The Impact of Exchange Rate on U.S.-China Bilateral Trade

BY

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Abstract

This paper examines the relationship between exchange rate and bilateral trade flows between U.S. and China, which is a hot topic in the trade-related fields. Specifically, the impact of exchange rate on trade has been much debated on two major dimensions: exchange rate volatility and exchange rate misalignments. Currently, a large body of empirical studies shows there is no significant relationship between exchange rate volatility and trade flow. Meanwhile, the second issue, currency misalignment, is predicted to have effect in the short run but not robust. In this study, we tried to model this relationship with quarterly bilateral data between U.S. and China from 1995 to 2012.

The results of error correction regression model confirm the theoretical works that exchange rate volatility impacts bilateral trade only slightly, but misalignment shows significant negative impact in U.S. import model. What’s more, the empirical study also helps to partially explain some specific trade patterns between China and U.S. during the above time periods.

Key words: trade flow, exchange rate volatility, exchange rate misalignments, U.S., China
1. Introduction

U.S.-China bilateral trade plays a significant and growing role in the current U.S.-China economic ties. The two countries’ bilateral trade grows rapidly in the recent three decades since China and U.S. established the diplomatic ties in 1979. China has become the U.S.’s second-largest trading partner in the world market today. According to the U.S. statistics, U.S. merchandise trade with China has rose from 2.7 billion in 1980 to 318.7 billion in 2013.

With growing trade value between the two countries, the bilateral trade imbalance has also been expanding dramatically. According to the data provided by U.S. Department of Commerce, the U.S. import with China grew from $84 billion in 1999 to $251 billion in 2006 and it further surge to 45 billion in 2013. At the same time, export to China only rises by small percent in above time period as the Figure 1 shows.

Regarding to China’s exchange rate system, it has been reformed several times during the period of trading with U.S. The annual real exchange rate (adjusted by CPI) over 1970 to 2014 is shown in the Figure 2 which indicating the currency volatility in the past 30 years.

![Figure 1: China-U.S. Bilateral Trade Value](image1)

![Figure 2: China-U.S. Real Exchange Rate](image2)

Source: U.S. Department of Commerce
The ever-increasing trade deficits are frequently attributed to exchange rate volatility and intentionally low or high exchange rate levels of Yuan-dollar rate by the U.S. policymakers, labor groups, and business representatives of import-sensitive industries (Morrison, 2011). Critics further charge that China’s currency policy has undervalued the Yuan’s value which becomes a major factor in the size and growth of the China’s export side.

However, the impact of the exchange rate on the bilateral trade is susceptible based on theoretical and empirical studies. To date, a large body of existing empirical literature does not suggest an unequivocally clear picture of the trade impacts of exchange rates. So in our paper, we aim to examine how exactly the exchange rate affects bilateral trade between China and U.S. And the result of the paper will serve as a piece of evidence regarding the ongoing debate and policy change.

This study will analyze the role of exchange rate in two dimensions: exchange rate volatility and currency misalignment. The remainder of the paper is organized as follows: Section 2 presents existing theoretical and empirical studies on the trade impact of exchange rate volatility and misalignment. Section 3 briefly states the objective of our study. And Section 4 begins with research data and methodology. Two models will be built respectively with the most recent 18-year trade quarterly data to test trade impact. Section 5 shows the results and analysis. Finally clear conclusions and limitations will be put forward based on previous work.
2. Literature Review

2.1 Exchange regime & bilateral trade movement

China’s exchange rate system has changed over time. Before 1994, Chinese government applied a dual exchange rate system under which the official exchange rate is different from real exchange rate. In succession, Chinese Yuan was pegged to U.S. dollar in 2000s. Since 2005, large capital inflows and expanding current account surplus exert pressure on Yuan. To prevent this, Chinese authorities tried to appreciate the value of Yuan and change the currency basket which not only includes dollar but also euro, yen, and etc. In 2008 onwards, further change of Yuan’s value has installed and China remains a managed floating exchange rate system until nowadays.

2.2 Exchange rate and bilateral trade flow

The impact of exchange rate on bilateral trade is widely discussed by academicians in recent years. Even though there is a large body of literatures, a clear agreement has not been reached on this topic. Moreover, two main areas are heatedly discussed in the trade policy community: exchange volatility and currency misalignment (Auboin & Ruta, 2013).

2.2.1 Exchange rate volatility

Theoretical works

The volatility issue draws researcher’s attention since the early 1970s, which came after the breakdown of Bretton-Wood system. Fluctuation of currencies brings large uncertainty to traders, especially the ones without hedging instruments.

In reviewing the literatures, there is no consensus on the effect of exchange rate risk. It means higher exchange rate volatility may hurt, help or have no impact on the bilateral trade.

The first batch of theoretical papers states that exchange rate risk exerts negative impact on trade flows. Clark (1973) demonstrated that great volatility of exchange rate will reduce exporter’s output due to uncertainty about future receipts which usually denominated in foreign currency. In absence of forward exchange tools, firm’s profitability is closely related to the exchange rate. And the exchange volatility poses commercial risks in international transactions. Therefore,
firms are unwilling to engage in international trade in response to the high risks. However, this adverse conclusion is restrained by stringent assumptions. For example, the firm is assumed to have limited access to forward market and it has no imported inputs for manufacturing of final goods. Moreover, the small firm finds high cost to adjusting its level of production.

Some early theoretical literature also points out that higher exchange rate may not discourage the international trade and its effect is kind of ambiguous if we lose above assumption. For example, the presence of imported inputs in one country’s export can offset risks if it buys inputs from a country whose currency undergoes depreciation. What’s more, the hedging tools can prevent exporters from necessarily loses from changes in the expected rate (Viaene and de Viries, 1992). These relevant factors suggest the link between exchange rate volatility and trade flow becomes less robust.

And there is another group of researchers hold a positive view between exchange rate volatility and trade flows (De Grauwe, 1998). One of the popular explanations for the positive relationship between two variables relates to trader’s degree of risk aversion. High risk-averse traders will exports more regarding the frequent change of exchange rate in order to seek compensations for decreasing revenue to encounter riskiness. And if the exporting firms have ability to adjust trade value and transaction cost, they can benefit more by adjusting the margin of products.

To summary, the theoretical results are conditional on the assumptions of firm’s attitude towards risks, the presence of hedging tools and adjustment cost, etc. which leads to the impact analytically indeterminable.

**Empirical Studies**

With mix conclusion from theoretical works about effect of exchange volatility on trade, a lot of academics also carry out vast of empirical studies on this topic.

In Chit, Rizov & Willenbockel (2010), an attempt is made to obtain conclusive empirical findings among five emerging countries. The results show a statistically negative impact of bilateral real exchange rate volatility on exports of emerging East Asian countries by using panel unit-root and cointegration tests. And in their model, the general effect of currency union has also been examined. The adoption of monetary integration in ASEAN has rather strong and positive effects
on trade flows.

Arize et al. (2000) also demonstrated a negative relationship between volatility and exports of least developed countries by applying similar technique in both short run and long run. The author described that due to the absence of forward market, firms in least developed countries have few access to hedging tools to hedge against risk and become risk aversion in international trade.

