Time Series Student Project (Fall 2012)

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Introduction:

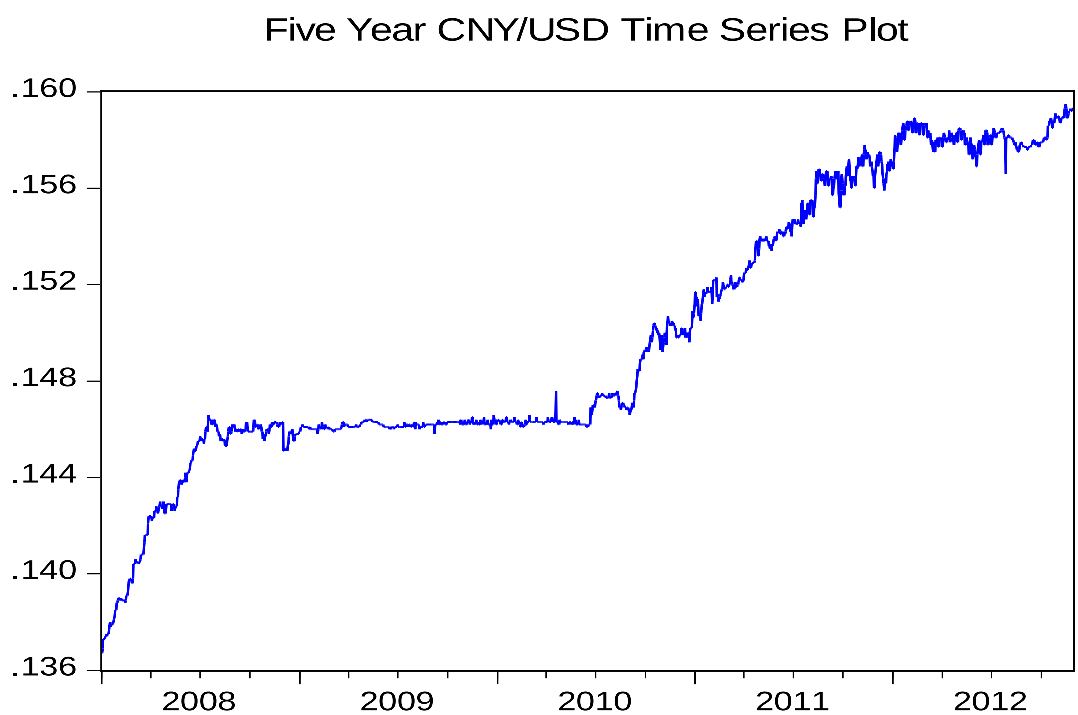
The practice of accumulating US dollars by each country's central banks has been more pronounced after the 1997 Asian financial crisis, when currency speculators hastened a balance of payments crisis in Thailand, Indonesia and South Korea by demanding dollars for local currency, depleting the central banks' dollar reserves.[1] After 15 years, the dollar's status as World's preferred reserve currency has come into question amid a ballooning budget deficit that keeps the US dependent on foreign financing. China is growing extremely fast in the past decade with an average GDP growth rate of 8%. In 2009, China suggested a type of super-sovereign reserve currency to challenge the dollar. Politically, China's foreign exchange policy is one of the biggest conflicts between the US and China central government. The US government blamed China for manipulating the Chinese currency (CNY) versus US dollars (USD) exchange rate, which benefits China's own economic growth. In this paper, I focused on how CNY/USD exchange rate changes over the past five years, from 2008 to 2012. Time series data analysis was utilized throughout the paper, and the ARIMA(1,1,1) model was chosen to fit to the data eventually.

[1] http://www.investmentpostcards.com/2010/03/05/global-reserve-currency-chinese-yuan-vs-us-dollar/

Data:

CNY/USD exchange rate data was collected for 1795 days, from 1/1/2008 to 11/29/2012. The data was obtained from a publicly available website www.oanda.com/currency/historical-rates/.

