The World Economy

The World Economy (2010)
doi: 10.1111/j.1467-9701.2009.01230.x

Exchange Rate Volatility and Exports: New Empirical Evidence from the Emerging East Asian Economies

Myint Moe Chit[1], *Marian Rizov*[1] *and Dirk Willenbockel*[2]

[1]*Middlesex University Business School and* [2]*Institute of Development Studies at the University of Sussex*

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 liberalisation of capital flows and the associated intensification of cross-border financial transactions also 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 reflected in the creation of the

Helpful comments from an anonymous referee which led to substantive improvements of the paper are gratefully acknowledged.

[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.

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

TABLE 1
Exports of Emerging East Asian Countries to Major Trading Partners (Per Cent 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$)	969,284	113,645	160,664	46,976	130,555

Source: IMF Direction of Trade Statistics Database.

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.

Some previous empirical studies analyse the impact of exchange rate volatility on trade of developing countries (e.g. Arize et al., 2000, 2008; Doğnalar, 2002) but they do not specifically focus on the emerging East Asian countries and do not use bilateral data.[3] The major advantage of analysing bilateral rather than aggregate multilateral trade flows is the possibility of controlling 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 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 industrialised 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 different estimation methods.

The paper contributes to the literature in two important ways. First, we explicitly recognise the specificity of the exports between the emerging East Asian and industrialised countries and employ a generalised gravity model to address 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 industrialised 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.

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, definition of variables and data sources. Section 4 presents and discusses the estimation results. Section 5 draws conclusions.

---

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

[3] Recently, Chit (2008) examines the relationship between real exchange rate volatility and bilateral trade flows but only among the members of the ASEAN–China Free Trade Area.

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 (see e.g. Clark, 1973; Ethier, 1973; Hooper and Kohlhagen, 1978; Kawai and Zilcha, 1986). 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 realised exchange rate. If the firm's objective is to maximise 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 minimise 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 opportunities for firms if they can protect themselves from negative effects by hedging or if they have the ability to adjust trade volumes to movements in the exchange rate. Franke (1991) and Sercu and Van Hulle (1992) demonstrate that an increase in exchange rate volatility can increase the value of exporting firms and thus can promote export activities. De Grauwe (1994) shows that the increase in exchange rate volatility can increase output and the 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 a large domestic market base has the ability to benefit from exchange rate movements by reallocating products between the domestic and foreign market. Thus, higher exchange rate volatility can increase the potential benefits from international trade. Moreover, from the political economy point of view asserted by Brada and Méndez (1988) exchange rate movements facilitate the adjustment of the balance of payments in the event of external shocks, and thus reduce the use of trade restrictions and capital controls to achieve equilibrium, and this in turn encourages international trade.

In brief, the theoretical results are conditional on 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 empirical 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.[4] 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 essentially find 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), also find a negative impact of exchange rate risk on trade volume, but the effect is, in most cases, relatively small.

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.

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 an 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 specification, 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

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

exchange rate volatility to zero in 1994 would have increased trade by 3 to 4 per cent.

Rose (2000), Clark et al. (2004) and Tenreyro (2007) also employ panel data covering more than 100 countries. Using a random-effect model, Rose (2000) found that the impact of exchange rate volatility on trade is significantly negative; an increase in exchange rate volatility by one standard deviation around the mean would reduce bilateral trade by 4 per cent. Clark et al. (2004) find a negative and significant impact of exchange rate volatility on trade in their benchmark results; a one standard deviation increase in exchange rate volatility would reduce trade by 7 per cent.[5] Recently, Tenreyro (2007) reports a small negative effect; reducing exchange rate volatility to zero raises trade by only 2 per cent. However, when an instrumental variables approach is used to overcome the problem of endogeneity, the effect of exchange rate volatility on trade becomes insignificant. By utilising a panel data and fixed-effect estimator, Chit (2008) finds that total elimination of exchange rate volatility in 2004 would have increased the intra-regional trade of ACFTA by 5 per cent.

A common feature of the majority of empirical studies is that they focus on the direct effect of exchange rate volatility on trade. However, Cushman (1986) argues that in addition to the direct effect of exchange rate in level terms and exchange rate volatility, it is also important to account for the possibility of third-country effects. Since exports between two countries are not only affected by the relative prices and exchange rate volatility between those countries, but also by the relative prices and exchange rate volatility of third-country competitors, omission of the third-country effects could lead to biased results when estimating bilateral trade equations. There are a number of studies which incorporate third-country effects, but the results of these studies are mixed. For instance, Cushman (1986) and Cho et al. (2002) find evidence suggesting that third-country effects do influence bilateral trade between two trading partners. In contrast, Wei (1996) and Dell'Ariccia (1999) report that the third-country effects are not significant.

