



UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

The effects of Chinese exchange rate depreciations on the
bilateral trade relationship between the US and China.

Maximilian Kärnfelt and Oscar Oddestad

Bachelor Thesis
First Semester 2014
The Department of Economics and Statistics

Abstract

This paper examines the impacts of real exchange depreciations on the bilateral trade between the US and China. Both the theoretical predictions and the empirical evidence suggest that Chinese real exchange rate depreciation would stimulate Chinese exports. Using an Error Correction Model the we estimate the following long run effects during the period between Q1 1995 and Q4 2013: a 1 % depreciation of the Chinese RMB would increase Chinese exports by 0,271 % and decrease US exports by 0,62 %. This however is dwarfed by the real effects of increasing economic activity in the importing countries.

Keywords

China and US trade, Exchange rate, Error Correction Model, Cointegration, Law of one price

Content

1. Introduction	3
2. Theory	7
2.1 Flexible Prices	7
2.2 Sticky Prices	11
2.3 Are prices sticky?	12
3. Method	14
3.1 The Simple Model	14
3.2 Computing the variables	15
3.2.1 Real Exports	15
3.2.2 Real GDP	16
3.2.3 Real bilateral exchange rates.....	16
3.2.4 Real exchange rate volatility.....	18
3.3 Unit root tests.....	18
3.4 Cointegration tests	19
3.5 Error Correction Model	19
4. Data	21
5. Results	22
5.1 Simple Model Results.....	26
5.2 Error Correction Model Results	27
6. Conclusions	31
References	32

1. Introduction

In recent years Chinese and American researchers and politicians have taken turns of either attacking or defending the Chinese monetary policy. The US government has repeatedly called for China to abandon its current exchange rate regime and let the renminbi float. Claims have been made that China is manipulating its currency, keeping it artificially low towards its chief trading partner's currencies. This is claimed to be done with the purpose of acquiring trade benefits, letting Chinese companies export at a premium. The purposes of our paper are to research the real effects these alleged currency manipulations would have had and present a viewpoint which is neither American nor Chinese.

Before 2005 the Chinese renminbi was pegged at a constant rate towards the dollar, they have since then been under increasing pressure from the international community to revise their exchange rate regime. Because of this they changed their exchange rate regime to be constant to a basket of currencies. The basket is weighted between what has been estimated to be 15 different currencies with the US dollar having the greatest weight, Oliver (2010), however the truth may never be known. They have also acquired the largest currency reserves in history the total which is currently not known, the US Treasury Department estimates it at \$3,3 trillion. This was expected to cause the exchange rate to appreciate greatly, however in the end it only appreciated by 2,1 %. The appreciation then continued until the renminbi finally was revalued in 2006. There is still however claims that the renminbi needs to further appreciate, Alan Greenspan, the former U.S. Federal reserve Chairman famously called it an "artificially weak currency". In 2011 Robert E. Scott of the US Economic Policy Institute claimed in his paper that a renminbi appreciation of 25-35 % would create 2,25 million US jobs.

Chinese monetary policy has been in the spotlight in recent years; its workings are mysterious to many. The People's Bank of China has since 2005 undertaken open market

operations with the purpose of balancing the renminbi against a basket of 15 unknown currencies with unknown weights. This in conjunction with theoretical evidence from the Balassa-Samuelson hypothesis, which states that as an underdeveloped country's productivity rises so should its exchange rate appreciate. This has caused many researchers to claim that the Chinese renminbi is severely undervalued. Many different estimations have been made, one of the most common being 15-41 % undervaluation (Chang, 2008; Chang and Shao, 2004; Cheung, Chinn and Fujii, 2009; Cline and Williamson, 2009; Coudert and Couharde, 2005; Frankel, 2004; Goldstein, 2004; Goldstein and Lardy, 2006; Subramanian, 2010; Zhang and Pan, 2004). In their 2009 paper Cline & Williamson argues that a 25-40 % revaluation would considerably alleviate the difficulties faced by the US by reducing their annual current account deficit by \$100-\$150 billion by stimulating US exports, a staggering number indeed. Yang, Zhang and Tokgoz (2013) come to the conclusion that a 5 % appreciation of the renminbi would lead to a 9,7 billion USD reduction in the Chinese trade balance, whilst a 15 % appreciation would lead to a 25 billion USD reduction. Baak (2008) concludes that in the long run a 1 % appreciation of the renminbi would lead to a 1,7 % reduction in Chinese exports and a 0,4 % increase in US exports.

The Balassa-Samuelsson hypothesis implies that when a country's marginal product of labor in the tradable goods sector increases, it should lead to its real exchange rate appreciating (Asea and Corden, 1994). In China however this has not been the case. Explosive economic development has not been followed by major appreciations in the real exchange rate. This has often been construed as evidence that China is artificially manipulating their exchange rate. If this is the case, what are the benefits which China can claim from doing so, and what are the effects other countries face?

Our hypothesis is that China's exchange rate depreciating towards their main trading partner, the US, is beneficial for their exports and has a negative effect on their imports. Whilst for the US we expect the opposite to be the case; a Chinese devaluation would be detrimental to their exports and facilitate imports. However it has been argued that the US's manufacturing industry is heavily reliant on imports of raw materials and components, suggesting that exchange rate depreciation would not hurt the US as much as it would help China (Yang, Zhang, Tokgoz, 2012).

In order to determine the effects of exchange rate devaluation this thesis analyses the effect of a real exchange rate depreciation on the bilateral trade between two countries; China and the US, the thesis analyses the period between 1995 and 2013 using quarterly data. China is currently the single largest exporter of goods to the US, taking up 18,7 % of all US imports

(All the percentages in this paragraph are from the US Census Bureau). They are however not the most significant trading partner of the US, this position is instead occupied by Canada (16,1 %), which is not surprising considering the geographical closeness of the two countries. Not only does the US import many goods from China, it also exports a significant part of their total exports to the country (7,1 %). With this situation in mind, the question of exchange rates effect on the trade balance is of utmost importance.

We first proceed to look at the theoretical evidence that exchange rate devaluation can create trade benefits. We accomplish this by using the “law of one price”, “terms of trade” and the Balassa-Samuelsson equations specified by Staiger and Sykes (2008). Finally we present the results from our empirical study to see if reality is similar to our theoretical predictions and make comparisons to other contemporary studies.

