP per capita, as reported in Table 2

Table 2: Estimation of Balassa-Samuelson relationship for 2000

```
Number of obs =     118
F(  1,   116) =  151.14          Prob > F      =  0.000
R-squared     =  0.566           Adj R-squared =  0.562
Root MSE      =  .393
------------------------------------------------------------------------------
    q 2000    |      Coef.          Std. Err.          t
--------------+---------------------------------------------------------------
       y 2000 |   .3821             .0311              12.29
     constant |  -4.159            .2686               -15.48
------------------------------------------------------------------------------
```

The estimation yields: $q = -4.15 + 0.382\, y$. The coefficient on log of per capita income is again statistically significant and similar to that estimated by Rogoff and others. The residual for each country was again calculated. Particularly interesting is the residual for China: -44.8 per cent. This means that $(q-\hat{q})_{2000} = -0.448$ in log terms, or $(Q/\hat{Q})_{2000} = 0.639$. In other words, China's real exchange rate is 64% of the value predicted by the regression.



Statistical tendency to close the gap over a decade

To examine whether the deviations from the regression in 1990 have predictive power, we run a regression of $q \equiv \log(\text{RER})$ in 2000 versus two variables: (i) deviations from the 1990 regression ($q - \hat{q}$) and (ii) the fitted values of the 2000 regression ($\hat{q}$).

Table 3: Predictive power of deviations from the 1990 regression

```
Number of obs =     118
F(  2,   115) =  153.5           Prob > F      =  0.000
R-squared     =  0.728           Adj R-squared =  0.723
Root MSE      =  .313
------------------------------------------------------
    q 2000    |      Coef.   Std. Err.      t    P>|t|
--------------+---------------------------------------
     q̂ 90     |    .474        .057        8.26   0.000
   (q−q̂) 90   |    .981        .065        15.15   0.000
    constant  |   -.017      .064          -0.26   0.795
------------------------------------------------------
```

To characterize the empirical literature on the Balassa-Samuelson effect, the relationship between the real exchange rate and real income is fairly robust on a cross-section basis, but is more uncertain on a time series basis, even when changes are observed over intervals as long as ten years. This raises the question of the predictive power of the relationship for a given country over time. But a plausible interpretation is readily at hand. Most economists believe that real exchange rates are influenced not solely by the long-term trend of the Balassa-Samuelson effect nor solely by the short-term fluctuations of monetary policy and nominal exchange rate changes, but rather are influenced by both.[8] A reasonable characterization is that in the long run Balassa-Samuelson factors dominate, but in the short run monetary factors can pull the real exchange rate away from the Balassa-Samuelson equation. This framework contains the powerful prediction that if a country lies substantially off the Balassa-Samuelson regression line in one year, it can be expected to return part way – not necessarily all the way – to the regression line over the subsequent decade. This claim has important implications for our ability to make predictions, and furthermore is testable with data from the last decade.

Implications for the outlook for the RMB

We have tested whether residuals from the 1990 regression have explanatory power for the year 2000. On a cross-section (of countries with data available for both years), we regressed the 2000 real exchange rate against the fitted values from the 2000

[8] One does not necessarily need prices of non-traded goods to be sticky – let alone prices of traded goods – to get the result that devaluations or changes in monetary policy can have transitory effects on the real exchange rate in the short run. Dornbusch (1973).

regression (which is also equivalent to regressing them against 2000 income levels, as before) *together with the residuals from the 1990 regression*. The coefficient on the predictions from 2000 incomes is .98, insignificantly different from 1, as expected. The coefficient on the 1990 residual is .48, which is not only highly significantly greater than zero, but is also highly significantly less than 1. This provides confirmation for the theory, and also provides the useful prediction that, in expected value terms, approximately half of any deviation from the Balassa-Samuelson regression line is corrected over the subsequent decade. For the case of China, it says that even if the big differential in productivity growth between China and its trading partners were to disappear tomorrow, Balassa-Samuelson factors nonetheless would predict that by 2010 the yuan should undergo an expected real appreciation of about half of the year-2000 gap, which is half of 44.8 percent, or 22.4%.[9]

A real appreciation toward long-run equilibrium could be accomplished with no change in exchange rate regime, by an inflation rate of 2.24% per year in excess of the US level, which is not especially large compared to recent swings in China's inflation rate. Nevertheless, the theory predicts that more movement in the same direction would have to continue over the subsequent decade, and, more importantly for present purposes,

