The impact of exchange rate volatility on international trade between South Africa, China and USA: The case of the manufacturing sector

Muteba Mwamba, John and Dube, Sandile

University of Johannesburg, University of Johannesburg

25 April 2014

The impact of exchange rate volatility on international trade between South Africa, China and USA: The case of the manufacturing sector

John Muteba Mwamba[1], and Sandile, S Dube[2]
Department of Economics and econometrics
University of Johannesburg
Email: johnmu@uj.ac.za

[1] Corresponding author
[2] Master's student in financial economics

Abstract

The main objective of this paper is to examine the effect of exchange rate volatility on international trade. We show that the impact of exchange rate volatility on international trade could be either positive or negative depending on various reasons that are discussed in this study. We focus mainly on the manufacturing trade between the Republic of South Africa with the United States and China. Aggregated manufacturing industry data and disaggregated manufacturing data, disaggregated to the 4 digit level using the Harmonized System tariff 2009 is used to investigate the impact of exchange rate volatility on international trades. The finding of this paper represents a challenge for policy recommendations as it reflects the fact that various industries, sectors and subsectors of the economy of the Republic of South Africa are impacted differently by the volatility of the Rand/Yuan and Rand/Dollar exchange rates, respectively, therefore any policy that is drawn up to improve international trade needs to be done on an individual basis for each industry, sector and subsector respectively taking into account the various dynamics and characteristics of each.

Keywords: international trade, exchange rate, volatility

Introduction

Numerous studies suggest that exchange rate volatility hampers international trade or has a negative effect on international trade, such as Sekantsi, (2008); Onafowora and Owoye, (2008); Chit, (2008); Vergil, (2002); Arize et al, (2000); Arize and Malindretos, (2002); Klaasen, (2004) and Doganlar, (2002). The argument of those that say that in fact exchange rate volatility has no impact on international trade, such as Raddatz, (2008); Frankel, (2007); Arize and Malindretos, (2002); Arize et al, (2000); Klaasen, (2004) and Chowdhury, (1993). Aggregated manufacturing industry data and disaggregated manufacturing data, disaggregated to the 4 digit level using the Harmonized System tariff 2009, is used to investigate the impact of exchange rate volatility. The data is disaggregated because negative effects could possibly be offset by some positive effects elsewhere, this is known as the "aggregation bias" as stated by Bahmani-Oskooee and Hergerty (2007). This bias could possibly also have an impact at the country level where different industries respond differently to exchange rate volatility giving misleading results when taken at the country's aggregate level. Wang and Barret (2007) note the possible reasons for this bias might be the level of competition across sectors, the nature of contracting and thus the price setting mechanism, the currency of contracting, the use of hedging instruments, the economic scale of production units, openness to international trade and the degree of homogeneity and storability of goods vary among sectors. McKenzie (1998) who compiled a survey of theoretical and empirical studies on the impact of exchange rate volatility on international trade flows deduces some general findings from the empirical studies. First whether nominal or real exchange rates are modelled does not seem to influence the result and secondly it seems that disaggregated sectoral data yield more reliable outcomes than aggregated or bilateral trade data. For this reason, the section level data is employed in hope of minimising bias and where it can also be shown whether a bias does in fact exist at the aggregate level. Only the four major sections in terms of export/import in manufacturing will be used in the disaggregated data. The four sections that will be used are, namely: 3510 (Basic Iron and Steel); 3520 (Basic Precious and Non-ferrous metals; 3810 (Motor Vehicles) and 3569 (Other general purpose machinery). Previous studies such as Klein (1990), Stokman (1995), McKenzie (1998) and Doyle (2001) also used sectoral disaggregation in their studies. However these studies present some major drawbacks in that the disaggregation level is very low (generally SITC 1 digit) so that the same industry includes a large number of different products which could have the potential of distorting the results of the studies.

The data period used is from 1995-2011. The choice of the period stems from the fact the period 1983-1995 marks the period where South Africa used a dual exchange rate system which could bias the results[3]. South Africa used the commercial rand along with the financial

[3] With the abolition of the financial rand in 1995, all exchange controls on non-residents were eliminated. They are free to purchase shares, bonds, and other assets without restriction and to repatriate dividends, interest receipts, and current and capital profits, as well as the original investment capital. Foreign companies, governments and institutions may list on South Africa's bond and securities exchanges.
Since 1995, exchange controls on capital transaction by residents have also been relaxed.
The South African Reserve Bank (SARB) reserves the right to stagger capital outflows relating to large foreign direct investments so as to manage any potential impact on the foreign exchange market.

rand. The commercial rand was determined in a managed floating and applied to all current transactions. The financial rand applied to the local sale or redemption proceeds of South Africa securities and other investments in South Africa owned by non-residents, capital remittances by emigrants and immigrants, and approved outward capital transfers by residents. The financial rand was then discontinued in 1995[4].

Volatility

There is one school of thought in the field of financial economics that has put forward the notion that the volatility that is experienced by some countries is a direct result of the type of exchange rate regime that was adopted by that particular country, such as South Africa, after the collapse of the Bretton Woods 1973 regime. Sekantsi (2008) and Gudmundsson (2003) assert that a majority of developing countries, including South Africa, that have adopted flexible or floating exchange rate regimes have experienced a significant amount of volatility.

In the literature, theorists like Raddatz (2008); Arize and Malindretos (2002); Klaasen (2004); Cote (1994) and Chowdhury (1993) have used a variety of methods to measure volatility. The different measures of volatility that have been proposed and adopted in the literature range from, Absolute percentage changes (Bailey et al, 1986), Autoregressive lag models (Raddatz, (2008), exponential generalized autoregressive conditional heteroscedasticity (EGARCH) models (Aziakpono et al, (2005), to average of absolute changes, standard deviations and deviations from the trend. Herwartz (2003) notes that recent studies based on panel estimation techniques in general and the so-called gravity model in particular tend to empirically establish a negative relation between trade and exchange rate volatility (Rose, 2000; De Grauwe and Skudelny, 2000; Dell'Ariccia, 1998; Anderton and Skudelny, 2001).

With so many different methods used to measure the very same idea of volatility being proposed and implemented by theorist through the times, the questions that policy makers may be struggling with is which method of measuring volatility is correct.

Table1. Methods used and Results obtained

Author(s)	Volatility Method Used	Results Obtained
Sekantsi (2008)	GARCH model	Negative effect found
Raddatz (2008)	Gravity model	Insignificant effect found
Aziakpono *et al* (2005)	EGARCH model	Negative effect found
Arize et al (2000)	Moving-sample standard deviation	Significantly negative effect found
Arize and Malindretos (2002)	ARCH model	Positive and negative effect found
Egert et al (2003)	Dynamic Ordinary Least Squares and ARDL	Negative effect found

[4] Source: International Monetary Fund: International Financial Statistics, September 2007. http://unstats.un.org/unsd/servicetradekb/attachments/Southper cent20Africa-GUID12b163af59f84098ba35adf71d5039c0.pdf

Poon et al (2005)	12-period moving standard deviation	Negative and positive effect found
Sauer and Bohara (2001)	ARCH model	Negative effect found
Qian and Varangis (1994)	ARCH model	Negative and positive effect found
Peridy (2003)	GARCH model	Positive and negative effect found
Herwartz (2003)	GARCH model	Insignificant effect found
Appuhamilage and Alhayky (2010)	Fixed Effects model	Negative effect found
Cheong et al (2006)	VAR model	Negative effect found
Boug and Fagereng (2010)	GARCH model	Insignificant effects found

Table 1 exhibits the results that have been obtained from various theorists who have investigated the impact that exchange rate volatility has on international trade. The lack of consensus in these results does in part stem from the different models that were used to capture the volatility in the exchange rates and also due to what has been explained as aggregation bias.

Exchange Rate Volatility and Central Bank Intervention

Studies by Edison et al (2006); Connolly and Taylor (1994); Dominguez (1998); Cheung and Chinn (1999); Ramchander and Raymond (2002); Beine et al. (2007) suggest that central bank intervention tends to increase the conditional exchange rate volatility. Studies by Kim and Sheen (2002); Shah et al (2009) find that intervention by the central bank may stabilize exchange rate volatility. Fischer (2001) agrees as long as countries are not perceived to be defending a particular rate.

Shah et al (2009) go on to explain why intervention may have the effect of increasing exchange rate volatility in the market. The authors suggest that although intervention reduces volatility contemporaneously, persistent operations actually increase volatility due to market uncertainty. The observations made by Shah et al (2009) seem to suggest that it is not the intervention by central banks alone that increases exchange rate volatility. Rather the timing of the intervention and the policies used by the central banks to supplement the intervention is what increases volatility. Hoshikawa (2008) finds in his results that the difference between his results where exchange rate intervention is seen to stabilize the exchange rate by reducing exchange rate volatility and previous studies that found otherwise is caused by a difference in the frequency of the data.

Does Exchange Rate Volatility Hamper Trade?

Chowdhury (1993), Arize et al (2000), Klaasen (2004) and Egert et al (2003) allege that if the agents in the market are risk averse then exchange rate volatility is seen to reduce trade while Sercu and Vanhulle (1992) suggest that exchange rate volatility may have a positive effect on international trade as they found that there is an uncertain and positive influence of the exchange rate on the international trade as firms, on average, enters a market sooner and exit later when exchange rate volatility increases.