To study this relationship we specify an empirical model explaining the linear relationship between exports and real exchange rates to test the hypothesis that:

H₀: Exchange rates have no real effect on exports and imports

and argue that it can be rejected in favor of:

H₁: Exchange rates have real effects on exports and imports.

We also expect the tests to show us a positive relationship, that is: as the real CNY/USD rate increases (i.e. the renminbi depreciates or the dollar appreciates) exports from China to the US will increase.

An important issue in this discussion is of course the stickiness of money; currency manipulation depends heavily on prices moving slower than the supply of money. If prices and money supply moved in unison it would take away the possibilities of manipulating a currency. The last century there has been much debate on this topic: Milton Friedman argued that money was in fact non-neutral while Keynes argued that it was long run neutral, i.e. that it had no real effects on the economy. To understand the reasons for the growing Chinese currency reserves and the alleged currency manipulations we devote a section of this thesis to presenting academic viewpoints that coincide with the belief that money is sticky or non-neutral in the “short run”

Our thesis will first discuss theoretical predictions in chapter 2, followed by a review of

our chosen empirical model in chapter 3. In chapter 4 we discuss our data sources and then finally in chapter 5 we review the results of our empirical study.

2. Theory

In this section we will discuss how exchange rates affect the bilateral trade relationship between two countries. This chapter is in most regards based on Staiger and Sykes' 2008 paper on exchange rate changes being equivalent to tariffs-cum-subsidies. We have altered their equations to instead show only the exchange rate effects.

Our aim is to create a theoretically sound picture that will justify our empirical study. Our first question is if exchange rate depreciation can create trade benefits for China. To do this we examine exchange rates in a flexible price world, sticky price world and lastly raise a discussion as to whether we can really expect prices to be sticky.

For simplicity this whole section operates under the assumption that there are only two countries in the world, China and the US. We let China act as our "home" country, and denote goods produced in China with h . We let the US act as the foreign country and goods produced denoted with f . Furthermore we assume that only one tradable goods is produced and is of the same quality whether it's produced in China or the US.

Another caveat for this chapter is our choice to refer to all the equations as expressions; this is simply to make this section differ from the method chapter.

2.1 Flexible Prices

We first assume that prices are fully flexible and start our analysis from there; this describes the "long run". We then proceed to examine the "short run" where prices are often considered to be sticky (Staiger and Sykes, 2008). This lets us compare the differences in each scenario.

In a world where prices are fully flexible, i.e. prices in one country can instantly adjust to compensate for price changes in another one, exchange rates would fully compensate for any price differences on tradable goods. In this world a country with floating exchange rates we would observe instant changes of exchange rate, while in a country with a fixed rate we

would observe instant changes in prices. Under this assumption the following price model would be true:

$$P_h^{\text{¥}} = P_h^{\text{\$}} * e \quad \text{Exp. 2.1.1}$$

And

$$P_f^{\text{\$}} = \frac{P_f^{\text{¥}}}{e} \quad \text{Exp. 2.1.2}$$

Where $P_h^{\text{¥}}$ denotes the renminbi price of the goods if produced in China and $P_f^{\text{\$}}$ denotes the USD price of the same goods if produced in the US and e is the renminbi/us dollar exchange rate. In a world where prices adjust instantly any change in the price of goods in china would instantly create a change in prices or the exchange rate between the two countries. This relationship is often referred to as “the law of one price”.

If we make the model a little more complicated and include shipping costs, subsidies, tolls and other factors we will still come to the point where no price differences allowing arbitrage will be present, e.g. no profit can be made by simply moving a good from one place to another as the cost of moving it will ensure that the profit is the same no matter where you sell it (shown by Staiger and Sykes (2008)).

For prices in a bilateral trade relationship to be in equilibrium three ratios must be in equality. $\frac{P_h^{\text{¥}}}{P_f^{\text{¥}}}$ the relative CNY price of the good, $\frac{P_h^{\text{\$}}}{P_f^{\text{\$}} * e}$ the “terms of trade” between the two countries and $\frac{P_h^{\text{\$}}}{P_f^{\text{\$}}}$ the relative USD price of the good, this leads us to the following expression:

$$\frac{P_h^{\text{¥}}}{P_f^{\text{¥}}} = \left[\frac{P_h^{\text{¥}}}{P_f^{\text{\$}} * e} \right] = \frac{P_h^{\text{\$}}}{P_f^{\text{\$}}} \quad \text{Exp. 2.1.3}$$

Meaning that the ratio of the good produced in h and f denoted in CNY should equal the dollar price of the good produced in h divided by the CNY price of the good produced in f subject to the exchange rate. This in turn should equal the dollar price of the good produced in

h divided by the good produced in f. We substitute in the first equation arriving at the following equation showing that with flexible prices we arrive at equilibrium:

$$\frac{P_h^{\text{¥}}}{P_f^{\text{¥}}} = \left[\frac{P_h^{\$} * e}{P_f^{\$} * e} \right] = \frac{P_h^{\$}}{P_f^{\$}} \quad \text{Exp. 2.1.4}$$

This implies that a change in e will not affect the price ratio of the same goods valued in different countries as both prices will rise at the same level and why shouldn't they? After all, prices can adjust on the spot and exchange rate is not a factor in the relationship between two domestic prices. Thus the "terms of trade" between China and the US will not be changed in this "long run" scenario.

Up to this point we've only discussed tradable goods. Anyone who has travelled abroad will testify to the sometimes extreme price-differences of non-branded goods and services; for example a haircut in one country can sometimes cost only a fraction of the price in another country. How are non-tradables priced then? According to the Balassa-Samuelsson hypothesis the prices would be determined from wages and marginal productivity of labour, henceforth referred to as MPL as follows:

$$P_{nt,i} = \frac{W_i}{MPL_{nt,i}} \quad \text{Exp. 2.1.5}$$

Here we see that the prices of non-tradables are determined by wage in country i , divided by MPL, i.e. the marginal product of labor of non-tradables in country i . Let's look at the following equations:

$$w_h = p_{nt,h} MPL_{nt,h} = P_{nt,h} = P_h^{\text{¥}} MPL_{t,h} \quad \text{Exp. 2.1.6}$$

$$w_f = p_{nt,f} MPL_{nt,f} = P_{nt,f} = P_f^{\$} MPL_{t,f} \quad \text{Exp. 2.1.7}$$

Expression 2.1.6 and 2.1.7 assume that $MPL_{nt,h} = MPL_{nt,f} = 1$ meaning that the productivity of non-tradable goods in both countries is equal or close to it, which is a rather safe assumption to make considering that non-tradable services are very similar across the world (Asea and Corden, 2006). But what if the productivity of tradable goods differs

$MPL_{t,f} > MPL_{t,h}$? Since prices of tradable goods only show small differences corrected by the exchange rate, a difference in productivity of tradable goods must then result in $P_{nt,f} > P_{nt,h}$. Thus marginal productivity differences in the trade sectors explain the prices differences of non-tradable goods we observe when we go travelling.