On the other hand, a lot of papers show the role of exchange rate volatility is insignificant in the international trade flow. Caglayan (Caglayan & Di, 2010) empirically tested the relationship between U.S. and its trading partners and finds that the effect of exchange rate volatility is negligible. And the sign of the impact is different between emerging countries and advanced countries.

Holly (1995) also found no evidence of negative trade impact of exchange volatility by examining time series data. Furthermore, other IMF reports also note the ambiguous results between the two variables.

In brief, the major reason for diversified empirical conclusions relate to the use of different econometric measurement of volatility and the limitations of sample size and the time horizon (short-run or long-run) etc.

With globalization production plays a more and more important role in the current trading market, Bahmani- Oskooee, M. & Xu, J. (2012) put the third country effect into consideration. They tried to investigate whether volatility of Canadian dollar has any implication on the U.S.-China bilateral trade flows. The affirmative result shows that short-run volatility of U.S. dollar and the Canadian dollar exchange rate contributes to the growth of U.S.- China bilateral trade flow to some extent.

Cushman(1986) also recognized trade impact of exchange rate volatility of third country. By excluding third country effect on U.S.-Canadian trade, he firstly found a significantly positive influence of Canadian exchange rate uncertainty on U.S. exports to Canada. But when the third country is added, the positive impact disappeared which implies the third country do have certain effect on trade.
2.2.2 Exchange rate misalignment

With rise of imported input in the modern trade structure and forward exchange rate market, the
domination of exchange volatility gradually decays away. Scholars tend to shift their view from
exchange rate volatility to currency misalignment’s effect on trade flows. Therefore, another side
of literature accounts for the impact of the “undervalued” exchange rate level on country’s export
surge.

Theoretical works

The exchange rate misalignment is defined as the situation in which the actual real exchange rate
deviates from the underlying real exchange rate, or called “the equilibrium real exchange rate”
(Razin & Collins, 1997). In general, it is caused by two reasons, one is the currency manipulation
due to government intervention, and the other is the side effect of macroeconomic policies.
Broadly speaking, currency misalignment affects the international trade through price signals
which have immediate effect on bilateral trade pattern. And on the other hand, it also changes the
investment decision and cause the transfer of resource between tradable and non-tradable sector.

Misalignment’s effect on trade closely relates to time length. In long-run, misalignment of
exchange rate has no effect on trade flows, because it does not change the relative price of goods
when price level is flexible to adjust. However, the effect is different in short-run because the price
adjustment takes time and the change in nominal exchange rate may affect the relative price. As a
result, a depreciation of domestic nominal exchange rate can lead to the real exchange rate
depreciation due to price rigidity in the short run, which causes the domestic exports relative
cheaper compared to the foreign countries. Therefore, the home country will export more because
the foreign consumers switch to low-cost home products in the world market.

In a word, it can be concluded that the exchange rate misalignment has a more significant short-run
effect on trade flow than long-run in the context of price rigidity.

However, the misalignment is difficult to estimate, even though it exerts some effect in the short
run. The currency level is highly related to the country’s degree of capital control and
macroeconomic policies. For example, a domestic monetary policy will have spillover effect on
the short-run exchange rate. Moreover, with the pace of globalization, the effect of currency
misalignment becomes more complex. Because a country’s currency adjustment will also affect other trading partners in the whole world context.

**Empirical Studies**

Large amount of empirical studies shows that exchange rate misalignment has robust impact on bilateral trade in the short run.

Marquez and Schindler (2007) found that Chinese exports respond quite strongly to movements in the real exchange rate, of which a 10 percentage appreciation in the real exchange rate of RMB results the aggregate Chinese exports decreased by nearly 1 percentage, while the responses on imports is negligible.

Naseem (2008) also discovered that exchange rate misalignment significantly hastened the level of Malaysia imports, especially during Asia financial crisis by using a VAR import model.

Moreover, recent UNCTAD research finds that currency undervaluation can promote exports and restrict imports in regard of impact directions. And misalignment across currencies results in trade diversion around 1 percent of world trade. The author also argues that misalignment also closely relates to trade policy such as anti-dumping intervention.

However, some other scholars find insignificant effect brought by misalignment. Cheung, Chinn, & Fujii (2010) discussed the trade elasticity of Chinese import and export with U.S. In their paper, a balance approach of measuring the sum of current account and capital inflows is applied to figure out the RMB misalignment. The result shows that RMB depreciation will lead to Chinese export growth but the effect is insignificant in the long run.

Meanwhile, Groenewold & He (2007) found that the relationship between revaluation of RMB and U.S.-China bilateral trade deficit is modest by examining the quarterly data from 1987(1) to 2003(4), of which a 10 percent appreciation of RMB improves the trade balance by less than 10 percent.

In addition, misalignment also shows different effect in various sectors of an economy. Kim, M., Sun, E., Jin, H., & Koo, W. W. (2003) examined the impact of misalignment by panel data analysis of 4 industry sectors over the period 1974-1999 among 10 developed countries. And they
found that overvaluation of nominal exchange rate negatively affects the agricultural export, while the effect is insignificant on the large scale manufacturing sectors.

Shaghil Ahmed (2009) further examined the sensitivity of Chinese export responses to exchange rate changes by distinguishing China’s exports into “processed” and “unprocessed” categories. Their results suggested that an appreciation of Chinese real exchange rate has a significant negative effect on Chinese non-processing exports, but insignificant effect on the processed exports using the quarterly data from 1996 (1) to 2009 (2).
3. Objective of Study

Even though there is a large body of existing literatures studies on exchange rate effect on bilateral trade flow, few of them incorporate trade impact of volatility and misalignment simultaneously. This paper aims to mitigate the above drawbacks in the current study in order to have a deeper understanding of the role of exchange rate in the U.S.–China bilateral trade flows.

We define bilateral trade flow as the total real export and total real import of goods between the U.S. and China. The major advantage of bilateral trade data than aggregate trade flows of a country is the ability to be more accurate. The pre-assumed factors will have impact on the dependent variables in our model include: country GDP, exchange rate volatility and misalignment.

An error correction model will be used to test the short-run impact of the real exchange rate volatility and misalignment on U.S. and China bilateral trade. Moreover, third country effect will be also considered in order to find out the sensible correlation between factors.

We will test the significance of the relationship between bilateral trade data and assumed factors, trying to explain the sign and magnitude of variables. Also we also try to detect the trade pattern reflected from the model results if possible.
4. Data and Methodology

4.1 Data sources

This paper uses quarterly data and the period under consideration ranges from 1995Q1 to 2012Q4, according to its availability. Because all variables related to Chinese nominal exchange rate are detected a structural break in 1994, the time when China authority change its exchange rate system. Therefore, we start our analysis from 1995 to obtain more stable model onwards.

It is known that there are distinctive discrepancies between trade flow reported by China and by US authorities. The major reasons are differences of record systems and computation methods used in China and U.S. bureau of statistics. And we follow other literatures to use U.S. figures in this paper because it shows more reliability.

Quarterly bilateral trade flows in value (thousands of U.S. dollars) for the U.S. and China are available in IMF’s Direction of Trade Statistics (DOTs).

Nominal monthly exchange rates of China, Canada are obtained from International Financial Statistics of the International Monetary Fund (IMF). It is defined in the number of the local currency per U.S. dollar at the end of period. Therefore, when the value of the number increases, it means the depreciation of local currency.

