Korea and the World Economy, Vol. 16, No. 3 (December 2015) 419-448

Effect of Exchange Rate Uncertainty on Trade Integration in ASEAN+3[*]

Seyed Komail Tayebi[**] · Zahra Zamani[***] ·
Chung Mo Koo[****]

Having focused on exchange rate, much of the controversy is linked to the choice of a process to represent the evolution of exchange rate, which is crucial to measure the impact of uncertainty on trade and investment decisions. It is also necessary to choose a movement that reflects as likely as possible the dynamics of the world exchange market (Postalli and Picchetti, 2006), and then its effect on trade. One way is trade integration which increases countries' economic relationship, but it may cause trade deviation due to exchange rate uncertainty. On the other hand, trade creation effects mostly result from an economic union through eliminating exchange rate uncertainty if a common currency arrangement is implemented properly (Sabri *et al*., 2012).

The objective of this study is to investigate the relationship between exchange rate uncertainty and trade integration in ASEAN+3 over the period 1995-2014. Exchange rate uncertainty is measured by Geometric Brownian Motion (GBM). The GBM is a continuous-time stochastic process, which follows a Brownian motion. Accordingly, the evaluation of exchange rate uncertainty is carried out by estimating an integration trade model using panel data approach. Estimation results have indicated that the effect of the exchange rate uncertainty on trade integration in ASEAN+3 has been significant and negative. The implication is that any shock to the exchange market may be harmful to trade integration in ASEAN+3.

---

* Received September 3, 2015. Revised November 11, 2015. Accepted December 26, 2015.
** Professor of International Economics, Director of the Center of Excellence for International Economics, University of Isfahan, Isfahan, Iran, E-mail: sk.tayebi@ase.ui.ac.ir
*** Author for Correspondence, Ph.D. in Economics, University of Isfahan, Isfahan, Iran, E-mail: z_zamani85@yahoo.com
**** Professor of Economics, Kangwon National University, Korea, E-mail: cmkoo@kangwon.ac.kr

JEL Classifications: D80, F15
Keywords: uncertainty, exchange rate, Geometric Brownian Motion (GBM), trade integration, ASEAN+3

1. INTRODUCTION

As international trade improves economic growth and development, all countries around the world try to find a way to increase trade. One way for this goal is trade integration which increases countries' trade relationship. But it may cause trade deviation due to exchange rate uncertainty, because such uncertainty might lead to reduction of the international trade volume due to high transaction cost (Sabri *et al*., 2012) and price distortion.

There are various ideas about the effect of exchange rate uncertainty on trade patterns, available in the related literature. Some studies suggest that the more increase in exchange rate volatility the more decrease in trade due to some assumptions in standard models. For instance, the standard model assumes a risk-averse exporting or importing firm. Therefore, increased volatility in the exchange rate is assumed to result in increased uncertainty by such firms about future profitability. The greater such uncertainty is, the less the supply of exports (or the demand for imports) and hence the negative relationship between volatility and the volume of international trade (Hodge, 2005).

Other studies show the positive effect of exchange rate uncertainty on trade flows. Firms can take advantages of exchange rate uncertainty if they are allowed to adjust later exchange rate volatility due to higher profit opportunities offered by good realizations of the exchange rate (Alexander and Mandler, 2006). Therefore, the effect of exchange rate uncertainty on trade flows can be found sometime ambiguous.

There are not only different ideas about the relationship between exchange rate uncertainty and trade flows but also there are different ways for calculating exchange rate uncertainty. In general, two different categories implement calculating exchange rate uncertainty including parametric and non-parametric estimation of periodicity. Parametric approach includes conditional mean and a set of VAR classes such as ARCH, GARCH and FIGARCH. Non-parametric process includes bi-power variation, realized outlyingness weighted variance, truncated power variation and so on (Erdemlioglu *et al*., 2012).

More specifically, there are different approaches in the literature that explain prices and exchange rate dynamics: fundamental approaches and stochastic models. In fundamental models, exchange rate is explained through the movement of supply and demand, and the relevant determinants that affect the exchange market. In general, structural models provide valuable insights into the determinants of exchange rate movements; hence, ideally, as Pindyck (1999) indicated, one would like to explain prices (including exchange rate) in structural terms, while such models are not appropriate in part to forecast endogenous variables so that much of their dynamics is linked to the choice of a stochastic process to represent the evolution of the resource changes (Postalli and Picchetti, 2006).

Early studies in stochastic models typically assumed that prices and exchange rates followed a random walk described by geometric Brownian motion. In this situation, they are expected to grow at some constant rate with the variance in future spot values increasing proportionally within time. If prices increase (or decrease) more than anticipated values in one time period, all future forecasts increase proportionally. Later studies have considered that mean reverting price/exchange rate models that are more appropriate in this manner (Dixit and Pindyck, 1995; Smith and McCardle, 1999). Intuitively, if the price of a currency is higher than its long run mean or equilibrium level, the supply of the currency will increase because of its profitability in the exchange market, thereby putting downward pressure on exchange rate. Conversely, if the rate of the currency is relatively low, demand for the currency will increase, putting upward pressure on exchange rate. If these entries and exits are not instantaneous, exchange rates may be temporarily high or low but will tend to revert toward the equilibrium level (Schwartz and Smith, 2000).

There are elements of truth in each of these simple models of prices. For most currencies, there appears to be some mean reversion in prices but there is also uncertainty about equilibrium price to which prices revert. Schwarts and Smith (2000) develop a two-factor model of prices that allows mean reversion in short-term and uncertainty in equilibrium level to which prices revert. In their model, volatilities in short term and long term are constant, while it is evident that the exchange rate and price volatilities are not constant over time. There are various ways to take this into account by poison jumps or by switching between two parameter regimes, or by using the generalized autoregressive conditional heteroscedasticity for explaining time-varying volatilities (Weron *et al*., 2004).

The objective of this study is to evaluate uncertainty of exchange rates in ASEAN+3. Therefore, we rely on a type of stochastic approach, Geometric Brownian Motion (GBM), through which we measure exchange rates' uncertainties in the region. To explore its effect on trade integration, in which it is a lack of study in the literature, we use the measured uncertainty index in our trade integration model to deal with the effect of exchange rate uncertainty on trade integration in ASEAN+3 during the period 1995-2014.

The remaining of this paper is classified to 5 sections. Section 2 reviews the related literature on trade and exchange rate uncertainty, and then 1997-1998 Asia financial crisis is overviewed shortly in section 3. Section 4 will focus on the methodology in two sub-sections: an introduction to the Geometric Brownian Motion (GBM) as a method of uncertainty measurement, and then the regression model specification to explore the effect of exchange rate uncertainty on trade integration in the region. Section 5 will analyzes the empirical results obtained by the model estimation. Finally, section 6 concludes remarks.

