

Introduction

We used Datastream (Version 4.0 Advance) to collect the data needed to do the IRP and PPP testing. During our collecting we made the strange observation, that China FX was available starting in 2002 eventhough we found other information stating that the China FX rate was introduced in 2005. Nevertheless we used the available information starting in 2002, since we think that the Datastream source is reliable and that we interpreted the used data correctly.

After the normal testing we designed a second model both for IRP and PPP where we divided that data into two periods. The following paragraph explains our thoughts on why and how we divided the data into periods.

In the studies of whether IRP and PPP hold between Chinese Yuan and the US dollar, we choose to divide the data into two sub-periods, which are from 2002 to 2005 and from 2005 to 2008. The rationale behind this is because after 2005, the Chinese government had unpegged its currency; thus, allowing the Chinese Yuan to, to a certain extent, fluctuate with the world's foreign exchange market. This action has a significant implication on the existence, or lack thereof, of the IRP and PPP between the two countries as these two parities can only exist under the assumption of an efficient market. If the Chinese Yuan remained pegged, the law of one price will not apply. Therefore, we do not expect the parities to hold in the first sub-period at all. However, we expect the probability of the persisting IRP and the PPP to improve in the second sub-period as the Chinese Yuan is then allowed to fluctuate more with the market, even though it can only move at a maximum daily rate of half a percent with the new policy.

The reason why we did not include the Asian crisis and the subprime crisis into our considerations when dividing the sub-periods is because, since the Asian crisis started in 1997 but our Yuan forward rates only extend from 2002, our data does not permit us to conclude that period of time. As for the subprime crisis, since our second sub-period spans from 2005, which is the period largely characterized by the crisis in the US, we see no need in further dividing the second sub-period into smaller periods.

IRP Test

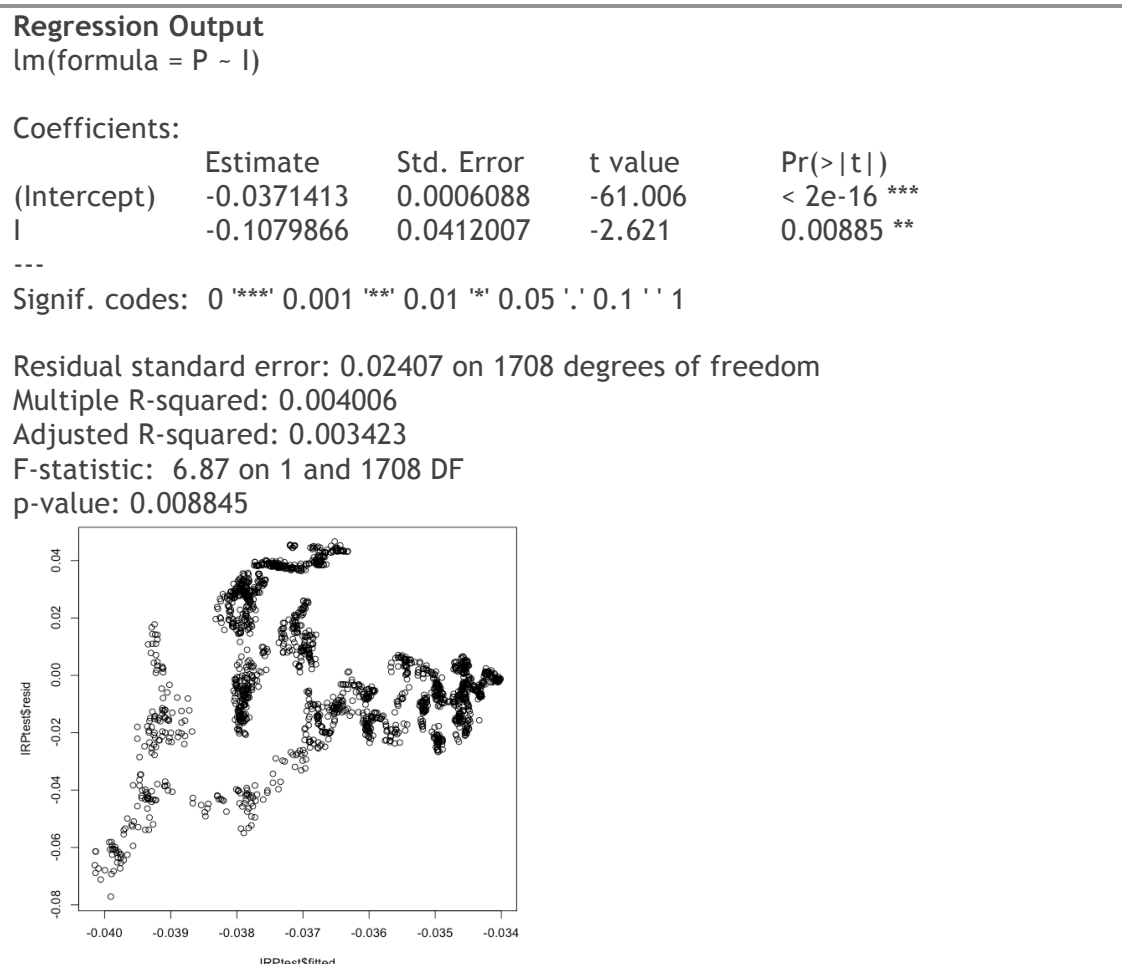
The relationship between the FX market and international interest rates exists due to the law of interest rate parity. Through international arbitrage investors seek higher returns by investing abroad. However such investments are subject to exchange rate risk. Generally investors are adverse to risk and so hedge in the forward exchange market. This guarantees the return to an investor. As a result, the level of demand for forward contracts for any particular currency is directly influenced by in interest rate differentials. If a particular country has relatively high interest rates, international investment will occur along with increased demand for forward contracts. This creates a forward premium for the currency. This process occurs until equilibrium is reached and arbitrage is no longer possible. In theory arbitrage should ensure that this equilibrium holds at all times. Thus we can use the interest rate differentials to estimate expected forward exchange rates.