3. RESEARCH METHODOLOGY

There are two apparent drawbacks of the research summarised in the previous section. The majority of the empirical studies that focus on the relationship between exchange rate volatility and bilateral trade employ the gravity model (e.g. Dell'Ariccia, 1999; Rose, 2000; Baak, 2004; Clark et al., 2004; Tenreyro, 2007). In these studies, the gravity model is augmented with other factors that

[5] However, the finding of a negative impact of exchange rate volatility is not significant in a specification with time-varying fixed effects.

can affect trade flows such as sharing a common border, common language, membership of a 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 the gravity model in studies with mixed samples 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, the longer time dimension of the panel data (for 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 (number 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 this paper aims to mitigate the drawbacks discussed above. First, a generalised 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

The empirical specification is a generalised gravity model in the spirit of Bergstrand (1985). Bergstrand derives a reduced-form equation for bilateral exports with gravity variables and additional price terms from a multi-country trade model with inter-country product differentiation. This specification may be considered more suitable for a panel data study of emerging economy exports than the standard gravity equation, which can be derived from a monopolistic competition intra-industry trade model with horizontal intra-country firm-level product differentiation. The latter appears more appropriate for bilateral trade flows among developed countries. In line with Aristotelous (2001), the additional price terms of the generalised gravity model are approximated by inclusion of a relative price variable. Although the emerging East

Asian economies are increasingly interdependent and attempt to promote their regional cooperation, they compete against each other in world markets. Roland-Holst and Weiss (2004) provide 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 a slowdown in the exports of other Asian countries, especially for consumer goods. Therefore, bilateral export flows may not only depend on bilateral real exchange rates between the trading partners when other countries compete on the destination markets. Bénassy-Quéré and Lahrèche-Révil (2003) state that this problem is particularly important for emerging countries since a large share of their exports go to the same developed-country markets and they have a relatively close specialisation structure. In order to control for the impact of competition for exports among the emerging East Asian countries, we also include third-country effect variables similar to those of Cushman (1986).[6]

Thus, our empirical model is specified as follows:

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

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 between the trading partners (RP), relative prices between the importing country and other exporting countries (RP^{Third}), bilateral exchange rate volatility (VOL), third-country exchange rate volatility (VOL^{Third}) and a set of gravity variables – the distance between the two countries ($Dist$), an indicator for sharing of a common border (CB), and an indicator for membership of the ASEAN Free Trade Area ($AFTA$).

According to the gravity model of international trade, the export volume between two countries is expected to be positively related to the GDPs of the exporting and importing country and negatively related to the distance between those countries. A higher price level in the importing country relative to the exporting country will induce more exports from the exporting country, so the real exports are expected to be positively related to the relative price variable. In contrast, price competition from third countries, which is represented by the weighted average of relative prices between the importing country and other exporting countries, is expected to have a negative impact on bilateral exports. In addition, sharing a common border and the membership of a free trade agreement are expected to increase bilateral trade flows between two countries whilst the distance between them is negatively related to bilateral exports.

[6] The authors owe thanks to an anonymous referee for pointing out the issue of third-country effects on bilateral trade.

b. Data and Definition of Variables

A panel dataset 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 US dollars. All other data except exports are taken from the IMF *International Financial Statistics*.[7] Following the same procedure as Eichengreen and Irwin (1996) and Clark et al. (2004), we use the US GDP deflator to transform export values denominated in current US dollars into real exports (X).

Real GDPs of the home country (Y) and of the importing country (Y^*) are constructed by deflating quarterly GDP in current local prices with each country's GDP deflator followed by conversion into a common currency (US dollars).

Theoretically, the bilateral relative price variable should be the ratio of an index of the prices of import-substitute goods in the importing country to an index of the export prices for the exporting country. This type of relative price can represent the substitution effect more realistically as the importer compares the price of imports with the domestic price level. Since such a measure is not readily available for the sample countries, this paper follows the method employed in Doyle (2001) and Sauer and Bohara (2001). The relative price variable (RP) is constructed as the ratio of the consumer price index (CPI) of an importing country to the wholesale price index (WPI) of an exporting country expressed in terms of the exporting country currency:

$$RP_{ijt} = \frac{CPI_{jt}}{WPI_{it}} E_{ijt}, \tag{2}$$

where E_{ijt} represents the price of importing country (j) currency in terms of exporting country (i) currency.

Third-country variables are computed as a weighted average of relative prices and exchange rate volatilities of the other exporting countries and each importing country. Specifically, the third-country competition measure is given by:

$$RP_{ijt}^{Third} = \sum w_{ijt} RP_{ijt}, \tag{3}$$

and the third-country exchange rate volatility is constructed as:

[7] For China, the data for quarterly CPI are 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.

$$Vol_{ijt}^{Third} = \sum w_{ijt} Vol_{ijt}, \tag{4}$$

where w_{ijt} represents the share of exports from country i in country j's total imports from the sample countries.[8]

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. Dell'Ariccia, 1999; Kumar and Dhawan, 1999; Clark et al., 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. Dell'Ariccia (1999) points out that 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:

$$V_{ijt} = \sqrt{\sum_{t=1}^{m} \left(\Delta e_{ijt} - \Delta \bar{e}_{ijt}\right)^2 \Big/ m - 1}, \tag{5}$$

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

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 (Klaassen, 2004). This measure defines exchange rate volatility as:

$$V_{ijt} = \sqrt{\sum_{k=1}^{m} (e_{ijt-k-1} - e_{ijt-k-2})^2 / m}, \tag{6}$$

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

[8] Our construction of third-country volatility is similar to the one used by Anderton and Skudelny (2001) and Cho et al. (2002).