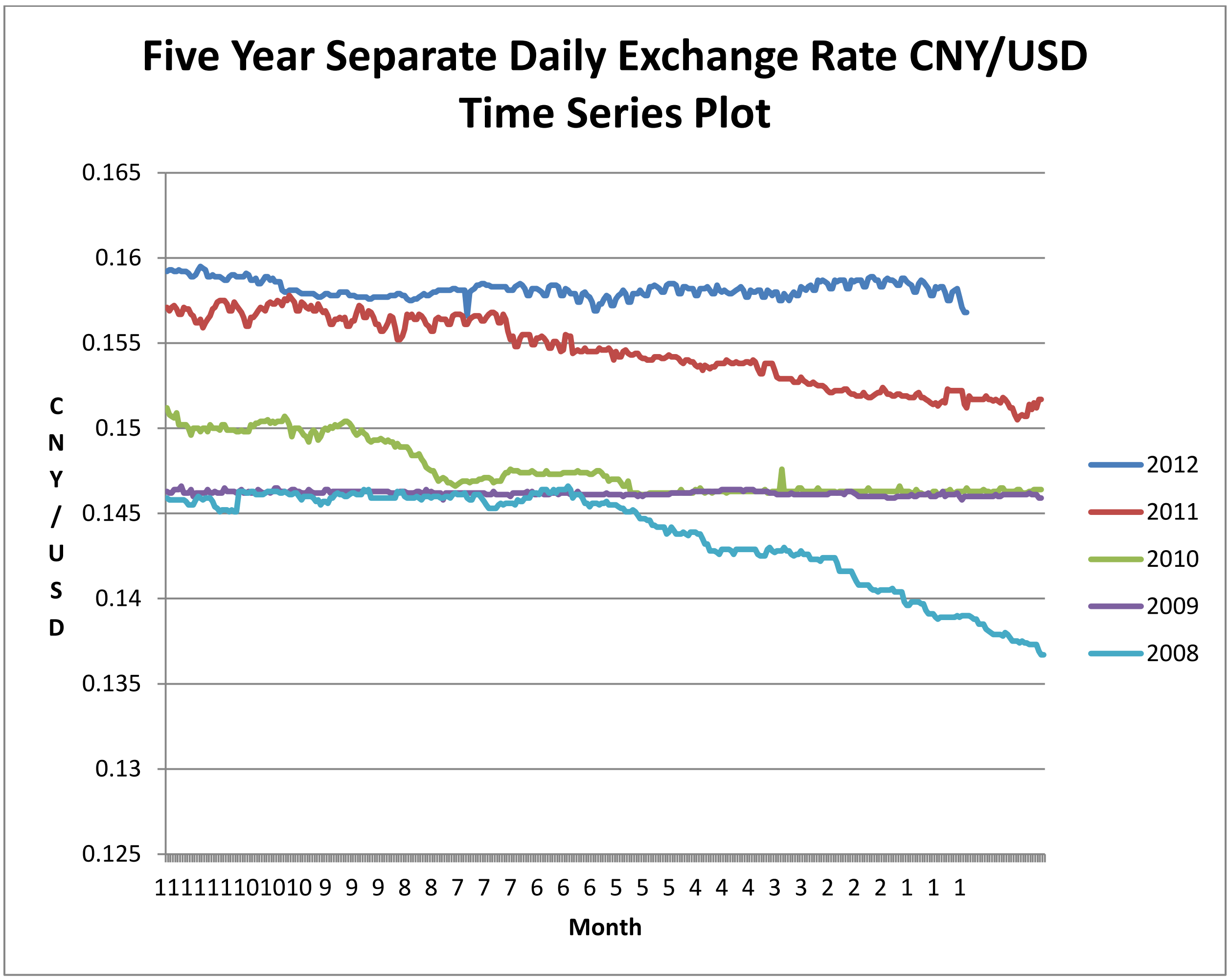
A plot of daily CNY/USD exchange rate time series from January 1, 2008 to December 29th, 2012 is shown below:



The plot was plotted using EViews. From the graph above, we can see over the past five years, CNY is getting stronger and stronger, and USD is becoming weaker and weaker. The rate has increase for over 15% since 2008. In 2008, the rates started increasing, however, between 2009 and 2010, the rates seemed very stable. But right into the year 2011, it started climbing dramatically.

Model Specification:

A time series line graph by year was plotted to check their there is any seasonality existing in the data. The plot is shown below:



From this plot above, we can clearly see that there is no similar pattern among these five years exchange rates. In the second half of 2008, the 2009 whole year, and earlier 2010, the rate is almost with no change. However, in 2011 and 2012, the rates steadily increased. By this, we could conclude that there is no seasonality existing in our current dataset, and we do not need to include a seasonality effect into our final model.