Model 1: Standard Theory

In order to test the standard theory we tested the following regression model:

$$(FX - EX)/EX = a + b * [(1+i_{CH}) / (1+i_{US}) - 1] + \hat{\epsilon}$$

To simplify the software output the model is denoted below as $P = a + I + \hat{\epsilon}$



There seems to be a significant negative correlation between the relative prospected change in the interest rate against the ration between China's and US's interest rates. Taking a look at the residual error diagram clearly shows a non-random distribution. That suggests that the existing relation cannot be approximated with a linear model.

Testing the IRP relation

$H_0: b = 1$
 $H_a: \text{otherwise}$

$t = -26.8924$

We cannot accept H_0 due to the high absolute t-value in favor of H_a . With this solution we can be very sure that the standard IRP model does not hold for China and the USA during this time period.

Model 2: Extended Standard Theory

In this model we still use the standard theory but we separate two distinguished time periods:

Period 1: 2002 until July 21 2005 where the Chinese currency was pegged to the US dollar.

Period 2: July 21 2005 onwards where the Chinese currency was allowed to float freely.

Regression Output for Period 1

lm(formula = P ~ I)

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-0.0229945	0.0007156	-32.135	< 2e-16 ***
I	0.4143904	0.1187749	3.489	0.00051 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

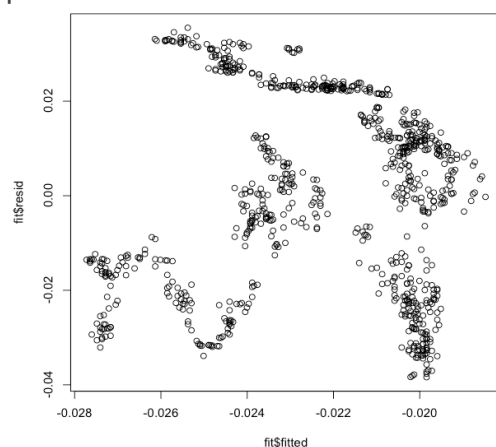
Residual standard error: 0.02013 on 853 degrees of freedom

Multiple R-squared: 0.01407

Adjusted R-squared: 0.01291

F-statistic: 12.17 on 1 and 853 DF

p-value: 0.0005099



Testing the IRP relation

$H_0: b = 1$

$H_a: \text{otherwise}$

$t = -4.9304$

We cannot accept H_0 due to the high absolute t-value in favor of H_a . With this solution we can be very sure that the standard IRP model does not hold for China and the USA during this time period.