2. TRADE AND EXCHANGE RATE UNCERTAINTY

Exchange rate and its volatility are key factors that influence economic activities in all economies. The first IMF (1984) study on the matter explained that exchange rates can affect trade in many ways. Real exchange rates, which are the relative prices of tradable to non-tradable products, have a potentially strong impact on the incentive to allocate resources (capital and labor for example) between the sectors producing tradable and non-tradable goods. Real exchange rates are also a measure of real competitiveness, as they capture the relative prices, costs, and productivity of one particular country vis-à-vis the rest of the world.

The early 1970s and 1980s theoretical analyses and models of the relationship between exchange rates and international trade focused primarily on the commercial risk involved in conducting international transactions and the uncertainty generated by short-term or longer-term volatility. How this uncertainty affected the decision to trade, its expected profitability, and eventually the allocation of resources between tradable and non-tradable goods and services was, then, the main target of attention (Auboin and Ruta, 2011).

In economic literature, there are four points of view about the relationship between trade and exchange rate, which are no relationship, negative relationship, positive relationship and ambiguous relationship. First idea shows no significant relationship between exchange rate uncertainty and trade such as Tenreyro (2007) who indicated that nominal exchange rate variability has no significant impact on trade flows in a sample of countries from 1970 to 1997 by using pseudo-maximum likelihood (PML) in the context of gravity equations. He mentioned that exchange rate variability does not harm export flows. The elimination of exchange rate variability alone, hence, should not be expected to create any significant gain in trade in the aftermath of the recent waves towards stronger pegs. The results of this estimation method point to the absence of any statistically significant causal effect from exchange rate variability to trade.

Modon (2009) examined the impact of exchange rate volatilities on international trade using a traditional gravity model. The study used quarterly panel data from 1994 to 2007 and incorporated trade flow between the United States and six East Asian countries. Standard deviations of the percentage change of the bilateral exchange rate are used in defining exchange rate volatility. After accounting for fixed effects, and with country-specific autocorrelation through the Parks Method, exchange rate volatility was found to have an insignificant effect on total trade between the US and countries of the Far East.

The reason for the lack of a significant effect can be rationalized by the fact that not only exchange rate fluctuations create uncertainty or risks, which tend to discourage risk-averse agents from trade across borders, but they might also create profitable opportunities. For example, if an exporting firm faces a randomly fluctuating price for its products, given the convexity of the profit function, the average profits with fluctuating price will be higher than the profits at the average price. Higher exchange rate volatility might then lead to a larger volume of trade. This positive effect will tend to counteract the negative effects usually cited in the discussion, leading to no significant effect on net. In addition, the availability of forward contracts, currency options, and other derivatives might provide substantial hedging to reduce the uncertainty associated with exchange rate fluctuations (Tenreyro, 2007).

Second idea indicates a negative relationship between trade and exchange rate volatility such as Caglayan *et al*. (2010), Sabri *et al*. (2012) and Serenis and Tsounis (2013). They believe that higher exchange-rate volatility leads to higher cost for risk-averse traders and to less foreign trade. This is because the exchange rate is agreed on at the time of the trade contract, but payment is not made until the future delivery actually takes place. If changes in exchange rates become unpredictable, this creates uncertainty about the profits to be made and, hence, reduces the benefits of international trade (Ilhan, 2006). Another reason for negative relationship is high transaction cost caused by exchange rate volatility (Sabri *et al*., 2012).

There are many studies that show the negative relationship between exchange rate volatility and trade as follows: Vergil (2002) investigated the impact of real exchange rate volatility on the export flows of Turkey to the United States and its three major trading partners in the European Union for the period 1990:1-2000:12. He used the standard deviation of the percentage change in the real exchange rate to measure the exchange rate volatility. Co-integration and error-correction models are used to obtain the estimates of the co-integrating relations and the short-run dynamics. The results obtained in this paper, provide evidence that the real exchange rate volatility has a significant negative effect on real exports.

Ilhan (2006) reviewed the literature dealing with the effects of exchange rate volatility on trade. He mentioned that the overall evidence is best characterized as mixed as the results are sensitive to the choices of sample period, model specification, proxies for exchange rate volatility and countries considered (developed vs. developing). Numerous empirical studies have been conducted to investigate whether trade is influenced by exchange rate volatility. It is widely believed that increased exchange rate volatility inhibits the growth of foreign trade.

Grier and Smallwood (2006) study a sample of nine developed and nine developing countries to evaluate the questions of how foreign income uncertainty and real exchange rate (RER) uncertainty impact international trade and how those impacts vary according to stage of development. They show that real exchange rate uncertainty has a negative and significant impact on export growth for six of the nine less developed countries in our sample, while it has an insignificant effect for a majority of the developed countries. In both groups, foreign income uncertainty has a more significant, and frequently larger, influence on trade than that of real exchange rate uncertainty.

Bahmani-Oskooee and Kovyryalova (2008) used disaggregated import and export data for 177 commodities traded between the United States and the United Kingdom to investigate whether volatility of the real bilateral dollar/pound exchange rate has any detrimental effect on trade flows at the commodity level. Additionally, they employ the bounds testing approach to co-integration and error-correction modeling that is suitable for the models used mostly because it does not require pre-unit-root testing and variables in the model could be stationary, non-stationary or a combination of the two. In most trade flow models estimated, they found a negative effect of exchange rate volatility on commodity trade.

Caglayan *et al*. (2010) investigated the effects of real exchange rate uncertainty and financial depth on manufactures exports from 28 emerging economies to the North and South over 1978-2005. They estimated a dynamic panel model using system GMM approach and show that for the majority of countries in the sample exchange rate uncertainty affects both South-South and South-North trade negatively. In addition, they found that while financial depth plays a trade enhancing role, exchange rate shocks can negate this effect.

Ramli and Podivinsky (2011) investigated empirically the long run impact of bilateral exchange rate volatilities on the export flows of five regional ASEAN countries, namely Malaysia, Singapore, the Philippines, Indonesia and Thailand, to the United States, over the period 1990-2010. Furthermore, the short-run relationship between exports and the exchange rate dynamics were obtained for each country utilizing an error correction model. In general, the real bilateral exchange rate volatility had a significant impact on exports at least for all the countries considered in the sample, while the impact overall was negative.

Sabri *et al*. (2012) investigated the impact of exchange rate volatility on trading between South-North Mediterranean countries during 2000-2011 by using Vector-Autoregressive regression. They concluded that the volatility of exchange rate leads to reduction of international trade volume.

Another research showed that the negative relationship between exchange rate variability and trade derived from the standard model depends on a number of restrictive assumptions. Relaxing these assumptions tends to weaken the negative relationship and may even result in a positive relationship. The main assumptions concern risk aversion, the extent to which transactions can be hedged, other sources of risk to the firm besides exchange rate variability, and the potential to profit from changes in exchange rates (Hodge, 2005).