Some other effects of exchange rate volatility that other authors, such as Obstfeld and Rogoff (1998), mention are the welfare effects of increased volatility. Obstfeld and Rogoff (1998) highlighted that exchange rate volatility may be costly for welfare in two ways. The first and direct way is based on the assumption that people prefer a constant value of consumption to an uncertain value which fluctuates over time. The second and indirect channel, through which exchange rate volatility can result in welfare loss, is related to the risk resulting from the exchange rate variability. If firms are risk-averse, they will attempt to hedge against the risk of future exchange rate movements. These firms will put a risk premium as an extra mark-up to cover the costs of movements when setting prices for their goods. Such higher prices exert a negative effect on demand, production, and hence, consumption, taking them to levels which are less than optimal for society (Bergin, 2004).

The idea that agents export more when exchange rate risk or volatility is higher is a notion that many other economists agree with (Raddatz, (2008); Egert et al, 2003; Cote, 1994; Arize and Malindretos, 2002 and Chowdhury, 1993). The underlying principle in this argument is that agents/firms in the international markets may view their participation in the markets as an option they hold (Chowdhury, 1993). Broll and Eckwert (1999) also agree with this notion of considering exporting as an option and show that exchange rate volatility makes this option more profitable. This view is supported by Sercu and Vanhulle (1992) as they suggest that the capacity to export is tantamount to holding an option and that when exchange rate volatility increases, the value of that option also increases, just as it would be for any conventional option, and so encourages trade. Raddatz (2008) and Arize and Malindretos (2002) agree with Chowdhury (1993) in this instance as in their research they have shown that agents that are extremely risk averse in the international goods markets trade substantially when exchange rate volatility increases.

Hooper and Kolhagen (1978), however do not agree with this notion that increased risk aversion has the ability to increase trade. They suggest that an increase in risk aversion on the part of the importers induces them to reduce demand and as a result to decrease prices, whereas an increase in risk aversion on the part of exporters causes them to reduce export supply and charge a higher price. In both instances increased risk aversion reduces the volume of international trade. However unlike Kolhagen (1978), De Grauwe shows that increased risk aversion may possibly increase international trade.

Another common argument that is put forward is that exporters can easily ensure against short-run exchange rate fluctuations through financial markets, while it is much more difficult and expensive to hedge against long-term risk. Cho, Sheldon and McCorriston (2002), De Grauwe and de Bellefroid (1986), Obstfeld (1995), and Peree and Steinherr (1989) for example demonstrate that longer-run changes in exchange rates seem to have more significant impacts on trade volumes than do short-run rate fluctuations that can be hedge at low cost.

Developing countries may not have financial markets that are well developed for agents to utilize hedging strategies to mitigate the risk imposed by exchange rate volatility. Since the appropriate hedging instruments may not be available or the costs may be too burdensome on some agents in developing countries the risk inherent in increased exchange rate volatility may still pose a threat to their revenues, which may also then have an impact on international trade, which is the view held by Hooper and Kohlhagen (1978). This view is supported by Doroodian (1999), Krugman (1989), Mundell (2000) and Wei (1999) who argues that hedging is both imperfect and costly as a basis to avoid exchange rate risk, particularly in developing countries and for smaller firms more likely to face liquidity constraints. So where the financial markets are underdeveloped or appropriate financial instruments are unavailable, imperfect and/or costly increased volatility may in fact depress trade. This is not the case in South Africa though as the Johannesburg Stock Exchange (JSE) Limited is the 18th largest exchange in the world by market capitalisation, as of September 2005 with a market capitalisation of R3.3 trillion, and offers an active derivatives market. Market traders can make use of the currency derivatives, options and futures contract available on the JSE to hedge against exchange rate volatility.

Cote (1994); Gudmundsson (1993) and Egert et al (2003) agree that the level of development in the financial markets plays a critical role for agents in the international markets but then also suggest that the ability of an agent to mitigate the risk present in exchange rate volatility is determined by the size of the particular agent, which also may have a direct impact on whether exchange rate volatility will increase or depress trade flows.

Appuhamilage and Alhayky (2010), Akhtar and Hilton (1984) and Arize et al (2000) agree with what Cote (1994); Gudmundsson (1993) and Egert et al (2003) in that financial markets may only mitigate the risk posed by exchange rate volatility. These authors are of the opinion that for some developed countries; currency forward markets and futures markets can be used to reduce or hedge exchange rate risk (volatility), but that it has been demonstrated that forward markets fail to completely eliminate exchange rate risk. There has been further evidence in the literature (Raddatz, 2008; Arize et al, 2000 and Cote, 1994) that suggests that the effect of exchange rate volatility is seen as being ambiguous when industry and firm-specific characteristics are explored. Raddatz (2008) suggests that depending on the kind of industry and the size of the organization. The impact of exchange rate volatility can either be positive or negative. Peridy (2003) agrees with theses authors as he in his study he concluded that the impact of exchange rate volatility is misleading at an aggregated level since the impact greatly varies between industries and between destination markets. He notes further that the case of the EU is particularly interesting as some studies indicate a negative relationship such as Dell'Ariccia (1998) or Bini-Smaghi (1991) while many other studies provide mixed or insignificant results. Fountas and Aristotelous (1999) show that the impact is negative for Germany, Italy, UK but insignificant for France, similarly Abbot et al (2001) find an insignificant relationship whereas Sapir et al (1994) and Belke and Gros (2001) suggest limited negative effects.

This idea is also seen in the studies of Arize et al (2000) and Cote (1994) who allege that whether the agents that are participating in the international markets operate in a competitive or oligopolistic environment will have a direct impact on trade flows. The argument is that agents that operate in an oligopolistic environment have the market power to impose price discrimination in certain international markets and in effect pass through the costs of increased exchange rate volatility to their end markets, so in that way exchange rate volatility would not affect trade flows. This is however not the case in South Africa. South Africa represents 0.6 per cent of world production and therefore does not have the market power globally to pass through cost through the end consumers. It is mainly the smaller local customers that are subjected to this extra cost as the automotive and packaging industries together with export products are exempt[5].

Peridy (2003) also makes the observation that exchange rate variations may have a positive or negative effect on exports depending on the sign of the forward risk premium and/or the sign of the trade balance of a country and this idea stems from the result those exporters and importers are on opposite sides of the forward market.

The theory of international trade as stated by Klaasen (2004), Chowdhury (1993) and Cote (1994) also emphasize the reason that the ambiguity in the findings of different theorists persists, they explain this through the substitution and income effects of international trade. The theory as explained by Cote (1994) states "an increase in risk has both a substitution and an income effect, which work in opposite directions. It lowers the attractiveness of the risky activity, leading agents to reduce that activity (substitution effect). However, it also lowers the expected total utility of the activity, and to compensate for that drop, additional resources might be devoted to the activity (income effect)". De Grauwe (1988) and Webber (2001) find that income effect does in fact dominate the substitution effect. Belanger et al (1992) supports this claim as in their study they find that the substitution effect had an insignificant impact on international trade in the face of exchange rate volatility. Other studies that have also found the impact of exchange rate volatility on international trade as inconclusive include Hooper and Kolhagen (1978); Bailey et al (1987); Koray and Lastrapes (1989); Assery and Peel (1991); Chowdhury; Kroner and Lastrapes (1993); Holly (1995) and Arize et al (2000). As Peridy (2003) has observed that it seems clear that the relationship between exchange rate volatility and trade depends highly on the characteristics of a particular firm or market, the degree of a firm's risk aversion, the access to forward markets, the size and degree of market competition, the price strategy of the firm (pricing to markets, exchange rate pass-through) and profit opportunities as well as entry and exit costs

[5] www.whoownswhom.co.za, "Research report on Basic Iron and Steel Industries, except Steel Pipe and tube Mills. SIC code 35101. July 2010

(including sunk costs) are all crucial factors which determine the sign of the relationship. Therefore the impact of exchange rate volatility may vary greatly from one firm (thus one industry) to another and also from one market (country) to another.

II. Methodology

Exchange rate volatility is not directly observable. Given that volatility in exchange rates is generally characterized as the clustering of large shocks to conditional variance, a GARCH model is used to measure the volatility of the exchange rate. Since this type of model captures non-constant time varying conditional variance such as excess kurtosis and fat-tailedness (Cheong et al, 2006). Herwartz (2003) mentions that recently there has emerged some consensus that the GARCH model introduced by Engle (1982) and Bollerslev (1986) is suitable to capture stylized facts of log foreign exchange rate processes such as the martingale property, volatility clustering and leptokurtosis. The SVAR is used to investigate the impact of exchange rate volatility on international trade

GARCH

The GARCH (1,1) model is used to capture the volatility of the exchange rates as it does not suffer from the inefficiencies of the other models mentioned above and it also has the ability to capture persistent volatility. The GARCH process is specified as follows:

$$Y_t = \alpha + \beta' X_t + \mu_t \tag{1}$$

$\mu_t | \Omega_t \sim iid\, N(0, h_t)$

$$h_t = \gamma_0 + \sum_{i=1}^{p} \delta_i h_{t-i} + \sum_{j=1}^{q} \gamma_1 \mu_{t-j}^{2} \tag{2}$$

which says that the value of the variance scaling parameter h_t now depends both on past values of the shocks, which are captured by the lagged squared residual terms, and on past values of itself, which are captured by lagged h_t terms.

