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Abstract:

This paper examines the impact of bilateral real exchange rate volatility on real exports of five emerging East Asian countries among themselves as well as to thirteen industrialised countries. We explicitly recognize the specificity of the exports between the emerging East Asian and industrialised countries and employ a generalized gravity model that combines a traditional long-run export demand model with gravity type variables. In the empirical analysis we use a panel comprising 25 years of quarterly data and perform unit-root and cointegration tests to verify the long-run relationship among the regression variables. The results provide strong evidence that exchange rate volatility has a negative impact on the exports of emerging East Asian countries. These results are robust across different estimation techniques and do not depend on the variable chosen to proxy exchange rate uncertainty.

Key words: Trade, exports, exchange rate, volatility, East Asia, emerging economies

JEL classification: F14, F31, O53

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This paper examines the impact of bilateral real exchange rate volatility on real exports of five emerging East Asian countries among themselves as well as to thirteen industrialised countries. We explicitly recognize the specificity of the exports between the emerging East Asian and industrialised countries and employ a generalized gravity model that combines a traditional long-run export demand model with gravity type variables. In the empirical analysis we use a panel comprising 25 years of quarterly data and perform unit-root and cointegration tests to verify the long-run relationship among the regression variables. The results provide strong evidence that exchange rate volatility has a negative impact on the exports of emerging East Asian countries. These results are robust across different estimation techniques and do not depend on the variable chosen to proxy exchange rate uncertainty.

1 Introduction

The collapse of the Bretton-Woods exchange rate system has led to significant fluctuation in both real and nominal exchange rates.[1] The liberalization of capital flows and the associated intensification of cross-border financial transactions appear to have amplified the volatility of exchange rates. The increase in exchange rate volatility is widely believed to have detrimental effects on international trade and thus have a negative economic impact, especially on emerging economies with underdeveloped capital markets and unstable economic policies (Prasad *et al.*, 2003).

Exchange rate volatility can have a negative effect on international trade, directly through uncertainty and adjustment costs, and indirectly through its effect on the allocation of resources and government policies (Côte, 1994). If exchange rate movements are not fully anticipated, an increase in exchange rate volatility may lead risk-averse agents to reduce their international trading activities. The presumption of a negative nexus between exchange rate volatility and trade is an argument routinely used by proponents of managed or fixed exchange rates. This argument has also been

[1] Flood and Rose (1999) and Frömmel and Menkhoff (2003) empirically examine the volatility of major floating exchange rates for the period from 1973 to 1998 and find evidence of increasing volatility for most currencies.

reflected in the establishment of the European Monetary Union, as one of the stated purposes of EMU is to reduce exchange rate uncertainty in order to promote intra-EU trade and investment (EEC Commission, 1990).

However, the empirical evidence in support of the hypothesis of a negative link between exchange rate volatility and trade is mixed. The pertinent survey of McKenzie (1999) concludes that exchange rate volatility may impact differently on different markets and calls for further tests using export market specific data. Therefore, in this paper we empirically examine the effects of exchange rate volatility on the bilateral export flows of five emerging East Asian countries – China, Indonesia, Malaysia, the Philippines, and Thailand. Given the fact that these emerging economies actively trade among themselves and depend on exports to industrialised countries as a driving force for their economic growth (see Table 1), an understanding of the degree to which bilateral exchange rate volatility affects their export activity is important for the optimal choice of exchange rate policy. Furthermore, the countries under consideration are the main members of the impending ASEAN-China Free Trade Area (ACFTA), and the options for closer monetary integration including proposals for the eventual formation of a currency union within the region are currently an active area of research and policy debate.[2] Thus, the results of this paper provide a valuable piece of evidence informing the ongoing debate and the evaluation of policy options.

The major advantage of analysing bilateral rather than aggregate multilateral trade flows is the ability to control not only for exchange rate volatility but also for a variety of other factors such as distance between each pair of countries, level of exchange rate, and cultural and geographical relationships that can affect trade

[2] See, e.g., Rajan (2002), Kwack (2005), Eichengreen (2006), Huang and Guo (2006), Sato and Zhang (2006), Kim (2007), Wilson and Ng Shang Reng (2007).

between countries. Furthermore, Klaassen (2004) points out that the use of bilateral instead of multilateral data can overcome the difficulties in constructing multi-country explanatory variables. To examine the impact of bilateral exchange rate volatility on exports among the five East Asian countries as well as on export flows to 13 other industrialized countries we use a panel dataset of 85 cross-sectional quarterly observations for the period from 1982:Q1 to 2006:Q4. To check the robustness of our findings, we employ three different measures of exchange rate volatility and three estimation methods.

Table 1 Exports of Emerging East Asian Countries to Major Trading Partners (% of 2006 Total Exports)

Importers	**Exporters**				
	China	**Indonesia**	**Malaysia**	**Philippines**	**Thailand**
Australia	1.41	2.84	2.83	1.02	3.35
Austria	0.11	0.08	0.18	0.11	0.23
Belgium	1.02	0.94	0.38	1.56	1.11
Canada	1.60	0.74	0.64	0.61	0.95
China	-	7.70	7.25	9.83	9.05
Denmark	0.38	0.16	0.23	0.05	0.27
France	1.44	0.87	1.36	0.45	1.10
Germany	4.16	2.32	2.17	3.78	1.79
Indonesia	0.98	-	2.54	0.77	2.56
Italy	1.65	1.43	0.62	0.42	1.15
Japan	9.47	19.37	8.86	16.48	12.63
Malaysia	1.40	3.96	-	5.57	5.10
Netherlands	3.18	2.10	3.64	10.12	2.50
Philippines	0.59	0.79	1.35	-	1.98
Spain	1.19	1.53	0.58	0.20	0.83
Thailand	1.01	2.79	5.29	2.82	-
United Kingdom	2.49	1.50	1.82	1.03	2.62
United States	21.04	11.47	18.79	18.32	15.03
Exports to major partners	**53.10**	**60.58**	**58.54**	**73.14**	**62.25**
Total exports (in million US$)	969284	113645	160664	46976	130555

Source: Direction of Trade Statistics.