Third idea, nonetheless, shows positive effect of exchange rate volatility on trade as bellow:

De Grauwe (1988) stressed that the dominance of income effects over substitution effects can lead to a positive relationship between trade and exchange-rate volatility. This is because, if exporters are sufficiently risk averse, an increase in exchange-rate volatility raises the expected marginal utility of export revenue and therefore induces them to increase exports. He suggested that the effects of exchange-rate uncertainty on exports should depend on the degree of risk aversion. Recently, theoretical models of hysteresis in international trade have shown that increased uncertainty from high volatility in exchange rates can also influence foreign trade, in particular if significant sunk costs are involved in international transactions (Ilhan, 2006).

Wang (2007) explored the effect of exchange rate volatility on international trade flows by studying the case of Taiwan’s exports to the United States from 1989-1999. In particular, they employed sector level, monthly data and an innovative multivariate GARCH-M estimator with corrections for leptokurtic errors. This estimator allows for the possibility that traders’ forward-looking contracting behavior might condition the way in which exchange rate movement and associated risk affect trade volumes. They found changes in importing countries’ industrial production and changes in the expected exchange rate, jointly affecting the trade volumes. More strikingly, monthly exchange rate volatility affects agricultural trade flows, but not trade in other sectors.

Akinlo and Adejumo (2014) investigated the impact of exchange rate volatility on non-oil exports in Nigeria over the period 1986(1)-2008(4). They confirmed the existence of statistically significant relationship between real exports and exchange rate volatility. The results show that exchange rate, exchange rate volatility and foreign income have significant and positive effects on non-oil exports in the long run. Imports, on the other hand, have a statistically negative effect on exports in the long run. The results show that short run impact of the exchange rate volatility is statistically insignificant. The positive coefficient of the exchange rate variable (though not significant) suggests that an appreciable depreciation of the exchange rate could lead to increase in non-oil exports in Nigeria. Essentially, the results suggest that the exchange rate volatility is only effective in the long run but not in the short run in the case of Nigeria.

In the other hand, recent theoretical developments suggest that exchange rates volatilities could be expected to have either negative or positive effects on trade patterns. Therefore, forth idea refers to ambiguous relationship between exchange rate volatility and trade: Hassan (2013) investigated fluctuations in trade of Pakistan resulting from volatility in exchange rate of three of the major trading partners including United States of America, United Kingdom, and the United Arab Emirates during 1988:8 to 2011:6 using monthly data. ADF is used to check stationarity of the variables, Garch estimates volatility of exchange rate, co-integration measures long-run relationship, VECM estimates adjustment in trade growth in the short-run due to change in exchange rate. Empirical results showed a negative effect between trade growth and exchange rate.

Aktas *et al*. (2015) explore the short-term and long-term effects of the real income of foreign countries, and the relative price and uncertainty of the real exchange rate on Turkey's real agricultural export income by using the Johansen co-integration method and the error correction model for Turkish monthly data from 2003 to 2013. They calculate the real exchange rate of uncertainty by using the EGARCH model. The Johansen co-integration test showed a weak co-integration between variables in the long-term. In addition, they conclude that the variable which affects agricultural exports in the long term is exchange rate uncertainty. They mentioned that while there is a negative relationship between exchange rate uncertainty and agricultural export income in the long term, there is a positive relationship in the short term. This can be interpreted as follows: the relationship between exchange rate uncertainty and agricultural exports in the short term is temporary because of the fact that producers take high risks and tend to export as a result of sales opportunities decreasing on the domestic market. In the long term, this is in accordance with the expectations.

According to the discussion raised in this section, we conclude that there are different views towards relationship between international trade and exchange rate volatilities. As we always call trade as a main factor of growth particularly in an open economy, and the steady state growth leads economic integration in a region, it is worthwhile to study the relationship between patterns of these two key economic variables, trade and exchange rate, the fact that there exists a gap in the related literature.

3. ASIA FINANCIAL CRISIS: EVIDENCE FOR EXCHANGE RATE UNCERTAINTY

Financial crises are often associated with unusual exchange rate uncertainty and a sharp rise in risk aversion, which itself drives up the price of risk. Both factors are reflected in volatilities implied from the prices of currency options. Implied volatilities for a number of Asian currencies such as the Korean won and the Thai baht increased in 1997 and 1998 (Kohler, 2010). Chue and Cook (2008) showed that between July 1, 1997 and December 31, 1998, as the Asia crisis period, Indonesia suffered the largest (225%), while Taiwan the mildest (15%) depreciation against the US dollar. The depreciation of the Korean won, the Malaysian ringgit, and the Thai baht against the US dollar all were between 35% and 50%. Over the same time period and measured in local currency, Malaysia's stock market experienced the sharpest decline of 55%, whereas Korea's decline of 15% was the mildest. They also reported that approximately 40% of the financial intermediaries had extant international debt at the time of the crisis. About 50% of the intermediaries in Indonesia, Korea, and Thailand had international debt, while only 10% in Malaysia and Taiwan did. The average size of international debt was largest in Korea and Thailand. The mean level of international debt was above US$ 150 million in Thailand and Korea, but less than US$ 50 million in Indonesia, Malaysia, and Taiwan. They defined short-term international debt as international debt that came due during the crisis, i.e., debt with a maturity date between July 1, 1997 and December 31, 1998. Long-term international debt was the difference between international debt and short-term international debt. Approximately 40% of the international debt issued by financial intermediaries in these five countries was short term, and a substantial portion of the short-term debt was concentrated in Thailand.

Moreover, Chue and Cook (2008) explained the size of foreign exchange losses relative to both assets and liabilities. Naturally, these were much smaller than the size of foreign exchange losses relative to market capitalization, as financial intermediaries were typically highly leverage. They used stock returns, as well as growth in assets and liabilities, to measure the performance of financial intermediaries during the crisis period. They indicated that the decline in the stock market value (in local currency) of the financial intermediaries had a mean of 25%, which was about the same size as the mean foreign exchange loss relative to pre-crisis market capitalization of 26% that they reported previously. This finding indicated that foreign exchange losses were a quantitatively important explanation for the decline in stock market values during the crisis.

The East Asian financial crisis of the late-1990s did not fit with the theoretical models of the first-generation and second-generation literature. The East Asian crisis called for an eventual third-generation model of currency crises, in which only modest deteriorations in fundamentals coexisted with herding behavior in international capital markets and regional contagion (Chang and Velasco, 1998; Bustelo, 1998).

According to Kaminsky *et al*. (1998), the leading indicators are the main determinant of the financial crises. These factors include low levels of international reserves, severe currency appreciation, high domestic credit growth, high proportion of credit to the public sector, high domestic inflation, deterioration in the trade balance, declining export performance, excessive money growth, low ratios of international reserves to narrow money, deceleration in real GDP growth, and rising public deficits. Of these eleven factors, only up to four applied to the East Asian case: currency appreciation (although this was not the case of Malaysia and South Korea), reversals in the trade balance, declining export performance and excessive money growth, arising from currency uncertainty.