A second implication of the Balassa-Samuelson equations is that Purchasing Power Parity or PPP is a function of the price of tradables and non-tradables and exchange rate is the ratio of domestic PPP denoted with * divided by foreign PPP:

$$PPP = f(P_t, P_{nt}) \quad \text{Exp. 2.1.8}$$

And

$$e = \frac{PPP^*}{PPP} \quad \text{Exp. 2.1.9}$$

When the marginal productivity of tradable goods in a country increases we can expect the prices of non-tradables to increase, so can we expect their PPP to increase (since it is in part a function of non-tradables). This in turn should lead to an appreciation of their exchange rate. During the last decades China has experienced tremendous growth, and also some exchange rate appreciation, many researchers some whom we mentioned in the introduction however argue that it is not enough and that the renminbi is still very much undervalued.

So far we've shown that the only price differences possible under fully flexible prices are those of non-tradables which is the result of differences in productivity in countries export sectors. We have thus shown that in a world where prices are fully flexible, accusations against China on the grounds that they are manipulating their currency to gain trade benefits hold no merit. Yet voices around the world have been raised with concerns regarding Chinese exchange rates the last decade.

But what if we revise our assumption that prices are flexible and move forward with sticky prices instead? Will exchange rates create price differences in this setting? And will this justify the concerns of the international community?

2.2 Sticky Prices

In the last section we applied the law of one price and the Balassa-Samuelsson hypothesis to a world of fully flexible prices and managed to show that exchange rates could not have any real effects and that existing price imbalances were all due to differences in productivity between the labor forces operating in the export sectors.

In this section we will instead assume that prices are sticky, meaning that it takes some time for any change in productivity, foreign prices and exchange rates to affect prices, they will have slow-moving effects. The idea here is that if an Chinese exchange rate devaluation occurs it will create a temporary price imbalance, effectively creating an opportunity to trade from a more advantageous position, e.g. a Chinese trader exporting commodities will be able to sell his or hers product at the same price as before but the buyer will in a sense purchase it at a discount effectively letting the Chinese trader undercut an American producer without lowering their prices. For now we assume that this captures the “short run” rather well, we will however return to this question and raise a discussion as to whether we can really expect prices to operate in this way in the real world.

Let’s look at the first equations from the last section, this time with sticky prices:

$$\bar{P}_h^{\text{¥}} = P_h^{\$} * e \quad \text{Exp. 2.2.1}$$

And

$$\bar{P}_f^{\$} = \frac{P_f^{\text{¥}}}{e} \quad \text{Exp. 2.2.2}$$

Here we denote $\bar{P}_h^{\text{¥}}$ as the sticky Chinese prices, meaning that the right hand side of the expression can experience changes that have no instant effect on the left hand. The result is that if renminbi, devaluation should occur, i.e. the renminbi becomes cheaper, prices of tradable goods in the US will rise to conserve the equality. However it needs to be noted that the prices rise only in a relative way, meaning that it will be effectively cheaper for the US to import a good even though the actual renminbi price has not changed. This is the source of much of the criticism aimed at China; it’s perceived that any appreciation of the CNY/USD rate will create possibilities for Chinese manufacturers to undercut their American

counterparts without any real losses to profitability, a prospect that has led many nations to call for the WTO to take action.

How does this affect the equilibrium expression from the first section then? The expression looks very much the same, the only difference being that sticky prices have been added:

$$\frac{\bar{P}_h^{\$}}{\bar{P}_f^{\$}} = \left[\frac{\bar{P}_h^{\$}}{\bar{P}_f^{\$} * e} \right] = \frac{P_h^{\$}}{P_f^{\$}} \quad \text{Exp. 2.2.3}$$

What we can observe here is that when e depreciates the CNY, price of goods in the US must decrease and the USD price of the same good in China increase. What effectively happens here is that imports become cheaper for the US and more expensive for the Chinese. The equality is preserved in this scenario; the terms of trade however are not unchanged as the denominator in the middle equation has in fact decreased, the Chinese now trade from a more advantageous position, i.e. the terms of trade have improved.

We've now shown that if prices are sticky then exchange rate changes can in the "short run" create profit opportunities which can be exploited. This leads us to the next section where we will reason as to whether we can expect prices to be sticky in the "short run"

2.3 Are prices sticky?

In this section we will make a claim as to the stickiness of money in the "short run". In the previous section we've shown that if this is the case exchange rates can be used by countries to create trade benefits by devaluing their currencies, letting them export at a premium.

Monetary neutrality is a key question in Macroeconomics and as such it's not surprising that it should also be raised here, however it's much too complex for the scope of this thesis, instead we show a number of viewpoints from researchers supporting the claim that money is non-neutral in the short run.

Most modern research suggests that money is neutral in the "long run" and non-neutral in the "short run" (Duczynsky 2005). According to the neoclassical view prices are not set with full information, referred to as "Indeterminacy" (Fiore 2010). The idea raised is that people do not have sufficient time to react on monetary changes in the "short run" causing monetary non-neutrality in the "short run". This viewpoint is also supported by Lucas (1970) in his paper on expectations and monetary neutrality.

A number of empirical studies have been performed with the aim of testing the merits of short-run monetary neutrality the following come to the conclusion that money is non-neutral in the short run: Cui, Yang, Gong, Zou (2008), Cecchetti (1986). With this much learned opinion on the side of short-run monetary non-neutrality (not to suggest that there are not conflicting views on the subject) we proceed to the next section where we will explain our choice of methodology.

3. Method

In order to test the theoretical relationship between exchange rates and exports that we showed in the previous chapter we need to specify a linear empirical model. We use ordinary least squares on historical data, attempting to connect different market states, e.g. high/low exchange rate with effects on the current account, real wages and so on. We then interpret the signs of the coefficients and perform inference testing to control if they are in fact statistically significant.