The paper contributes to the literature in two important ways. First, we explicitly recognize the specificity of the exports between the emerging East Asian and industrialised countries and employ a generalized gravity model that combines a traditional long-run export demand model with gravity type variables. The use of the generalised gravity model helps to overcome potential misspecification problems which may arise as a result of employing a pure gravity model to analyse the trade patterns of emerging economies. Second, we use a panel comprising 25 years of quarterly data for the five East Asian countries as well as for a sample of 13 importing industrialized countries. Furthermore, in order to verify the robustness of the long-run relationship between exchange rate volatility and exports, panel unit roots and cointegration tests are conducted. [3]

The paper is organised as follows. Section 2 briefly reviews the theoretical and empirical literature on the impact of exchange rate volatility on international trade. Section 3 presents the research methodology. First a simple model is specified to investigate the impact of exchange rate volatility on bilateral exports. Then, data sources, definitions of variables, and econometric methods are discussed. Section 4 presents the estimation results and discussion. Section 5 draws conclusions.

2 Exchange rate volatility and exports

a. The theory

Early theoretical partial equilibrium models of risk-averse firms that are constrained to decide trade volumes before exchange rate uncertainty is resolved have suggested a negative effect of volatility on trade if hedging is not possible or is costly (Clark, 1973;

[3] There are previous empirical studies analysing the impact of exchange rate volatility on trade of developing countries (for example, Arize *et al.*, 2000, 2008; Dognalar, 2002), but not specifically focusing on the emerging East Asian countries and not using bilateral data. Recently, Chit (2008) examines the relationship between real exchange rate volatility and bilateral trade flows but only among the members of ASEAN-China Free Trade Area.

Hooper and Kohlhagen, 1978). This theoretical proposition can be applied to most of the developing and emerging countries where well developed financial markets simply do not exist. In this situation the variability of the firm's profit depends entirely on the realized exchange rate. If the firm's objective is to maximize the expected utility of profit, then higher volatility of the exchange rate – while maintaining its average level – will lead to a reduction in exports in order to minimize the risk exposure.

However, subsequent theoretical studies reveal that this prediction is based on restrictive assumptions about the form of the utility function (De Grauwe, 1988; Dellas and Zilberfarb, 1993). Even under the maintained hypothesis of risk aversion, the sign of the effect becomes ambiguous once the restrictions are relaxed. As pointed out by De Grauwe (1988), an increase in risk has both a substitution and an income effect. The substitution effect per se decreases export activities as an increase in exchange rate risk induces agents to shift from risky export activities to less risky ones. The income effect, on the other hand, induces a shift of resources into the export sector when expected utility of export revenues declines as a result of the increase in exchange rate risk. Hence, if the income effect dominates the substitution effect, exchange rate volatility will have a positive impact on export activity.

In addition, an increase in exchange rate volatility can create profit opportunity for firms if they can protect themselves from negative effects by hedging or if they have ability to adjust trade volumes to movements in the exchange rate. Franke (1991) and Sercu and Vanhull (1992) demonstrate that an increase in exchange rate volatility can increase the value of exporting firms and thus can promote exporting activities. De Grauwe (1994) shows that increase in exchange rate volatility can increase the output and thus volume of trade if the firm can adjust its output in response to price changes. Broll and Eckwert (1999) demonstrate that an international firm with huge domestic market base has the ability to benefit from exchange rate movements by reallocating their products between domestic and foreign market. Thus, higher volatility can increase the potential benefits from international trade. Moreover, from the political economy point of view, Brada and Méndez (1988) note that exchange rate movements facilitate the adjustment of the balance of payments in an event of external shocks, and thus, reduce the use of trade restrictions and capital controls to achieve the equilibrium, and this in turn encourages international trade.

In brief, the theoretical results are conditional on the assumptions about attitudes towards risk, functional forms, type of trader, presence of adjustment costs, market structure and availability of hedging opportunities. Ultimately, the relationship between exchange rate volatility and trade flows is analytically indeterminate. Thus, the direction and magnitude of the impact of exchange rate volatility on trade becomes an empirical issue.

b. Empirical evidence

Most of the earlier papers (circa 1978 to the mid-1990s) employ only cross-sectional or time-series data and the empirical evidence of these earlier studies is mixed. For example, Hooper and Kohlhagen (1978), Bailey and Tavlas (1988), and Holly (1995) use time-series data to examine the impact of exchange rate volatility on exports of industrialised countries and find essentially no evidence of any negative effect. Cushman (1986), De Grauwe (1988) and Bini-Smaghi (1991) also examine samples of industrialised countries using time-series data and, in contrast, find evidence of a significant negative effect. Cross-sectional studies, such as Brada and Mendez (1988) and Frankel and Wei (1993) find also a negative impact of exchange risk on trade volume, but the effect is, in most cases, relatively small.

More recent panel data studies have tended to find evidence of negative impact of exchange rate volatility on bilateral trade. There are apparent advantages of using panel data. Dell'Arricia (1999) notes that unobservable cross-sectional specific effects which may have impact on the trade flows - such as cross-country structural and policy differences – can be accounted for either via fixed effects or random effects specification. Using fixed effects, Dell'Ariccia (1999) estimates the impact of exchange rate volatility on the bilateral trade of 15 EU member states plus Switzerland over the 20 years, from 1975 to 1994, and finds that exchange rate volatility has a small but significant negative impact on trade; eliminating exchange rate volatility to zero in 1994 would have increased trade by 3 to 4 percent.

Rose (2000), Clark *et al.,* (2004) and Tenreyro (2007) also employ panel data containing over 100 countries. In the benchmark result of Rose (2000), the impact of exchange rate volatility on trade is significantly negative; increase in exchange rate volatility by one standard deviation around the mean would reduce bilateral trade by 13 percent. Tenreyro (2007) finds a small negative effect similar to Dell'Ariccia (1999); reducing exchange rate volatility to zero raises trade by only 2 percent. Using fixed effect estimation, Clark, Tamirisa and Wei (2004) find a negative and significant impact of exchange rate volatility on trade; a one standard deviation increase in exchange rate volatility would reduce trade by 7 percent.