Quarterly real GDP of the U.S. is also collected from IFS. In case of China, quarterly real GDP is not available so that the annual data were used to estimate. Consumer price index (CPI) are not reported either. Instead, the annual growth of monthly CPI from 1986 to 2012 is reported in IFS. Therefore, quarterly data of CPI is interpolated based on the recent data from FRED and growth rate.

All the data used in the empirical model is in real terms.
4.2 Variables definition

Real exports ($LnEX$)/ imports ($LnIM$)

In this paper, the real exports denote as the log value of U.S. export to China. And real imports are defined as log value of import of US from China. The computation method is as follows:

$$LnEX \equiv Ln(EX_{US}/CPI_{US}\times100) \enspace ; \enspace LnIM \equiv Ln(IM_{US}/CPI_{US}\times100)$$

Real GDP

The real GDP of importing countries is commonly used as a proxy for economic activity. The real GDP in this paper is also adjusted by CPI of US or China. In case of China’s GDP, quarterly data is available only after 1999. Therefore, we use some interpolation techniques to estimate.

Real bilateral exchange rate

The real exchange rate is computed as follows:

$$ER \equiv Ln(NER\times CPI_i/CPI_j)$$

$ER$ denotes the log value of bilateral real exchange rate. In this paper, we select two countries’ exchange rate as explanatory variables in our model. In addition to exchange rate between China and U.S., Canadian exchange rate is also included by taking third country effect into consideration. Canada is regarded as the biggest trading partner with U.S. According to the recent study by Fraser Institute, China has emerged as Canada’s second largest trading partner, with 272% value growth from 1998 to 2007 in export market. It is believed that price of third country’s goods will affect bilateral trade between U.S. and China.

4.3 Measure of core variables

4.3.1 Measure of volatility

The volatility of bilateral real exchange rate is defined as variable $Volt$. Various measures have been reported in the past empirical studies. And there is no consensus on whether the nominal exchange rate or real exchange rate should be chosen. In this paper, the real exchange rate is used. Major approaches to measure volatility are: (1) Conditional volatilities of the exchange
rate deriving by GARCH model. (2) Standard deviation of the log real exchange rate (3) Moving average standard deviation of log real exchange rate. Since the final result is influenced by measure of exchange rate volatility, selection of measures is crucial to the study onwards.

GARCH models are defined as Generalized ARCH models. As an important feature of time series “volatility clustering”, It is introduced by Engle in 1982 which can serve as a strong tool to capture the above relationship and forecast conditional variance. Because the RMB exchange rate from 1995 to 2012 does not show strong volatility clustering, we do not choose to use this method.

As for the standard deviation of log real exchange rate (2nd method), it has a drawback to give large weight to the extreme volatility. In addition, this measure may become zero if the exchange rate is constant during a certain period. Thus, it cannot be a perfect approach to measure volatility.

In this paper, moving average standard deviation of the real bilateral exchange rate is used:

\[ Volt = \sqrt{\frac{1}{m} \times (\text{LnRE}_{t+i-1} - \text{LnRE}_{t+i-2})^2} \]

Where, \( m \) is the order of moving average. \( \text{RE}_t \) is the real exchange rate in a certain time period. And we use \( m=3 \) to obtain quarterly real exchange rate volatility.
From the figure above, we can see the volatility of RMB is smaller than Canadian dollar at the same period after Chinese government tried to loose dual exchange rate system.

4.3.2 Measure of misalignments

The misalignment of bilateral real exchange rate is defined as variable $Mis$. There are substantial quantities of studies on measuring misalignment in the empirical studies. Cheung, Chinn and Fujii (2010) classified these approaches into five categories: (1) Relative PPP approach; (2) Absolute PPP approach; (3) The productivity approach and the behavioral equilibrium exchange rate (BEER) Approach; (4) The macroeconomic balance effect approach; and (5) The basic flows approach.

The core of the misalignment is to find the difference between observed exchange rate and its equilibrium exchange rate level. In this paper, we use the simple relative PPP approach which put forward by Rodrik (2008).

This approach normally covers three steps to calculate misalignment. Firstly, we need to estimate the long run equilibrium level of real exchange rate as $\text{LnER}_t = \text{Ln} (\text{NER}_t / \text{PPP}_t)$, where $\text{NER}_t$ is the official exchange rate defined as the price of RMB in terms of U.S. Dollar. And $\text{PPP}_t$ is the purchasing power parity conversion factors. However, as the data of PPP is not available, we derive real exchange rate by multiplying the nominal exchange rate by the ratio of the U.S. to China Consumer Price Index (CPI), and it has similar effect as dividing by PPP. Therefore, the real exchange rate ($\text{ER}_t$) is regarded as the amount of Chinese goods or service can be traded for equivalent goods or service in U.S.

Secondly, we regress the real exchange rate on real GDP in order to control the Balassa-Samuelson effect, of which both the tradable and non-tradable goods are cheaper in relative poor country.

$$\text{LnER}_t = \beta_0 + \beta_1 \text{LnGDP}\_\text{CHA} + T + \epsilon_t \tag{1}$$

where $\text{GDP}\_\text{CHA}$ is the real GDP of China, $T$ is the linear time trend, and $\epsilon_t$ is the error term. By running the above model, one of the diagnostic statistic (Durbin-Watson stat. 0.746918) shows there is strong autocorrelation in the error term. It means the error term we will use as level of misalignment in the next step is biased.
To obtain an unbiased series as misalignment, we improve the old simple regress model into a autoregressive distributed lag ADL (2,4) model.

\[ \text{LnER}_t = \beta_0 + \beta_1 \text{LnGDP}_{-CHAt-1} + \beta_2 \text{LnGDP}_{-CHAt-2} + \beta_3 \text{LnGDP}_{-CHAt-3} + \beta_4 \text{LnGDP}_{-CHAt-4} + \alpha_1 \text{LnER}_{t-1} + \alpha_2 \text{LnER}_{t-2} + \epsilon_t \]  

(2)

The estimation result can be seen from Appendix I. This model is well built and shows no serial correlation in the error term with Durbin-Watson statistic (2.002127) and Breush-Godfrey Serial Correlation LM Test statistic (15.30975>C.V.5%=3.14).

In the third step, the exchange rate misalignment can be calculated as the different between the actual real exchange rate \( \text{LnER}_t \) and the fitted value \( \text{LnER}_t \) from equation (2).

\[ \text{Mis}_t = \text{LnER}_t - \text{LnER}_t \]

The higher value of \( \text{ER}_t \) means the stronger of U.S. dollar. In analyzing the effect of misalignment more naturally, we assume ourselves as U.S. citizens. In summary, we have:

When \( \text{Mis}_t >0 \), the U.S. dollar is overvalued; and when \( \text{Mis}_t <0 \), the U.S. dollar is undervalued.

And the result of testing the exchange rate misalignment is shown in the graph below, in which the red line is the actual value, the green line is the fitted value and the blue line is the value of \( \text{Mis}_t \).