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Assignment: IRP and PPP testing

Regression Output for Period 2

lm(formula = P ~ I)

Residuals:

Min	1Q	Median	3Q	Max
-3.808e-02	-7.862e-03	-5.106e-05	6.743e-03	5.273e-02

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-0.0590495	0.0005078	-116.29	<2e-16 ***
I	-0.7775249	0.0253765	-30.64	<2e-16 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

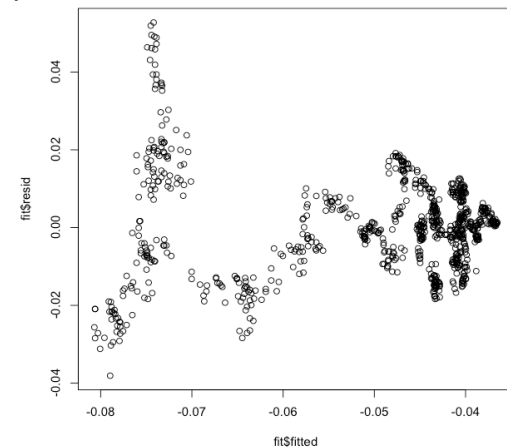
Residual standard error: 0.01272 on 853 degrees of freedom

Multiple R-squared: 0.5239,

Adjusted R-squared: 0.5234

F-statistic: 938.8 on 1 and 853 DF

p-value: < 2.2e-16



Testing the IRP relation

$H_0: b = 1$

$H_a: \text{otherwise}$

$t = -70.0461$

We cannot accept H_0 due to the high absolute t-value in favor of H_a . With this solution we can be very sure that the standard IRP model does not hold for China and the USA during this time period.

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Assignment: IRP and PPP testing

Interpreting the Model

Comparing the t-values from the two models and the two periods in the second model we can conclude the following:

- All three models clearly state that the IRP does not hold.
- The IRP holds the “best” in Period 1. Reasons see below.
- The plots which show the residual errors suggest the same. The plot of the first model and the Period 2 in the second model show that the errors are not randomly distributed. The best approximation is given by the regression in Period 1.

Given the standard formula:

$$F = S [(1+i_{CH}) / (1+i_{US})]$$

we can measure the impact of the estimated “I”.

$$(FX/EX) * I * (1+i_{US}) = (1+i_{CH})$$

that means,

- **If $I > 1$:** The return in the US would be greater than in China, so an arbitrage would exist that everybody would lend US dollars and invest in the US.
- **If $I < 1$:** The return in China would be greater so everybody would lend Yuan and invest in China.

When comparing the two periods:

- **Period 1:** $I = 0.414$
- **Period 2:** $I = -0.778$

That means that the arbitrage when investing in China was smaller in Period 1 than in Period 2. But in Period 1 the Chinese government controlled more of the market than it did during Period 2. The theory predicts that any control of the market would increase the arbitrage and that a perfect and free market would result in zero arbitrage. But our analysis suggests the opposite.

The interesting question arises whether the Chinese government wanted to have lower arbitrage in China when it controlled the market. This would suggest, that China wanted to keep foreign investment at a lower level than it would have been in a free market, where arbitrage would have been higher.

Conclusion

We can conclude that the IRP does not in both models. We can be very sure of that because we can reject the hypothesis that $b = 1$. The coefficient needs to equal 1 in order to satisfy the IRP equation.

The theories we based our formulas upon are only theoretical. We have proven that, in reality they do not always hold true. This may be due to a number of factors. Firstly, Each theory is fundamentally flawed due to the influence of

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Assignment: IRP and PPP testing

external factors. The IRP theory cannot be applied affectly due to both capital controls and transaction costs. Testing our hypothesis was made additionally difficult due to China's unique economic situation. With a pegged currency our relationships are vital undermined as they require pureley free markets. Even in recent years China's tight capital controls and currency manipulation has attributed to further deviations from our projected outcomes in eash test.

The interesting finding of the two large differences between the two selected time periods need further investigation. Such as why the arbitrage during the pegging was lower than after the pegging - which clearly contradicts the standard theory.