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 et al. (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:

$$e_{it} = \alpha_0 + \alpha_1 e_{it-1} + \mu_{it}, \tag{7}$$

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

$$h_{it} = \beta_0 + \beta_1 \mu^2_{it-1} + \beta_2 h_{it-1}. \tag{8}$$

The conditional variance represents three terms: the mean, β_0; the one-period lag of the squared residual from the exchange rate equation, μ^2_{it-1} which represents news about the volatility from the previous period (the ARCH term), and the 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; the information is available from http://www.portworld.com.

Summary statistics of the main variables, real exports, relative prices 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 volatility of real exchange rates. The correlations between exchange rate volatility and exports are negative except for two exchange rate volatility measures for Indonesia.

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. Log of relative prices						
Mean	–2.1356	7.5233	0.3412	2.8457	2.7187	–1.3969
Std. Dev.	5.9895	1.6298	1.8243	1.2361	1.2137	7.0341
C. Log of third-country relative prices						
Mean	4.0203	0.6041	4.0028	4.2137	4.1107	3.3903
Std. Dev.	3.2639	2.1692	3.2151	3.1079	3.3680	3.3588
D. 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
E. Third-country volatility						
1. Standard Deviation: 8 quarters (SD-8q)						
Mean	0.0549	0.0495	0.0599	0.0571	0.0583	0.0559
Std. Dev.	0.3191	0.0197	0.0295	0.0331	0.0273	0.0289
2. Moving Average Standard Deviation (MASD)						
Mean	0.0740	0.0665	0.0793	0.0769	0.0772	0.0748
Std. Dev.	0.0487	0.0324	0.0419	0.0499	0.0384	0.0430
3. GARCH volatility						
Mean	0.0024	0.0014	0.0028	0.0024	0.0027	0.0024
Std. Dev.	0.0060	0.0015	0.0063	0.0059	0.0051	0.0053
4. Standard Deviation: 4 quarters (SD-4q)						
Mean	0.0508	0.0463	0.0553	0.0528	0.0542	0.0519
Std. Dev.	0.0347	0.0240	0.0329	0.0360	0.0309	0.0321
F. 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: IMF Direction of Trade Statistics Database.

c. Methods of Estimation

We examine the impact of real exchange rate volatility on the exports of the sample of five emerging East Asian economies over the period from 1982 to

2006 by using a panel data approach. 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 (Baltagi, 2001). 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 an 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:

$$\ln X_{ijt} = \gamma_t + \alpha_{ij} + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln RP_{ijt} + \beta_4 \ln RP_{ijt}^{Third} + \beta_5 VOL_{ijt} + \beta_6 Vol_{ijt}^{Third} + \beta_7 CB_{ij} + \beta_8 AFTA_{ijt} + \beta_9 Dist_{ij} + \varepsilon_{ijt}, \quad (9)$$

where α_{ij} is the unobservable country-pair specific effect which captures the time invariant country-pair-specific effects, such as cultural, economic and institutional country-pair-specific factors that are not explicitly represented in the model.[9]

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, a time-fixed effect variable (γ_t) is also included in the model. This variable will control for the temporal effects, for example changes in world income, technological change, oil price shocks or liquidity shocks, which are specific to each time period but are the same for all country pairs. Clark et al. (2004) emphasise that the time-fixed effect is particularly important since it can also control for temporal changes in the income of the rest of the world with respect to two trading partners. Their argument is that any changes in world income affect the share of income of a country, as well as its bilateral trade flows.[10]

[9] Mátyás (1998) proposes including two sets of country dummies (for exporting and importing countries). However, Egger and Pfaffermayr (2003) show that instead of having one dummy variable per country, individual country-pair dummies (fixed effects) and time dummies to control for common shocks should be used to get efficient estimators.

[10] For instance, a decrease in an importing country's income compared to the prior period would lead to a reduction in imports. However, if the world income decreases faster than the income of an importing country, the share of importer's income in the world income increases, resulting in more imports.

However, a major limitation of the fixed-effect estimation is that it wipes out all time-invariant explanatory variables because of the 'within transformation' process. In order to check the robustness of results and to control for the effects of the time-invariant explanatory variables – 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, we first verify the existence of long-run relationships among the variables. In this paper, the IPS test (Im, Pesaran and Shin, 2003) and the Hadri Lagrange Multiplier (LM) test (Hadri, 2000) are employed to test for panel unit roots and the results are presented in Table 3. The results of the IPS test indicate that the null of non-stationarity is rejected except for the relative price and foreign income variables.[11] However, Karlsson and Löthgren (2000) demonstrate that, for a panel dataset 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 non-stationarity by the IPS test might be a result of over-rejection associated with the test.

In order to overcome the inconclusiveness of the IPS test, we also conducted another panel unit-root test proposed by Hadri (2000).[12] The null hypothesis of Hadri's (2000) LM test is that all series in the panel are stationary. The results of the Hadri LM test reported in Table 3 reject the null of stationarity in all series of the panel. Although there is some ambiguity in the test results for stationarity of exchange rate volatility variables in level terms, both the IPS test and Hadri LM test prove that the first differences of all variables are stationary; that is, all 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 exists a long-run equilibrium relationship among the variables. We conducted panel cointegration tests proposed by Pedroni (1999) and report the results in

[11] 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. For instance, if one of the series in the panel is stationary, the IPS test will reject the null of non-stationarity in all series. 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.

[12] Thorbecke (2008) also employs three variants of panel unit-root tests in order to overcome the inconclusiveness of using only one panel unit-root test.