4. THE METHODOLOGY

4.1. Geometric Brownian Motion (GBM): A New Approach to Uncertainty Measurement

The discussion about the most suitable process to model the exchange rate is extensive and it is related to the market profile. Early works in this area, following the applications in the option's evaluation (Paddock *et al*., 1988; McDonald and Siegel, 1985) used to model the commodities prices as a Geometric Brownian Motion (GBM) which is a continuous-time stochastic process that the logarithm of the randomly varying quantity follows a Brownian motion or a Wiener process (Tayebi *et al*., 2011). Hence, a continuous-time stochastic differential equation of exchange rate can be defined and used for measuring exchange rate uncertainty as follows:

$$de_t = \mu e_t dt + \sigma e_t dz_t \,, \qquad (1)$$

where e_t is an exchange rate at time t, and z_t is standard Brownian motion under the following conditions:

1. $z_0 = 0$
2. $\{z_t,\ t \geq 0\}$: stands for a stationary and independent increment.
3. For $t > 0$, z_t: follows the normal distribution with a variance, t, and a mean, 0.

The drift coefficient μ represents a trend in the relative exchange rate, and the volatility coefficient σ (as the index for exchange rate uncertainty) is the instantaneous standard deviation of the relative exchange rate. Dividing both sides by e_t, we have:

$$\frac{de_t}{e_t} = \mu dt + \sigma dz_t. \tag{2}$$

It thus results in the following equations:

$$\text{Var}\left(\frac{de_t}{e_t}\right) = \sigma^2 dt,$$

$$\sigma = \sqrt{\frac{\text{Var}\left(de_t / e_t\right)}{dt}}, \tag{3}$$

where Var(.) is a variance operated. Thus, we can interpret σ as a standard deviation of the relative exchange rate change, de_t / e_t, over a small time interval, i.e., an instantaneous time (Yoshimoto and Kato, 2004). The GBM model is the consequence of three hypotheses concerning an exchange rate or a price process: independence of the increments, stationary of the increments and continuity of the trajectories. The instantaneous standard deviation, σ, is also constant, meaning an increasing expected exchange rate/price variability as time horizon increases (Espinosa and Vives, 2006). If exchange rates/prices increase (or decrease) more than predicted in a given instant, all future forecasts are increased (or decreased) at the same ratio. This means that GBM implies a high degree of volatility in predicted exchange rates/prices and embeds a high level of uncertainty (Postalli and Picchetti, 2006). In some cases, however, many researchers prefer mean reverting to GBM since there is one more parameter to be estimated, which allows a better description of the market dynamics (Pindyck, 2001).

4.2. The Model

It is possible to derive an export supply function of a firm by considering a model of profit-maximizing behaviour subject to a set of underlying production constraints (Jehle and Reny, 1998). Let p be a vector of prices for inputs and outputs of the firm. The profit maximization problem of the firm can be specified as

$$\pi(p) = \max px, \tag{4}$$

where $\pi(p)$ is the profit function and stands for the maximum profit as a function of prices. x denotes output which is in X. We assume that the firm produces only one exportable output; the profit function can be defined as

$$\pi(p,\ w) = \max pf(x) - wx, \tag{5}$$

where p is now the (scalar) price of the exportable output, w is the vector of factor prices, and the inputs are measured by the (nonnegative) vector $x= (x_1, x_2, \ldots, x_n)$.

Profit-maximizing behavior can be characterized by calculus when the technology is described by a differentiable production function (Tian and Zhang, 1993). To our case, the first-order condition (FOC) for the exportable output profit maximization problem with interior solution is:

$$p\frac{\partial f(x^*)}{\partial x_i} = w_i. \tag{6}$$

Using vector notation, we can also write these conditions as

$$pDf(x^*) = w. \tag{7}$$

Based on the first-order conditions, marginal revenue equals marginal cost at the profiting maximizing production plan. The second-order condition (SOC) for profit maximization holds for the matrix of second derivatives of the production function must be negative semi-definite at the optimal point:

$$D^2 f(x^*) p \frac{\partial^2 f(x^*)}{\partial x_i \partial x_j}, \tag{8}$$

where the SOC requires that the Hessian matrix must satisfy the condition that $hD^2 f(x^*)h' \leq 0$ for all vectors h. Given both conditions, the export supply function, *ex*(.), is specified as follows:

$$ex = f(x(p,\ w)) = f(y), \tag{9}$$

where *y* denotes output in equilibrium. Now, exporters enter foreign markets through their exports, while they should experience a per-period fixed cost for market development, which must be paid for deserving exchange rate volatilities within that period. Hence, the critical difference is that some producers may not end up exporting to some foreign markets, depending on the perceived volatility of exchange rates (Helpman and Krugman, 1985). Technically, a given Taylor expansion of the 'export function' should include squared exchange rate term that can be interpreted as its volatility:

$$ex = f(x(p,\ w),\ ER,\ ERV) = ex(y,\ ER,\ ERV), \tag{10}$$

where *ER* and *ERV* are real exchange rate and its volatility (ER^2 based on Taylor expansion), respectively.

The theoretical model, shown in equation (10), is thus designed to motivate the relationship between exports and exchange rate uncertainty. In order to preserve the main implications of the theoretical model and at the same time provide a simple and feasible export equation, we assume that the relationship between the logarithm of exports, exchange rate and the standard deviation of the real exchange rate is approximately linear.

Prior to the realization of the exchange rate shock, all trading partner countries are alike with a number of exporting firms in each country. Hence, profitability in each country is a function of the number of domestic firms and the number of foreign firms that export to that country. In general, the proportion of integrated exporters that export to nearby markets and the proportion that export to distant markets will depend on transport costs, market entry costs, the parameter governing risk aversion, and the distribution of exchange rates. Different proportions of trade integration in a region are therefore different functions of expected exchange rate volatility (Broda and Romalis, 2011). As discussed previously, if the distribution of volatility is unknown or unpredicted, the risk aversion of exchange rate stands for uncertainty.

According to the theoretical discussion raised above and Masron and Niaz (2008), we define a vector, *W*, that consists of export pattern, *XINT*, which stands for trade integration, and its relevant exchange rate uncertainty, σER, measured by the *GBM* approach, *GDP* of each trading partner, *GDP* dispersion, *LIN*, that explains income convergence in a region:

$$W = [XINT,\ GDP,\ ER,\ \sigma ER,\ LIN], \tag{11}$$

where *XINT*, which is the trade integration variable, can be measured in several ways. Two proxies are used here to measure the variables: $IRTS_{1ijt}$ and $IRTS_{2ijt}$, respectively. The former variable stands for intra-regional trade share which is the percentage of total intra-regional exports to total exports of the region to the world, while the later variable is the share of intra-regional exports to average exports of the region.[1] These two proxies are calculated as follows:

$$IRTS_{1ijt} = \sum X_{ijt} / TXR_t, \tag{12}$$

[1] For more details, visit: http://aric.adb.org/integrationindicators/technotes.

$$IRTS_{2ijt} = X_{ijt} \; / \; AXR_t, \tag{13}$$

where X_{ijt} is exports of country i to country j, which both of them belong to a region, and TXR_t is total exports of the region to the world at time t. AXR_t denotes average exports of the region at time t. Again, a higher share of each indicator shows a higher degree of dependency on the world and regional trade, respectively.