Our empirical study examines the time period between Q1 1995 and Q4 2013, this is done by examining quarterly data due to unavailable monthly data on some figures. The starting point of 1995 is chosen due to evidence of structural breaks before that, Baak (2008)

3.1 The Simple Model

For the empirical hypothesis testing we will start our estimation with the following model (Baak, 2008). We use this model in both directions, to estimate the real exchange effect on the exports for both US and China. (With changed notation that is more familiar to us):

$$EXPORTS_{ijt} = \alpha_0 + \beta_1 GDP_{jt} + \beta_2 RER_{ijt} + \beta_3 \sigma_{ijt} + \beta_4 RER_{cjt} + u_{ijt} \quad \text{Eq. 3.1.1}$$

Let $EXPORTS_{ijt}$ denote US imports from China (or vice versa) at time zero (US import figures are more readily available than Chinese export figures and as such will act as a proxy for Chinese exports in all future calculations), GDP_{jt} the economic activity of the importing country, RER_{ijt} the real CNY/USD exchange rate, σ_{ijt} the volatility of the exchange rate, RER_{cjt} the real exchange rate between the importing country and a competing exporter, such as Korea or Japan. We choose Korea trading with the KRW (Korean Won) as the major competitor for US imports due to their similarity to China, both geographically and the in manner of produce they tend to export. Germany was originally intended to compete with the US in our model, however due to the shift from dmark to euro we instead choose Japan trading with the JPY (Japanese Yen). Finally we include u_{ijt} the error term. This regression aims to capture the relationship between the exchange rates and the magnitude of goods (in millions of US dollars/Chinese RMB) imported.

3.2 Computing the variables

The reader will notice that we've applied natural logarithms to all the following variables; this is to make them approximate percentages.

3.2.1 Real Exports

In all following equations i represent the exporting country and j the importing country. We define real exports as following:

$$EXPORTS_{ijt} = \ln \left(\frac{EX_{ij}}{EXUV_{it}} * 100 \right) \quad \text{Eq. 3.2.1.1}$$

Where $EXPORTS_{ijt}$ denotes the natural logarithm of the real exports of US to China, EX_{ij} denotes nominal exports from US to China, $EXUV_{it}$ denotes export unit value of the exporting country which we use as a price deflator to more accurately measure change in exports over time.

Chinese export statistics and unit value indices are in many cases not available so we represent Chinese exports to the US as US imports from China; these statistics are much more readily available.

$$IMPORTS_{jit} = \ln \left(\frac{IM_{ji}}{IMUV_{it}} * 100 \right) \quad \text{Eq. 3.2.1.2}$$

Here we define $IMPORTS_{jit}$ as the natural logarithm of US real imports from China, IM_{ji} denotes US nominal imports from China, $IMUV_{it}$ is the import unit value index for China and Hong Kong. As such we define this real import function as the Chinese real export function.

3.2.2 Real GDP

Real GDP is often used as a proxy for economic activity (Baak, 2008), and as such we also use this measure. Unfortunately monthly data is unavailable for many years, forcing us to use quarterly data. We calculate real GDP as following:

$$GDP_{real,t} = \ln \left(\frac{GDP_{nom,t}}{CPI_t} * 100 \right) \quad \text{Eq. 3.2.2.1}$$

Only annual gdp deflators are available we instead use quarterly consumer price index to replace them. Since Baak's paper quarterly GDP data for China has been made available allowing us to circumvent some of his calculations.

3.2.3 Real bilateral exchange rates

$$RER_{ijt} = \ln \left(RER_{ijt,nom} \frac{CPI_{jt}}{CPI_{it}} \right), (RER_{ijt}, RER_{cjt}) \quad \text{Eq. 3.2.3.1}$$

Where RER_{ijt} is the real the natural logarithm of the real exchange rate between country i and j , $RER_{ijt,nom}$ is the nominal exchange rate between country i and j . RER_{cjt} is the real exchange rate between the importing country and the main competitor, denoted by c (we use Japan as the largest competitor for the US imports, and South Korea as the largest competitor for Chinese imports as suggested by Baak, (2008) this is computed in exactly the same way as the ij rate. Real exchange rate is used in our empirical model due to the staggering differences between the real rate and the nominal rate, as expressed in diagram 3.2.3.1 and 3.2.3.2.