Tests of robustness are conducted to ensure the variables are not serially correlated and that there is no co-integration present amongst the variables. Co-integration exists between variables where the variables share a common stochastic drift or have an underlying long run relationship; if the variables are in fact co-integrated then results could be biased. To test whether the variables are serially correlated the Augmented Dicker-Fuller test is used on the results obtained and the Johansen approach is implemented if there is co-integration amongst the variables. If in testing the variables co-integration is indeed present then a second competitive model i.e. vector error correction model (VECM) will be used to correct for the long run relationship.

The VECM

A VECM model can be specified as follows, considering that the initial VAR model equation is defined as:

$$Y_t = A_1 y_{t-1} + \ldots . + A_p y_{t-p} + \mu_t \quad \textbf{(3)}$$

where the A_i's are $n \times n$ coefficient matrices and $u_t = (u_{1t}, u_{2t}, \ldots \mu_{nt})'$ is an unobservable i.i.d. zero mean error term. Y_t is a vector of time series variables.

The following vector error correction specifications which can be estimated are as follows:

$$\Delta y_t = \alpha\beta^{-1} y_{y-p} + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{p-1} y_{t-p+1} + \mu_t \quad \textbf{(4)}$$

more detail is given in (Pfaff, 2006).

With:

$\Gamma_i = -(I - A_1 - \ldots - A_i), \quad i = 1, \ldots, p-1.$

$\pi = \alpha\beta^{-1} = -(I - A_1 - \ldots - A_p)$

The Γ_i matrices contain the cumulative long-run impacts; hence the VECM specification is signified by "long-run" form.

Structured Vector Autoregressive Model

VAR models explain the endogenous variables solely by their own history, apart from deterministic regressors. In contrast, structural vector autoregressive models (SVAR) allow the explicit modelling of contemporaneous interdependence between the left-hand side variables. Stock and Watson (2001) have a similar view that although in data description and forecasting, VARs have proven to be powerful and reliable tools. Structural inference and policy analysis are, however, inherently more difficult because they require differentiating between correlation and causation; this is the "identification problem" in the jargon of econometrics. The problem cannot be solved by a purely statistical tool, even a powerful tool like a VAR. Rather, economic theory or institutional knowledge is required to solve the identification (causation versus correlation) problem. This observation made by these authors clearly sets out that the VAR model may not be sufficient as policy analysis is identified as one of the shortfalls of this model.

The model used to determine the impact of exchange rate volatility on international trade is the Structured Vector Autoregressive (SVAR) model. As stated by Lin (2006) Structural VAR embeds economic theory within time series models, providing a convenient and powerful framework for policy analysis. Stock and Watson (2001) agree with Lin (2006) in their paper also stating that the structural VAR uses economic theory to sort out the contemporaneous links between variables (Bernanke, 1986; Blanchard and Watson, 1986; Sims, 1986). Structural VARs require "identifying assumptions" that allow correlations to be interpreted easily. These identifying assumptions can involve the entire VAR, so that all the casual links in the model are spelled out, or just a single equation, so that only a specific causal link is identified. This model will also reveal interrelation relationships between our variables through the analysis of the Impulse Response Functions (IRF) which tracks the impact of any variable on others in the system.

Consider the simple model of simultaneous equations:

$$\begin{aligned} Y_{1t} &= \gamma_{10} - b_{12}Y_{2t} + \gamma_{11}Y_{1t-1} + \gamma_{12}Y_{2t-1} + \varepsilon_{1t} \\ Y_{2t} &= \gamma_{20} - b_{21}Y_{2t} + \gamma_{21}Y_{1t-1} + \gamma_{22}Y_{2t-1} + \varepsilon_{2t} \end{aligned} \quad \textbf{(5)}$$

Where:

$$\begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \sim i.i.d. \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{pmatrix} \right)$$

The sample consists of observations from $t = 1, \ldots, T$ with a fixed initial value $y_0 = (y_{10}, y_{20})$.The model in Equation (5) is called a Structural VAR (SVAR). It is derived by underlying economic theory. The exogenous error terms ε_{1t} and ε_{2t} are independent and are interpreted as structural innovations. Equation (5) can also be represented in matrix form:

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \gamma_{10} \\ \gamma_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad \textbf{(6)}$$

Impulse Response Function

An impulse response function stimulates the effects of a shock to one variable in the system on the conditional forecast of another variable. As discussed in Elder (2003) and Lin (2006) there are numerous interesting applications in which a researcher might be interested in calculating an impulse response function, for example, he considers a researcher interested in estimating the dynamic response of international trade to an exchange rate shock. An impulse response function for the usual homoskedastic VAR, which is extended to the SVAR, will estimate this effect, accommodating interaction between the conditional means of the variables in the system (such as trade, exchange rates, interest rates and income).

In order to derive an "impulse response function", it is necessary to be precise about what is meant by this term. Elder (2003) describes an impulse-response function as the revision in the conditional forecast of $y_{i,t+k}$ given a primitive impulse $\varepsilon_{i,t}$ denoted:

$$\frac{\partial\, E\left(y_{j,t+k}\,|\varepsilon_{i,t}\,,\Psi_{t-1}\right)}{\partial\, \varepsilon_{i,t}} \qquad \textbf{(7)}$$

Specifically what an impulse response function aims to achieve is to trace out the time path of effect of structural shocks on the dependent variables of the model.

III. Data and Empirical Results

Monthly data from January 1995 to June 2011 for total South African, China and United States imports and exports, respectively. The variables that will be used for exports, imports and the US Dollar-Rand (Rand/Yuan) exchange rate volatility are the returns (EX_t), (IM_t), (V_t) and the growth of South African GDP is used as the proxy for foreign income (GDP_t). A method of linear extrapolation[6] is used to convert the quarterly GDP data into a series of monthly data points, with no loss of consistency in the data, as the frequency is monthly.To investigate whether there is an interrelationship between exports and imports in international trade one model for exports and imports is used to analysis whether the profits that are made through export activities influence the imports through the possible increase in foreign income, which is measure by the GDP growth. All the variables in the model are treated as endogenous variables and therefore in our SVAR model there are no variables that are used as exogenous variables in the model. The lag lengths of the SVAR models are selected on the basis of the Akiake Information Criterion (AIC). The selected lag lengths are four months

[6]The method of linear extrapolation that was used is as follows. The values for the current and following quarter were subtracted from each other, divided by 3, the result of that calculation were then added to the value of the current quarter to get the values of the month preceding that quarter. In other words: (March values – June values)/3 = Difference (D); then March values + D = April "values"; April "values" + D = May "values". This process was then continued for all the other months that were missing values in the study.

for both the exports and imports. To investigate the impact exchange rate volatility on the trade returns, we apply the orthogonalized impulse response functions based on the Cholesky decomposition of the covariance matrix of the residuals in the SVARs.

Firstly the results of the GARCH (1,1) model that was used to capture the volatility of the two exchange rates, namely the Rand/dollar and the Rand/Yuan exchange rates, will be presented. This will be followed by the results of the unit root estimations, using the Augmented Dicker-Fuller (ADF)method, of each of the variables to determine whether the variables are all stationary in order to be used in the SVAR model. The results of the unit root estimations will then be followed by the presentation of the SVAR model which will illustrate how the different variables that were used in this study interact and most importantly present what the impact of exchange rate volatility (GARCH series) is on the international trade variables. With each output of the SVAR model the results of the Johansen co-integration test will be presented in order to illustrate that the variables presented in that output are not co-integrated. Should a co-integrating equation be found to exist amongst the variables then the VECM model will be applied to those variables and that output interpreted accordingly. Lastly the results that will be presented will be the impacts and behaviour of certain variables when shocks into other variables in the model are introduced, such as the behaviour of the GDP of the Republic of South Africa when a shock to the Rand/Yuan exchange rate is introduced. These will be illustrated through the impulse response function graphs that will be presented and these observations will have major implications in terms of the policy recommendations that will be presented in the conclusion of this min paper.

Table 2: GARCH (1,1) of the Rand/Dollar

Variable	Coefficient	Std. Error	z-Statistic	Prob.
				Variance Equation
C	0.000640	7.29E-05	8.785481	0.0000
RESID(-1)^2	0.893251	0.126732	7.048357	0.0000
GARCH(-1)	-0.018672	0.021182	-0.881538	0.3780
R-squared	-0.007614		Mean dependent var	0.003295
Adjusted R-squared	-0.002525		S.D. dependent var	0.037852
S.E. of regression	0.037900		Akaike info criterion	-3.843637
Sum squared resid	0.284412		Schwarz criterion	-3.793815
Log likelihood	383.5201		Hannan-Quinn criter	-3.823471
Durbin-Watson stat	1.322379			

Table 2 shows that the GARCH (1,1) series above is a good approximation of the actual exchange rate volatility displayed by the Rand/Dollar exchange rate. The condition that $\alpha+\beta < 1$ has been met in the regression above as $0.893251 + (-0.018672) < 1$. This means that our GARCH series estimated above converges. This is also depicted by Figure 1 of the residuals of our GARCH estimation as the actual and fitted series show a similar pattern of volatility.