![Misalignment estimation of China exchange rate](image)

The regression results show that misalignment of Chinese real exchange rate fluctuates over time.
In the early part of our samples, especially from 2000 to early 2006, Chinese Yuan seems to be undervalued ($M_{is} > 0$). Later on, the value of RMB changes more frequently as the graph shown.

### 4.4 Variables unit root test

To prepare for cointegration test, ADF test is put into application in this paper to test variable’s unit root. Because the economic variables normally have a significant time trend, we apply ADF test by including intercept and time trend simultaneously. See table below for the ADF result:

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF Test Values</th>
<th>Critical value</th>
<th>Stationarity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>LnEX</td>
<td>-2.108019</td>
<td>-4.050509</td>
<td>-3.454471</td>
</tr>
<tr>
<td>LnIM</td>
<td>-1.585631</td>
<td>-4.050509</td>
<td>-3.454471</td>
</tr>
<tr>
<td>LnER_CHN</td>
<td>-1.120255</td>
<td>-4.409586</td>
<td>-3.454032</td>
</tr>
<tr>
<td>LnER_CAN</td>
<td>-0.684528</td>
<td>-4.049586</td>
<td>-3.454032</td>
</tr>
<tr>
<td>LnGDP_CHN</td>
<td>-1.117132</td>
<td>-4.049586</td>
<td>-3.454032</td>
</tr>
<tr>
<td>LnGDP_US</td>
<td>-1.290253</td>
<td>-4.049586</td>
<td>-3.454032</td>
</tr>
<tr>
<td>D(LnEX)</td>
<td>-10.68039</td>
<td>-4.05145</td>
<td>-3.454919</td>
</tr>
<tr>
<td>D(LnIM)</td>
<td>-10.0569</td>
<td>-4.050509</td>
<td>-3.454471</td>
</tr>
<tr>
<td>D(LnER_CHN)</td>
<td>-9.667456</td>
<td>-4.050509</td>
<td>-3.454471</td>
</tr>
<tr>
<td>D(LnER_CAN)</td>
<td>-8.799476</td>
<td>-4.050509</td>
<td>-3.454471</td>
</tr>
<tr>
<td>D(LnGDP_CHN)</td>
<td>-10.40849</td>
<td>-4.050509</td>
<td>-3.454471</td>
</tr>
<tr>
<td>D(LnGDP_US)</td>
<td>-3.795243</td>
<td>-4.054393</td>
<td>-3.456319</td>
</tr>
</tbody>
</table>

Referring to the test result, ADF statistics of quarterly GDP, exchange rate and bilateral trade value are all greater than the critical value at the 5% significant level, which indicates non-stationary characteristics. However, when we take the first difference of each variable, they tend to be stable at the 5% significant level. In conclusion, they are all I (1) sequences, which is suitable for us to take the next step of cointegration test.
4.5 Cointegration test

Many multiple non-stationary time series can be correlated in certain time period, when they show an apparent linear relationship with same stochastic trend. Cointegration test can reveal such long-run equilibrium among I (1) time series.

According to basic theories, when we have two non-stationary time series $y_t$ and $x_t$, the common method is to test whether we can find $a$ and $b$ such that $u_t = y_t - \frac{a}{b}x_t$ is stationary. If so, we call $\frac{a}{b}$ the cointegrating coefficient and $(1, -\frac{a}{b})$ the cointegrating vector. In this paper, we try to test if there is any long run equilibrium among I (1) time series in our model.

$$
\ln EX_t = \alpha_0 + \alpha_1 \ln GDP_{CHN} + \alpha_2 \ln ER_{CHN} + \alpha_3 \ln ER_{CAN} \\
\ln IM_t = \beta_0 + \beta_1 \ln GDP_{US} + \beta_2 \ln ER_{CHN} + \beta_3 \ln ER_{CAN}
$$

To test if the variables are cointegrated, we first obtain the residuals named as ECM01 and ECM02 of the above regression model and carry out Philip-Perron test to see whether it is stationary. If the null hypotheses of non-stationary are rejected, then we conclude the above variables (export, GDP, exchange rate, etc.) are cointegrated in the long run. Here we do not use Engle and Granger ADF test is because the power of that unit root test is too small.

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>ECM01 /02 has a unit root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exogenous</td>
<td>Constant, linear trend</td>
</tr>
<tr>
<td>Phillip-Perron test stat.</td>
<td>ECM01 -5.140562 0.0003</td>
</tr>
<tr>
<td>Test critical value</td>
<td>1% level -4.052411</td>
</tr>
</tbody>
</table>

According to the unit root test, we find both residuals (ECM01 and ECM02) are stationary, rejecting the null hypothesis at 1% significance level. Therefore, it is confirmed the macro variables are cointegrated together in the long run. The meaning of the cointegrating vectors...
appeared in the cointegration test will be analyzed in the discussion part.

4.6 Model specification

Since the cointegration test in the previous section has detected long run equilibrium between bilateral trade flow, exchange rate and GDP. In this part, we try to explore more short-run dynamics by including more stationary factors obtained before such as exchange rate volatility and exchange rate misalignment.

The impact of exchange rate volatility and misalignment on U.S.-China bilateral trade flow is estimated under the context of two error correction model. And due to the time lag of international transaction, lagged terms are also included in the two models. The number of lagged terms is determined by the value of Akaike info criterion.

Export and import functions are constructed as follows:

\[
D(LnEX_t) = \alpha_0 + \alpha_1 D(LnGDP_{CHN,t}) + \alpha_2 Volt_{CHN,t} + \alpha_3 Volt_{CAN,t} + \alpha_4 Mis_t \\
+ \alpha_5 \sum_{k=1}^4 D(LnGDP_{CHN,t+k}) + \alpha_6 \sum_{k=1}^2 D(LnEX_{t+k}) + \alpha_7 ECM01_{t-1} + \epsilon_{1,t}
\]

\[
D(LnIM_t) = \beta_0 + \beta_1 D(LnGDP_{US,t}) + \beta_2 Volt_{CHN,t} + \beta_3 Volt_{CAN,t} + \beta_4 Mis_t \\
+ \beta_5 \sum_{k=1}^3 D(LnGDP_{US,t+k}) + \beta_6 \sum_{k=1}^2 D(LnIM_{t+k}) + \beta_7 ECM02_{t-1} + \epsilon_{2,t}
\]

Both Models are built from the U.S. perspective. The two dependent variables, \(IM_t\) and \(EX_t\), are the real value of U.S. bilateral imports from China and U.S. exports with China in the \(t\) time, respectively.

Several factors which have significant impact on the U.S.-China bilateral trade flow are chosen as the independent variables.

\(GDP_{US_t}\) is the real GDP of US at time \(t\) as the proxy of US income, while

\(GDP_{CHN_t}\) is the real GDP of China as the proxy of US income.

\(Volt_{CHN_t}\) is the proxy of exchange rate volatility of RMB, while
\( \text{Volt}_C A N_t \) is the proxy of exchange rate volatility of Canadian Dollar.

\( \text{Mis}_t \) is the proxy of exchange rate misalignments of RMB.

And \( \epsilon \) is the error term.