Figure 3.2.3.1 Nominal CNY/USD exchange rate

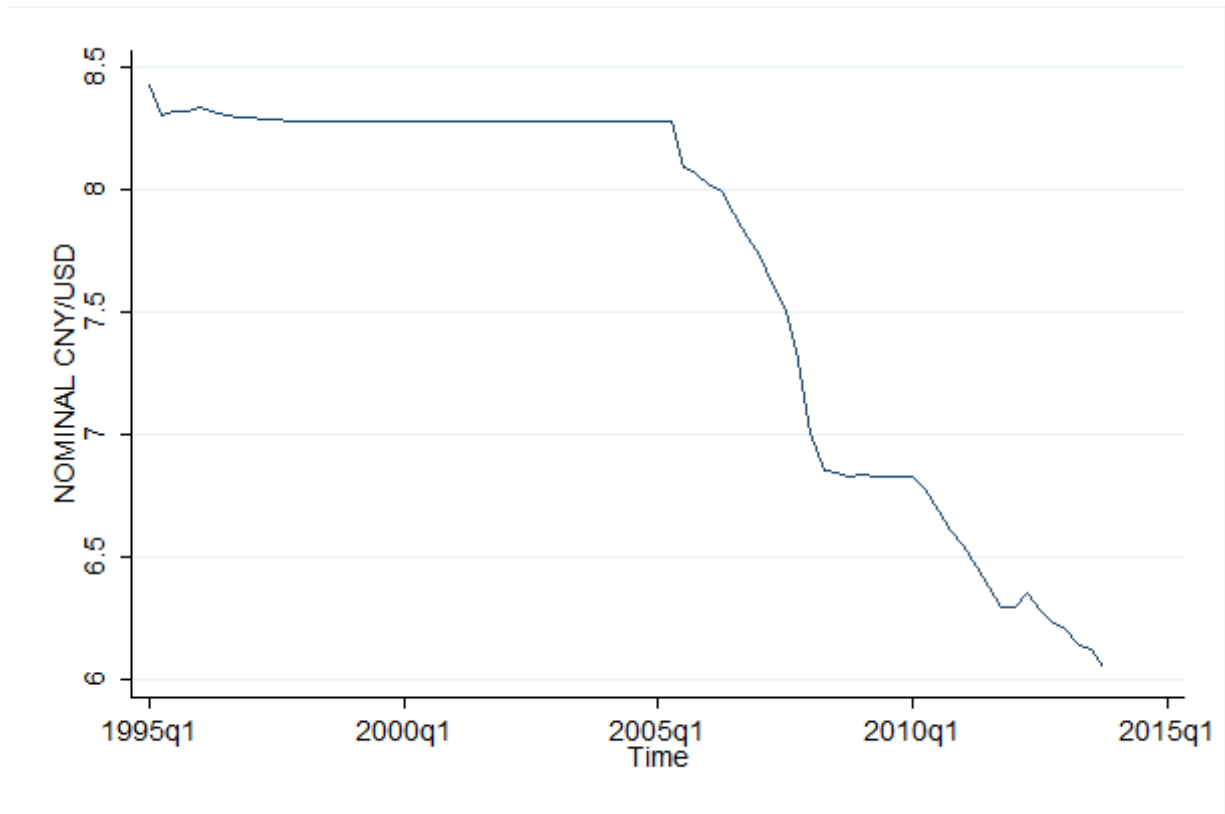


Figure 3.2.3.2 Real CNY/USD exchange rate



3.2.4 Real exchange rate volatility

$$\sigma_{ij,t} = \ln \left(\sqrt{\frac{1}{n-1} \sum_{k=tm}^{tn} (e_{nom.ijk} - \overline{e_{nom.ij}})^2} \right) \quad \text{Eq. 3.2.4.1}$$

Where σ_{ij} is the natural logarithm of the standard deviation of real exchange rates between the importing and exporting country, e.g. CNY/USD this is the quarterly figure, denoted by t . This is computed by using daily figures for the nominal exchange rates. This variable is included due to our suspicions that exchange rate volatility has a negative effect on trade due to price uncertainties.

3.3 Unit root tests

We perform the following augmented Dickey-Fuller test to test for non-stationarity and unit roots, where $H:0$ is that $\beta = 0$ in which case the variable has a unit root (Becketti, 2013):

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{j=1}^k \varphi_j \Delta y_{t-j} + u_t \quad \text{Eq 3.3.1}$$

Let βy_{t-1} denote the trending relationship while $\sum_{j=1}^k \varphi_j \Delta y_{t-j}$ denotes the non-trading relationship with lags. Where k is the amount of lags used in each test as determined by the Akaike Information Criterion. The test is performed on all the variables as can be seen in table 5.1.1 (p.20).

3.4 Cointegration tests

When many variables in a model show evidence of unit roots, it's also wise to check cointegrating relationships between the variables. We perform cointegration tests by creating new variable for each of the explanatory variables included in our model using the following formula, (Monogan, 2012):

$$z_t = EXPORTS_t - \alpha - \beta x_{it} \quad \text{Eq. 3.4.1}$$

We then perform the Dickey-Fuller unit root tests from 3.3 on the variable. If the new variable is found to be stationary we conclude that the variables it's comprised of have a cointegrating relationship.

3.5 Error Correction Model

Due to the results of the cointegration tests (table 5.1.1, 5.1.2, p 25) we adopt a two-step Engel-Granger Error Correction Model as specified by Best (2008) and Monogan (2012), we first estimate the coefficients in the error correction term using standard OLS and then estimate the coefficients for the whole model to grasp both the short and long term relationship between the variables.

$$\Delta EXPORTS_{ijt} = \delta_0 + \delta_1 \Delta GDP_{jt} + \delta_2 \Delta RER_{ijt} + \delta_3 \Delta \sigma_{ijt} + \delta_4 \Delta RER_{cjt} + \delta_5 EC + u_{ijt} \quad \text{Eq. 3.5.1}$$

$$EC = EXPORTS_{ij,t-1} - \alpha_0 - \beta_1 GDP_{j,t-1} - \beta_2 RER_{ij,t-1} \quad \text{Eq. 3.5.2}$$

Let EC determine the error correction term comprised of lags of the dependent and explanatory variables, where only GDP and real exchange rate have been added as they were the only processes we found to be cointegrated with the dependent variable. All the other variables are the same as those listed in Eq 3.1.1 (p.12).

When adding lags to the model (excluding the lags of the dependent variable for simplicity) it will look almost like Baak's (2008) Error Correction Model:

$$\Delta EXPORTS_{ijt} = \mu_0 + \sum_{h=0}^{nx} \delta_h \Delta GDP_{ijt-h} + \sum_{h=0}^{np} \varepsilon_h \Delta RER_{ijt-h} + \sum_{h=0}^{ng} \theta_h \Delta \sigma_{ijt-h} + \sum_{h=0}^{ns} \omega_h \Delta RER_{cjt-h} + \gamma EC_{ijt-h} + u_{ijt} \quad \text{Eq. 3.5.3}$$

We use sigma to denote lagged explanatory variables, where h determines the amount of lags included in each variable as determined by the Akaike Information criterion, Hu (2007). After that we remove individual lags to create a balance between overall explanatory power and individual variable significance. We take care to not remove individual lags if their removal leads to large losses of overall explanatory power.

4. Data

The nominal exchange rates, Chinese export unit value index, US export unit value index, Chinese CPI, US urban consumer CPI, Korean CPI and real gdp in percentages of China and the US have all been collected from Bloomberg. US exports and imports (used as a proxy for Chinese exports, due to lack of data) to/from China were taken from the US Census Bureau. All the figures correspond to the time period between Q1 1995 to Q4 2013.

All the Consumer Price indices and the export unit value indices have been converted so as to make 1995 the base year.

The Chinese imports are denoted in billions of CNY, whilst the US imports are denoted in millions of USD. This is not an issue due to us applying natural logarithms on all the variables so as to keep them in percentage form.

5. Results & Analysis

Table 5.1 Descriptive Statistics, real variables

VARIABLE	Mean	Standard Deviation
China Export	10,671	0,748
US Export	8,977	0,725
China GDP	9,652	0,683
US GDP	9,156	0,111
CNY/USD	1,887	0,206
CNY/USD Volatility	-5,901	2,083
KRW/USD	-2,479	0,188
JPY/CNY	-2,776	0,162

*76 observations

In this section we will present the results of our empirical study, the results of the Unit Root tests, Cointegration tests, the differentiated simple model, and finally the results of the error correction model.

The Error Correction Models has lags included which have been determined by using the Akaike information criterion and then rolling back lags to find a balance between overall explanatory power and statistical significance of the explanatory variables. When interpreting the results of the Error Correction Model we first look at the short term effects by looking at the individual coefficients of the lags of the explanatory variables. We then proceed to interpret the long term effects by adding the coefficients of the lags together as suggested by McKinnish (2002).