Then correlogram and partial correlogram was plotted using EViews to see whether the data is stationary. The graph (plotted by EViews) is shown below:

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.997	0.997	1787.8	0.000
		2	0.994	0.004	3566.6	0.000
		3	0.992	0.037	5337.1	0.000
		4	0.989	0.033	7100.0	0.000
		5	0.987	0.006	8855.5	0.000
		6	0.985	0.019	10604.	0.000
		7	0.982	0.005	12345.	0.000
		8	0.980	-0.050	14079.	0.000
		9	0.977	-0.002	15804.	0.000
		10	0.975	0.024	17522.	0.000
		11	0.973	0.008	19233.	0.000
		12	0.970	0.009	20936.	0.000
		13	0.968	0.013	22633.	0.000
		14	0.966	-0.012	24323.	0.000
		15	0.963	-0.045	26005.	0.000
		16	0.961	0.008	27680.	0.000
		17	0.959	0.023	29347.	0.000
		18	0.956	0.003	31007.	0.000
		19	0.954	0.009	32661.	0.000
		20	0.952	0.006	34308.	0.000

The sample ACF for these data is displayed. All values shown are significant far from zero, and the only pattern is perhaps a linear decrease with increasing lag. We can also see that the autocorrelation function plot doesn't die off rapidly; instead it dies off very slowly. This is due to the tendency of non-stationary time series to drift slowly either up or down. The autocorrelation function would decrease geometrically after lag p and then tails off for autoregressive process, and for moving average process, the autocorrelation function cuts off after lag q. However, this is neither the case. And we conclude that this is non-stationary. We also conducted a unit root test:

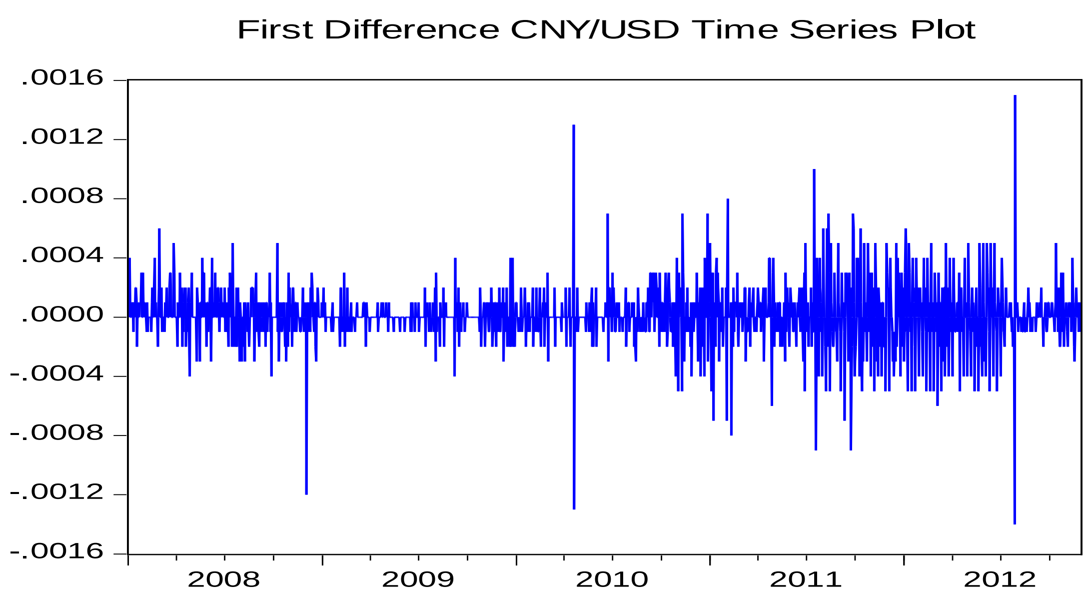
Null Hypothesis: SER03 has a unit root
Exogenous: Constant
Lag Length: 14 (Automatic based on SIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.604070	0.4803
Test critical values:	1% level	-3.433821	
	5% level	-2.862960	
	10% level	-2.567573	

*MacKinnon (1996) one-sided p-values.