4.7 Statement of hypotheses

\[
D(\text{LnEX}_t) = \alpha_0 + \alpha_1 D(\text{LnGDP}_C H N_t) + \alpha_2 \text{Volt}_C H N_t + \alpha_3 \text{Volt}_C A N_t + \alpha_4 \text{Mis}_t + \\
+ \alpha_5 \sum_{k=1}^{4} D(\text{LnGDP}_C H N_{t-k}) + \alpha_6 \sum_{k=1}^{2} D(\text{LnEX}_{t-k}) + \alpha_7 \text{ECM01}_{t-1} + \epsilon_{1,t}
\]

According to the empirical studies, we hypothesize that the signs of major coefficients in export model are:

\( \alpha_1 > 0 \): It is expected that increase of partner country’s income (\( \text{GDP}_C H N_t \)) corresponds to increase of the country’s export. The major reason is residents have higher purchasing power with increasing income will consume more.

\( \alpha_2 < 0 \): High exchange rate volatility of RMB means more riskiness in international trade. Therefore, it will lead to less export goods.

\( \alpha_3 < 0 \): If a third country exchange rate demonstrates high volatility, U.S. manufacturers will choose to export to China rather than Canada in our model due to lower risk.

\( \alpha_4 < 0 \): Higher value of exchange rate misalignment means U.S. dollar is overvalued or RMB is undervalued more. It makes the price of US products relatively expensive compared to Chinese good, leads to less export.
As for the import model,

\[ D(\text{LnIM})_t = \beta_0 + \beta_1 D(\text{LnGDP-US})_t + \beta_2 \text{Volt_CHN}_t + \beta_3 \text{Volt_CAN}_t + \beta_4 \text{Mis}_t \]

\[ + \beta_5 \sum_{k=1}^{3} D(\text{LnGDP-US}_{t-k}) + \beta_6 \sum_{k=1}^{2} D(\text{LnIM}_{t-k}) + \beta_7 \text{ECM02}_t + \epsilon_{2,t} \]

Some of the coefficients are opposed to the export one with the same logic, showing as follow:

\( \beta_1 > 0, \beta_2 < 0, \beta_3 > 0, \beta_4 > 0. \)
5. Result and Analysis

5.1 Overall model evaluation

Diagnostic statistic

<table>
<thead>
<tr>
<th></th>
<th>Adjusted R-squared</th>
<th>F-Statistic</th>
<th>AIC</th>
<th>Durbin-Waston Stat</th>
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<tr>
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<td>0.660688</td>
<td>10.62077</td>
<td>-1.678363</td>
<td>2.112323</td>
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<td>Import</td>
<td>0.833664</td>
<td>30.57280</td>
<td>-2.594004</td>
<td>2.683056</td>
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</table>

We take first step to evaluate the overall effectiveness of two error correction models, and then further look at meanings of each variables.

After running the two error correction models, several key diagnostic statistics are chosen as criteria for evaluation. According to the table above, 66.07% variation of export value can be illustrated by the variation of independent variables, while 83.37% variation of import value can be explained in the import model. Moreover, both models have high F-statistic, rejecting the null hypothesis that the entire regression coefficients are equal to zero. It implies both models are significant. And the Durbin-Waston statistic of model is also relatively close to 2, which shows the residuals are almost random.

5.2 Coefficient explanation

Building error correction model is a useful approach to figure out both long-run and short-run effects of one series on another. Therefore, in this part, we firstly explain the long run equilibrium and then pay more attention to the short run dynamics which includes volatility and misalignment.

5.2.1 Long run equilibrium

The cointegrating vectors which show long run relationship between export/import and the exchange rate in our model are estimated by dynamic OLS proposed by Stock and Watson.
Estimates of the cointegrating vectors by dynamic OLS for the period from 1995Q1 to 2012Q4

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>LnGDP_CHN</th>
<th>LnER_CHN</th>
<th>LnER_CAN</th>
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<tbody>
<tr>
<td><strong>US export function</strong></td>
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<tr>
<td>Coefficient</td>
<td>-5.652203***</td>
<td>1.007998***</td>
<td>0.795199***</td>
<td>-0.792369***</td>
<td>0.020949</td>
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<tr>
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<td>0.063017</td>
<td>0.234723</td>
<td>0.263467</td>
<td>Prob&gt;0.2</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>LnGDP_US</th>
<th>LnER_CHN</th>
<th>LnER_CAN</th>
<th>Lc</th>
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</thead>
<tbody>
<tr>
<td><strong>US import function</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient</td>
<td>-102.0995***</td>
<td>4.687365***</td>
<td>1.260705***</td>
<td>-0.302734</td>
<td>0.029760</td>
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<tr>
<td>Standard error</td>
<td>7.268462</td>
<td>0.283159</td>
<td>0.214260</td>
<td>0.306686</td>
<td>Prob&gt;0.2</td>
</tr>
</tbody>
</table>

Note: The asterisks (***) and (**) means rejection of the null hypothesis of zero coefficient at 1% and 5% level. Lc is the Hansen parameter instability statistics with null hypothesis of series are cointegrated.

The cointegration test statistic (Lc) proposed by Hansen (1992) shows all series are cointegrated in the long run (Prob.>0.2).

Most of cointegrating vectors are significant at 5% significance level. The reported estimators show country’s GDP increase has positive effect on bilateral trade. One percent increase in US GDP turn to increase U.S. import by 4.68% while 1% increase of China GDP will raises U.S. export by 1.01%. The income elasticity shows that U.S. import is more sensitive to income changes and price changes than U.S. export.

The depreciation of RMB which reflected by the increase of value of LnER_CHN has positive impact on both export and import. It is out of our expectation from the US export function side, which hypothesized that RMB depreciation will hinder U.S. export rather than boost it. One of the explanations to justify the positive sign is the presence of global production. In the past 30 years, products are not solely manufactured by one firms rather than sourcing inputs from other countries at cheaper price and then assemble into final goods. In this environment, the depreciation of Chinese Yuan can lower the price of intermediate good’s price, and U.S.’s final export good become more competitive in the world market. Therefore, Chinese exchange rate depreciation may have a positive impact on U.S. export flow. This also gives us some insight of U.S.- China bilateral
trade pattern. Intermediate product in bilateral trade such as fertilizers, chemical materials, oils and other metals accounted for around 45% of total bilateral trade flow.

In case of the magnitude of exchange rate’s impact, test predicts that 1% decrease in RMB will raises more import value (1.26%) than that of export (0.795%).

As for the third country effect, the depreciation of other country’s currency value exerts negative effect on China-U.S. bilateral trade flow which confirms with our hypothesis. For example, by sharing similar geographical and cultural background with U.S., Canada behaves as a competing country for U.S. in exporting goods to China. If the price of Canadian good decrease, China will export more from Canada rather than U.S.. It finally leads to the decrease of U.S.- China bilateral trade.

In the error correction model, the coefficient of ECM01 (-0.183009) and ECM02 (-0.196005) tells us how export or import value return to equilibrium after a deviation has occurred, that is, the speed of adjustment to deviation. If there is a shock to increase export at the time t-1, than the export value will decrease gradually at the next period by 0.183 to restore the equilibrium and vice versa.

5.2.2 Short run dynamics

In addition to explore the cointegration relationship among non-stationary macroeconomic data, we also aim to find the short run impact of exchange rate volatility and misalignment in the error correction model. The estimated values of error correction model are presented in the appendix III and appendix IV.