Inference testing for short term effects is done using t-statistics, long term effects are tested for joint significance using F-tests.

Due to the lags added the original time span of 76 observations from Q1 1995 to Q4 2013 has been reduced to 71 observations from Q2 1996 to Q4 2013. The results are applicable only to that time period.

5.1 Unit Root Tests Results

Table 5.1.1 Unit Root Test

VARIABLE	Test Statistics	5 % Critical Value	Reject at the 5 % level
China Export, 4 lags	-2,464	-2,913	No
US Export, 4 lags	-0,82	-2,91	No
China GDP, 3 lags	-0,163	-2,912	No
US GDP, 2 lags	-2,183	-2,912	No
CNY/USD, 1 lag	-0,164	-2,911	No
CNY/USD Volatility, 2 lags	-1,608	-2,912	No
USD/KRW, lag 1	-2,914	-2,911	Yes
CNY/JPY, 4 lags	-1,533	-2,913	No

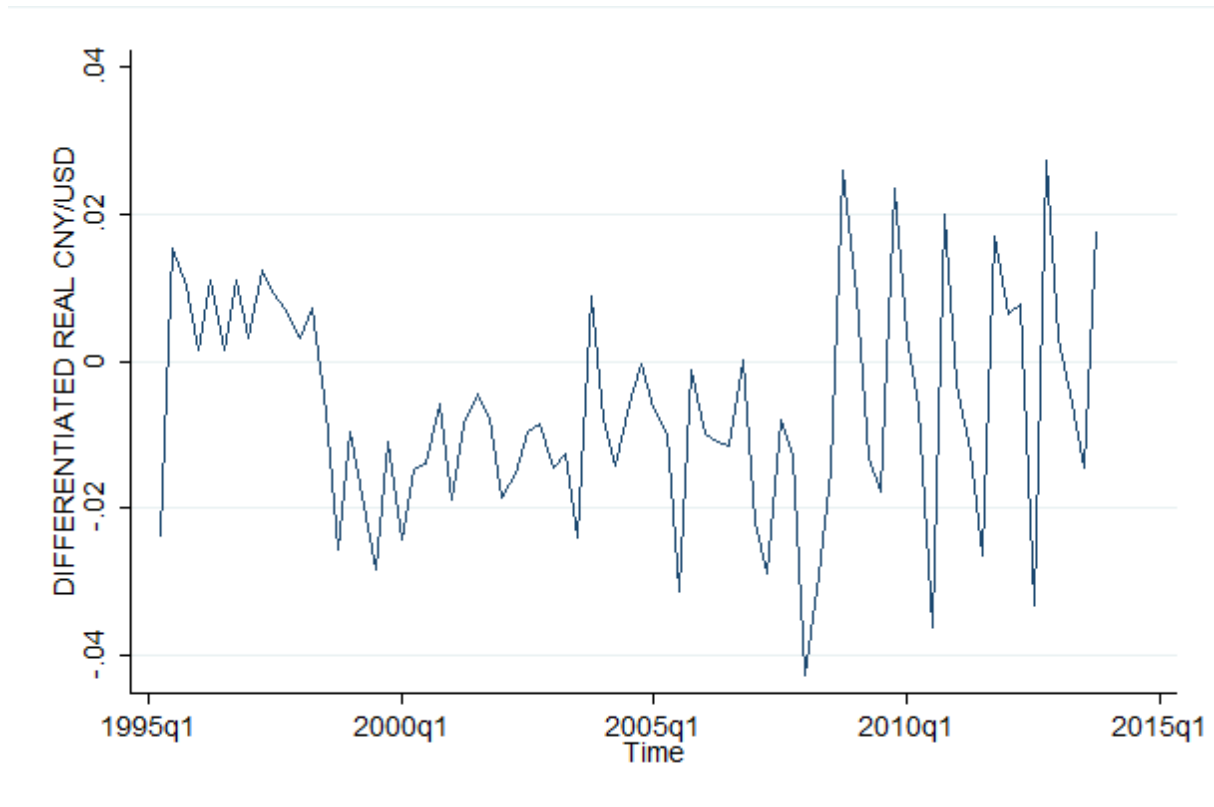
* The Akaike information criterion was used to determine the lag length for the tests.

In our own experiments regressing the variables resulted in bloated t-statistics and abnormally high R-squared. We thus tested all the variables during the time period of Q1 1995 to Q4 2013 using the unit root test described in the methodology chapter. We found that all the variables except for the USD/KRW exchange rate are non-stationary. The test statistics are all higher than the 5 % critical value, suggesting the presence of unit roots. To amend this problem we instead use the differentials of all the variables, this is found to be successful. After this all the variables are found to be stationary as is shown in the below diagrams:

Figure 5.1.1 Real CNY/USD exchange rate



Figure 5.1.2 Differentiated Real CNY/USD exchange rate



5.2 Cointegration Test Results

Due to unit roots with one exception being present in all the variables cointegration tests are performed to examine whether the independent variables in each export function have long run trending relationships with the dependent variable.

Table 5.2.1 Cointegration Test, regression, Chinese Export

China Export	Test Statistics	Critical Value	Reject at the 5 % level
US GDP	-4,807	-2,91	Yes
CNY/USD	-3,589	-2,91	Yes
USD/KRW	-1,283	-2,91	No
CNY/USD Volatility, 4 lags*	-2,756	-2,91	No

*Using no lags the CNY/USD volatility series was found to be cointegrated with the Chinese Export series, however this is not particularly likely, we thus added lags to make the test more robust.

The test results in table 5.1.1 indicate two cointegrating relationships; in the case of both the US GDP and the CNY/USD exchange we reject the null hypothesis of a joint unit root at the 5 % level. We can conclude that the variables are cointegrated.

Table 5.2.2 Cointegration Test, regression, US Export

US Export	Test Statistics	Critical Value	Reject at the 5 % level
China GDP	-6,65	-2,91	Yes
CNY/USD	-4,862	-2,91	Yes
CNY/JPY	-2,167	-2,91	No
CNY/USD Volatility	-2,645	-2,91	No

Once more two cointegrating relationships are indicated, the Chinese GDP and the CNY/USD exchange rate. We reject the null hypothesis of a unit root at the 5 % level for both those variables.