Empirical studies focusing on emerging and developing countries and using time-series data support the hypothesis of a negative impact of exchange rate volatility on trade. For instance, Arize *et al.* (2000; 2008) and Doğnalar (2002) investigate the relationship between exports and exchange rate volatility in emerging and developing economies. However, these studies focus on the impact of real effective exchange rate volatility on total exports of a country, not on bilateral trade. Only Chit (2008) examines the bilateral exports among five ACFTA countries, and finds that total elimination of exchange rate volatility, in 2004, would have increased the intra-regional trade of ACFTA by 5 percent. [4]

3 Research methodology

There are two apparent drawbacks of previous studies. The majority of the empirical papers that focus on the relationship between exchange rate volatility and bilateral trade employ the gravity model (see, for example, Dell'Ariccia, 1999; Rose, 2000; Anderton and Skudenly, 2001; Baak, 2004; Clark *et al.,* 2004; Tenereyro, 2007). In these studies, the gravity model is augmented with other factors that can affect trade flows such as sharing a common border, common language, membership of free trade area and exchange rate volatility. However, Dell'Ariccia (1999) argues that the gravity model is more suitable for the estimation of intra-industry trade flows between developed country pairs since the theoretical foundations of the model assume identical and homothetic preferences across countries and rely heavily on the concept of intra-industry trade. The use of gravity model in studies with a mixed sample of developed and developing countries is questionable since the developed and developing countries might have different structural circumstances and trade patterns (Bayoumi and Eichengreen, 1995).

The second drawback of previous studies concerns the stationarity of data. Although panel data analysis has particular advantages in examining the impact of exchange rate volatility on trade, longer time dimension of the panel data (for

[4] See McKenzie (1999) and Bahmani-Oskooee and Hegerty (2007) for detailed surveys of the empirical literature.

example, Dell'Ariccia, 1999; Baak, 2004) may lead to the problem of non-stationarity and spurious regression. Baltagi (2001) notes that for a macro-panel with large N (numbers of cross-sectional observations) and larger T (length of time series) non-stationarity deserves more attention. None of the existing published papers utilising panel data, except Chit (2008), conduct panel unit-root and cointegration tests to verify the long-run relationship among the variables. Thus, previous studies might be affected by the problem of spurious regression.

The empirical specification adopted in the current paper aims to mitigate these drawbacks. First, a generalized gravity model, which is arguably more suitable for the context of emerging economies and their trade relationships with industrialised countries, is employed to overcome the potential misspecification problems. Second, using unit root tests, we verify the long-run relationship between exchange rate volatility and trade in order to avoid problems of spurious regression.

a. Model specification

Instead of a standard gravity model, the trade model employed in the paper is a combination of the gravity model and a long-run export demand model. In effect, our model is similar to the generalised gravity model in the spirit of Bergstrand (1989) and used by Aristotelous (2001). The empirical model is specified as follows:

$$X = f\,(Y, Y^{*}, RP, VOL, Dist, CB, AFTA), \qquad (1)$$

where real exports (X) from one country to another are a function of home country's GDP (Y), importing country's GDP (Y^{*}), relative price (RP), exchange rate volatility (VOL), and a set of gravity variables – the distance between the two countries ($Dist$), sharing of a common border (CB), and membership of the ASEAN Free Trade Area ($AFTA$).

The generalised gravity model differs from the standard gravity model in two important respects. First, the dependent variable is not bilateral trade (the product of the exports of two trading countries) but exports from one country to another. Secondly, because the dependent variable is exports, not bilateral trade, a variable representing relative competitiveness between the two countries can be included as an explanatory variable.

b. Data and definition of variables

A panel data set of 85 cross-sectional observations for the period from 1982:Q1 to 2006:Q4 is used. The source of bilateral exports data is the IMF Direction of Trade Statistics (DOTS) in which the values of export flows are expressed in current U.S. dollars. All other data except exports are taken from the IMF International Financial Statistics. Following the same procedure as Eichengreen and Irwin (1996) and Clark, Tamirisa and Wei (2004), we use the US GDP deflator to transform export values in current U.S. dollar into real exports (*X*).

Next we define the explanatory variables. Real GDP of home country (*Y*) and the importing country (*Y**) is constructed as follows. Quarterly GDP in current local prices is transformed into constant prices by using each country's GDP deflator and then converted into a common currency (U.S. dollars).

Theoretically, the bilateral relative price variable should be the ratio of an index of export prices, for the exporting country, and an index of prices of similar goods in the importing country, expressed in the same currency. Since such a measure is not available, the relative price variable (*RP*) is the bilateral real exchange rate which is measured by the end-of-period nominal bilateral exchange rate, adjusted by the relative price level (CPI) of respective countries.[4]

In the literature there is no universal consensus with respect to the most appropriate proxy to represent volatility. Consequently, a number of studies employ multiple proxies (e.g., Kumar and Dhawan, 1999; Dell'Arricia, 1999; Clark, Tamirisa and Wei, 2004). Similarly, we employ three measures of exchange rate volatility (*VOL*): the standard deviation of the first difference of the log real exchange rate, the moving average standard deviation (MASD) of the quarterly log of bilateral real exchange rate, and the conditional volatilities of the exchange rates estimated using a GARCH (General Autoregressive Conditional Heteroscedasticity) model.

A key characteristic of the first measure is that it gives large weight to extreme volatility. Since the countries being considered focus on export promotion and their domestic markets cannot absorb the entire production, their exports might not be affected by relatively small volatility. In addition, this measure will equal zero when the exchange rate follows a constant trend. If the exchange rate follows a constant trend it could be perfectly anticipated and therefore would not be a source of exchange risk. This measure is employed as a benchmark proxy for exchange rate volatility. Formally:

$$V_{ijt} = \sqrt{\sum_{t=1}^{m} \left(\Delta e_{ijt} - \Delta \overline{e}_{ijt} \right)^2 / m - 1} \quad , \tag{2}$$

where Δe_{ijt} is the first difference of the log quarterly exchange rate and m is the number of quarters.