Model 3: Balance of Payments Theory

The relationship between the BOP and exchange rates is one of arbitrary nature. Using BOP account balances alone is a poor measure of predicting exchange rates. However, when a country's trade surplus is in an upward trend, speculators expect demand for the currency to continue to increase and thus the currency will appreciate. As a result we would expect a forward premium for the currency in accordance with speculators expectations.

The Balance of Payments multiplied with a factor should explain the ratio of the forward rate to the spot rate. For reasons see below. We tested the model on China using following formula:

$$FX/EX = X*(BOP)$$

We believe that the rate of change of the exchange rate should be equal the BOP times an unknown parameter X. The reason for this assumption is the following: If the BOP is positive, the country will have an increase in its federal reserves. If they increase, the demand for domestic currency is high which suggests an increase in its value.

If the domestic currency increases its value that means that for the direct rate (Yuan / \$) FX will be smaller than EX.

Thus, $FX/EX < 1$.

The corresponding BOP will be > 0 .

So if the theory holds, we expect X to be smaller than zero. This because if BOP increases, FX/EX should decrease further.

Regression Output

lm(formula = EXRate ~ BOPC)

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	9.957e-01	1.242e-02	80.147	1.45e-07 ***
BOPC	-1.072e-07	4.944e-08	-2.168	0.096 .

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01493 on 4 degrees of freedom

Multiple R-squared: 0.5402

Adjusted R-squared: 0.4253

F-statistic: 4.7 on 1 and 4 DF

p-value: 0.09602

The problem of this analysis are the few observations (6 in total). Eventhough the t-statistic suggests that there is a correlation between the two variables on a 10% significance level. In order to answer the question, whether this correlation holds, we would need to collect further data and then compare this model to the corresponding model of the United States.

PPP Test

The law of one price states that the exchange rate between currencies of two countries should be equal to the ratio of the countries' price levels. This implies that exchange rates are directly affected by inflation rate differentials. International traders seek to purchase goods from countries with lower price levels. This increases demand for the currencies of nations with low inflation while increasing supply of nations with high inflation. In theory this process occurs until purchasing power parity is reached. Traders engage in the forward exchange market in order to hedge their exchange rate risk. Therefore, we expect that forward premiums or discounts on any currency can be explained by interest rate differentials.

Model 1: Standard Theory

In order to test the purchasing power parity we use the following model that is suggested by the standard theory. We use the difference between China's and the United States' inflation rate to explain the ratio of the forward rate to the spot rate. This is because if the inflation rate is high, the corresponding currency loses value for goods priced in that currency. So if the exchange rate does not adjust, the home currency would be overvalued compared to the other currency, since people from another country could buy less in the home country given the same exchange rate.