5.3 Differentiated Simple Model Results

Table 5.3.1 Simple model results

Δ China Export	R2=0,1166		Δ US Export	R2=0,067		
	Coefficient	t		Coefficient	t	
Δ US GDP	5,77	2,61	**	Δ China GDP	0,81	1,42
Δ CNY/USD	-0,35	-0,32		Δ CNY/USD	1,51	1,27
Δ USD/KRW	0,16	0,84		Δ CNY/JPY	0,19	0,67
Δ CNY/USD Volatility	-0,13	-0,96		Δ CNY/USD Volatility	0,02	1,31
Constant	0,001	0,04		Constant	0,02	0,75

*denotes 10 % significance

**denotes 5 % significance

***denotes 1 % significance

Due to the results of the Unit Root Tests the simple model is regressed using the differentials of the variables presented in the export function presented in Eq. 3.1.1 (p. 12); this is to alleviate non-stationarity that was discovered in the unit root tests. We found that the results from the simple model are not especially telling, only one variable in the two functions is found to be statistically significant. Furthermore, the results, had they been significant are not

in line with our hypothesis, in-fact they point in the opposite direction. We find that the US GDP has a positive effect on the Chinese exports, a 1 % change in US GDP increases Chinese exports by 5,77 %. On the other hand the CNY/USD exchange rate has a negative effect on the Chinese exports to the US which is not in line with our hypothesis. We found that a 1 % appreciation of the rate leads to a 0,35 % decrease in Chinese exports, which is not statistically significant at the 5 % level.

As for the US exports function we also found results that are in opposition to our hypothesis. The Chinese GDP has a statistically insignificant positive effect on exports, however the CNY/USD exchange rate has a positive effect on the exports meaning that as the US dollar increases in value China would be importing more goods, and this is somewhat counter-intuitive.

All in all the results of the differentiated simple model does not seem to explain anything, we've chosen to include it to show the need for more complicated model, the results of which we will review in section 5.2.

5.4 Error Correction Model Results

Due to the results of the cointegration tests we estimate two Error Correction Models as in Eq. 3.5.3. In this section we will review the results of the Error Correction Model. We first review the short run effects on the two export functions; we do this by considering individual lags of the explanatory variables. We then move on to the long run results where we add together the coefficient of the lagged variables to model long run effects as suggested by McKinnish (2002). Due to the lags added the Error Correction Models are estimated for the time period between Q2 1996 to Q4 2013.

Table 5.4.1 Error Correction Model results

Δ China Export				Δ US Export			
R2=0,5434				R2=0,540			
	Coefficient	t			Coefficient	t	
Δ US GDP	5,35	2,66	***	Δ China GDP	0,65	1,84	*
Lag 1	-2,73	1,36					
Δ CNY/USD	0,27	0,24		Δ CNY/USD	-0,93	-0,78	
Lag 1	-0,32	-0,31		Lag 1	1,07	1,14	
Lag 2	-2,52	-2,72	***	Lag 2	-1,77	-1,79	*
Lag 3	1,29	1,31		Lag 3	-1,71	-1,75	*
Lag 4	1,56	1,47		Lag 4	2,72	2,61	**
Δ USD/KRW	-0,07	-0,47		Δ CNY/JPY,	0,1	0,41	
				Lag 1	-0,18	-0,77	
				Lag 2	-0,02	-0,08	
Δ CNY/USD Volatility	-0,002	-0,47		Δ CNY/USD Volatility	0,01	1,14	
Lag 1	0,01	0,86		Lag 1	0,002	1,15	
Lag 2	0,02	1,56		Lag 2	0,02	1,23	
Lag 3	-0,01	-0,67		Lag 3	0	0,47	
Lag 4	-0,001	-0,09					
Error Correction	-0,63	-0,49	***	Error Correction	-0,72	-5,82	***
Constant	0,47	5	***	Constant	0,02	0,88	

*denotes 10 % significance

**denotes 5 % significance

***denotes 1 % significance

The short run results of the Error Correction model is presented in table 5.2.1. The differences between the error correction model and the simple differentiated are apparent.

For the Chinese export function R-squared has increased from 0,1167 to 0,5434 implying that explanatory power has increased. However it should be noted that the coefficients of the variables are with the exception of the level US GDP and the second lag of the CNY/USD exchange rate not significant. Furthermore the lagged coefficients often change in magnitude and sometimes even change sign completely.

The US export function suffers from much the same problems as the Chinese one, however more statistical significance is found in this function. Both the Chinese GDP and 3 of the CNY/USD exchange rate lags are found to be statistically significant.

Baak (2008) runs into the same kind of issues in his paper, he concludes that the short run effects are hard to pinpoint and instead points to the long term effects; just as we will do in the next section. However McKinnish (2002) suggests that unruly coefficients that don't make any economic sense might be due to problems with multicollinearity. McKinnish suggests that weighted restrictions should be imposed on the coefficients to battle this problem. This kind of solution is however not included in this thesis.

Table 5.4.2 Error Correction Model results, joint effects

Δ China Export				Δ US Export			
R2=0,5434				R2=0,540			
	Coefficient	F			Coefficient	F	
Δ US GDP, 1 lag	2,62	3,73	**	Δ China GDP, 0 lags	0,65	3,39	*
Δ CNY/USD, 4 lags	0,28	2,32	*	Δ CNY/USD, 4 lags	-0,62	2,97	**
Δ USD/KRW, 0 lags	-0,07	0,22		Δ CNY/JPY, 2 lags	-0,1	0,27	
Δ CNY/USD Volatility, 4 lags	0,02	0,85		Δ CNY/USD Volatility, 4 lags	0,04	0,78	
Error Correction	-0,63	-0,49	***	Error Correction	-0,72	-5,82	***
Constant	0,47	5	***	Constant	0,02	0,88	

*denotes 10 % significance

**denotes 5 % significance

***denotes 1 % significance

The long run effects are presented in table 5.2.2. The results are computed by adding up the lagged coefficients from the short run results presented in table 5.2.3 as suggested by McKinnish (2002).

US GDP is found to have a significant and positive effect on Chinese exports, a 1 % increase in US GDP leads to a 2,62 % increase in Chinese exports to the US. The CNY/USD exchange rate now instead has a positive and significant coefficient, when the RMB depreciates by 1 % Chinese exports to the US increase by 0,28 %.

Chinese GDP is also found to have a positive and significant (10 % level) effect on US exports, a 1 % increase in Chinese GDP leads to a 0,65 % increase in US exports to China.