[4] For China, the data for quarterly CPI is not readily available for the whole sample period and the missing data are constructed by using the Otani-Riechel method to transform the annual data obtained from WDI (World Development Indicators, 2005) and various Chinese Statistical Yearbooks into quarterly data.

The second measure (MASD) captures the movements of exchange rate uncertainty over time. The main characteristic of this measure is its ability to capture the higher persistence of real exchange rate movements in the exchange rate (Klaassen, 2004). This measure defines exchange rate volatility as

$$V_{ijt} = \left[(1/m) \sum_{i=1}^{m} \left(e_{ijt+i-1} - e_{ijt+i-2} \right)^2 \right]^{1/2}, \qquad (3)$$

where e_{ijt} is the log bilateral exchange rate, and m is the order of moving average.

In both standard-deviation-based measures, the temporal window is chosen as eight quarters in order to stress the importance of medium-run uncertainty. The current volatility is calculated on the movements of exchange rate during the previous eight quarters reflecting the backward-looking nature of risk, that is, firms use past volatility to predict present risk. As part of the robustness analysis, we also employ a four-quarter window.

The third measure is based on a GARCH model following, e.g., Sauer and Bohara (2001) and Clark, Tamirisa and Wei (2004). It allows for volatility clustering such that large variances in the past generate large variances in the future. Hence, volatility can be predicted on the basis of past values. In this model the log difference of monthly exchange rates is assumed to follow a random walk with a drift:

$$\boldsymbol{e}_{it} = \alpha_0 + \alpha_1 \boldsymbol{e}_{it-1} + \mu_{it}, \qquad (4)$$

where $\mu_{it} \sim \boldsymbol{N}(0, \boldsymbol{h}_{it})$ and the conditional variance is:

$$\boldsymbol{h}_{it} = \beta_0 + \beta_1 \mu_{it-1}^2 + \beta_2 \boldsymbol{h}_{it-1}. \qquad (5)$$

The conditional variance represents three terms: the mean, β_0; the one-period lag of the squared residual from the exchange rate equation, μ_{it-1}^2 which represents news about the volatility from previous period (the ARCH term); and last period's forecast error variance, h_{it-1} (the GARCH term). The estimated conditional standard deviation of the first month of the quarter will be used as the approximation of the conditional volatility of that quarter.

Among the sample countries, Indonesia, Malaysia, the Philippines and Thailand are members of the Association of South East Asian Nations (ASEAN). These countries established the ASEAN Free Trade Area (AFTA) in January 1992. Therefore, a dummy variable for the membership of AFTA is included from 1993:Q1 onwards. In addition a dummy that represents the presence of a common border (*CB*) is included. Distance (*Dist*) is the shipping distance between two countries and the information is available from www.portworld.com.

Table 2 Descriptive Statistics of the Main Variables

	China	Indonesia	Malaysia	Philippines	Thailand	All Countries
A. Log of real exports						
Mean	19.7410	18.6642	19.0864	17.8807	18.9541	18.8653
Std. Dev.	1.6978	1.8715	1.5385	1.6948	1.4702	1.7671
Min	14.7062	4.6363	13.8552	13.4289	14.1361	4.6363
Max	24.6001	22.4048	22.6719	21.8714	22.2581	24.6001
B. Real exchange rate volatility						
1. Standard Deviation: 8 quarters (SD-8q)						
Mean	0.0689	0.0971	0.0545	0.0731	0.0614	0.0710
Std. Dev.	0.0444	0.0792	0.0332	0.0368	0.0424	0.0521
2. Moving Average Standard Deviation (MASD)						
Mean	0.0877	0.1283	0.0728	0.0997	0.0825	0.0942
Std. Dev.	0.0552	0.1087	0.0484	0.0566	0.0657	0.0729
3. GARCH volatility						
Mean	0.0028	0.0067	0.0013	0.0026	0.0017	0.0030
Std. Dev.	0.0064	0.0184	0.0029	0.0088	0.0087	0.0105
4. Standard Deviation: 4 quarters (SD-4q)						
Mean	0.0638	0.0881	0.0509	0.0700	0.0559	0.0657
Std. Dev.	0.0512	0.0871	0.0386	0.0451	0.0487	0.0582
C. Correlations between aggregate exports and exchange rate volatility						
SD-8q	-0.1223	0.0023	-0.0470	-0.1992	-0.0689	-0.0904
MASD	-0.0649	0.0025	-0.0529	-0.1748	-0.0626	-0.0871
GARCH	-0.0915	-0.0203	-0.0229	-0.0720	-0.0337	-0.0471
SD-4q	-0.0995	-0.0120	-0.0480	-0.1579	-0.0455	-0.0842

Source: Direction of Trade Statistics.

Summary statistics of the two main variables, real exports and exchange rate volatility, are presented in Table 2. Among the five countries, the real exchange rate of Indonesia exhibits the highest volatility during the sample periods. In contrast, the Malaysian Ringgit is relatively stable. It is noteworthy that China has the third most volatile real exchange rate among the sample countries, although its nominal exchange rate was pegged to the US dollar until July 2005. Pegging to one currency still leaves the economy exposed to macroeconomic fluctuations that affect price levels and lead to the volatility of real exchange rates. The correlations between exchange rate volatility and exports are negative except for two exchange rate volatility measures for Indonesia.

c. Methods of estimation

There are apparent advantages of using panel data (Baltagi, 2001). Panel data estimation allows us to control for unobserved individual heterogeneity. If such unobservable effects are omitted and are correlated with the independent variables, OLS estimates would be biased. In addition, the use of panel data can eliminate the effects of omitted variables that are specific to individual cross-sectional units but stay constant over time (Hsiao, 1999). This advantage is important for the current analysis since cross-country structural and policy differences may have impact on trade flows.