TABLE 3
Panel Unit Root Tests

Variables	*IPS Test (t-statistics)*		*Hadri LM Test (Z_μ statistics)*	
	Level	*Difference*	*Level*	*Difference*
Real Exports	–3.318*	–9.850*	484.116*	–6.289
	(0.000)	(0.000)	(0.000)	(1.000)
Home Income	–2.401*	–9.423*	563.317*	–1.745
	(0.004)	(0.000)	(0.000)	(0.959)
Foreign Income	–2.043	–8.633*	575.029*	–6.273
	(0.947)	(0.000)	(0.000)	(1.000)
Relative Price	–2.230	–7.260*	362.871*	–4.269
	(0.275)	(0.000)	(0.000)	(1.000)
Relative Price Competition	–2.765*	–8.345*	406.754*	–4.102
	(0.000)	(0.000)	(0.000)	(1.000)
Volatility (SD-8q)	–2.614*	–6.054*	50.360*	–5.262
	(0.000)	(0.000)	(0.000)	(1.000)
Volatility (MASD)	–2.876*	–7.957*	49.403*	–5.489
	(0.000)	(0.000)	(0.000)	(1.000)
Volatility (GARCH)	–4.949*	–9.365*	23.885*	–9.542
	(0.000)	(0.000)	(0.000)	(1.000)
Volatility (SD-4q)	–3.998*	–7.265*	26.165*	–8.478
	(0.000)	(0.000)	(0.000)	(1.000)
Third-country Volatility (SD-8q)	–2.744*	–6.858*	33.975*	–4.277
	(0.000)	(0.000)	(0.000)	(0.999)
Third-country Volatility (MASD)	–3.888*	–10.204*	31.724*	–5.425
	(0.000)	(0.000)	(0.000)	(1.000)
Third-country Volatility (GARCH)	–5.894*	–10.563*	6.182*	–9.590
	(0.000)	(0.000)	(0.000)	(1.000)
Third-country Volatility (SD-4q)	–3.912*	–7.682*	19.480*	–8.474
	(0.000)	(0.000)	(0.000)	(1.000)

Notes:
* indicates significance at 1 per cent 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 heteroscedastic disturbances across units. SD, MASD and GARCH are different measures of exchange rate volatility which are standard deviation, moving average standard deviation and Generalised Autoregressive Conditional Heteroscedasticity, respectively.

Table 4. The statistics calculated suggest that the null of no cointegration is rejected in all cases. Therefore, there is strong evidence in support of the existence of long-run relationships among the variables used in our analysis.

b. The Impact of Exchange Rate Volatility on Exports

The main results of the country-pair fixed-effect and random-effect regressions 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 the fixed-

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 per cent 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.

effect and the random-effect regressions.[13] Importantly, the finding of significant negative impact of exchange rate volatility on exports is robust for all sample periods, across different measures of exchange rate volatility, and to the inclusion of third-country effect variables.[14] Our 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 (e.g. Bénassy-Quéré and Lahrèche-Révil, 2003; Baak, 2004; Chit, 2008). All other variables are also significant and show the expected sign.

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.[15] Based on model selection criteria such as R-square, AIC (Akaike Information Criterion), and BIC (Schwarz Bayesian Information Criterion), the model based on the standard deviation of real exchange rate over eight quarters seems to be the optimal model. Therefore, the exchange rate volatility measure based on standard deviation of the first

[13] This equation was also estimated without country-fixed effects and time-fixed effects (results not reported), and an F-test (Chow test) confirmed that the inclusion of such effects is warranted.
[14] The coefficients of the GARCH exchange rate volatility measure are relatively larger than the coefficients of other measures of exchange rate volatility. This is due to the smaller value of GARCH volatility. It has been reported that GARCH measure is more suitable for high frequency data such as hourly or daily data. Since we used the monthly exchange rate to calculate GARCH volatility in our paper, it seems the capacity of capturing the underlying volatility has significantly reduced and as a result the calculated volatility measures are much smaller than other standard deviation-based volatilities. But when we compare the impact of exchange rate volatility, the impact is more or less the same as that calculated from other volatilities. (See also footnote 16.)
[15] 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.