We run the CUSUM (cumulative sum) and CUSUM-square tests to test for stability of coefficient in error correction model proposed by Brown et al (1975). The result in appendix V demonstrates the coefficients of both models are consistent since the line is well located within the 5% confidence bands.

(1) The role of exchange rate volatility on trade flow

As can be seen from the table in appendix III of export model, volatility of exchange rate between China and U.S. has insignificant impact on both export and import models.

As for trade impact on export, the result reveals 1% increase in Chinese exchange rate volatility
will lead to 4.01% decrease in real U.S. export. This result aligns with most of empirical studies on this topic. In the context of high volatile exchange rate, exporters or importers are reluctant to participant in international trade transaction because the uncertainty about future exchange rate will affect profitability.

In case of import model, the estimator is different from our expectation but not robust. Exchange rate volatility tends to increase U.S. import value from China. This can be justified in two ways: firstly, positive sign implies that Chinese exporters are very risk averse. They tend to export more in the high volatile environment in order to compensate for the loss. Secondly, the estimator is susceptible to present the short-run impacts of volatility on imports. Some studies address similar situation by concluding that short run effect do not seem to follow a specific pattern.

As for the real exchange rate volatility of Canada, the model reveals that their short run movements have insignificant impact on trade flow between U.S. and China. And their direction of impact is not determined. The increase volatility of third country exchange rate may have positive or negative effect on two country’s’ bilateral trade.

(2) The role of exchange rate misalignment on trade flow

Referring to the literature, misalignment has little impact on bilateral trade in the long run but may have effect in the short run. The empirical results show expected signs of misalignment in both models, especially in import models. It is hypothesized that overvalue (increase of value of $Mis$) of U.S. dollar will reduce U.S. real export value while undervalue (decrease of $Mis$ value) can drive U.S. export up.

In export model, 1% overvalue of U.S. dollar will decrease its export by 0.383%. Overvalue of U.S. dollar makes the U.S. goods relative expensive in the exporting market. Therefore, it leads to the decrease of U.S. export to China.

In case of import model, 1% undervalue of RMB will raise U.S. Import by 1.56%, which is significant at 1% significance level. This result also aligns with natural logic: decrease price of importable goods in bilateral trade will boost import value to some extent.

By comparing the misalignment effect between export and import model, it can be found that misalignment exerts deeper effect on import side. It may be one of the evidence why U.S.
authorities always propose Chinese government to appreciation of RMB in order to reduce trade deficit.

(3) The role of GDP in the short run

It is easy to understand higher income will lead to higher trade value between two countries. It is reasonable to see when China’s GDP rises, the U.S. export value become larger in the bilateral trade. The coefficient is statistically significant at 1% level. It indicates that 1% increase in China’s GDP can contribute to 1.10% increase in U.S. export value in the short run.

Meanwhile, in the import model, the impact of U.S. income is also robust at 1% significance level. 1% increase in U.S. GDP will raise U.S. import by 2.24%. By comparing the magnitude of the two coefficients, it can found that U.S. has higher income elasticity of demand than China.

In brief, GDP is the most important explanatory variables to trade flow in the short run with relatively large magnitudes and significances.

(4) Significance of Lagged terms

A lagged variable in an OLS regression model is often used as a means of capturing dynamic effect of a process. As for the lagged terms of GDP and trade value, both positive and negative impacts are mingled in one variable. This may be a reflection of real dynamics in the short run or it reveals the paper does not fully capture the short run specific impacts of variables. Some literatures such as S.Baak (2008) also reports similar results.

For example, the export value in the time t-1 increase by 1%, the current export will decrease by 0.294% in order to adjust an appropriate level. On the other hand, inclusion of some lagged terms also helps to remove serial correlation in the regression model which makes the whole model more sensible.
6. Conclusion

In this paper, we examine the impact of exchange rate on U.S.-China bilateral trade for the period of 1995Q1 to 2012Q4. The analysis is done under the context of a very large body of existing literatures and empirical studies.

Unit root and cointegration test are applied to test the long run relationship among variables. And we also analyze the impact of exchange volatility and misalignment by error correction model in the short run. The result demonstrates that trade impact of exchange rate volatility is only slightly. However, the study finds that undervaluation of Chinese exchange rate will boost U.S. import in the short run.

The empirical result shows:

(1) In the long run, real export and import value enjoy significant positive relationship between income of China and U.S. 1% increase in U.S. GDP will raise 4.68% U.S. import. Meanwhile, 1% raise in China’s GDP will drive up 1.01% of U.S. export. Therefore, the import demand of U.S. is more sensitive to income growth and consumption driven.

(2) In the long run, Chinese exchange rate exerts unexpected positive impact on both U.S. export and import. 1% depreciation of RMB will increase 0.79% of U.S. export and 1.26% U.S. import as well. The positive sign in export model can be justified by special trading pattern between the U.S. and China, which indicates that U.S. imports cheaper intermediate goods and export more final goods with lower price. What’s more, the study finds that imports are more sensitive to export to changes in exchange rate levels, which implies depreciation of RMB may exacerbate U.S.-China trade deficit.

(3) In the short run, Chinese exchange rate volatility has negative impact on U.S. export, but not significant. Third country effect on exchange rate volatility is not robust in either the import or the export side. Since the exchange rate hedging mechanism is available, the risk of exchange rate volatility has been reduced in the international trade.

(4) In the short run, currency misalignment tends to have significant effect in U.S. import model. 1% undervalue of RMB will contribute to 1.56% increase in import value. One reason for this may be
the U.S. importable goods are more homogeneous, when the price of importable goods changes compared to other country, U.S. importer will have strong response toward it.

From the whole paper analysis, some instrumental variables such as country’s income are leading factors which are strongly correlated to fluctuation of bilateral trade flow. Exchange rate volatility and misalignment only have smaller impact on it. The findings in this paper confirms some of the analysis that bilateral trade flow is not a solely question of exchange rate but need to take more factors into consideration. For example, U.S.-China trade deficit is not fully result from exchange rate manipulation but caused by some specific factors such as relative price, trade barriers, and features of bilateral trade pattern, etc. Both explicit factors and implicit ones remain in the bilateral trade issue.

Moreover, this study reveals a little bit of the general picture of U.S.-China trade patterns such as price elasticity, income elasticity, etc. As for China’s export, it need to seek more add-value services rather than intermediated goods during the production chain since other Asia countries shows more and more competitiveness in the cost reduction. And to face with U.S.’s economic downturn these year, China needs to give more incentives for the internal consumption which driven by internal demand.

An understanding to what degree the exchange rate will affect bilateral China-U.S. trade helps to achieve an optimal exchange rate policy in the future.
7. Limitations

7.1 Interpolations of incomplete data set

One of the limitation in our econometric analysis relate to incomplete China data. The quarterly CPI data set is not provided in IFS. And China’s GDP data is only available after 1999 which denominated in Yuan. We interpolate CPI and GDP data by ourselves, which may affect the quality of findings to some extent.

Since empirical results are also influenced by the measure of volatility and misalignment, our selection of measurement is restricted by relatively small quantity of observations (72 observations) and current capability of technical analysis.

7.2 Omission of other related factor

It is worthwhile to note that this methodology does not fully include or test all the related factors which also influence bilateral trade.