Because our analysis focuses on a specific set of East Asian and industrialised countries and employs data with a relatively long time dimension, the fixed-effect estimator is considered as the most appropriate method. Hsiao (1999) notes that if the time dimension (T) of the panel is sufficiently larger than the cross-sectional dimension (N), then the fixed effects coefficients are consistent and asymptotically efficient. The fixed-effect regression equation to be estimated is

$$\ln X_{ijt} = \gamma_t + \alpha_{ij} + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln RP_{ijt} + \beta_4 VOL_{ijt} + \beta_5 CB_{ij} + \beta_6 AFTA_{ijt} + \beta_7 Dist_{ij} + \varepsilon_{ijt}, \quad (6)$$

where α_{ij} is the unobservable country-pair specific effect. In this analysis, there are 85 country-pair-specific dummy variables. These dummy variables capture the time invariant country-pair specific effects, such as cultural, economical, and institutional country-pair-specific factors that are constant over time and are not explicitly represented in the model (Dell'Arricia, 1999).

Note that the intercept is allowed to change over time in order to account for the effects of omitted variables that are specific to each time period but are the same for all country-pairs. For example, the temporal effects of technological change or oil price shocks will be captured by the time-variant intercept. In order to check the robustness of results and to control for the effect of the time-invariant explanatory variable – existence of common border and distance between two countries – the random-effects estimation technique is also employed.

4 Estimation results

a. Panel unit root and cointegration tests

As explained in the previous section, the time dimension of the panel data used in this study is relatively long. In order to avoid problems of spurious regression, the first step is to verify the existence of long-rung relationships among the variables. In this paper, the IPS test (Im, Pesaran, and Shin, 2003) and the Hadri LM test (Hadri, 2000) are employed to test for panel unit root and the results are presented in Table 3. The results of the IPS test indicate that the null of non-stationarity is rejected for exchange rate volatility variables. However, the null hypothesis of the IPS test is that all series in the panel are non-stationary processes against the alternative hypothesis of a fraction of the series in the panel being stationary. If one of the series of the panel is stationary, the IPS test will reject the null of non-stationarity in all series. Karlsson and Löthgren (2000) demonstrate that, for a panel data set with large *T*, the IPS test has high power and there is a potential risk of concluding that the whole panel is stationary even when there is only a small proportion of stationary series in the panel. Therefore the rejection of the null of non-stationary suggested by the IPS test does not imply that all series in the panel are stationary processes.

Table 3 Panel Unit Root Tests

Variables	**IPS test (t-statistics)**		**Hadri LM test (Z_μ statistics)**	
	Level	Difference	Level	Difference
Real Exports	4.802	-83.356*	484.116*	-6.289
	(1.000)	(0.000)	(0.000)	(1.000)
Home Income	2.969	-44.983*	563.317*	-1.745
	(0.998)	(0.000)	(0.000)	(0.959)
Foreign Income	-1.036	-91.615*	575.029*	-6.273
	(0.150)	(0.000)	(0.000)	(1.000)
Relative Price	-0.938	-7.256*	362.871*	-4.269
	(1.000)	(0.000)	(0.000)	(1.000)
Volatility (SD-8q)	-5.748*	-68.328*	50.360*	-5.262
	(0.000)	(0.000)	(0.000)	(1.000)
Volatility (MASD)	-10.631*	-78.641*	49.403*	-5.489
	(0.000)	(0.000)	(0.000)	(1.000)
Volatility (GARCH)	-45.927*	-112.237*	23.885*	-9.542
	(0.000)	(0.000)	(0.000)	(1.000)
Volatility (SD-4q)	-16.999*	-77.175*	26.165*	-8.478
	(0.000)	(0.000)	(0.000)	(1.000)

Notes: * indicates significance at 1 percent level. Values in parentheses are p-values. Null hypothesis of IPS test is that each series in the panel is integrated of order one. Null hypothesis of Hadri LM test is that each series is level stationary with heteroskedastic disturbances across units. SD, MASD and GARCH are different measures of exchange rate volatility which are standard deviation, moving average standard deviation and Generalised Auto-Regressive Conditional Heteroskedasticity, respectively.

In contrast, the null hypothesis of Hadri's (2000) Lagrange multiplier test is that all series in the panel are stationary. The results of the Hadri LM test in Table 3 reject the null of stationarity in all series of the panel. However, these results should also be interpreted with care. As the Hadri LM test is a generalization of the univariate KPSS unit root test, it may cause size distortion and tends to reject the true null hypothesis. When testing the stationarity of the first differences, the IPS test rejects the null of non-stationarity in all variables and the Hadri LM test suggests that all series of the panel are stationary. Therefore it can be concluded that variables of the sample follow an $I(1)$ process. If a linear combination of a set of $I(1)$ variables is $I(0)$, then there is a long-run equilibrium relationship. Table 4 reports the results of Pedroni's (1999) panel cointegration tests. Out of the seven statistics suggested by Pedroni (1999) we present four. The calculated statistics suggest that the null of no cointegration is rejected for all estimations. Therefore, there is strong evidence that supports the existence of a long-run relationship among the variables used in the paper.