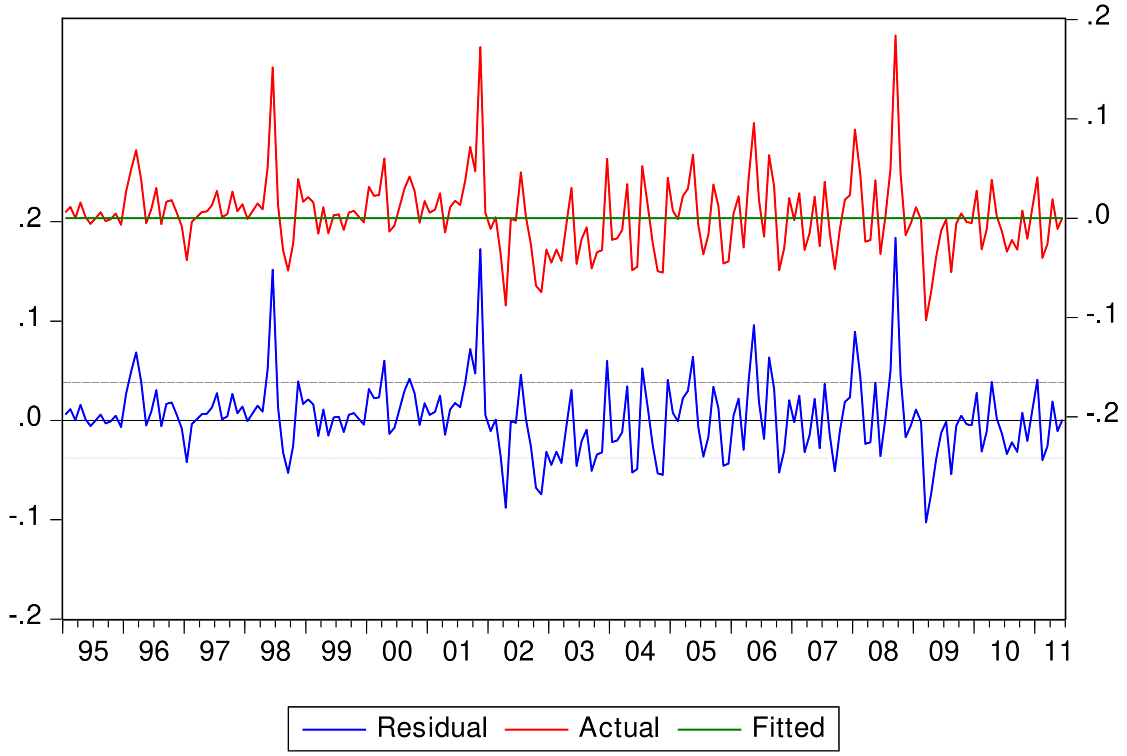

Figure 1. Residuals and actual Rand/Dollar exchange rate GARCH (1,1) estimation.

Table 3: GARCH (1,1) of the Rand/Yuan

Variable	Coefficient	Std. Error	z-Statistic	Prob.
		Variance Equation		
C	0.000647	7.46E-05	8.670560	0.0000
RESID(-1)^2	0.873570	0.124362	7.024417	0.0000
GARCH(-1)	-0.019693	0.021512	-0.915449	0.3600
R-squared	-0.015086		Mean dependent var	0.004648
Adjusted R-squared	-0.009959		S.D. dependent var	0.037936
S.E. of regression	0.038124		Akaike info criterion	-3.846377
Sum squared resid	0.287785		Schwarz criterion	-3.796554
Log likelihood	383.7913		Hannan-Quinn criter	-3.826210
Durbin-Watson stat	1.301663			

Table 3 exhibits that the GARCH (1,1) series above is a good approximation of the actual exchange rate volatility displayed by the Rand/Yuan exchange rate. The condition that $\alpha + \beta < 1$, as the GARCH estimation presented earlier, has been met in the regression above as $0.873570 + (-0.019693) < 1$. This means that our GARCH series estimated above converges. This graph of this estimation has not been presented below as it shows a similar result as that of the Rand/Dollar graph seen above, which is that the actual and fitted series show a similar pattern of volatility.

The two results of the exchange rate volatilities displayed above suggest that the GARCH (1,1) is a good approximation of the volatility series of both our exchange rates and as such the GARCH series are used in the SVAR model to investigate what the impact of the volatilities of the Rand/Dollar and the Rand/Yuan exchange rates respectively is on the international trade variables stated earlier. The GARCH (1,1) estimation of the Rand/Dollar exchange rate that will be used in the SVAR model estimations below is named "GARCHRD" while the GARCH (1,1) estimations of the Rand/Yuan exchange rate that will be used is named "GARCHRY". This convention is followed for all the SVAR estimations presented below.

All of the variables under scrutiny in this study are found to be stationary as illustrated by Table 5 in the Appendix. Table 4 summarizes the impacts of the volatility of the Rand/Yuan and the Rand/Dollar exchange rates respectively as noted above. What is most notable is that the impact of the volatility of the respective exchange rates affects subsectors differently. In some instances, the same subsectors in different countries are affected differently. This goes to suggest that the impact of the volatility of exchange rates cannot be suggested to have the same impact on each industry, sector or subsector. The impact is neither consistently positive nor negative in any one country which is involved in international trade with the Republic of South Africa, hence the impact of the volatility of the exchange rates is determined to be indeterminate.

Table 4. Summary of the output results of the VECM regressions.

Variable	Results Obtained	Significance Level 5% * 10% **
China Total Manufacturing Exports	Insignificant impact	*
China Total Manufacturing Imports	Insignificant impact	*
China Basic Iron and Steel Exports	Insignificant impact	*
China Basic Iron and Steel Imports	Insignificant impact	*
China Basic Precious & Non-ferrous Metal Exports	Insignificant impact	*
China Basic Precious & Non-ferrous Metal Imports	Insignificant impact	*
China Motor Vehicle Exports	Insignificant impact	*
China Motor Vehicle Imports	Insignificant impact	*
China Other Manufacturing Exports	Insignificant impact	*
China Other Manufacturing Imports	Insignificant impact	*

United States Total Manufacturing Exports	Insignificant impact	*
United States Total Manufacturing Imports	Insignificant impact	*
United States Basic Iron and Steel Exports	**Positive impact**	*
United States Basic Iron and Steel Imports	Insignificant impact	*
United States Basic Precious & Non-ferrous Metal Exports	**Positive impact**	*
United States Basic Precious & Non-ferrous Metal Imports	Insignificant impact	*
United States Motor Vehicle Exports	Insignificant impact	*
United States Motor Vehicle Imports	Insignificant impact	*
United States Other Manufacturing Exports	Insignificant impact	*
United States Other Manufacturing Imports	Insignificant impact	*

Traditionally, the most important means of analysing an estimated structural VAR has been through the impulse responses of the system (Hall, 1995). The impulse response function represents the dynamic response of a particular variable in the system to a shock ("error") in one of the structural form equations. A few examples of significant shocks for the international trade between the Republic of South Africa, China and the United States are represented by Figure 2 and their implications are also explained. We begin by illustrating the impulse responses of the Total Manufacturing Exports from China to the Republic of South Africa to various shocks and then proceed to illustrate the impulse responses for the Total Manufacturing Exports from the United States to the Republic of South Africa.

The third graph in the first row depicted below shows the responses of China's Total Manufacturing Exports to a shock in the Rand/Yuan exchange rate. As can be seen the shock to the Rand/Yuan exchange does not seem to have any observable effects to the international trade in the Chinese exports in the manufacturing industry on the whole, as it can be seen that the graph above does not show any significant movements. Despite the volatility that was observed to be present in the Rand/Yuan exchange rate, which was depicted in a graph previously, a shock to this exchange rate does not seem to alter the Total Manufacturing Exports to the Republic of South Africa in any way. This result is in line with what was observed through the VECM estimations as the GARCHRY variable was seen to be insignificant in explaining the movements in the Total Manufacturing exports from China to the Republic of South Africa.

The first graph in the fourth row depicted below shows the responses of the Republic of South Africa's GDP to a shock in the Total Manufacturing Exports coming from China. These shocks could be any industry occurrences in China that result in disruptions in the manufacturing industry and causes some effects on the volumes that China is able to export to the Republic of South Africa. The graph below shows that a shock to the Total Manufacturing Exports coming from China cause the GDP of the Republic of South Africa to experience a slight increase in the first two periods of the shock and then converges to its long-run equilibrium value in the fourth period. In other words a shock to the total Manufacturing Exports from China causes an increase in the GDP of the Republic of South Africa in the first two months, lasting until the fourth month where the GDP of the Republic of South Africa converges to its long-run equilibrium value.