Additionally, *LIN* denotes the Linder variable which is a main determinant of trade pattern, including trade integration, bilateral exports and imports. Based on the theoretical literature of international trade (Deardorff, 1998), income convergence/divergence may affect directly/indirectly the countries' export flows. Therefore, the Linder variable, LIN_{it}, is applied to explain the role of income convergence/divergence in the Asian selected countries export flows. This variable is calculated as follows:

$$LIN_{it} = \mathrm{Log}(GDPC_{it} - AGDPC_t)^2, \tag{14}$$

where $GDPC_{it}$ and $AGDPC_{jt}$ are the *GDP* per-capita of country i and average *GDP* per capita of the region, respectively.

As explained previously in section 4.1., the exchange rate uncertainty, σER, for each partner is measured by the *GBM* method. To explore the effects of exchange rate as well as its uncertainty on trade integration in ASEAN+3, we define equation (15) in form of the panel trade integration regressions:

$$\begin{aligned} XINT_{kijt} = \beta_0 + \beta_{ij} + \beta_1 LGDP_{it} + \beta_2 LGDP_{jt} + \beta_3 LER_{it} + \beta_4 LER_{jt} \\ + \beta_5 A\sigma ER_{ijt} + \beta_6 LIN_{it} + \beta_7 DIS_{ij} + \alpha_{kijt}, \end{aligned} \tag{15}$$

where k=1, 2, so that $XINT_{1ijt}$ and $XINT_{2ijt}$ stand for $IRTS_{1ijt}$ and $IRTS_{2ijt}$, respectively. Indeed this has been specified based on the gravity approach since we use bilateral exports from country i to country j, vice versa. In this equation $LGDP_{it}$, $LGDP_{jt}$, LER_{it}, LER_{jt} and DIS_{ij} are logarithm of country i's

GDP, country *j*'s *GDP*, country *i*'s exchange rate, country *j*'s exchange rate and geographical distance between two partners (proxied for transportation cost of trade), respectively, all at time *t* except for DIS_{ij}. $A\sigma ER_{ijt}$ denotes the average measure of the exchange rate uncertainty indicators of two partners in ASEAN+3, while its effect on regional trade integration is expected to be negative, that is, if the exchange rate uncertainty rises, the degree of trade integration decreases. Finally, α_i and β_{ij} are individual effects while ε_{1ijt} and ε_{2ijt} stand for the model error terms.

Based on the proxies for trade integration in ASEAN+3, the regression equation can be estimated by econometric methods in 2 cases regarding the variables of $IRTS_{1ijt}$ and $IRTS_{2ijt}$. The data used for the model variables have been obtained from World Bank database, the UNcomtrade website and www.fx.sauder.ubc.ca. The data for geographical distance has been taken from Indo.com website.

5. EMPIRICAL RESULTS

5.1. Measurement of Exchange Rate Uncertainty

The continuous-time stochastic differential equation of exchange rate based GBM, which was defined in equation (1), has been estimated by programming in MATLAB, using 1995-2014 time series of the selected ASEAN+3 members (Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Japan and Korea). Real effective exchange rate has been used in which a measure of the value of a currency against a weighted average of several foreign currencies is divided by a price deflator or an index of costs, where the relevant annual data have been collected from the World Bank database. Table 1 reports the estimated parameters of μ and σ as the trends of the relative exchange rates and the standard deviation of the exchange rates, respectively, in which the later parameter stands for the measurement of exchange rate uncertainty in the region.

Table 1 Measurements of Exchange Rate Uncertainty for the Selected ASEAN+3 Members

Year	Indonesia		Malaysia		Philippines		Singapore	
	μ	σ	μ	σ	μ	σ	μ	σ
1995	0.1841	0.1235	–0.0560	1.1876	–0.0010	0.0113	–0.2335	1.0087
1996	6.4196	102.0980	–0.1163	0.2365	0.0149	0.0116	–0.1405	0.1178
1997	–2.2225	247.6440	3.7583	16.0441	3.2714	15.1838	1.4499	1.9410
1998	–1.4653	50.7542	–1.2853	28.7471	–0.8032	12.5772	–0.5040	8.1013
1999	2.3926	15.1015	0.0017	0.0001	0.5231	1.4868	–0.0239	0.9276
2000	0.7728	59.2471	0.0017	0.0000	1.9268	2.5691	0.3219	0.6899
2001	–1.3902	5.7864	0.0002	0.0003	0.1435	6.2060	0.5072	2.8344
2002	–0.4194	2.9124	0.0000	0.0000	0.3616	1.3236	–0.4323	0.6774
2003	0.8644	5.6802	0.0005	0.0000	0.3089	1.9154	–0.1319	0.9761
2004	0.6309	2.1194	0.0000	0.0000	0.1066	0.1986	–0.3007	0.7653
2005	–0.3591	3.0491	–0.0499	0.0616	–0.3506	1.3261	0.2020	0.7586
2006	0.2675	2.9606	–0.5011	1.0232	–0.5548	1.5782	–0.5229	0.5424
2007	1.6140	24.2186	–0.4614	1.2067	–1.4886	2.2937	–0.5414	1.1446
2008	–1.4625	11.5027	0.7641	2.5872	1.4865	2.8593	0.2981	3.6925
2009	–0.2402	1.0524	–0.4221	1.8693	–0.1380	1.4320	–0.6040	1.5630
2010	0.0129	1.6733	–0.6876	2.5967	–0.4257	2.5855	–0.6085	1.2811
2011	0.5746	0.3530	0.2908	1.4033	–0.1142	0.7811	0.0627	2.2142
2012	2.0378	5.0430	–0.1704	2.0262	–0.5471	0.7912	–0.4236	0.9580
2013	0.1986	4.4222	0.6025	3.5845	0.7423	1.5335	0.2208	0.6398
2014	1.1254	1.2724	0.4641	2.3242	–0.0699	0.6751	0.2979	0.7452
Year	Thailand		China		Japan		Korea	
	μ	σ	μ	σ	μ	σ	μ	σ
1995	0.0116	0.3084	–0.1359	0.1249	0.1930	22.3282	–0.2527	0.5910
1996	0.0979	0.0564	–0.0404	0.0104	0.6813	1.2921	0.5599	0.7824
1997	4.8607	49.7942	–0.0176	0.0005	0.8650	8.7313	5.1790	113.1990
1998	–3.3887	30.1162	–0.0010	0.0001	–0.9139	18.7095	–3.0451	16.7981
1999	0.4061	3.9078	–0.0001	0.0001	–0.9019	7.0807	–0.2939	3.9028
2000	1.3319	1.7451	–0.0013	0.0001	0.5596	4.1305	0.6479	2.5128
2001	0.1641	2.6819	–0.0003	0.0000	0.7948	5.1085	0.0957	2.9014
2002	–0.1474	1.9354	0.0014	0.0000	–0.7632	4.4080	–0.7626	4.6068
2003	–0.6675	1.0745	–0.0003	0.0001	–0.8845	2.9945	0.1259	2.5672
2004	0.0306	2.1601	–0.0005	0.0000	–0.2088	3.7899	–1.0738	3.0232
2005	0.5422	1.5586	–0.2254	0.1891	1.2476	2.1461	–0.1347	1.8817
2006	–0.9178	1.0337	–0.2772	0.0281	0.1395	3.3212	–0.5428	1.3024
2007	–1.3818	8.1733	–0.5024	0.0937	–0.6318	4.3873	–0.0577	1.0383
2008	1.2787	0.9946	–0.4982	0.3203	–1.5036	11.0384	3.3730	24.6432
2009	–0.4527	0.9945	–0.0116	0.0045	–0.0306	6.1602	–1.3864	13.1735
2010	–0.8467	1.5758	–0.2414	0.1365	–0.8120	3.6479	0.0587	6.0440
2011	0.1734	1.0630	–0.3472	0.0409	–0.5533	1.9481	0.2341	4.1402
2012	–0.2687	1.2062	–0.1245	0.1721	0.7625	4.2396	–0.5370	1.4073
2013	0.6637	2.6343	–0.2184	0.0531	1.3531	5.8643	–0.0942	2.4575
2014	–0.0094	0.5243	0.2066	0.4328	1.2682	1.7100	0.3035	2.6312