The CNY/USD exchange rate has a negative effect on US exports; meaning that as the Chinese RMB depreciates the US exports to China decrease which seems to make more sense than the results we saw in the differentiated simple model from 5.2.

It's worth noting here that the most significant variable in all the regressions is always the GDP of respective countries, it has much larger effect on the exports than the exchange rate, particularly in the case of the Chinese exports to the US.

6. Conclusions

Our thesis has analyzed the real effects of exchange rate on the US-Chinese bilateral trade using a “law of one price” theoretical framework and ordinary least squares regression using both a differentiated simple model and an Error Correction Model. We also estimated the effect of other relevant variables such as GDP, exchange rate volatility and a competing country’s exchange rate using the OLS. Theoretical evidence suggests that if prices are sticky exchange rate devaluation can be used to claim trade benefits which empirical evidence also supports in a long run (4 quarters) framework.

Our empirical study found that 1 % depreciation of the Chinese RMB would increase Chinese exports to the US by 0,271 % and decrease US exports to China by 0,621 %, which is very much in line with our hypothesis.

Our findings show that historically China has received benefits from their exchange rate depreciating. We have presented no evidence that China have in-fact manipulated their exchange rate, but it is clear that some benefits could possibly be had from doing so.

Even though we have found the real exchange rate to have significant effect on the trade relationship between the US and China one must remember that this is very much overshadowed by the effect of increasing economic activity. When analyzing the trade relationship between two countries we strongly recommend not staring one-self blind on various financial variables and noting that real variable such as GDP have the largest effect.

Further research on the topic is needed. A study that takes into account the possibility of multicollinearity in the variables and take steps to amend the problem of unruly lagged coefficients by imposing restrictions on them, might well be able to more accurately pinpoint the short term effects.

References

- Asea, Patrick. K and Corden, W. Max, 2006. *The Balassa-Samuelson Model: an Overview*. Review of International economics, 8 p. 192-200.
- Baak, Saangjoon , 2008. *The bilateral real exchange rates and trade between China and the U.S.* China Economic Review, 19 p. 117-127.
- Beckett, Sean, 2013. *Introduction to Time Series Using Stata*. Stata Press. P.5
- Best, Robin, 2008. *An introduction to Error Correction Models*. Oxford Spring School for Quantative Methods in Social Research, p 12. Available Online: <http://springschool.politics.ox.ac.uk/archive/2008/OxfordECM.pdf>
- Stephen G. Cecchetti, 1986. *Testing short-run neutrality*. Journal of Monetary Economics, volume 17, Issue 3, p 409-423
- Chang, Gene Hsin, 2008 *Estimation of the undervaluation of the Chinese currency by a non-linear model*. Asia-Pacific Journal of Accounting and Economics, 15, p 29-40
- Chang, Gene Hsin and Shao, Qin, 2004. *How much is the Chinese currency undervalued? A quantitative estimation*. China Economic Review, 15, p. 366-371
- Cheung, Yin-Wong, Menzie D. Chinn and Fujii Eiji 2009. *China's Current Account and Exchange Rate*, *the National Bureau of Economic Research*.

- Cline, R. William and Williamson, John, 2009. *2009 estimates of fundamental equilibrium exchange rates*. Peterson Institute for International Economics. (2009) Policy Brief .
- Coudert, Virginie and Couharde, Cécile, 2005. *Real equilibrium exchange rate in China*. Working paper no. 2005-01, CEPII. Available online:
http://cepii.com/PDF_PUB/wp/2005/wp2005-01.pdf
- Cui, Xiaoyong, Gong, Liutang, Yang, Jianfang and Zou, Heng-fu, 2008. *Marshallian time preferences and monetary non-neutrality* Economic Modeling, p 1196-1205
- Duczynski, Petr, 2005. *On the Empirics of the Non-neutrality of Money: Evidence from Developed Countries*. Czech Journal of Economics and Finance, 55 c 5-6.
- De Fiore, Fiorella, 2000. *Can Indeterminacy explain the short-run non-neutrality of money?* European Central Bank, Working Paper Series, Working paper no. 32. Available Online: <http://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp032.pdf>
- Frankel, Jeffrey, 2004. *On the Renminbi: The choice between adjustment under a fixed exchange rate and adjustment under a flexible rate*. National Bureau of Economic Research working paper 11274, National Bureau of Economic Research, Cambridge, MA. Available Online: <http://www.nber.org/papers/w11274>
- Goldstein, Morris and Lardy, Nicholas, 2006. *China's Exchange rate policy dilemma*. Asian Currency Matters, 96 p. 422-426.
- Hu, Shuhu, 2007. *Akaike Information Criterion*. Center for Research in Scientific Computation. North Carolina State University. Available Online:
<http://www4.ncsu.edu/~shu3/Presentation/AIC.pdf>
- Lucas, Robert, 1972. *Expectations and the Neutrality of Money*. Carnegie-Mellon University.
- McKinnish, Terra G, 2002. *Interpreting Lagged Effects of the Independent Variable: How does the Local Economy Affect Welfare Caseloads?* University of Colorado, p. 18
 Available Online: <http://stripe.colorado.edu/~mckinnis/spectest081202.pdf>
- Monogan, Jaime, 2012. *Cointegration and Error Correction, a Third Model of Causality*. University of Georgia, p. 17 Available Online:
<http://monogan.myweb.uga.edu/teaching/ts/Mecm.pdf>
- Oliver, Chris, 2010. *Chinese yuan likely tracking 15 currencies, Merrill says*. MarketWatch, The Wall Street Journal.

- Scott, Robert E, 2011. *Revaluation of the Chinese Yuan would improve the U.S. trade balance*. Huffington Post.
- Staiger, Robert W. and Sykes, Alan O, 2008. "Currency Manipulation" and World Trade. *The National Bureau of Economic Research*. Available Online:
<http://www.nber.org/papers/w14600>
- Subramanian, Arvind, 2010. *New PPP-Based estimates of renminbi undervaluation and policy implications*. Policy brief, Peterson Institute for International Economics.
- Yang, Jun, Zhang, Wei and Tokgoz, Simla, 2012. Macroeconomic impacts of Chinese currency appreciation on China and the Rest of World: A global CGE analysis. *Journal of Policy Modeling*,
- Zhang, Fan and Pan, Zuohong, 2004. *Determination of China's long-run nominal exchange rate and official intervention*, China Economic Review, 15 p. 360-365.