[9] To fine-tune this calculation, we could allow for whatever movement in the real exchange rate has taken place since 2000, the year of the last Penn World Table. The cumulative change over the last four years turns out to have been relatively small, as reported in Appendix Tables 2 and 4. The nominal exchange rate is virtually unchanged vis-à-vis the dollar, due to the peg which has been little altered even with the announced move to flexibility in 2005, and the Chinese price level is evidently not far from where it was in 2000, because deflation in 2002 offset inflation in 2000-01 (and 2003). Thus, amazingly, that leaves as the dominant component of the change in the real exchange rate: US inflation, which cumulated to 5 % from 2000 to 2002. It would be foolish to rely too much on the precision of these numbers. The important point is that the

that an allowance for Chinese growth to continue on the order of 6 % greater than US growth would require adding another 2.3 % of real appreciation per year (.38 times the relative growth rate). Adding together the correction of the past undervaluation and the continued trend gives a real appreciation in excess of 4% per year.

*

"undervaluation" in the sense of the Balassa-Samuelson equation has, if anything, widened since the calculation of the gap on 2000 data.

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Data Appendix

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Real exchange rate and real income for China, 1990-2000

Nominal Ex Rate Nominal: Exchange rate in RMB /$
P (US=1): Price Level of Gross Domestic Product relative to US
Real GDP/capita ($ chain): Real GDP per capita (Constant price: Chain series)

Table 1 -Real exchange rate and Real Income for China, 1990-2000

year	Nominal ExRate	p	Real GDP/Capita	US Real GDP/Capita	Real GDP/Capita rel. to the US
1990	4.7832	0.2351	1786.5474	26457.82	0.0675
1991	5.3234	0.2112	1975.3807	25897.92	0.0763
1992	5.5146	0.2154	2202.6613	26488.70	0.0832
1993	5.7620	0.2380	2455.4704	26956.07	0.0911
1994	8.6187	0.1925	2644.9477	27877.94	0.0949
1995	8.3514	0.2282	2818.1204	28408.86	0.0992
1996	8.3142	0.2433	2968.5394	29193.91	0.1017
1997	8.2898	0.2454	3109.6103	30190.34	0.1030
1998	8.2790	0.2396	3275.9917	31090.66	0.1054
1999	8.2782	0.2351	3414.9809	32127.90	0.1063
2000	8.2785	0.2314	3747.2977	33292.99	0.1126
averg.	7.2539	0.2287	2763.5953	28907.6	0.0946

1 Data Source: Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.1

Table 2 - Real Exchange Rates for China, 2001-2003

	USA			China				
	Inflation	Pu		Inflation	Pc		NomEx	Change in LogRER rel 2000	RER
2001	2.8	119.458		0.5	128.18		8.277	0.050	0.243
2002	1.6	121.353		-0.8	127.20		8.277	0.027	0.238
2003	1.2	122.809		1.2	128.73		8.277	0.027	0.238

[1] Data Source: IMF – International Financial Statistics, Country Tables: http://imfstatistics.org/

Table 3 – Chinese Real Exchange Rates - Log Form, 1990-2000

year		Log RER		Log GDP		Log relative real GDP
1990		-1.4477		7.4880		-2.6953
1991		-1.5547		7.5885		-2.5734
1992		-1.5354		7.6974		-2.4871
1993		-1.4354		7.8061		-2.3959
1994		-1.6475		7.8804		-2.3552
1995		-1.4774		7.9438		-2.3106
1996		-1.4134		7.9958		-2.2859
1997		-1.4051		8.0423		-2.2730
1998		-1.4290		8.0944		-2.2503
1999		-1.4478		8.1359		-2.2416
2000		-1.4637		8.2288		-2.1843
average		-1.4779		7.9001		-2.3684

1 Data Source: Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.1

Table 4 - Real Exchange Rates for China-Log Form, 2001-2003

	USA			China				
		LogPu			LogPc		Log (NomEx)	Change in LogRER rel 2000	Log RER
2001		4.783			4.853		2.113	0.050	-1.413
2002		4.799			4.846		2.114	0.027	-1.437
2003		4.811			4.858		2.113	0.027	-1.437

[1] Data Source: IMF – International Financial Statistics, Country Tables: http://imfstatistics.org/