Table 4 Pedroni (1999) Panel Cointegration Tests

Models	**Panel-*PP***		**Panel-*ADF***		**Group-*PP***		**Group-*ADF***	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Using SD 8 quarters	-12.01	-14.33	-4.09	-14.03	-11.80	-12.33	-4.82	-12.17
Using the MASD	-12.15	-14.59	-9.77	-14.27	-11.79	-12.41	-7.80	-12.25
Using GARCH	-12.01	-15.42	-5.38	-14.49	-11.46	-12.66	-6.64	-11.91
Using SD 4-quarters	-11.82	-14.36	-4.21	-6.34	-11.83	-12.50	-4.90	-6.23

Notes: The critical value at 1% significance level is -2.0. Null hypothesis is no cointegration. Column (1) shows the statistics of the model with heterogeneous intercept. Column (2) shows the statistics of the model with deterministic intercept and trend.

b. The impact of exchange rate volatility on exports

The main results of the country-pair fixed effect and random effect estimations for the period from 1982:Q1 to 2006:Q4 are presented in Table 5. All estimation results confirm that the impact of bilateral exchange rate volatility on bilateral exports is negative and statistically significant in both fixed-effect and random-effect estimations. The finding of significant negative impact of exchange rate volatility is evident in all sample periods. The result is also robust across the different measures of exchange rate volatility. As the sample countries are not randomly drawn from some underlying population and the prediction to be made is for these particular countries, the fixed-effect estimation approach is considered to be more appropriate for the current analysis. But the results from the random-effect estimation are also presented to report the estimated coefficients of time-invariant variables – the sharing of a common border and the distance between two countries.

As discussed in the methodology section, there is no theoretically obvious optimal measure of exchange rate volatility. A common if questionable approach in the literature has been to choose the measure of volatility which provides the most significant results of the appropriate sign based on econometric model selection criteria. [5] Based on model selection criteria such as R-square, AIC (Akaike Information Criterion) and BIC (Schwarz Bayesian Information Criterion), the model based on the GARCH measure seems to be the “optimal” model of estimation. However, it has been argued that the ARCH-based volatility measure is more suitable for high frequency data such as daily exchange rates. Data on quarterly exchange rates are collected at the end of each quarter. During two collection points exchange rate may fluctuate widely, but it may end up close to their previous quarter value at the end of the quarter. For this reason, it may not be vary precise to measure the volatility of low frequency data using GARCH.[6] Therefore, exchange rate volatility measure based on standard deviation of the first difference of the log real exchange rate over 8 quarters is considered as a suitable measure and is employed as benchmark measure of volatility.

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[5] For example Kumar and Dhawan (1991) tested over 15 different measures of exchange rate volatility and selected the optimal measure based on the standard criteria of ‘Goodness of fit’ such as R-square or *t*-statistics.

[6] In order to overcome the problem Klaassen (2004) and Baum *et al.* (2004) use daily exchange rate to construct the volatility of monthly exchange rate. But for our sample countries, during the sample period, daily exchange rates are not readily available.

Table 5 Effect of Exchange Rate Volatility on Exports

Variables	SD (8q)		MASD		GARCH		SD (4q)	
	FE	RE	FE	RE	FE	RE	FE	RE
Home Income	0.8179*	0.8013*	0.8205*	0.8036*	0.8245*	0.8087*	0.8223*	0.8051*
	(0.0327)	(0.0314)	(0.0327)	(0.0314)	(0.0326)	(0.0314)	(0.0326)	(0.0313)
Foreign income	0.9673*	0.9433*	0.9689*	0.9446*	0.9633*	0.9415*	0.9678*	0.9434*
	(0.0400)	(0.0352)	(0.0400)	(0.0351)	(0.0399)	(0.0354)	(0.0400)	(0.0351)
Relative price	-0.0008	-0.0012	-0.0001	-0.0006	-0.0006	-0.0010	-0.0007	-0.0011
	(0.0056)	(0.0055)	(0.0056)	(0.0055)	(0.0056)	(0.0055)	(0.0056)	(0.0055)
Volatility	-0.6786*	-0.6960*	-0.3021*	-0.3140*	-3.4688*	-3.4929*	-0.5048*	-0.5161*
	(0.1463)	(0.1464)	(0.1065)	(0.1066)	(0.6167)	(0.6169)	(0.1246)	(0.1247)
Common border	-	0.7697^	-	0.7734^	-	0.7675^	-	0.7713^
		(0.4227)		(0.4222)		(0.4379)		(0.4188)
FTA	0.1438*	0.1513*	0.1389*	0.1493*	0.1451*	0.1547*	0.1427*	0.1533
	(0.0358)	(0.0352)	(0.0359)	(0.0352)	(0.0358)	(0.0352)	(0.0359)	(0.0352)
Distance	-	-0.8343*	-	-0.8319*	-	-0.8369*	-	-0.8340*
		(0.1384)		(0.1382)		(0.1432)		(0.1371)
R-square (within)	0.7188		0.7183		0.7191		0.7186	
AIC	13129.01		13142.77		13118.69		13134.23	
BIC	13869.04		13882.79		13858.71		13874.25	

Notes: The figures in parentheses are standard errors. *, ** and ^ in the table denote statistical significant coefficients at 1%, 5% and 10% level, respectively. SD, MASD and GARCH are different measures of exchange rate volatility which are standard deviation, moving average standard deviation and Generalised Auto-Regressive Conditional Heteroskedasticity, respectively. R-square *within* describes the goodness of fit for the observations that have been adjusted for their individual means.

The estimation results confirm that the impact of bilateral exchange rate volatility on the exports of emerging East Asian countries is negative and statistically significant for both estimation methods although the magnitudes are different across the volatility measures. The finding of a negative impact of bilateral exchange rate volatility on exports is consistent with some previous studies which analyse different samples of Asian countries (for example, Bénassy-Quéré and Lahrèche-Révil, 2003; Baak, 2004; Chit, 2008).

The estimation results using the benchmark volatility measure suggest that an increase in exchange rate volatility by one standard deviation (5.2 percent) around its mean would lead to a 3.5 percent reduction of the bilateral aggregate exports of the East Asian countries among themselves and to 13 industrialised countries.[7] This finding can be compared to the results of Chit (2008) who found only in the sample of ACFTA countries that an increase of one standard deviation leads to a 2.7 percent reduction in these countries' regional trade. It is interesting to point out that the impact of exchange rate volatility on exports to the world market is about 30 percent larger than the impact on intra-regional exports.