TABLE 5
Estimation Results

Variables	*SD (8q)*		*MASD*		*GARCH*		*SD (4q)*	
	FE	*RE*	*FE*	*RE*	*FE*	*RE*	*FE*	*RE*
Home Income	0.7792***	0.7768***	0.7872***	0.7828***	0.7985***	0.7935***	0.7913***	0.7865***
	(0.0329)	(0.0315)	(0.0329)	(0.0316)	(0.0327)	(0.0315)	(0.0328)	(0.0315)
Foreign Income	1.0132***	0.9690***	1.0014***	0.9612***	1.0070***	0.9663***	1.0076***	0.9647***
	(0.0403)	(0.0354)	(0.0403)	(0.0354)	(0.0403)	(0.0356)	(0.0404)	(0.0353)
Relative Price	0.0903***	0.0580***	0.0793***	0.0496***	0.0852***	0.0552***	0.0827***	0.0518***
	(0.0139)	(0.0120)	(0.0138)	(0.0119)	(0.0138)	(0.0120)	(0.0137)	(0.0119)
Relative Price Competition	–0.0901***	–0.0602***	–0.0822***	–0.0544***	–0.0862	–0.0584***	–0.0838***	–0.0550***
	(0.0128)	(0.0112)	(0.0127)	(0.0111)	(0.0127)	(0.0112)	(0.0127)	(0.0111)
Volatility	–0.8004***	–0.7699***	–0.3853***	–0.3703***	–4.2341***	–4.07055***	–0.6006***	–0.5822***
	(0.1478)	(0.1477)	(0.1070)	(0.1070)	(0.6230)	(0.6228)	(0.1250)	(0.1251)
Third-country Volatility	2.0953***	1.9618***	1.1777***	1.1136***	5.9154***	5.5447***	1.6143***	1.5251***
	(0.3861)	(0.3857)	(0.2623)	(0.2623)	(1.4792)	(1.4795)	(0.3171)	(0.3171)
Common Border	–	0.8513**	–	0.8451**	–	0.8441**	–	0.8448**
		(0.4269)		(0.4258)		(0.4375)		(0.4213)
FTA	0.1434***	0.1515***	0.1489***	0.1563***	0.1493***	0.1564	0.1428***	0.1510***
	(0.0357)	(0.0352)	(0.0358)	(0.0352)	(0.0358)	(0.0352)	(0.0358)	(0.0352)
Distance	–	–0.8272***	–	–0.8263***	–	–0.8209***	–	–0.8249***
		(0.1397)		(0.1393)		(0.1431)		(0.1379)
R-square (within)	0.7211		0.7202		0.7210		0.7207	
AIC	13,061.42		13,090.38		13,064.66		13,074.53	
BIC	13,815.54		13,844.50		13,818.78		13,828.65	

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

difference of the log real exchange rate over eight quarters is employed as the benchmark measure of volatility.

Given that our volatility measures are not expressed in logarithms, the coefficients of the volatility terms are not elasticities. Therefore, we calculate the impact of exchange rate volatility by multiplying the estimated coefficient of volatility measure in the benchmark equation by one standard deviation of the volatility measure over the sample period, and then multiply the figure by 100 to convert into per cent. The estimation results using the benchmark volatility measure suggest that an increase in exchange rate volatility by one standard deviation (0.052) around its mean would lead to a 4.2 per cent reduction of the bilateral aggregate exports of the East Asian countries among themselves and to 13 industrialised countries.[16] Although such quantitative interpretation should be treated with caution, the estimation results appear to be quite consistent with the findings of other papers which employ comparable estimation techniques. Dell'Ariccia (1999), Rose (2000) and Clark et al. (2004) reported that an increase in exchange rate volatility by around 5 per cent would lead to a reduction in exports ranging from 4 per cent to 7 per cent.

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 close to unity as the theoretical foundations of the gravity model suggest.[17] Furthermore, the estimated coefficient of the home country's income is less than that of the importing country's income. This finding is consistent with the theoretical prediction and empirical findings of Feenstra et al. (2001) which demonstrate that a country's exports of homogeneous and internationally-differentiated products are more sensitive to the importing country's income than to its own income. Thus our result is in line with the presumption underlying our model specification that exports from the emerging East Asian countries are predominantly inter-industry trade flows comprising raw materials and intermediate goods.

Our estimation results also show that an increase in the relative price (real exchange rate depreciation) has a positive impact on bilateral exports between two countries. The estimated coefficient is 0.09. Given that the relative price variable is expressed in logarithms, it can be interpreted as a 1 per cent decrease in the relative price (real depreciation in exporting country currency

[16] 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 2.8 per cent (MASD measure) to 4.5 per cent (GARCH measure).

[17] See Baldwin and Taglioni (2006) for a theoretical derivation of gravity model predictions. Our empirical result can be compared to the study by Bénassy-Quéré and Lahrèche-Révil (2003) who estimate the relationship between exports and exchange rate volatility in several Asian countries and find that the income elasticity of exports is around 1.1.

with respect to the destination country currency) will lead to a 0.09 per cent increase in bilateral exports.

On the other hand, an increase in the price competitiveness (favourable exchange rate of the competitor countries) of other emerging East Asian countries has a negative impact on a country's exports to a destination market. The magnitude of the impact is 0.09 which is quite small in our study compared with the findings of Bénassy-Quéré and Lahrèche-Révil (2003) which reports the elasticity of 0.2. The possible explanation of this finding might be that the exports of the sample of East Asian countries consist to a large extent of necessary raw material and intermediate inputs and hence have relatively low price-sensitivity. In contrast, the sample of exporting countries used by Bénassy-Quéré and Lahrèche-Révil (2003) include Singapore, South Korea, Hong Kong and Taiwan which export relatively highly price-sensitive advanced manufactured and electronic products.

In addition to the bilateral exchange rate volatility, we also tested the impact of the third-country's exchange rate volatility. Our results suggest that a rise in exchange rate volatility between the importing country and other exporting countries encourages bilateral exports between two trading partners. It confirms that not only absolute volatility but also relative volatility is important for the bilateral export flows of emerging East Asian countries. The estimation results using the benchmark volatility measure (standard deviation – eight quarters) suggest that one standard deviation (0.0289) increase in exchange rate volatility between the importing country and other exporting countries would lead to a 6.04 per cent increase in the bilateral aggregate exports.