Source: Authors.

The values of standard deviation reported in table 1 represent a wide range of uncertainty in exchange rate for all countries during 1995-2014. The uncertainty values have been more pronounced to Indonesia while the less to Singapore and China. The measures of exchange rate indicate much higher values for 1997 and 2008, years of the Asia financial crisis and the global financial crisis, respectively. Due to higher values of uncertainty obtained for the region, it reveals the fact that uncertainty in exchange rate caused financial crises in two recent decades. As mentioned earlier in section 3, Indonesia and Thailand suffered from the largest depreciation against the US dollar in 1997 and 2008. The implication is that a proper exchange rate policy can be quite reliable to reduce the degree of the exchange rate uncertainty, and then to prevent currency crisis.

5.2. Regression Estimation: Uncertainty Effect

In this section we have estimated equation (15) by the econometric method to examine the effects of exchange rate uncertainty and other determinants on trade integration in ASEAN+3 during 1995-2014. Table 2 reports the empirical results for the trade model of the region, using $IRTS_{1ij}$ as the dependent variable, which is a proxy for trade integration. It is defined as the share of total intra-regional exports to total exports of the region to the world. The model is estimated by the Panel Feasible Generalized Least Squares (PFGLS) method (Greene 2003), to deal with the issues of model specification, heteroscedasticity across countries and autocorrelation. Accordingly, diagnostic tests are applied to the model estimates in which the Wald Statistic is used for the ‘goodness of fit’ of the model estimation. The F-Leamer test is applied to test a consistent selection of pooling against fixed effects (FE). The LR test is used to examine homoscedasticity vs. heteroscedasticity of the error components. As reported by table 2 and table 3, all tests confirm the use of PFGLS method where the results look consistent and reliable in ‘goodness of fit’, fixed effects, homoscedasticity of the error components and no autocorrelation.

Table 2 Empirical Results for the Trade Model of ASEAN+3 Specified by Equation (15), Using $IRTS_{1ij}$ as a Proxy for Trade Integration*

Variable	Coefficient	*z*	$P > \|z\|$
Constant	–33.20	–56.05	0.000
$LGDP_{it}$	0.418	25.24	0.000
$LGDP_{jt}$	0.427	25.77	0.000
LER_{it}	–0.516	–28.44	0.000
LER_{jt}	–0.525	–28.92	0.000
$A\sigma ER_{it}$	–0.001	–2.16	0.007
LIN_{it}	0.002	0.33	0.742
DIS_{ij}	–0.00004	–4.18	0.000

Diagnostic Tests

Wald chi2(7) = 1,586.19[a]
Prob. > chi2 = 0.0000
F-Leamer = 61.33[b]
Prob > *F* = 0.0000
LR chi2(55) = 544.18[c]
Prob > chi2 = 0.0000

Notes: * To deal with issues of heteroscedasticity across countries and autocorrelation, these estimates are obtained via Panel Feasible Generalized Least Squares (PFGLS) correcting for those problems (using the *xtgls* command in Stata). a The Wald Statistic which is used for the 'goodness of fit' of the model estimation. b The *F*-Leamer test which is used for testing a consistent selection of Pooling against Fixed Effects. c The LR test which is used to test heteroscedasticity of the error components.
Source: Authors.

Except for the Linder variable, *LIN*, all the explanatory variables have different effects, but significant, on trade integration in ASEAN+3. The coefficient of logarithm of the member's GDP, either an exporter or an importer, has been estimated significantly and positively. It means a higher economic growth rate of the member should lead to a relative increase in the degree of trade integration in the region. However, a 1% increase in exchange rate in the exporting country (country *i*) and in the importing country

Table 3 Empirical Results for the Trade Mmodel of ASEAN+3 Specified by Equation (15), Using $IRTS_{2ij}$ as a Proxy for Trade Integration

Variable	Coefficient	z	$P > \|z\|$
Constant	–30.91	–50.85	0.000
$LGDP_{it}$	0.415	24.38	0.000
$LGDP_{jt}$	0.423	24.89	0.002
LER_{it}	–0.511	–27.44	0.000
LER_{jt}	–0.520	–27.91	0.000
$A\sigma ER_{it}$	–0.001	–1.84	0.065
LIN_{it}	0.001	0.21	0.830
DIS_{ij}	–0.00004	–4.00	0.000

Diagnostic Tests

Wald chi2(7) = 1,474.22[a]
Prob > chi2 = 0.0000
F_{Leamer} = 52.68[b]
Prob > F = 0.0000
LR chi2(55) = 480.33[c]
Prob > chi2 = 0.0000

Notes: [*] To deal with issues of heteroscedasticity across countries and autocorrelation, these estimates are obtained via Panel Feasible Generalized Least Squares (PFGLS) correcting for those problems (using the *xtgls* command in Stata). a The Wald Statistic which is used for the 'goodness of fit' of the model estimation. b The *F*-Leamer test which is used for testing a consistent selection of Pooling against Fixed Effects. c The LR test which is used to test heteroscedasticity of the error components.
Source: Authors.

(country *j*) makes about 0.52% and 0.53% decreases in the share of total intra-regional exports to total exports of the region to the world, respectively. Moreover, due to the negative sign of the estimated coefficient of $A\sigma ER$, the regional exchange rate uncertainty affects significantly, but indirectly, trade integration. It implies the higher uncertainty and volatility of the region's currencies, the lower share of total intra-regional exports to total exports of the region to the world.