The estimated coefficients of the remaining variables are very similar across the different estimation methods and volatility measures. The coefficient of the importing country's income variable is significant and positive but markedly less than unity. It indicates that income elasticity of demand for the exports of the five East Asian countries is positive but less than one which suggests that the exports of these countries are normal, but necessity, goods. This finding is in line with the presumption underlying our model specification choice that exports from the

[7] This impact is computed as the estimated coefficient of volatility measure in the benchmark equation is multiplied by one standard deviation of the volatility measure and then multiplied by 100 to convert into percent. For other measures of exchange rate volatility, reduction in exports as a result of one standard deviation increase in the exchange rate volatility ranges from 2.2% (MASD measure) to 3.6% (GARCH measure).

emerging East Asian countries are predominantly inter-industry trade flows comprising raw materials and intermediate goods. Our finding can be compared to the study by Hondroyiannis *et al*. (2006) who found income elasticities of exports in the range of 1.6-1.7 for the G-7 countries. Bénassy-Quéré and Lahrèche-Révil (2003) who estimate the relationship between exports and exchange rate in several Asian countries found that the income elasticity of exports is around 1.1, yet the sample of their study is the combination of emerging and developed Asian economies.

The estimated coefficient of the exporting country's income, which represents the size of exporting country, is positive and significant as expected. All dummy variables are significant and show the expected sign. However, the coefficient of the relative price variable is insignificant in all estimations. A potential explanation for this finding might be that bilateral imports among the sample East Asian countries consist, to a large extent, of non-competing imports of necessity goods such as raw material and intermediate inputs, which are price-insensitive.

c. Controlling for potential endogeneity

The results from the fixed-effect estimation may not be reliable because of two problems. The first one is the potential problem of endogeneity. If the sample countries implement policies aimed at lowering bilateral exchange rate volatility in order to increase their exports, the model considered would suffer an endogeneity bias. The inclusion of country-pair fixed-effect dummy variables could control for the potential endogeneity if the relative size of trade partners remains the same over the period considered (see Dell'Ariccia, 1999). If this is not the case, the assumption that exchange rate volatility is exogenous to exports may not be warranted. Tenreyro (2007) points out that the potential endogeneity is one of the main problems that cast doubt on the findings of previous empirical studies. In order to control for this possibility, the instrumental variable (IV) approach is employed. Following Frankel and Wei (1993) and Clark *et al.* (2004), the volatility in the relative money supply is used as an instrumental variable. The rationale of using the standard deviation of the relative money supply as an instrument for the exchange rate volatility is that although relative money supplies are highly correlated with bilateral exchange rate, the monetary policies are less affected by export considerations than exchange rate policies (Frankel and Wei, 1993).

The second potential problem is that individual effects may vary over time as a result of omitted macroeconomic shocks. If the sample countries respond differently to time-varying unobservable macroeconomic shocks, the fixed-effect panel data estimation may be subject to the problem of heteroskedasticity. Tenreyro (2007) demonstrates that when residuals are heteroskedastic, the estimated OLS coefficients will be biased. In order to control for this possibility and as a further robustness check, the Generalised Method of Moments (GMM) estimation technique is employed. Baum *et al.* (2003) point out that in the presence of heteroskedasticity the GMM estimator is more efficient than the simple IV estimator.

The results of the GMM-IV estimation for the benchmark model are presented in Table 6. In order to estimate the coefficients of time invariant variables, the results of Generalised Two Stages Least Square (G2SLS) estimation are also reported. Various diagnostic tests confirm that the volatility of relative money supply is a valid instrument for the exchange rate volatility. The Anderson-Canon test is used to check for underidentification, i.e., whether the instruments are correlated with endogenous regressors. Rejecting the null hypothesis means that the model is identified. We also perform a weak ID test suggested by Stock and Yogo (2005) to identify the problem of weak instruments. If the instruments were weak, the IV estimators would be biased.[8] We find that the Cragg-Donald *F*-statistic is greater than the critical value provided by Stock and Yogo (2005). Therefore, the null hypothesis of weak instruments can be rejected. The Sargan-Hansen test is for verifying overidentification. The joint null hypothesis is that the instruments are valid, i.e., uncorrelated with the error term, and that the instruments are correctly excluded from the estimated equation. Applying the test we were not able to reject the joint null hypothesis.

Table 6 Controlling for Endogeneity of Exchange Rate Volatility

Variable	**GMM-IV (with Robust Standard Error)**	**G2SLS-IV (Random Effects)**
Home income	0.7751*	0.7616*
	(0.0361)	(0.0343)
Foreign income	0.9771*	0.9466*
	(0.0506)	(0.0372)
Relative price	0.0039	0.0035
	(0.0057)	(0.0058)
Volatility	-5.2566*	-5.2351*
	(0.9429)	(0.6535)
Common border	-	0.7155^
		(0.4275)
FTA	0.1474*	0.1603*
	(0.0406)	(0.0372)
Distance	-	-0.8393*
		(0.1398)
R-square (within)	0.6840	
Anderson-Canon Corr. LR statistic	262.943*	
Cragg-Donald F-statistic	153.702*	
Hansen J statistic	0.013	

Notes: *, ** and ^ in the table denote statistical significant coefficients at 1%, 5% and 10% level, respectively. The null hypothesis of Anderson Canon test is underidentification. Cragg-Donald F-statistics tests for weak identification. 10% critical value of Stock-Yogo weak ID test is 19.93.

[8] Stock and Yogo (2005) suggest two definitions of weak instruments and provide a table of critical values to test whether instruments are weak by using the Cragg-Donald *F*-statistic (first-stage *F*-statistics). The null hypothesis is that a given group of instruments is weak against the alternative that it is strong.

The results of the GMM-IV estimation show that all coefficients still have the right sign and are significant at 1 percent level, except the relative price variable. The results are qualitatively and quantitatively similar to our main results. Note that the coefficient of exchange rate volatility variable is considerably larger than previous estimates.[9] The results of the GMM-IV estimation suggest that the assumption of exchange rate volatility being exogenous to exports is valid. In other words, the negative correlation between real exchange rate volatility and exports of the sample countries is not determined solely by simultaneous causality bias.

d. Competitiveness of the East Asian countries on third markets

One characteristic of the emerging East Asian economies is that although they are increasingly interdependent and attempt to promote their regional cooperation, they compete against each other in world markets. The study of Roland-Holst and Weiss (2004) provides strong evidence that the main ASEAN countries have been exposed to increasing competition from China. Eichengreen *et al.* (2007) also find that the growth of Chinese exports led to slow-down in the exports of other Asian countries, especially for consumer goods. In this section we examine the effect of relative competitiveness on the exports of emerging East Asian countries.