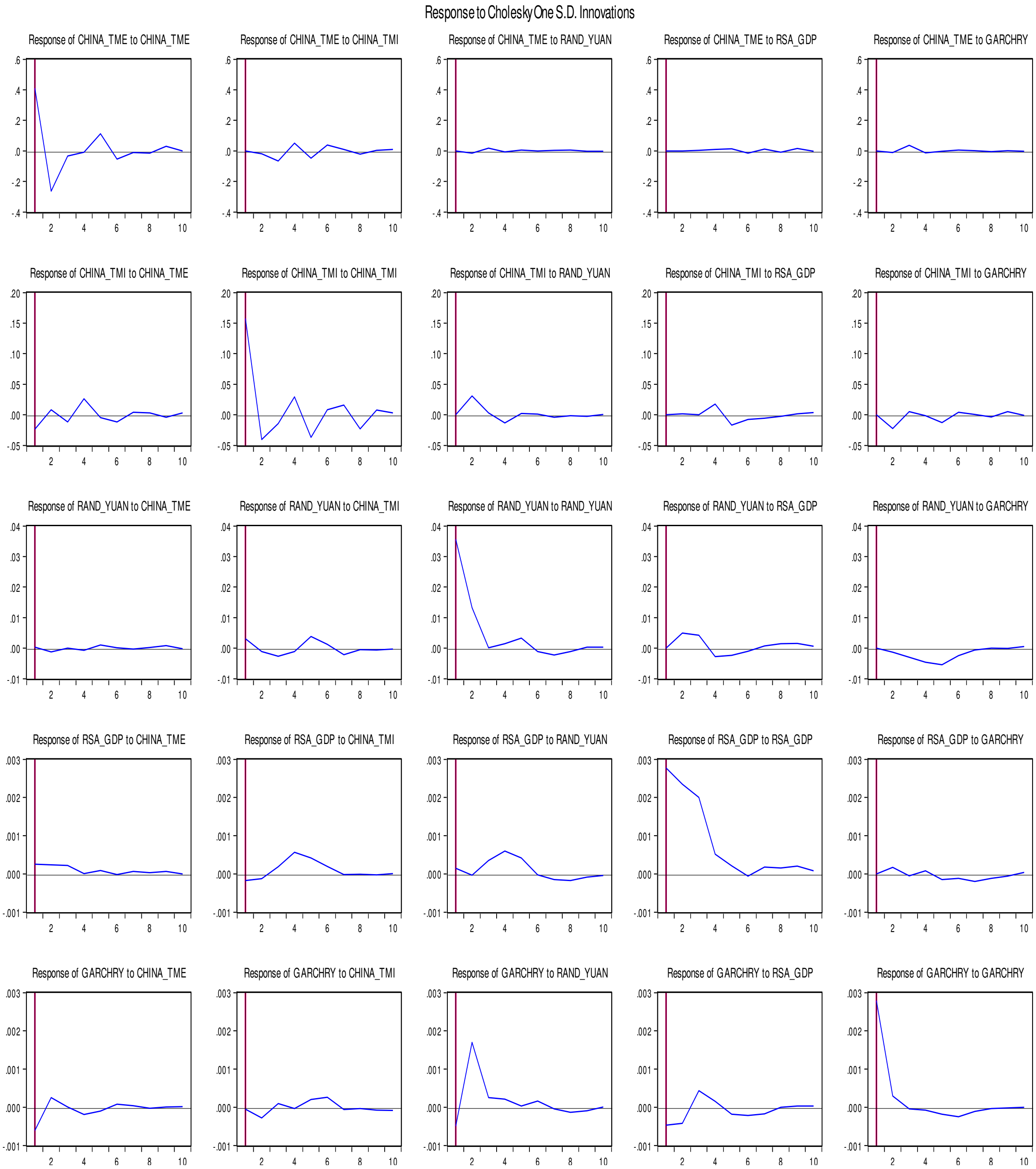

Figure 2: Impulse responses of China's Total Manufacturing Exports.

Figure 3 illustrates the Total Manufacturing exports from the United States to the Republic of South Africa we find that in the third graph in the first row depicted below, which shows the responses of the United States' Total Manufacturing Exports to a shock in the Rand/Dollar exchange rate, it can be seen that a shock to the Rand/Dollar exchange does not seem to have any significant effects to the international trade of the United States exports in the manufacturing industry for the first four months after the shock is experienced. There does seem to be a slight increase in the Total Manufacturing exports of the United States in the fifth month after the shock but this declines thereafter and converges to its long run equilibrium, after becoming slightly negative. This result does coincide with the result that was observed through the VECM estimations as the GARCHRD variable was seen to be insignificant in explaining the movements in the Total Manufacturing exports from the United Statesto the Republic of South Africa and the impulse responses show that only a slight impact is observed in the fifth month after the shock experienced.

The first graph in the fifth row depicted below shows the responses of the Republic of South Africa's GDP to a shock in the Total Manufacturing Exports coming from the United States. As mentioned above in the Chinese case,these shocks could be any industry occurrences in the United States that result in disruptions in the manufacturing industry and cause some effects on the volumes that theUnited States is able to export to the Republic of South Africa. The graph below shows that a shock to the Total Manufacturing Exports coming from the United States causes the GDP of the Republic of South Africa to experience a significant increase in the first eight periods of the shock and then only converges to its long-run equilibrium value after the eighth period. In other words a shock to the total Manufacturing Exports from United States causes a significant boost tothe GDP of the Republic of South Africa for a significant period of time, which may reflect that competition in the manufacturing industry between the two nations is high, such that a shock in the United States industry results in a significant increase in the GDP of the Republic of South Africa which lasts for eight months before it converges to its long-run equilibrium value.

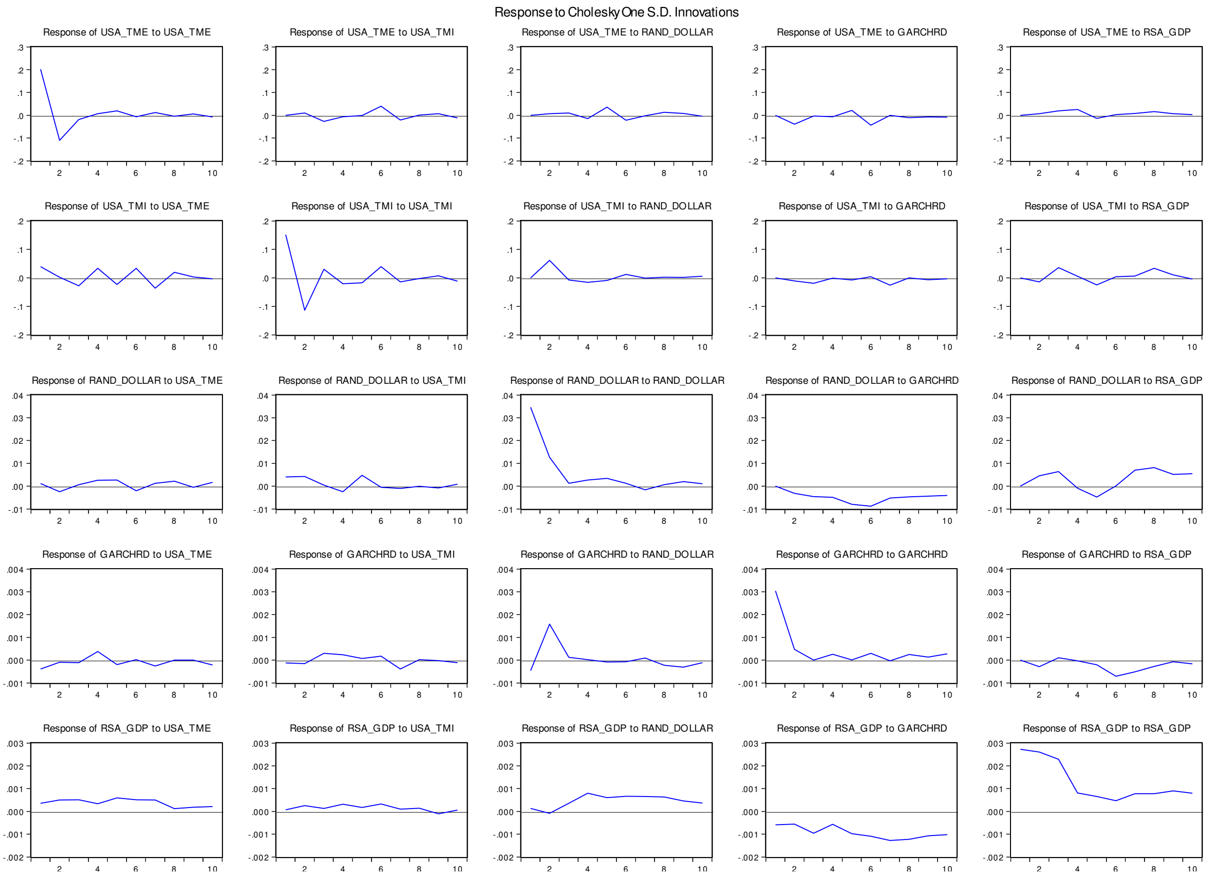

Figure 3: Impulse responses of the United States' Total Manufacturing Exports

IV. Conclusion

The aim of this study was to determine the impact of the exchange rate volatility of the Rand/Yuan and Rand/Dollar exchange rates, respectively, on the international trade in the manufacturing industry between the Republic of South Africa, China and the United States. For this purpose the SVAR model, VECM model and its impulse response function were carried out. The finding of this mini paper is that the impact of exchange rate volatility on the various countries' total manufacturing industry trade and the four subsectors that were investigated in this mini paper is insignificant, apart from the two subsectors were a positive impact was found. These two subsectors both beingin the United States VECM model estimations, the Basic Iron and Steel exports and the Basic Precious and Non-ferrous metals exports.