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 variables (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 heteroscedasticity. Tenreyro (2007) demonstrates that when residuals are heteroscedastic, the estimated OLS coefficients will be biased. To control for this possibility and as a further robustness check, a Generalised Method of Moments (GMM) estimator is employed. Baum et al. (2003) point out that in the presence of heteroscedasticity the GMM estimator is more efficient than the simple IV estimator.

TABLE 6
Controlling for Endogeneity of Exchange Rate Volatility

Variable	*GMM-IV (With robust standard error)*	*G2SLS-IV (Random effects)*
Home Income	0.7129***	0.7251***
	(0.0378)	(0.0351)
Foreign Income	1.0499***	0.9836***
	(0.0503)	(0.0376)
Relative Price	0.1607***	0.1047***
	(0.0239)	(0.0148)
Relative Price Competition	–0.1564***	–0.1050***
	(0.0221)	(0.0139)
Volatility	–5.9928***	–5.7154***
	(1.0231)	(0.7135)
Third-country Volatility	1.6462***	1.4354***
	(0.5159)	(0.4184)
Common Border	–	0.8457**
		(0.4235)
FTA	0.1577***	0.1655***
	(0.0404)	(0.0375)
Distance	–	–0.8135***
		(0.1388)
R-square (within)	0.6838	
Cragg–Donald (F)	143.930***	
Sargen–Hansen J-statistic	0.039 (p = 0.8433)	

Notes:
***, ** and * in the table denote statistical significant coefficients at 1 per cent, 5 per cent and 10 per cent level, respectively. Estimates are efficient for arbitrary heteroscedasticity and autocorrelation. Statistics are robust to heteroscedasticity and autocorrelation. Cragg–Donald F-statistic tests for weak identification. Ten per cent and 15 per cent critical value of Stock–Yogo weak ID test is 19.93 and 11.59, respectively.

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 a 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 exchange rate volatility. We conduct the Sargan–Hansen test to verify the validity of our instrument. The joint null hypothesis of the test 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. 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.[18] 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 results of the GMM-IV estimation show that all coefficients still have the right sign and are significant at the 5 per cent level. The results are qualitatively and quantitatively similar to our main results. Note that the coefficient of the exchange rate volatility variable is considerably larger than our previous estimates.[19] 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.

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 relationships among the variables. The results provide evidence that exchange rate volatility has a statistically significant negative impact on the exports of emerging East Asian countries.

Our estimation results also show that an increase in the price competitiveness of other emerging East Asian countries has a negative impact on a country's exports to a destination market, but the magnitude of the impact is relatively quite small. This reinforces the views of Adams et al. (2006) and

[18] 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.

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

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. Exports also depend on other factors such as specialisation, technology sophistication and consumer preferences.

We also tested the impact of exchange rate volatility of third countries to find out whether a rise in exchange rate volatility between the importing country and other exporting countries encourages bilateral exports between two trading partners. It confirms that not only absolute volatility but also relative volatility is important for bilateral export flows of emerging East Asian countries. These results are robust across different estimation techniques and seemingly do not depend on the variable chosen to proxy exchange rate uncertainty. In addition, we find that the negative impact of exchange rate volatility on bilateral exports is robust to the inclusion of a third-country volatility variable.

The problems of a possible simultaneity bias and heteroscedasticity are addressed by employing GMM-IV estimation techniques. 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 empirical results derived in our paper are consistent with the 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. Thus, our results suggest that sample countries should focus on stabilising their exchange rates vis-à-vis the main trading partners rather than solely pursuing regional monetary and exchange rate policy cooperation, at least in the short run.

REFERENCES

Adams, F., B. Gangnes and Y. Shachmurove (2006), 'Why is China So Competitive? Measuring and Explaining China's Competitiveness', *The World Economy*, **29**, 2, 95–122.

Anderton, R. and F. Skudelny (2001), 'Exchange Rate Volatility and Euro Area Imports', ECB Working Paper No. 64 (Frankfurt, European Central Bank).

Aristotelous, K. (2001), 'Exchange-rate Volatility, Exchange-rate Regime, and Trade Volume: Evidence from the UK–US Export Function (1889–1999)', *Economics Letters*, **72**, 1, 87–94.

Arize, A. C., T. Osang and D. J. Slottje (2000), 'Exchange-rate Volatility and Foreign Trade: Evidence from Thirteen LDCs', *Journal of Business and Economic Statistics*, **18**, 1, 10–17.

Arize, A. C., T. Osang and D. J. Slottje (2008), 'Exchange-rate Volatility in Latin America and its Impact on Foreign Trade', *International Review of Economics and Finance*, **17**, 1, 33–44.

Baak, S. J. (2004), 'Exchange Rate Volatility and Trade among the Asia Pacific Countries', Econometric Society Far Eastern Meeting, 2004.

Bahmani-Oskooee, M. and S. Hegerty (2007), 'Exchange Rate Volatility and Trade Flows: A Review Article', *Journal of Economic Studies*, **34**, 3, 211–55.

Bailey, M. J. and G. S. Tavlas (1988), 'Trading and Investment under Floating Rates: The US Experience', *Cato Journal*, **8**, 2, 421–49.

Baldwin, R. E. and D. Taglioni (2006), 'Gravity for Dummies and Dummies for Gravity Equations', NBER Working Paper No. W12516 (Cambridge, MA: National Bureau of Economic Research).