Additionally, this result confirms the empirical findings obtained by Bahmani-Oskooee and Kovyryalova (2008), Ramli and Podivinsky (2011), Caglayan *et al*. (2010) and Sabri *et al*. (2012) who found indirect relationships between exchange rate volatilities and trade patterns, while contradicts Tenreyro (2007) who indicated that nominal exchange rate variability had no significant impact on trade flows of a sample of developing countries.

Although a small value for the estimated coefficient of the geographical distance, as reported in table 2, it has a negative and significant sign that implies the existence of negative effect of transportation cost on trade integration in ASEAN+3. In fact export to the region's distant markets will depend on transport costs, market entry costs, risk aversion and the distribution of exchange rates. According to Deardorff (1998), income dispersion can affect the countries' export flows; while our results show that the effect of this indicator (*LIN*) is not statistically significant implying that income convergence/divergence is not a main determinant in the region. Finally, even though statistically significant, the value of estimated coefficient of the physical distance is quite small (even close to zero); while Shin and Yang (2012) indicate that physical distance is an important element in determining both cross-border trade flows and financial flows of the selected countries worldwide. The fact can explain the observed complementarities between bilateral trade and financial integration.

Table 3 also summarizes the empirical results for the trade model of ASEAN+3 specified by equation (15), using $IRTS_{2ij}$ as a proxy for trade integration, which is the share of total intra-regional exports to average exports of the region. Indeed the same results (with small differences) and the same interpretations are applied to this case. Overall, the exchange rate uncertainty has reduced the share of total intra-regional exports to average exports in the region during 1995-2014.

6. CONCLUSION

In this paper we discussed that exchange rate uncertainty might have a negative effect on trade patterns as recent theoretical and empirical studies show that the high variability of exchange rates and associated uncertainty can influence the decision to enter or exit foreign trade markets, particularly in the presence of 'sunk' costs. Such costs of course can be related to uncertain effects on trade patterns in which firms and countries would tend to be less reactive to uncertainties in exchange rates (Auboin and Ruta, 2011).

In this study we investigated the relationship between exchange rate uncertainty and trade integration in ASEAN+3 during 1995-2014. To measure the region's exchange rate uncertainty we firstly used the Geometric Brownian Motion (GBM) method, which is a continuous-time stochastic process, following a Brownian motion. Accordingly, we estimated the parameter of σ as the trend of the standard deviation of the region's exchange rates, which represented a new measurement of exchange rate uncertainty in the region. The relevant results indicated a wide range of uncertainty in exchange rate for all countries, where Indonesia and Thailand suffered from the higher rates of the exchange rate uncertainty during the period. The results also showed that greater values for all members in 1997 and 2008, years of the Asia financial crisis and the global financial crisis, respectively.

We then estimated the specified trade models by the econometric methods of panel data to examine the impact of exchange rate uncertainty on trade integration in ASEAN+3 during the period under consideration. The empirical results indicated that the effect of the exchange rate uncertainty on trade integration in ASEAN+3 was significant and negative; implying any shock to the exchange market may be harmful to trade integration in ASEAN+3. The reason is that the increasing region's exchange rate uncertainty may lead to export divergence while reduces the share of intra-regional exports to total exports of the region. Overall, our findings cover the majority of studies in the literature that approve the significant indirect effect of exchange rate volatilities on trade patterns including trade integration in economic regions such as ASEAN. However, the innovation of our study rather than the literature relies on a modern measurement of the exchange rate volatilities, GBM, through which a continuous-time stochastic differential equation of exchange rate has been used to estimate exchange rate uncertainty of each ASEAN+3 members.

The implication of our finding is that an appropriate exchange rate policy can be reliable to reduce the degree of the exchange rate uncertainty, and then to prevent currency crisis. A lower rate of the exchange rate uncertainty would lead to more deepening integration in the ASAEAN+3 members' trade flows.

REFERENCES

Akinlo, E. A. and V. A. Adejumo, "Exchange Rate Volatility and Non-oil Exports in Nigeria: 1986-2008," *International Business and Management*, 9(2), 2014, pp. 70-79.

Aktas, A., F. Kaplan, B. Ozkan, and R. G. Brumfield, "The Effect of Exchange Rate Uncertainty on Agricultural Exports: A Study of Turkey," *Business Management Dynamics*, 4(8), 2015, pp. 1-8.

Alexander, V. and M. Mandler, "Economic Integration, Uncertainty, and Trade — The European Experience," Paper Prepared for Presentation at the 2006 ASSA Conference, Boston, January 6-8, Ali S. (n.d), Convergence Criteria: Why These Are Inevitable for Monetary Union?, *The World Trade Review*, 2006 (https://www.aeaweb.org/annual_mtg_papers/2006/0107_1015_1901.pdf).

Auboin, M. and M. Ruta, "The Relationship between Exchange Rates and International Trade: A Literature Review," World Trade Organization, Staff Working Paper ERSD-2011-17, 2011.

Bahmani-Oskooee, M. and M. Kovyryalova, "Impact of Exchange Rate Uncertainty on Trade Flows: Evidence from Commodity Trade between the United States and the United Kingdom," *World Economy*, 31(8), 2008, pp. 1097-1128.

Brennen, M. and E. Schwartz, "Evaluating Natural Resource Investments," *The Journal of Business*, 58(2), 1985, pp. 135-157.

Broda, C. and J. Romalis, "Identifying the Relationship between Trade and Exchange Rate Volatility," in Takatoshi Ito and Andrew K. Rose, eds., *Commodity Prices and Markets, East Asia Seminar on Economics*, Volume 20, 2011, pp. 79-110.

Bustelo, P., "The East Asian Financial Crises: an Analytical Survey," ICEI Working Papers, No. 10, Complutense Institute for International Studies, Complutense University of Madrid, 1998 (Spain, http://pendientedemigracion.ucm.es/info/eid/pb/ICEIwp10.pdf).

Caballero, J. R. and V. Corbo, "The Effect of Real Exchange Rate Uncertainty on Exports: Empirical Evidence," *The World Bank Economic Review*, 3(2), 1989, pp. 263-278.

Caglayan, M., O. S. Dahi, and F. Demir, "Trade Flows, Exchange Rate Uncertainty and Financial Depth: Evidence from 28 Emerging Countries," Sheffield Economic Research Paper Series 2010011, 2010 (http://eprints.whiterose.ac.uk/10860/).

Chang, R. and A. Velasco, "Financial Crises in Emerging Markets: A Canonical Model," Federal Reserve Bank of Atlanta Working Paper, No. 98-10, July 1998.

Chue, T. K. and D. Cook, "Sudden Stops and Liability Dollarization: Evidence from Asia's Financial Intermediaries," *Pacific-Basin Finance Journal*, 16, 2008, pp. 436-452.

Deardorff, V. A., *Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World?*, London: University of Chicago Press, 1998.