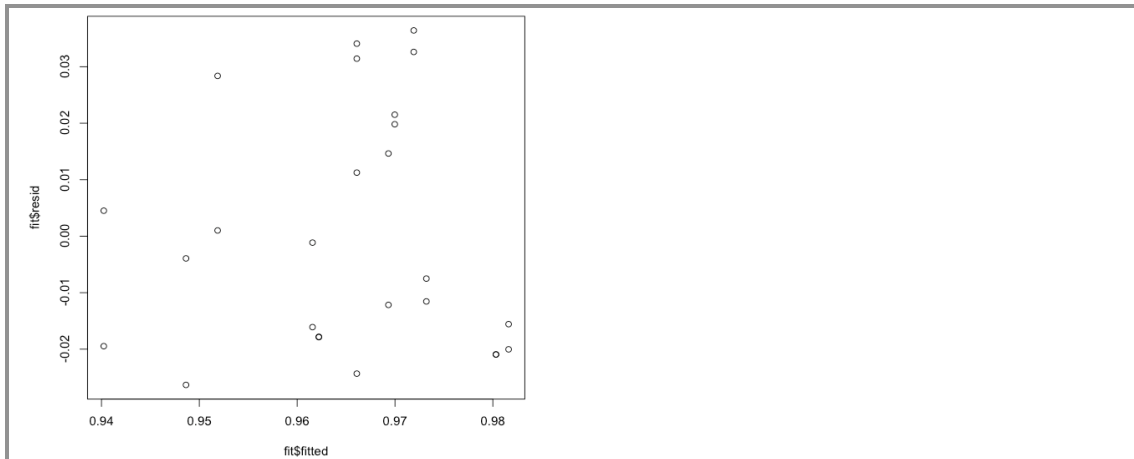
$$F/S = e = \pi_{CH} - \pi_{US}$$

Regression Output					
lm(formula = EXRatio ~ I(PiCH - PiUS))					
Residuals:					
Min	1Q	Median	3Q	Max	
-0.026329	-0.017858	-0.005718		0.018523	0.036423
Coefficients:					
	Estimate	Std. Error	t value	Pr(> t)	
(Intercept)	0.966094	0.004222	228.802	<2e-16 ***	
I(PiCH - PiUS)	-0.006465	0.002343	-2.759	0.0109 *	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					
Residual standard error: 0.02141 on 24 degrees of freedom					
Multiple R-squared: 0.2408,					
Adjusted R-squared: 0.2092					
F-statistic: 7.613 on 1 and 24 DF					
p-value: 0.01092					

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Assignment: IRP and PPP testing



Testing the IRP relation

$H_0: b = 1$
 $H_a: \text{otherwise}$

$t = -429.5625$

We cannot accept H_0 due to the high absolute t-value in favor of H_a . With this solution we can be very sure that the standard PPP model does not hold for China and the USA during this time period.

Interpretation of this model

On problem of this regression analysis are the few observations available from Datastream. For a good analysis we should have more than 50 observations, but now we only have 23. Eventhough, the plot shows randomly distributet error terms.

The calculated model cannot be rejected on a 98% certainty level. The coefficient is slightly negative ($\beta = -0.00645$) which contradicts the PPP theory. The calculated model suggests, that for a relative increase of Chinese inflation compared to US inflation the exchange rate would even go down.

Model 2: Extended Standard Theory

As in the previous section we divide the analysis in the previous two periods.

Regression Output of Period 1

lm(formula = EXRatio ~ I(PiCH - PiUS))

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.979334	0.005523	177.307	<2e-16 ***
I(PiCH - PiUS)	-0.010866	0.005625	-1.932	0.0773 .

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02049 on 12 degrees of freedom

Multiple R-squared: 0.2372

Adjusted R-squared: 0.1737

F-statistic: 3.732 on 1 and 12 DF

p-value: 0.07733

Regression Output of Period 2

lm(formula = EXRatio ~ I(PiCH - PiUS))

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.950992	0.002487	382.383	< 2e-16 ***
I(PiCH - PiUS)	-0.005282	0.001023	-5.163	0.000423 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.008563 on 10 degrees of freedom

Multiple R-squared: 0.7272

Adjusted R-squared: 0.6999

F-statistic: 26.66 on 1 and 10 DF

p-value: 0.0004232

The interesting fact that we can read from the given outputs is that the first period has a significant lower (more negative) coefficient than period 2. That suggests that after the pegging of the Yuan to the dollar was abolished, the market was slightly more efficient. But the coefficient is still far below the theoretical value "1".

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Assignment: IRP and PPP testing

Model 3: Consumer Price Index

Our third approach is replacing the inflation rate with the change in consumer price index. This would more reflect the change in price of goods which are actually bought by the country's population. The model would therefore be:

$$FX/EX = \text{ChangeCPI}_{CH} - \text{ChangeCPI}_{US}$$

Regression Output

lm(formula = EXRatio ~ I(CPICH - CPIUS))

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.970815	0.009487	102.336	5.47e-08 ***
I(CPICH - CPIUS)	0.003678	0.005559	0.662	0.544

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02167 on 4 degrees of freedom

Multiple R-squared: 0.09866

Adjusted R-squared: -0.1267

F-statistic: 0.4378 on 1 and 4 DF

p-value: 0.5443

Taking a look at the p-value shows that this model is a very bad approximation. After gathering more data about the countries we could run this regression again to see if it is improving. One would also have to analyze whether the goods in the basket of the CPI are movable and shippable goods and whether import/export tariffs are imposed on these goods. These distortion factors could lead to the state where the PPP does not hold.

Suggested conclusion:

In conclusion we found that all three of our hypothesis were disproven. Each test performed resulted in a weak correlation for the selected variables. PPP is also undermined by the high prices of services in developed countries as well as shipping costs, quotas and tariffs.