What has been discovered in this mini paper, through using the VECM model, is that any policy that the South African government decides to implement in the manufacturing industry of South Africa may not have the intended consequences of enhancing the international trade in the manufacturing industry as a whole or in the specific sector or subsector that the government is targeting. Therefore any policy that aims to enhance the international trade of the manufacturing industry between the Republic of South Africa, China and the United States by targeting the volatility of either the Rand/Yuan or the Rand/Dollar exchange rates may not produce the desired results in the sectors either than the two subsectors just mentioned. This fact is further substantiated by the results depicted in the impulse response function graphs for both the United States and for China. In the Chinese case it was observed that any shock that could be introduced in the Rand/Yuan exchange rate would have no observable impact in the Total Manufacturing Exports of China. In the case of the United States it was observed that any shock that could be introduced to the Rand/Dollar exchange rate would have no significant impact on the Total Manufacturing Exports of the United States until the fourth month after the shock was experienced, the impact would still only result in a slight increase in the Total Manufacturing exports of the United States which would converge towards their long run equilibrium level in one period.

This study investigated the impact of exchange rate volatility on international trade using data from January 1995 to June 2011. In the model estimation the data was not investigated for the possible impact that the 2007/8 financial crisis may have had on the trade variables, gross domestic products (GDP) and exchange rates of the countries used in this study. A further possible extension to this study could be to look what the impact of the 2007/8 financial crisis was on the variables previous mentioned through an event study or using structural breaks that look at the variables pre and post the financial crisis, then the variables could then be used in the specified model that would be used to investigate the impact of exchange rate volatility on international trade.

References

Abbot, A. A.D, and L. Evans (2001) The influence of exchange rate variability on UK exports, *Applied Economics Letters*, 8, 47-49.

Akhtar, M.A. and Spence-Hilton (1984) Effects of exchange rate uncertainty on German and US trade, *Federal Reserve Bank of New York Quarterly Review*, 9, 7-16.

Anderton, R., and R Skudelny (2001) Exchange rate volatility and Euro area imports, European Central Bank Working Paper Series No. 64, Frankfurt/Main.

Appuhamilage, K.S.A and Alhayky, A.A.A (2010) Exchange rate movements' effect on Sri Lanka-China trade, *Journal of Chinese Economic and Foreign Trade Studies*, 3, 254-267.

Arize, A.C., T. Osang and D.J. Slottje (2000) Exchange rate volatility and foreign trade: Evidence from thirteen LDCs, *Journal of Business and Economic statistics*, 18, 10-17.

Assery, A. and D.A. Peel (1991) The effects of exchange rate volatility on exports, *Economics Letters*, 37, 173–177.

Aziakpono, M., Tsheole, T. and Takaendasa, P. (2005), Real exchange rate and its effect on trade flows: New evidence from South Africa. [Online]. Available: http:/www.essa.org.za/download/2005Conference/Takaendesa.pdf.

Bailey, M.J., Tavlas, G.S. and Ulan, M. (1986) Exchange rate variability and trade performance: Evidence for the big seven industrial countries. *Weltwirtschaftliches Archiv*, 122, 466-77.

Bailey, M.J., Tavlas, G.S. and Ulan, M. (1987) The impact of exchange rate variability on export growth: Some theoretical considerations and empirical results, *Journal of Policy Modelling*, 9, 225–243.

Beine, M., Lahaye, J., Laurent, S., Neely, C.J. and Palm, F.C. (2007) Central bank intervention and exchange rate volatility, its continuous and jump components, *International Journal of Finance and Economics*, 12, 201-23.

Belanger, D., Guitierrez, S. and Raynauld, J. (1992) Exchange rate variability and trade flows: preliminary sectoral estimates for the US-Canada case", *Ecole des Haules Etudes Commerciales: Cahiers de Recherche,* 89.

Belke, A., and D. Gros (2001). Real Impacts of Intra- European Exchange Rate Variability: A Case for EMU? *Open Economies Review*, 12 , 231-264.

Bergin, P. (2004) Measuring the costs of exchange rate volatility," *Federal Reserve Bank of San Francisco Economic Letter* 22, 1–3.

Bernanke, B.S. (1986) Alternative explorations of the money-income correlation, *Carnegie-Rochester Conference Series on Public Policy*. 25, 49 – 99.

Bini-Smaghi, L. (1991) Exchange rate variability and trade: Why is it so difficult to find any empirical relationship? *Applied Economics*, 23, 927- 935.

Blanchard, O.J., and Watson M.W. (1986) Are business cycles all alike?, *The American Business Cycle*. R.J. Gordon, editor. Chicago: University of Chicago Press.

Boug, P., and Fagereng, A. (2010) Exchange rate volatility and export performance: a cointegrated VAR approach, *Applied Economics*, 42, 851-864.

Broll, U., and B. Eckwert (1999) Exchange rate volatility and international trade. *Southern Economic Journal*, 66, 178-185.

Cheong, C., Mehari, T. and Williams, L.V. (2006) Dynamic links between unexpected exchange rate variation, prices, and international trade, *Open Economics Review*, 17, 221-233.

Cheung, Y.W. and Chinn, M. (1999) Macroeconomic implications of the beliefs and behaviour of foreign exchange traders, Unpublished Paper, University of California, Santa Cruz.

Chit, M.M (2008) Exchange rate volatility and exports: evidence from the ASEAN-China Free Trade Area”, *Journal of Chinese Economic and Business Studies*, 6, 261-277.

Cho, G., I. M. Sheldon, and S. McCorriston (2002), "Exchange Rate Uncertainty and Agricultural Trade." *American Journal of Agricultural Economics,* Vol. 84, No.4. pp.931-942.

Chowdhury, A. R. (1993) Does exchange rate volatility depress trade flows? Evidence from Error- Correction models, *The Review of Economics and Statistics*, 75, 700-706.

Connolly, R. and Taylor, W. (1994) Volume and intervention effects of Yen/Dollar exchange rate volatility, 1977-1979, *Advances in Financial Planning and Forecasting*, 5, 181-200.

Cote, A. (1994). Exchange Rate Volatility and Trade: A Survey. Working paper No. 94-5 International Department Bank of Canada.

De Grauwe, P. (1988) Exchange rate variability and the slowdown in the growth of International Trade, *IMF Staff Papers 35*, 63–84.

De Grauwe, P., and B. de Bellefroid (1986) Long-Run Exchange Rate Variability and International Trade. In Real-Financial Linkages Among Open Economies, eds., S. Arndt and J. D. Richardson. Cambridge, MA: MIT Press.

De Grauwe, P., and F. Skudelny (2000) The impact of EMU on trade flows, *Weltwirtschaftliches Archiv*, 136, 381-402.

Dell'Ariccia, G. (1998) Exchange rate fluctuations and trade flows: Evidence from the European Union. IMF Working Paper No. 107. Washington, D.C.

Doganlar, M. (2002) Estimating the impact of exchange rate volatility on exports: evidence from Asian countries, *Applied Economics Letters*, 9, 859-63.

Dominguez, K. M. (1998) Central bank intervention and exchange rate volatility, *Journal of International Money and Finance*, 17, 161-190.

Doroodian, K. (1999) Does exchange rate volatility deter international trade in developing countries? , *Journal of Asian Economics*, 10, 465-474

Edison, H., Cashin, P. and Liang, H. (2006) Foreign exchange intervention and the Austrilian dollar: Has it mattered?, *International Journal of Finance and Economics*, 11, 155-171.

Elder, J. (2003) An Impulse-Response Function for a vector autoregression with multivariate GARCH-in-Mean, *Forthcoming Economics Letters*, 79, 1-10.

Fischer, S. (2001), “Exchange Rate Regimes: Is the Bipolar View Correct?” *Journal of Economic Perspectives*, Vol. 15, No.2, pp. 3-24.

Fountas, S., and K. Aristotelous (1999) Has the European Monetary System led to more exports? Evidence from four European Union Countries. *Economics Letters*, 62, 357-363.

Frankel, J. (2007). On the Rand: Determinantsn of the South African exchange rate. National Bureau of Economic Research,Working paper No. 13050.

Hall, S. (1995). Macroeconomics and a bit more reality, *Economic Journal*, 105, 974 – 88.

Herwartz, H. (2003) On the (Nonlinear) relationship between exchange rate uncertainty and trade – An invesigation of US trade figures in the Group of Seven, *Review of World Economic*, 139, 650-682.

Holly, S. (1995) Exchange rate uncertainty and export performance: supply and demand effects, *Scottish Journal of Political Economy*, 42, 381–391.

Hooper, P. and Kohlhagen S.W. (1978) The effect of exchange rate uncertainty on the prices and volume of international trade, *Journal of International Economics*, 8, 483-511.

Hoshikawa, T. (2008) Does foreign exchange intervention reduces the exchange rate volatility?, *Applied Financial Economics Letters*, 4, 221-224.

Industrial Policy Action Plan 2010/11 – 2012/13 (February, 2010) Economic Sectors and Employment Cluster, pp 1-95.

Kim, S.J. and Sheen, J. (2002) The determinants of central bank intervention by central banks: evidence from Austrilia, *Journal of International Money and Finance*, 21, 619-649.

Klaasen, F. (2004) Why is it so difficult to find an effect of exchange rate risk on trade?, *Journal of International Money and Finance.* 23 , 817–839.