We construct an appropriate variable that represents the competitiveness of each East Asian country relative to other countries from the sample. The level of competitiveness of an exporting country relative to other countries is computed as the ratio of the bilateral real exchange rate between the exporting country and the importing country, $\boldsymbol{E}_{ijt}$, and the real effective exchange rate of the sample countries, $\boldsymbol{RE}_{Sjt}$, which is weighted by the export share of sample countries to the importing

[9] Clark *et al.* (2004) also report larger coefficients when using IV estimation.

country.[10] Thus, an increase in the level of competitiveness of the exporting country *i*, relative to the rest of the sample East Asia countries, to the destination country *j* is expected to have positive impact on the exports of *i* to *j*. The benchmark model becomes:

$$\begin{aligned}\ln \boldsymbol{X}_{ijt} &= \gamma_t + \alpha_{ij} + \beta_1 \ln \boldsymbol{Y}_{it} + \beta_2 \ln \boldsymbol{Y}_{jt} + \beta_3 \boldsymbol{Comp}_{ijt} + \beta_4 \boldsymbol{VOL}_{ijt} \\ &+ \beta_5 \boldsymbol{CB}_{ij} + \beta_6 \boldsymbol{AFTA}_{ijt} + \beta_7 \boldsymbol{Dist}_{ij} + \varepsilon_{ijt}\end{aligned}, \qquad (7)$$

where $Comp_{ijt}$ represents the level of competitiveness of the exporting country against the rest of the sample countries to a destination market.

The estimation results presented in Table 7 show that an increase in the competitiveness of an emerging East Asian country against others has positive impact on its exports to a destination market, but the magnitude of the impact is very small relative to the negative impact of exchange rate volatility. Our estimation results suggest that the impact of a favourable exchange rate, relative to other regional competitors, on exports is inconsequential. This reinforces the views of Adams *et al.* (2006) and Roland-Holst and Weiss (2004) who find that there is no monocausal explanation for the export performance of East Asia and the favourable exchange rate is only one factor. It also depends on other factors such as specialization, technology sophistication and consumer preferences.

We also tested for the impact of the 1997 financial crisis on exports of the sample countries. During the crisis period, East Asian countries experienced a rapid fall in their currencies value against the U.S. dollar. For example, between June 1997 and September 1998, Indonesia's currency depreciated 77.7 percent in nominal terms and 56.3 percent in real terms. In addition, the extent of the changes in macroeconomic indicators – such as interest rate and stock market index – was very

[10] Bénassy-Quéré and Lahrèche-Révil (2003) construct the same variable to estimate the level of competitiveness of East Asian countries competing in the world market.

large and the level of macroeconomic uncertainty was very high in these countries during the crisis period.[11] However, testing for the impact of the 1997 financial crisis by including a dummy variable, we find its coefficient insignificant (regression results are not reported). This result seems to suggest that in line with theory all potential adverse effects on exports, due to additional macroeconomic uncertainty during the crisis, are adequately captured by the volatility variable.

Table 7 Competitiveness of East Asian Countries on Third Markets

Variable	Fixed Effect	Random Effect
Home income	0.8177*	0.8014*
	(0.0327)	(0.0314)
Foreign income	0.9661*	0.9429*
	(0.0392)	(0.0347)
Competitiveness	0.0059*	0.0058*
	(0.0018)	(0.0018)
Volatility	-0.6921*	-0.7097*
	(0.1462)	(0.1462)
Common border	-	0.7683^
		(0.4246)
FTA	0.1412*	0.1517*
	(0.0356)	(0.0349)
Distance	-	-0.8367*
		(0.1385)
R-square (within)		0.7191

Notes: *, ** and ^ in the table denote statistical significant coefficients at 1%, 5% and 10% level, respectively.

5 Conclusion

In this paper we examine the impact of bilateral real exchange rate volatility on real exports of five emerging East Asian countries among themselves as well as to 13 industrialised countries. Panel unit-root and cointegration tests are used to verify the long-run relationship among the variables. The results provide evidence that exchange rate volatility has a negative impact on the exports of emerging East Asian countries.

[11] For example, before the financial crisis, average interest rate of the Philippines was 11.7% in 1996. During the crisis period it hit the highest point of 85% in October, 1997. During that period Malaysia experienced 52.2% fall in the stock market (Karunatilleka, 1999)

These results are robust across different estimation techniques and seemingly do not depend on the variable chosen to proxy exchange rate uncertainty.

The problems of a possible simultaneity bias and heteroskedasticity are addressed by employing GMM-IV estimation technique. The results of the GMM-IV estimation also confirm the negative impact of exchange rate volatility on exports and suggest that this negative relationship is not driven by simultaneous causality bias.

The impact of the level of competitiveness among the sample countries is also examined. The findings confirm that, for the sample countries, the increase in competitiveness of a country relative to others has positive impact on exports, but the magnitude is relatively inconsequential.

The empirical results derived in this paper are consistent with findings of studies on both developed and less developed countries suggesting that exchange-rate volatility in emerging East Asia economies has a significant negative impact on the export flows to the world market. Compared with the results of Chit (2008) who examines the effect of exchange rate volatility on the bilateral exports among the main members of ACFTA countries, the impact of exchange rate volatility on exports to the world market is about 30 percent larger than its impact on intra-regional exports.

Thus, the results of our paper suggest that sample countries should focus on stabilising their exchange rates vis-a-vis the main trading partners rather than solely pursuing regional monetary and exchange rate policy cooperation, at least in the short run.

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