We can see that the Dickey-Fuller test statistic is -1.6, which leads to a P-value of 0.4803 (bigger than 0.05). We would not reject the null hypothesis that the time series has a unit root.

Since the original time series is not stationary, we will now do a first-differencing to our original time series. It is shown in the graph below:



From the graph above, we could see that first differencing time series is more stationary than the original ones. An autocorrelation and partial correlation graph was produced to check the first difference stationary. It is shown in the following graph.

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.046	-0.046	3.7400	0.053
		2	-0.157	-0.159	47.909	0.000
		3	-0.077	-0.095	58.536	0.000
		4	-0.033	-0.071	60.482	0.000
		5	-0.111	-0.152	82.523	0.000
		6	-0.011	-0.060	82.746	0.000
		7	0.276	0.230	220.56	0.000
		8	0.004	0.007	220.59	0.000
		9	-0.114	-0.054	244.13	0.000
		10	-0.055	-0.036	249.60	0.000
		11	-0.025	-0.041	250.69	0.000
		12	-0.088	-0.076	264.79	0.000
		13	0.014	-0.013	265.14	0.000
		14	0.254	0.162	382.27	0.000
		15	0.006	0.008	382.34	0.000
		16	-0.120	-0.044	408.56	0.000
		17	-0.024	0.011	409.58	0.000
		18	-0.024	-0.028	410.66	0.000
		19	-0.058	-0.018	416.70	0.000
		20	0.025	0.010	417.87	0.000
		21	0.250	0.145	531.54	0.000
		22	0.023	0.042	532.54	0.000
		23	-0.127	-0.023	561.72	0.000
		24	-0.035	0.007	563.95	0.000
		25	0.020	0.012	564.72	0.000

From the graph, we could see that the autocorrelation values are all around 0. We may conclude that the first differencing is stationary. We also tested the unit root, and the results are shown below:

Null Hypothesis: DSER03 has a unit root
Exogenous: Constant
Lag Length: 13 (Automatic based on SIC, MAXLAG=24)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.36565	0.0000
Test critical values:	1% level	-3.433821	
	5% level	-2.862960	
	10% level	-2.567573	

We can see from the Unit Root test that we should reject the null hypothesis that the first differenced time series has a unit root.

Parameter Estimation:

Since first differencing time series is a stationary series. Various ARIMA with difference p and q and first difference are fitted to the data. The AIC value is obtained for each model. The results are shown in the table below:

AIC values for ARIMA (p, 1, q) models

AR/MA	1	2	3
1	-14.34	-14.34	-14.32
2	-14.34	-14.34	-14.35
3	-14.32	-14.35	-14.33

Since AIC doesn't have a huge difference, the simplest model was chosen to be the final model, which is ARIMR(1,1,1) model. The output generated by EViews is shown below:

Sample (adjusted): 1/03/2008 11/29/2012
Included observations: 1793 after adjustments
Convergence achieved after 12 iterations
MA Backcast: 1/02/2008

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.622574	0.071590	8.696384	0.0000
MA(1)	-0.754044	0.060075	-12.55173	0.0000

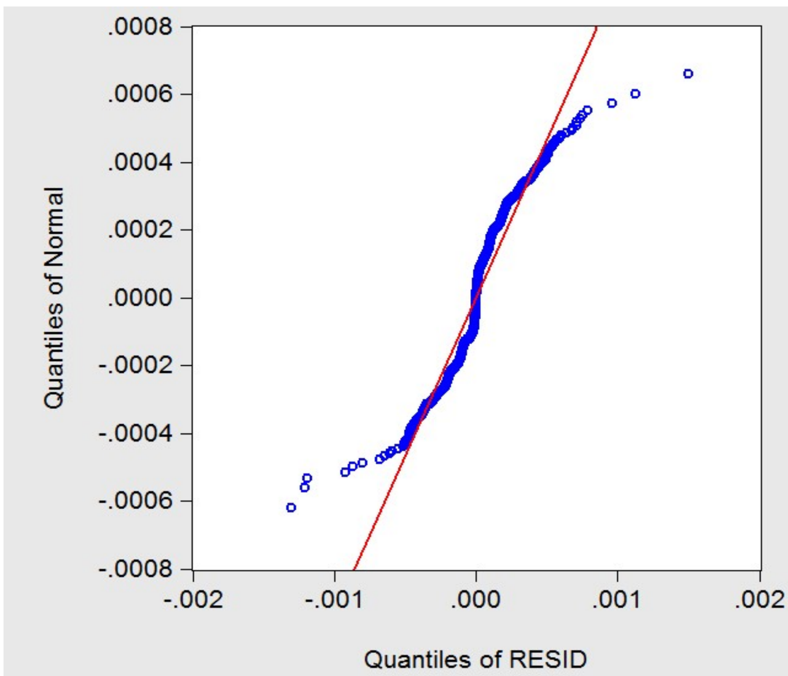
R-squared	0.024859	Mean dependent var	1.25E-05
Adjusted R-squared	0.024315	S.D. dependent var	0.000188
S.E. of regression	0.000186	Akaike info criterion	-14.34232
Sum squared resid	6.19E-05	Schwarz criterion	-14.33620
Log likelihood	12859.89	Hannan-Quinn criter.	-14.34006
Durbin-Watson stat	1.884011		