Klein, M. W. (1990) Sectoral effects of exchange rate volatility on United States exports. *Journal of International Money and Finance*, 9, 299-308.

Koray, F. and Lastrapes, W. D. (1989) Real exchange rate volatility and U.S. bilateral trade: A VAR approach, *Review of economics and Statistics*, 71, 708–712.

Kroner, K.F. and Lastrapes, W.D. (1993) The impact of exchange rate volatility on international trade: Reduced form estimates from a GARCH-in-mean model, *Journal of International Money and Finance*, 12, 298–318.

Krugman, P. (1989) Exchange Rate Instability, The Lionel Robbins Lectures. Cambridge, MA: The MIT Press.

Lin, JL. (2006) Teaching notes on impulse response functions and structural VAR, Institute of Economics, Academia Sinica, Department of Economics, National Chengchi University, 1-9.

Malindretos, A.A. (1998) The long-run and short-run effects of exchange-rate volatility on exports: The case of Australia and New Zealand, *Journal of Econornics and Finance*, 22, 43-56.

McKenzie, M. D. (1999) The impact of exchange rate volatility on international trade flows. *Journal of Economic Surveys*, 13, 71-106.

Mundell, R. A. (2000) Currency areas, exchange rate systems, and international monetary reform, *Journal of Applied Economics*, 3, 217-256.

Obstfeld, M. (1995) International currency experience: New lessons and lessons relearned, *Brookings Papers on Economic Activity,* 1, 119-196.

Obstfeld, M. and Rogoff, K.S. (1998) Risk and exchange rates, NBER working paper No. 6694.

Onafowora, A.O and Owoye, O. (2008) Exchange rate volatility and export growth in Nigeria, *Journal of Applied Economics*, 40, 1547-1556.

Peridy, N. (2003) Exchange rate volatility, Sectoral trade, and the Aggregation bias, *Review of World Economics/Welwirtschaftliches Archiv*, 139, 389-418.

Pfaff, B. (2006) Analysis of integrated and cointegrated time series with R, *Springer-Verlag, New York*. URL http://CRAN.R-project.org/package=urca.

Poon, W.C., Choong, C.K. and Habibubullah, M.S. (2005) Exchange rate volatility and exports for selected East Asian countries: evidence from error correction model, ASEAN *Econometric Bulletin*, 22, 144-59.

Qian, Y. and Varangis, P. (1994) Does exchange rate volatility hinder export growth? Additional Evidence, *Journal Empirical Economics*, 19, 371-96.

Raddatz, C. (2008) Exchange rate volatility and trade in South Africa. The World Bank . Working Paper No. 1-44.

Ramchander, S. and Raymond, S. R. (2002) The impact of Federal Reserve intervention on exchange rate volatility: evidence from the futures markets, *Applied Financial Economics*, 12, 231-40.

Research report on Basic Iron and Steel Industries, except Steel Pipe and tube Mills, SIC code: 35101, July (2010). [Online] Available: http://www.whoownswhom.co.za/?title=SA Sector&url=http://www.whoownswhom.co.za/sasector/majorsectors.php

Rose, A. K. (2000) One Money, One Market: The effect of common currencies on trade". *Economic Policy*, 15, 9-45.

Sauer, C. and Bohara, A.K. (2001) Exchange rate volatility and exports:regional differences between developing and industrialized countries, *Review of International Economics*, 9, 133-52

Sapir, A., K. Sekkat, and A. A. Weber (1994). The Impact of Exchange Rate Fluctuations on European Union Trade. CEPR Discussion Paper No 1041. London.

Sekantsi, L,. (2008); The impact of exchange rate volatility on South African exports to the United States (US): A bounds test approach, available at: http://www.eiit.org/WorkingPapers/Papers/TradePatterns/FREIT191.pdf

Sercu, P. and Vanhulle, C. (1992) Exchange rate volatility, exposure and the value of exporting firms, *Journal of Banking and Finance*, 16, 155-82.

Shah, M. K. A., Hyder, Z. and Pervaiz, M. K. (2009) Central bank intervention and exchange rate volatility in Pakistan: an analysis using GARCH-X model, *Applied Financial Economics*, 19, 1497-1508.

Sims, C.A. (1986) Are forecasting models usable for policy analysis?, *Federal Reserve Bank of Minneapolis Quarterly Review*. Winter, 2 – 16.

South African Reserve Bank, 2004. South African Reserve Bank Quarterly Bulletin, December: 28–9.

South African Reserve Bank, 2006. South African Reserve Bank Quarterly Bulletin, March: 32–3.

Stokman, A. (1995) Effects of exchange rate risk on Intra-EC trade", *De Economist*, 143, 41-54.

Vergil, H. (2002) Exchange rate volatility in Turkey and its effects on trade flows, *Journal of Economic and Social Research*, 4, 67-80.

Wang, K.L and Barrett, C.B. (2007) Estimating the effects of exchange rate volatility on export volumes, *Journal of Agricultural and Resources Economics*, 32, 225-255.

Webber, A.G. (2001) Exchange rate volatility and co-integration in tourism demand, *Journal of Travel research*, Vol. 39. [Online] Available at http://jtr.sagepub.com/content/39/4/398.

Appendix

VECM

Another specification is given as follows and commonly employed:

$$\Delta y_t \ \alpha\beta^{-1} y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ ... + \Gamma_{p-1} y_{t-p+1} + \mu_t \qquad \textbf{(8)}$$

With:

$\Gamma_i = -(A_{i+1} + \ldots + A_p) \quad i = 1, \ldots, p-1.$

The π matrix is the same as in the first specification. However, the Γ_i matrices now differ, in the sense that they measure the transitory effects. Therefore this specification is signified as "transitory" form. In case of cointegration, the matrix $\pi = \alpha\beta^{-1}$ is of reduced rank. The dimensions of α and β is $K \times r$ where r is the cointegration rank, i.e. how many long-run relationships between the variables y_t do exist. The matrix $\alpha$is the loading matrix and the coefficients of the long run relationships are contained in β (Pfaff, 2006).

SVAR

Example: let Y_{1t} denote the log of real GDP and Y_{2t} denote the log of nominal money supply. Then realizations of ε_{1t} are interpreted as capturing unexpected shocks to output that are uncorrelated with ε_{2t}, the unexpected shocks to the money supply.

In Equation (5), the endogeneity of Y_{1t} and Y_{2t} is determined by the values of b_{12} and b_{21}.

In matrix form, Equation (5) becomes:

$$\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \gamma_{10} \\ \gamma_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

Or

$$\mathbf{B}\mathbf{y}_t = \gamma_0 + \Gamma_1 y_{t-1} + \varepsilon_t \qquad \textbf{(3)}$$

$E(\varepsilon_t \varepsilon_t')$, where D is a diagonal matrix of elements $\sigma_1^2$and σ_2^2

The reduced form of the SVAR, a standard VAR model, is found by multiplying (9) by $\mathbf{B}^{-1}$, assuming it exists, and solving for Y_t in terms Y_{1t} and ε_t:

$$\begin{aligned}\mathbf{y}_t &= \mathbf{B}^{-1}\gamma_0 + \mathbf{B}^{-1}\Gamma_1\mathbf{y}_{t-1} + \mathbf{B}^{-1}\varepsilon_t \\ &= \mathbf{a_0} + \mathbf{A}_1\mathbf{y_{t-1}} + \mathbf{u_t}\end{aligned} \tag{4}$$

or:

$$\mathbf{A(L)y_t = a_0 + u_t}$$
$$\mathbf{A(L) = I_2 + A_1L}$$

$$\mathbf{B}^{-1} = \frac{1}{\Delta}\begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}$$
$$\Delta = \det \mathbf{B} = 1 - b_{12}b_{21}$$

we have:

$$\mathbf{a_0} = \mathbf{B}^{-1}\gamma = \frac{1}{\Delta}\begin{bmatrix} \gamma_{10} & -b_{12}\gamma_{20} \\ \gamma_{20} & -b_{21}\gamma_{10} \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix}$$

$$\mathbf{A_1} = \mathbf{B}^{-1}\Gamma_\mathbf{1} = \frac{1}{\Delta}\begin{bmatrix} \gamma_{11} - b_{12}\gamma_{21} & \gamma_{12} - b_{12}\gamma_{22} \\ \gamma_{21} - b_{21}\gamma_{11} & \gamma_{22} - b_{22}\gamma_{12} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

$$\mathbf{u_t} = \mathbf{B}^{-1}\varepsilon_t = \frac{1}{\Delta}\begin{bmatrix} \varepsilon_{1t} - b_{12}\varepsilon_{2t} \\ \varepsilon_{2t} - b_{21}\varepsilon_{1t} \end{bmatrix} = \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}$$

The reduced form errors u_t linear combinations of the structural errors ε_t and have the covariance matrix $E(u_t u_t') = \mathbf{B}^{-1}E(\varepsilon_t\varepsilon_t')\mathbf{B}^{-1} = \mathbf{B}^{-1}\mathbf{D}\mathbf{B}^{-1} = \mathbf{\Omega} = \begin{bmatrix} \omega_1^2 & \omega_{12} \\ \omega_{12} & \omega_2^2 \end{bmatrix} = \frac{1}{\Delta^2}\begin{bmatrix} \sigma_1^2 + b_{12}^2\sigma_2^2 & -(b_{21}\sigma_1^2 + b_{12}\sigma_2^2 \\ (b_{21}\sigma_1^2 + b_{12}\sigma_2^2 & \sigma_2^2 + b_{21}^2\sigma_1^2 \end{bmatrix}$

That is diagonal only if $b_{12} = b_{21} = 0$.