De Grauwe, P., "Exchange Rate Variability and the Slowdown in Growth of International Trade," *IMF Staff Papers*, 35, 1988, pp. 63-84.

Dixit, A. K. and R. Pindyck, "The Options Approach to Capital Investment," *Harvard Business Review*, 77(3), 1995, pp. 105-115.

Erdemlioglu, D., S. Laurent, and C. J. Neely, "Econometric Modeling of

Exchange Rate Volatility and Jumps," Federal Reserve Bank of St. Louis, Working Paper, 2012-008A, 2012 (http://research.stlouisfed.org/wp/2012/2012-008.pdf).

Espinosa, F. and J. Vives, "A Volatility Varying Jump-Diffusion Merton Type Model of Interest Rate Risk," *Insurance, Mathematics and Economics*, 38(1), 2006, pp. 157-166.

Greene, W. H., *Econometric Analysis*, 5th ed., Upper Saddle River, NJ: Prentice Hall, 2003.

Grier, B. K. and A. D. Smallwood, "Uncertainty and Export Performance: Evidence from 18 Countries," *Journal of Money, Credit and Banking*, 39(4), 2006, pp. 965-979.

Hassan, M., "Volatility of Exchange Rate Effecting Trade Growth — A Case of Pakistan with US, UK and UAE," *European Scientific Journal*, 9(22), 2013, pp. 277-288.

Helpman, E. and P. Krugman, *Market Structure and Foreign Trade*, Cambridge: MIT Press, 1985.

Hodge, D., "The Effect of Exchange Rate Volatility on Trade and Employment: A Brief Review of the Literature," *Macroeconomy, Economic Bias & Employment*, Human Science Research Council, 2005 (http://www.hsrc.ac.za/en/research-data/ktree-doc/1308).

Ilhan, O., "Exchange Rate Volatility and Trade: A Literature Survey," *International Journal of Applied Econometrics and Quantitative Studies*, 3(1), 2006, pp. 85-102.

IMF, "Exchange Rate Volatility and World Trade," IMF Occasional Paper, 30, 1984.

Jehle, G. A. and P. Reny, *Advanced Microeconomic Theory*, Addison-Wesley, 1998, Chapter 5.

Kaminsky, G., S. Lizondo, and C. M. Reinhart, "Leading Indicators of Currency Crises," IMF Staff Papers, 45(1), 1998, pp. 1-48.

Kohler, M., "Exchange Rates during Financial Crises," *BIS Quarterly Review*, March 2010 (www.bis.org/ publ/qtrpdf/r_qt1003f.pdf).

Masron, A. T. and A. M. N. Niaz, "Export, Economic Integration and

Exchange Rate Volatility in Turkey and Malaysia," MPRA Paper, No. 41519, 2008 (http://mpra.ub.uni-muenchen.de/41519/).

Mcdonald, R. L. and D. R. Seigel, "Investment and Valuation of Firm When There Is an Option to Shut Down," *International Economic Review*, 26(2), 1985, pp. 331-349.

Modon, M., "The Effect of Exchange Rate Volatility on Trade Flows between the US and Countries of the Far East," mimeo, 2009 (http://economics.uakron.edu/SeniorProjects/2009/MichaelModon.pdf).

Paddock, I. and D. R. Seigel, and L. Smith, "Option Valuation of Claim on Real Assets: The Case of Offshore Petroleum Lease," *The Quarterly Journal of Economics*, 103, 1988, pp. 479-508.

Pindyck, R., "Adjustment Costs, Uncertainty and the Behavior of the Firm," *American Economic Review*, 72(3), 1982, pp. 415-427.

____________, "Long Run Evaluation of Energy Price," *The Energy Journal*, 20, 1999, pp. 1-27.

____________, "Volatility and Commodity Price Dynamics," CEEPR Working Paper, No. 007/2001, MIT, 2001.

Postalli Fernando and P. Picchetti, "Geometric Brownian Motion and Structural Breaks in Oil Prices: A Quantitative Analysis," *Energy Economics*, 28, 2006, pp. 506-522.

Ramli, N. and J. M. Podivinsky, "The Effects of Exchange Rate Volatility on Exports: Some New Evidence for Regional ASEAN Countries," 7th ESDS Annual Conference, 28th November, Institute of Materials, London, 2011 (ukdataservice.ac.uk/media/263176/normiah-paper.pdf).

Sabri, R. N., M. Peeters, and D. K. Abulaben, "The Impact of Exchange Rate Volatility on Trade Integration among North and South Mediterranean Countries," MPRA Paper, No. 38080, 2012 (http://mpra.ub.uni-muenchen.de/38080/).

Schwartz, E. and J. Smith, "Short Term Variation and Long Term Dynamics in Commodity Prices," *Management Science*, 46(7), 2000, pp. 893-911.

Serenis, D. and N. Tsounis, "Exchange Rate Volatility and Foreign Trade: The Case for Cyprus and Croatia," *Procedia Economics and Finance*, 5, 2013, pp. 677-685.

Shin, K. and D. Y. Yang, “Complementarities between Bilateral Trade and Financial Integration,” *Korea and the World Economy*, 13(1), 2012, pp. 39-68.

Smith, J. E. and K. F. McCardle, “Options in the Real World: Lessons Learned in Evaluating Oil Gas Investment,” *Operations Research*, 47(1), 1999, pp. 1-15.

Tayebi, S. K., R. Khoshakhlagh, and M. Farahani, “The Estimation of Uncertainty in Heavy Oil Price of Iran and OPEC Portfolio: Application of Random Differential Equations,” *Journal of Energy Economy Studies*, 31, 2011, pp. 1-25.

Tenreyro, S., “On the Trade Impact of Nominal Exchange Rate Volatility,” *Journal of Development Economics*, 82, 2007, pp. 485-508.

Tian, G. and F. Zhang, “Market Economics for Masses,” in G. Tian, ed., *A Series of Market Economics*, Vol. 1, Shanghai People’s Publishing House and Hong Kong’s Intelligent Book Ltd., Chapters 1-2, 1993 (in Chinese).

Vergil, H., “Exchange Rate Volatility in Turkey and Its Effect on Trade Flows,” *Journal of Economic and Social Research*, 4(1), 2002, pp. 83-99.

Wang, L., “Estimating the Effects of Exchange Rate Volatility on Export Volumes,” *Journal of Agricultural and Resource Economics*, 32(2), 2007, pp. 225-255.

Weron R., M. Bierbrauer, and S. Trück, “Modeling Electricity Prices: Jump Diffusion and Regime Switching,” *Physica A: Statistical Mechanics and Its Applications*, 336(1-2), 2004, pp. 39-48.

Yoshimoto, A. and T. Kato, “Effects of Estimation Length on Parameter Estimates of Geometric Brownian Motion for Log Price Dynamics,” *Journal of Forest Research*, 9(3), 2004, pp. 239-248.

http://data.worldbank.org/data-catalog/world-development-indicators.

http://fx.sauder.ubc.ca/data.html.

www.uncomtrade.com.