Trade is also driven by country’s integration degree in the world trade market such as market openness, degree of diversification of export goods, and the value added exports, etc. (Evenett, 2010) Our model only attempt to show the relationship between exchange rate and bilateral trade flow.

7.3 Endogeneity effect

Model specification in our model contains a potential problem. The causality between exchange rate and trade is not clear-cut theoretically. Exchange rate affect bilateral trade, trade can also impact exchange rate as a feedback effect. Therefore, the partial equilibrium model is misspecified to some extent.

According to theories, exchange rate is endogenous variables that results from macroeconomic policy, financial and trade determinants, etc. But from the perspective of small firms, currency level and movement becomes exogenous. Therefore, when we run this model, an assumption is needed to be hold: exchange rate volatility and misalignment is exogenous.
In order to tackle the endogeneity effect in empirical studies, sectorial analysis is taken into consideration as a potential approach to eliminate aggregation biases. Bahmani-Oskooee and Hegerty (2008) examined U.S. Japan bilateral trade using disaggregate data from 117 Japanese industries and found that some industries are influenced by currency volatility in the short run. Further researches which focus on sectorial data are needed to be carried out.

7.4 Special characteristic in China-U.S. bilateral trade

In this paper, we do not take special characteristics of China-U.S. special characteristics into consideration. China shows distinctive trade pattern in the world market, characterized as “the World Factory” since 1990s. Most of Chinese export goods are low value-added products, which used the imported raw material or semi-manufactured products, then assembled in China and final exported to other country including U.S. .

Some studies argue that the Chinese trade surplus is exaggerated because the structural issues of Chinese manufacturing industry and global production networks (Xing & Detert, 2010). One of the reasons is that traditional measuring approach of U.S.-China bilateral trade data calculates all of the value of export goods rather than the value-added into the trade surplus. In consequence, Chinese trade surplus with US was overvalued as for the structural factors, especially for the high-tech products category such as iPhone.

To eliminate this illusion, some studies take different approaches to revalue trade balance of China. Shagil Ahmed (2009) classify Chinese export products into two categories: processed export, whose raw materials mainly import from abroad and assembled in China and export final product; and non-processed export, which produced using components from domestic input.

This classification helps to eliminate the structural overvaluation caused by the China assembling issue. This study indicated that an appreciation of real exchange rate has a positive but insignificant on processing export, while it has a significantly negative effect on the non-processing exports.
Bibliography


23. Xing, Yuqing; Detert, Neal (2010). How the iphone widens the United States trade deficit with the People's Republic of China, ADBI working paper series, No. 257


Appendix I: Measurement of Misalignment

Regression results for Model (1):

\[ \ln ER_t = \beta_0 + \beta_1 \ln GDP\_CHN_t + T + \varepsilon_t \]

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>P-value</th>
</tr>
</thead>
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<td>( \ln GDP_CHN_t )</td>
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<td>( T )</td>
<td>0.006354</td>
<td>9.153522</td>
<td>0.000000</td>
</tr>
</tbody>
</table>

Adj.R\(^2\) 0.600995 D-W statistics 0.746918 No. of obs 72

Regression results for Model (2):

\[ \ln ER_t = \beta_0 + \beta_1 \ln GDP\_CHN_{t-1} + \beta_2 \ln GDP\_CHN_{t-2} + \beta_3 \ln GDP\_CHN_{t-3} + \beta_4 \ln GDP\_CHN_{t-4} + \alpha_1 \ln ER\_CHN_{t-1} + \alpha_1 \ln ER\_CHN_{t-2} + \varepsilon_t \]

<table>
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Adj.R\(^2\) 0.909416 D-W statistics 2.002127 No. of obs 72
Breush-Godfrey Serial Correlation LM Test
F-Stat 15.30957 Prob.(2,63) 0.00000
### Appendix II: Cointegration Test

#### Export:

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#### Import:

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Appendix III: Error Correction Model by using Mis as Measure of Misalignment

Export:

\[ D(LnEX_t) = \alpha_0 + \alpha_1 D(LnGDP_{CHN,t}) + \alpha_2 Volt_{CHN,t} + \alpha_3 Volt_{CAN,t} + \alpha_4 Mis_t + \sum_{k=1}^{4} D(LnGDP_{CHN,t-k}) + \alpha_6 \sum_{k=1}^{2} D(LnEX_{t-k}) + \alpha_7 ECM01_{t-1} + \epsilon_{1,t} \]

<table>
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<td>0.969815</td>
<td>0.3360</td>
</tr>
<tr>
<td>( D(LnGDP_{CHN}) )</td>
<td>1.099717</td>
<td>4.447404</td>
<td>0.0000***</td>
</tr>
<tr>
<td>( Volt_{CHN,t} )</td>
<td>0.767536</td>
<td>0.496594</td>
<td>0.6213</td>
</tr>
<tr>
<td>( Volt_{CAN,t} )</td>
<td>-4.008948</td>
<td>-0.760214</td>
<td>0.4501</td>
</tr>
<tr>
<td>( Mis_t )</td>
<td>-0.383347</td>
<td>-0.473619</td>
<td>0.6375</td>
</tr>
<tr>
<td>( D(LnGDP_{CHN,t-1}) )</td>
<td>0.102313</td>
<td>0.462917</td>
<td>0.6451</td>
</tr>
<tr>
<td>( D(LnGDP_{CHN,t-2}) )</td>
<td>0.157859</td>
<td>0.741262</td>
<td>0.4614</td>
</tr>
<tr>
<td>( D(LnGDP_{CHN,t-3}) )</td>
<td>-0.038050</td>
<td>-0.182737</td>
<td>0.8556</td>
</tr>
<tr>
<td>( D(LnGDP_{CHN,t-4}) )</td>
<td>-0.632429</td>
<td>-3.168807</td>
<td>0.0024***</td>
</tr>
<tr>
<td>( D(LnEX_{t-1}) )</td>
<td>-0.293522</td>
<td>-2.620272</td>
<td>0.0111**</td>
</tr>
<tr>
<td>( D(LnEX_{t-2}) )</td>
<td>-0.307382</td>
<td>-2.963602</td>
<td>0.0044***</td>
</tr>
<tr>
<td>( ECM01_{t-1} )</td>
<td>-0.183009</td>
<td>-2.207092</td>
<td>0.0311**</td>
</tr>
</tbody>
</table>

Adj.\( R^2 \) 0.598481  D-W statistics 2.112323  No. of obs 72

Note: *, **, and *** denote the significance at 10, 5 and 1 percent level, respectively.
Import:

\[ D(LnIM) = \beta_0 + \beta_1 D(LnGDP_US)_t + \beta_2 Volt_{CHN_t} + \beta_3 Volt_{CAN_t} + \beta_4 Mist_t \]

\[ + \beta_5 \sum_{k=1}^{3} D(LnGDP_{US_{t-k}}) + \beta_6 \sum_{k=1}^{2} D(LnIM_{t-k}) + \beta_7 ECM02_{t-1} + \epsilon_{2_t} \]