Baltagi, B. H. (2001), *Econometric Analysis of Panel Data* (2nd edn) (Chichester: Wiley).

Baum, C., M. Schaffer and S. Stillman (2003), 'Instrumental Variables and GMM: Estimation and Testing', *Stata Journal*, **3**, 1, 1–31.

Bayoumi, T. and B. Eichengreen (1995), 'Is Regionalism Simply a Diversion? Evidence from the Evolution of the EC and EFTA', CEPR Discussion Paper No. 1294 (London: CEPR).

Bénassy-Quéré, A. and A. Lahrèche-Révil (2003), 'Trade Linkages and Exchange Rates in Asia: The Role of China', CEPII Working Paper No. 2003–21 (Paris: CEPII).

Bergstrand, J. H. (1985), 'The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence', *Review of Economics and Statistics* **67**, 3, 474–81.

Bini-Smaghi, L. (1991), 'Exchange Rate Variability and Trade: Why is it so Difficult to Find Any Empirical Relationship?', *Applied Economics*, **23**, 5, 927–35.

Brada, J. C. and J. A. Méndez (1988), 'Exchange Rate Risk, Exchange Rate Regime and the Volume of International Trade', *Kyklos*, **41**, 2, 263–80.

Broll, U. and B. Eckwert (1999), 'Exchange Rate Volatility and International Trade', *Southern Economic Journal*, **66**, 1, 178–85.

Chit, M. (2008), 'Exchange Rate Volatility and Exports: Evidence from the ASEAN–China Free Trade Area', *Journal of Chinese Economics and Business Studies*, **6**, 3, 261–77.

Cho, G., I. Sheldon and S. McCorriston (2002), 'Exchange Rate Uncertainty and Agricultural Trade', *American Journal of Agricultural Economics*, **84**, 4, 931–42.

Clark, P. (1973), 'Uncertainty, Exchange Risk, and the Level of International Trade', *Western Economic Journal*, **11**, 3, 302–13.

Clark, P., N. Tamirisa and S. Wei (2004), 'A New Look at Exchange Rate Volatility and Trade Flows', IMF Occasional Paper No. 235 (Washington, DC: IMF).

Côte, A. (1994), 'Exchange Rate Volatility and Trade', Bank of Canada Working Paper, No. 94-5 (Ottawa: Bank of Canada).

Cushman, D. O. (1986), 'Has Exchange Risk Depressed International Trade? The Impact of Third-country Exchange Risk', *Journal of International Money and Finance*, **5**, 3, 361–79.

De Grauwe, P. (1988), 'Exchange Rate Variability and the Slowdown in Growth of International Trade', *IMF Staff Papers*, **35**, 1, 63–84.

De Grauwe, P. (1994), *The Economics of Monetary Integration* (New York: Oxford University Press).

Dell'Ariccia, G. (1999), 'Exchange Rate Fluctuations and Trade Flows: Evidence from the European Union', *IMF Staff Papers*, **46**, 3, 315–34.

Dellas, H. and B.-Z. Zilberfarb (1993), 'Real Exchange Rate Volatility and International Trade: A Reexamination of the Theory', *Southern Economic Journal*, **59**, 4, 641–47.

Doğnalar, M. (2002), 'Estimating the Impact of Exchange Rate Volatility on Exports: Evidence from Asian Countries', *Applied Economics Letters*, **9**, 13, 859–63.

Doyle, E. (2001), 'Exchange Rate Volatility and Irish–UK Trade', *Applied Economics*, **33**, 2, 249–65.

Egger, P. and M. Pfaffermayr (2003), 'The Proper Panel Econometric Specification of the Gravity Equation: A Three-way Model with Bilateral Interaction Effects', *Empirical Economics*, **28**, 3, 571–80.

Eichengreen, B. (2006), 'The Parallel Currency Approach to Asian Monetary Integration', *American Economic Review*, **96**, 2, 432–36.

Eichengreen, B. and D. Irwin (1996), 'The Role of History in Bilateral Trade Flows', NBER Working Paper No. 5565 (Cambridge, MA: National Bureau of Economic Research).

Eichengreen, B., Y. Rhee and H. Tong (2007), 'China and the Exports of Other Asian Countries', *Review of World Economics*, **143**, 2, 201–26.

Ethier, W. (1973), 'International Trade and the Forward Exchange Market', *American Economic Review*, **63**, 3, 494–503.

European Commission (1990), ‘One Market, One Money: An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union’, *European Economy*, **44**.

Feenstra, R., J. Markusen and A. Rose (2001), ‘Using the Gravity Equation to Differentiate among Alternative Theories of Trade’, *Canadian Journal of Economics*, **34**, 2, 430–47.

Flood, R. P. and A. K. Rose (1999), ‘Understanding Exchange Rate Volatility without the Contrivance of Macroeconomics’, *Economic Journal*, **109**, 459, F660–72.

Franke, G. (1991), ‘Exchange Rate Volatility and International Trading Strategy’, *Journal of International Money and Finance*, **10**, 2, 292–307.

Frankel, J. A. and S. J. Wei (1993), ‘Trade Blocs and Currency Blocs’, NBER Working Paper No. 4335 (Cambridge, MA: National Bureau of Economic Research).