Inverted AR Roots	.62
Inverted MA Roots	.75

Both of the coefficients for AR(1) and MA(1) are significant with P value far smaller than 0.05. This is a solid model.

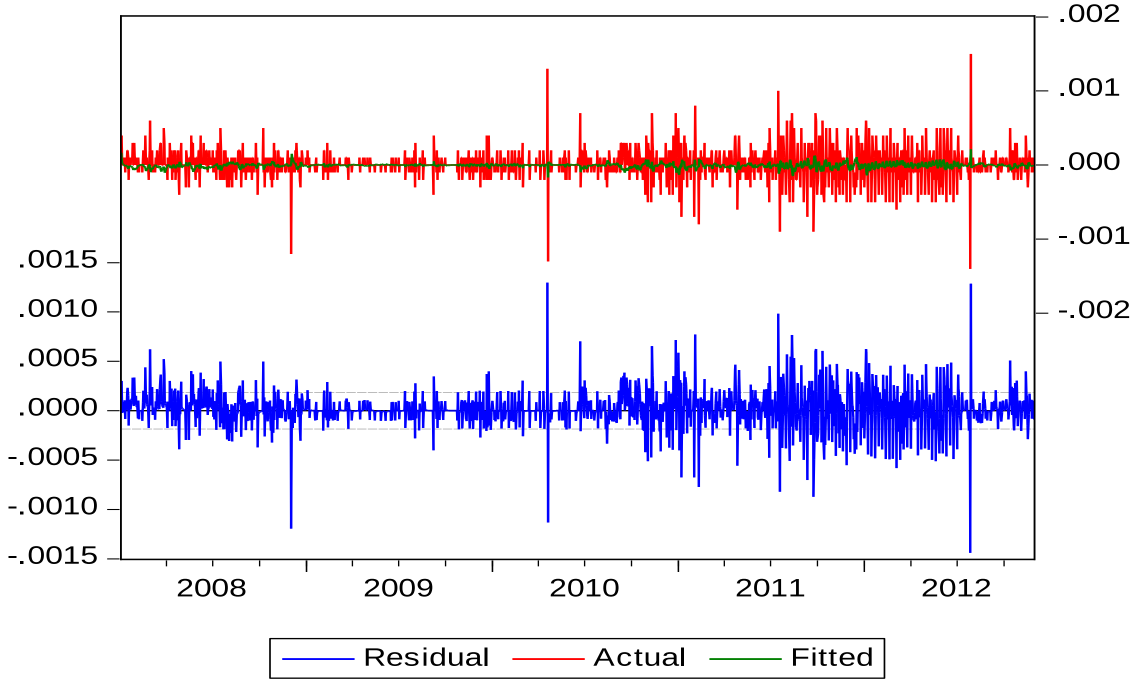
Model Diagnostic:

The normality of the residuals for the ARIMA(1,1,1) model is checked by plotting the Normal Q-Q plot. The plot is shown below:



From the plot, we could see that the residuals are approximately normal with slightly dispersion towards the ends of the Q-Q normal plot.

Constant variance assumption is checked by plotting the residuals against the fitted values. It does seem that in 2011 and 2012 the residuals show more variance than the variance in 2008 and 2009. More investigations need to be done in the future.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2008
2009
2010
2011
2012
Residual
Actual
Fitted