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.057402</td>
<td>3.409624</td>
<td>0.0012***</td>
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<tr>
<td>( D(LnGDP_{US_t}) )</td>
<td>2.235420</td>
<td>2.937090</td>
<td>0.0047***</td>
</tr>
<tr>
<td>Volt_{CHN_t}</td>
<td>3.634188</td>
<td>1.056815</td>
<td>0.2948</td>
</tr>
<tr>
<td>Volt_{CAN_t}</td>
<td>-0.531340</td>
<td>-0.562919</td>
<td>0.5756</td>
</tr>
<tr>
<td>Mist_t</td>
<td>1.560137</td>
<td>3.172389</td>
<td>0.0024***</td>
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<tr>
<td>( D(LnGDP_{CHN_{t-1}}) )</td>
<td>-2.371158</td>
<td>-3.494791</td>
<td>0.0009***</td>
</tr>
<tr>
<td>( D(LnGDP_{CHN_{t-2}}) )</td>
<td>-0.289260</td>
<td>-0.389881</td>
<td>0.6980</td>
</tr>
<tr>
<td>( D(LnGDP_{CHN_{t-3}}) )</td>
<td>-1.790863</td>
<td>-2.471563</td>
<td>0.0163***</td>
</tr>
<tr>
<td>( D(LnIM_{t-1}) )</td>
<td>0.097288</td>
<td>1.433090</td>
<td>0.1569</td>
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<tr>
<td>( D(LnIM_{t-2}) )</td>
<td>-0.729494</td>
<td>-11.89348</td>
<td>0.0000***</td>
</tr>
<tr>
<td>ECM01_{t-1}</td>
<td>-0.196005</td>
<td>-2.808627</td>
<td>0.0067***</td>
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</table>

Adj.R² 0.806396  D-W statistics 2.683056  No. of obs 72

Note: *, **, and *** denote the significance at 10, 5 and 1 percent level, respectively.
Appendix IV: Error Correction Model by using $D(LnER\_CHN_t)$ to Measure Misalignment

Export

$$D(LnEX_t) = \alpha_0 + \alpha_1D(LnGDP\_CHN_t) + \alpha_2D(LnER\_CHN_t) + \alpha_3 Volt\_CHN_t + \alpha_4 Volt\_CAN_t + \alpha_5 \sum_{k=1}^{4} D(LnGDP\_CHN_{t-k}) + \alpha_6 \sum_{k=1}^{2} D(LnEX_{t-k}) + \alpha_7 ECM01_{t-1} + \varepsilon_{t, t}$$

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>0.025770</td>
<td>0.894575</td>
<td>0.3746</td>
</tr>
<tr>
<td>$D(LnGDP_CHN_t)$</td>
<td>1.088608</td>
<td>4.339397</td>
<td>0.0001***</td>
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<tr>
<td>$D(LnER_CHN_t)$</td>
<td>-0.198992</td>
<td>-0.255786</td>
<td>0.7990</td>
</tr>
<tr>
<td>Volt_CHN_t</td>
<td>-3.518573</td>
<td>-0.656545</td>
<td>0.5140</td>
</tr>
<tr>
<td>Volt_CAN_t</td>
<td>0.822851</td>
<td>0.529984</td>
<td>0.5981</td>
</tr>
<tr>
<td>$D(LnGDP_CHN_{t-1})$</td>
<td>0.111238</td>
<td>0.497184</td>
<td>0.6209</td>
</tr>
<tr>
<td>$D(LnGDP_CHN_{t-2})$</td>
<td>0.151008</td>
<td>0.685367</td>
<td>0.4958</td>
</tr>
<tr>
<td>$D(LnGDP_CHN_{t-3})$</td>
<td>-0.056620</td>
<td>-0.276600</td>
<td>0.7830</td>
</tr>
<tr>
<td>$D(LnGDP_CHN_{t-4})$</td>
<td>-0.639970</td>
<td>-3.211114</td>
<td>0.0021***</td>
</tr>
<tr>
<td>$D(LnEX_{t-1})$</td>
<td>-0.303502</td>
<td>-2.757211</td>
<td>0.0077***</td>
</tr>
<tr>
<td>$D(LnEX_{t-2})$</td>
<td>-0.315560</td>
<td>-3.094694</td>
<td>0.0030***</td>
</tr>
<tr>
<td>ECM01_{t-1}</td>
<td>-0.167529</td>
<td>-2.217145</td>
<td>0.0304**</td>
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</table>

Adj. $R^2$ 0.597419  D-W statistics 2.116310  No. of obs 72

Note: *, **, and *** denote the significance at 10, 5 and 1 percent level, respectively.

Note: Here we use $D(LnER\_CHN_t)$ to measure exchange rate misalignment in two error correction models. It shows similar result to the model where we use variable $Mis$. By comparing major diagnostics statistics between the four models, we finally choose the Variable $Mis$ as the final explanatory variables. And the attempt of substitution partially confirms the collinearity between the above two variables.
Import:

$$D(LnIM_t) = \beta_0 + \beta_1 D(LnGDP_{US_t}) + \beta_2 D(LnER_{CHN_t}) + \beta_3 Volt_{CHN_t} + \beta_4 Volt_{CAN_t} + \beta_5 \sum_{k=1}^{3} D(LnGDP_{US_{t-k}}) + \beta_6 \sum_{k=1}^{2} D(LnIM_{t-k}) + \beta_7 ECM02_{t-1} + \epsilon_{2,t}$$

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>t-statistics</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D(LnGDP_{US_t})$</td>
<td>2.957029</td>
<td>3.116113</td>
<td>0.0028***</td>
</tr>
<tr>
<td>$D(LnER_{CHN_t})$</td>
<td>1.854828</td>
<td>2.820125</td>
<td>0.0065***</td>
</tr>
<tr>
<td>Volt$_{CHN_t}$</td>
<td>6.899247</td>
<td>1.598804</td>
<td>0.1150</td>
</tr>
<tr>
<td>Volt$_{CAN_t}$</td>
<td>-0.321186</td>
<td>-0.336416</td>
<td>0.7377</td>
</tr>
<tr>
<td>$D(LnGDP_{US_{t-1}})$</td>
<td>-2.092795</td>
<td>-2.947388</td>
<td>0.0045***</td>
</tr>
<tr>
<td>$D(LnGDP_{US_{t-2}})$</td>
<td>-0.064939</td>
<td>-0.087510</td>
<td>0.9306</td>
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<tr>
<td>$D(LnGDP_{US_{t-3}})$</td>
<td>-1.842779</td>
<td>-2.507558</td>
<td>0.0148**</td>
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<tr>
<td>$D(LnEX_{t-1})$</td>
<td>0.101942</td>
<td>1.468973</td>
<td>0.1470</td>
</tr>
<tr>
<td>$D(LnEX_{t-2})$</td>
<td>-0.672999</td>
<td>-9.420085</td>
<td>0.0000***</td>
</tr>
<tr>
<td>ECM01$_{t-1}$</td>
<td>-0.212503</td>
<td>-3.002010</td>
<td>0.0039***</td>
</tr>
</tbody>
</table>

Adj.R$^2$ 0.800469  D-W statistics 2.511123  No. of obs 72

Note: *, **, and *** denote the significance at 10, 5 and 1 percent level, respectively.
Appendix V: CUSUM and CUSUM-Square test for ECM models

Export Model

Import Model