Frömmel, M. and L. Menkhoff (2003), ‘Increasing Exchange Rate Volatility during the Recent Float’, *Applied Financial Economics*, **13**, 12, 877–83.

Hadri, K. (2000), ‘Testing for Stationarity in Heterogeneous Panel Data’, *Econometrics Journal*, **3**, 2, 148–61.

Holly, S. (1995), ‘Exchange Rate Uncertainty and Export Performance: Supply and Demand Effects’, *Scottish Journal of Political Economy*, **42**, 4, 381–91.

Hooper, P. and S.W. Kohlhagen (1978), ‘The Effect of Exchange Rate Uncertainty on the Prices and Volume of International Trade’, *Journal of International Economics*, **8**, 4, 483–511.

Hsiao, C. (1999), *Analysis of Panel Data* (Cambridge: Cambridge University Press).

Huang, Y. and F. Guo (2006), ‘Is Currency Union a Feasible Option in East Asia? A Multivariate Structural VAR Approach’, *Research in International Business and Finance*, **20**, 1, 77–94.

Im, K. S., M. H. Pesaran and Y. Shin (2003), ‘Testing for Unit Roots in Heterogeneous Panels’, *Journal of Econometrics*, **115**, 53–74.

Karlsson, S. and M. Löthgren (2000), ‘On the Power and Interpretation of Panel Unit Root Tests’, *Economics Letters*, **66**, 3, 249–55.

Kawai, M. and I. Zilcha (1986), ‘International Trade with Forward-futures Markets under Exchange Rate and Price Uncertainty’, *Journal of International Economics*, **20**, 1, 83–98.

Kim, D. (2007), ‘An East Asian Currency Union? The Empirical Nature of Macroeconomic Shocks in East Asia’, *Journal of Asian Economics*, **18**, 6, 847–66.

Klaassen, F. (2004), ‘Why is it So Difficult to Find an Effect of Exchange Rate Risk on Trade?’, *Journal of International Money and Finance*, **23**, 5, 817–39.

Kumar, R. and R. Dhawan (1991), ‘Exchange Rate Volatility and Pakistan Exports to the Developed World: 1974–85’, *World Development*, **19**, 9, 1225–40.

Kwack, S. Y. (2005), ‘Exchange Rate and Monetary Regime Options for Regional Cooperation in East Asia’, *Journal of Asian Economics*, **16**, 1, 57–75.

Mátyás, L. (1998), ‘The Gravity Model: Some Econometric Considerations’, *The World Economy*, **21**, 3, 397–401.

McKenzie, M. D. (1999), ‘The Impact of Exchange Rate Volatility on International Trade Flows’, *Journal of Economic Surveys*, **13**, 1, 71–106.

Pedroni, P. (1999), ‘Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors’, *Oxford Bulletin of Economics and Statistics*, **61**, 4, 653–70.

Prasad, E., K. Rogoff, S. Wei and M. A. Kose (2003), ‘Effects of Financial Globalization on Developing Countries: Some Empirical Evidence’, IMF Occasional Paper No. 220 (Washington, DC: IMF).

Rajan, R. (2002), ‘Exchange Rate Policy Options for Post-crisis Southeast Asia: Is There a Case for Currency Baskets?’, *The World Economy*, **25**, 1, 137–63.

Roland-Holst, D. and J. Weiss (2004), ‘ASEAN and China: Export Rivals or Partners in Regional Growth?’, *The World Economy*, **27**, 8, 1255–74.

Rose, A. K. (2000), ‘One Money, One Market: The Effect of Common Currencies on Trade’, *Economic Policy*, **30**, 7–46.

Sato, K. and Z. Zhang (2006), ‘Real Output Co-movements in East Asia: Any Evidence for a Monetary Union?’, *The World Economy*, **29**, 12, 1671–89.

Sauer, C. and A. K. Bohara (2001), 'Exchange Rate Volatility and Exports: Regional Differences between Developing and Industrialized Countries', *Review of International Economics*, **9**, 1, 133–52.

Sercu, P. and C. Van Hulle (1992), 'Exchange Rate Volatility, International Trade, and the Value of Exporting Firms', *Journal of Banking and Finance*, **16**, 1, 155–82.

Stock, J. and M. Yogo (2005), 'Testing for Weak Instruments in Linear IV Regression', in J. Stock and D. Andrews (eds.), *Identification and Inference for Econometric Models: A Festschrift in Honor of Thomas Rothenberg* (Cambridge: Cambridge University Press), 80–108.

Tenreyro, S. (2007), 'On the Trade Impact of Nominal Exchange Rate Volatility', *Journal of Development Economics*, **82**, 485–508.

Thorbecke, W. (2008), 'The Effect of Exchange Rate Volatility on Fragmentation in East Asia: Evidence from the Electronics Industry', *Journal of the Japanese and International Economies*, **22**, 4, 535–44.

Wei, S. J. (1996), 'Intra-national versus International Trade: How Stubborn are Nations in Global Integration?', NBER Working Paper No. 5531 (Cambridge, MA: National Bureau of Economic Research).

Wilson, P. and H. Ng Shang Reng (2007), 'The Choice of Exchange Rate Regime and the Volatility of Exchange Rates after the Asian Crisis: A Counterfactual Analysis', *The World Economy*, **30**, 11, 1646–61.