Impulse Response Function

For this to be achieved we first transform the representation of the model. Rewrite the SVAR more compactly:

$$X_t = A_o + A_1X_{t-1} + e_t \Rightarrow X_t = \frac{A_o}{I - A_1L} + \frac{e_t}{I - A_1L} \tag{5}$$

First, consider the first component on the RHS:

$$\frac{A_0}{I-A_1} = (I-A_1)^{-1}A_0 = \frac{(I-A_1)^a A_0}{|I-A_1|} = \frac{\begin{bmatrix} 1-a_{11} & -a_{12} \\ -a_{21} & 1-a_{22} \end{bmatrix} A_0}{\begin{vmatrix} 1-a_{11} & -a_{12} \\ -a_{21} & 1-a_{22} \end{vmatrix}} = \frac{\begin{bmatrix} 1-a_{11} & -a_{12} \\ -a_{21} & 1-a_{22} \end{bmatrix}\begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix}}{(1-a_{11})(1-a_{22})-a_{21}a_{12}} \qquad \textbf{(6)}$$

$$= \frac{1}{\Delta}\begin{bmatrix} (1-a_{22})a_{10} + a_{21}a_{20} \\ a_{12}a_{10} + (1-a_{22})a_{20} \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} \qquad \textbf{(7)}$$

Stability requires that the roots of $I - A_1 L$ lie outside the unit circle. We will assume that it is the case. Then, we can write the second component as:

$$\frac{e_t}{I - A_1 L} = \sum_{i=0}^{\infty} A_1^i e_{t-1} = \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} e_{1,t-i} \\ e_{2,t-i} \end{bmatrix} \qquad \textbf{(8)}$$

We can thus write the model with the standard VAR's error terms.

$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \underbrace{\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i}_{A^i} \begin{bmatrix} e_{1,t-i} \\ e_{2,t-i} \end{bmatrix} \qquad \textbf{(9)}$$

But these are composite errors consisting of the structural innovations. We must thus replace e with ε:

$$e_t = \frac{1}{|I - A_1 L|} \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \varepsilon_t \qquad \textbf{(10)}$$

Impact multipliers trace the impact effect of a one unit change in a structural innovation. Therefore in other words if we needed to find the impact effect of $\varepsilon_{z,t}$ on y_t and z_t these are the impact multipliers that we would use:

$$\frac{dy_t}{d\varepsilon_{z,t}} = \phi_{12}(0) \qquad \frac{dz_t}{d\varepsilon_{z,t}} = \phi_{22}(0)$$

Lets trace the effect one period ahead on y_{t+1} and z_{t+1}

$$\frac{dy_{t+1}}{d\varepsilon_{z,t}} = \phi_{12}(1) \qquad \frac{dz_{t+1}}{d\varepsilon_{z,t}} = \phi_{22}(1)$$

Note that this is the same effect on y_t and z_t of a structural innovation one period ago:

$$\frac{dy_t}{d\varepsilon_{z,t-1}} = \phi_{12}(1) \qquad \frac{dz_t}{d\varepsilon_{z,t-1}} = \phi_{22}(1)$$

Impulse response functions are the plots of the effect of $\varepsilon_{z,t}$ on current and all future y and z. IRS shows how y_t or z_t react to different shocks. In practice we cannot calculate these effects since the SVAR is underidentified. So we must impose additional restrictions on the VAR to identify the impulse responses.

If we use the Choleski decomposition and assume that y does not have a contemporaneous effect on z, then $b_{12} = 0$. Thus the error structure becomes lower triangular:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = \begin{bmatrix} 1 & -b_{12} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}$$

The ε_y shock doesn't affect z directly but it affects it indirectly through its lagged effect in VAR. (Enders, Chapter 5).

Stationarity

The results of the unit roots tests using the ADF method are presented for each of the variables used in the SVAR are presented in Table 5. The results of the test will be presented in a table below. For a variable to be considered stationary it has to be stationary at all three levels, i.e. firstly at "intercept", "trend and intercept" and finally at "none" using the Eviews 7 software package. What will also be shown is that the coefficient of Y(-1) in the ADF test should also be negative for the test to be robust. The null hypopaper for the ADF test is that "variables are not stationary, i.e. that the variables has a unit root, therefore if the P-value is less than 5 per cent (0.05), we reject the null hypopaper which means that the variable is stationary and should the P-value be greater than 0.05 we cannot reject the null hypopaper and this would mean that the variable has a unit root and is non-stationary.

Table 4. Output results of the Unit Root test, using the Augmented Dicker-Fuller method.

	China_TME		
	Intercept	**Trend & Intercept**	**None**
ADF test statistic	-14.28778	-14.25285	-14.16586
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-2.363480	-2.363607	-2.338707
	China_TMI		
	Intercept	**Trend & Intercept**	**None**
ADF test statistics	-3.275129	-3.580955	-2.058303
Prob. (P-value)	0.0175	0.0342	0.0383
Coefficient Y(-1)	-1.948889	-2.256115	-0.680344
	China_BISE		
	Intercept	**Trend & Intercept**	**None**

ADF test statistics	-15.23202	-15.20401	-15.22060
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.757508	-1.759852	-1.750749

China_BISI

	Intercept	Trend & Intercept	None
ADF test statistics	-12.49140	-12.45621	-15.09671
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-2.128636	-2.128192	-1.813516

China_BPNE

	Intercept	Trend & Intercept	None
ADF test statistics	-12.66082	-12.68077	-12.68077
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-2.085054	-2.091896	-2.0810810

China_BPNI

	Intercept	Trend & Intercept	None
ADF test statistics	-16.26985	-14.87600	-16.29114
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.836241	-2.305197	-1.833957

China_MVE

	Intercept	Trend & Intercept	None
ADF test statistics	-18.41153	-18.39715	-18.40415
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.252293	-1.254877	-1.248874

China_MVI

	Intercept	Trend & Intercept	None
ADF test statistics	-7.238016	-7.253729	-6.658195
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-3.402019	-3.414512	-3.006834

China_OIE

	Intercept	Trend & Intercept	None
ADF test statistics	-18.83032	-18.79484	-18.87180
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.284057	-1.284426	-1.283576

China_OII

	Intercept	Trend & Intercept	None
ADF test statistics	-7.993203	-15.93600	-2.163956
Prob. (P-value)	0.00000	0.00000	0.0297
Coefficient Y(-1)	-5.917473	-7.877863	-1.292474

China_GDP

	Intercept	Trend & Intercept	None
ADF test statistics	-5.914902	-5.921171	-5.932022
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-3.137624	-3.160669	-3.137325

RSA_GDP

	Intercept	Trend & Intercept	None
ADF test statistics	-4.869675	-4.864896	-7.886604
Prob. (P-value)	0.0001	0.0005	0.00000
Coefficient Y(-1)	-0.321904	-0322538	-2.432278

USA_GDP

	Intercept	Trend & Intercept	None
ADF test statistics	-2.896151	-11.59041	-11.64771
Prob. (P-value)	0.0476	0.00000	0.00000
Coefficient Y(-1)	.0113544	-1.359138	-1.358703

USA_TME

	Intercept	Trend & Intercept	None
ADF test statistic	-12.54594	-12.60205	-12.33398
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-2.113730	-2.127482	-2.064835

USA_TMI

	Intercept	Trend & Intercept	None
ADF test statistics	-11.11699	-11.09458	-10.93714
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-2.499640	-2.501946	-2.441790

USA_BISE

	Intercept	Trend & Intercept	None
ADF test statistics	-15.79580	-15.75416	-15.82214
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.861920	-1.862015	-1.859792

USA_BISI

	Intercept	Trend & Intercept	None
ADF test statistics	-15.07193	-15.03748	-15.09598
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.908352	-1.909043	-1.906776

USA_BPNE

	Intercept	Trend & Intercept	None
ADF test statistics	-19.26952	-19.23790	-19.27795
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.312871	-1.313629	-1.310622

USA_BPNI

	Intercept	Trend & Intercept	None
ADF test statistics	-15.93378	-15.90313	-15.96832
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.833052	-1.834414	-1.832149

USA_MVE

	Intercept	Trend & Intercept	None
ADF test statistics	-13.15027	-13.12878	-13.04758
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-2.093521	-2.097634	-2.067043

USA_MVI

	Intercept	Trend & Intercept	None
ADF test statistics	-18.95978	-18.91140	-18.86839
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-2.239537	-2.239587	-2.228031

USA_OIE

	Intercept	Trend & Intercept	None
ADF test statistics	-10.67932	-10.70361	-10.60604
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-3.748622	-3.772518	-3.698622

USA_OII

	Intercept	Trend & Intercept	None
ADF test statistics	-17.04021	-17.10245	-17.05381
Prob. (P-value)	0.00000	0.00000	0.00000
Coefficient Y(-1)	-1.975913	-1.984902	-1.973028

The results above illustrate that all the variables used in the SVAR model to investigate the impact of exchange rate volatility on international trade are in fact all stationary and therefore the regression output obtained through the regressions will not be spurious.