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Exchange rate volatility and bilateral exports of Malaysia to Singapore, China, Japan, the USA and Korea

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Abstract This study examines the impact of exchange rate volatility on bilateral exports of Malaysia to Singapore, China, Japan, the USA and Korea. Exchange rate volatility is estimated by an autoregressive conditional heteroscedasticity model. The Johansen cointegration method and the dynamic ordinary least squares estimator are used in the estimations. There is some evidence of exchange rate volatility to have significant impact on real total exports in the long run, but more evidence of exchange rate volatility is found to have significant impact on sub-categories of real total exports in the short run. The impact of exchange rate volatility differs across bilateral exports. The impact of exchange rate volatility on exports can be negative or positive. Generally, exchange rate volatility is not harmful to bilateral exports of Malaysia.

Keywords Exchange rate volatility · Exports · Malaysia · Singapore · China · Japan · The USA · Korea

JEL Classification F31 · F14

1 Introduction

Exchange rate volatility is argued to have an adverse impact on exports (Bahmani-Oskooee and Hegerty 2007; Bahmani-Oskooee et al. 2013, 2014). An increase in exchange rate volatility is a risk for exporters, and therefore, exporters which are risk averse will reduce their exports. Nonetheless, there is no consensus in the literature of the impact of exchange rate volatility on exports. There are some studies

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which find exchange rate volatility to have insignificant impact on export and some studies which report exchange rate volatility to have positive impact on export (De Grauwe 1988; Bahmani-Oskooee and Hegerty 2007). Exchange rate is found to have insignificant impact on export which can be due to exporters hedging their position in the forward or futures market. Thus, the risk of exchange rate volatility is hedged. Exporters which are risk neutral will take the advantage of exchange rate volatility to increase their returns through more exports. Therefore, the impact of exchange rate volatility on exports can be good to be investigated based on a case by case basis. The recent literature of the impact of exchange rate volatility on exports uses the sub-category of export data. In contrast, a huge literature in the past examined the impact of exchange rate volatility on total export using annual data (Bahmani-Oskooee and Harvey 2011; Bahmani-Oskooee et al. 2013, 2014). The impact of exchange rate volatility on exports can be influenced by the measurement of exchange rate volatility, that is, the impact of exchange rate volatility on exports might be different because of the use of different measure of exchange rate volatility. The autoregressive distributed lag (ARDL) approach, which is a state-of-the-art estimator, is mainly used in the estimation in the current literature of the impact of exchange rate volatility on exports. The use of the different estimator might produce different result, and thus, different conclusion of the impact of exchange rate volatility on exports is derived (De Grauwe 1988; Bahmani-Oskooee and Hegerty 2007; Fang et al. 2009; Ćorić and Pugh 2010; Bahmani-Oskooee and Harvey 2011; Verheyen 2012; Nishimura and Hirayama 2013; Thorbecke and Kato 2013; Baek 2013; Bahmani-Oskooee et al. 2013, 2014; Wong 2014; Choudhry and Hassan 2015).

This study examines the impact of exchange rate volatility on real total export and all the sub-categories of real total export by standard international trade code (SITC) from 0 to 9 of Malaysia to Singapore, China, Japan, the United States of America (the USA), and Korea using monthly data for the period from January 2010 to May 2015. The impact of exchange rate volatility on a specific category of export can be assessed more directly by using the sub-category of data, that is, all the sub-categories of real total export. Conversely, the literature of the impact of exchange rate volatility on exports is mainly investigated using aggregated or certain industry data in yearly or quarterly basis. The impact of exchange rate volatility on exports can be different from industries. This is because some industries are more sensitive or elastic to exchange rate change while some industries are not sensitive or inelastic to exchange rate change. Moreover, the use of the sub-category of export data can avoid the problem of aggregation bias in examining the impact of exchange rate volatility on exports and the impact of exchange rate volatility on a category of exports can be evaluated more specifically. The policy recommendation can be specifically addressed to certain industry more easily. The use of monthly data might produce different conclusion of the impact of exchange rate volatility on exports. Singapore, China, Japan and the USA are the main exporting countries of Malaysia while Korea is a relatively less exporting country of Malaysia in Asia. Hence, the impact of exchange rate volatility on exports can be compared between countries with relatively high volume of exports and countries with relatively low volume of exports. Moreover, there are not many studies on the impact of exchange rate volatility on bilateral exports of Malaysia to Singapore, China, Japan, the USA and Korea. The sample period in this study is a period without major financial crisis in the world, and therefore, the impact of exchange rate volatility on exports can be evaluated more precisely without influenced by structural break. Financial crisis could have a significant impact of international trade (Choudhry and Hassan 2015). Exchange rate volatility is estimated by an autoregressive conditional heteroscedasticity (ARCH) model, which is selected from a group of the ARCH model with different assumption of the distribution of the disturbance terms. The export demand model is used, which real export is estimated a function of real exchange rate, real foreign demand and exchange rate volatility. Real export is expressed by export value divided by export price and not expressed by export value divided by export unit value, that is, export value is divided by export quantity. The Johansen cointegration method and the dynamic ordinary least squares (DOLS) estimator are used in the estimation. The use of the two well-known estimators is expected to produce good conclusion on the impact of exchange rate volatility on exports.

This study finds that different exchange rate can be best to be estimated by a different ARCH model with different assumption of the disturbance term. The impact of exchange rate volatility on export is more important in the short run than in the long run. Conversely, real exchange rate and real foreign demand are mostly found to be important in influencing export in the long run. There is some evidence that country which is less important to export of Malaysia is less affected by exchange rate volatility. Furthermore, the impact of exchange rate volatility differs across sectors of exports. Real exports of SITC 7 and SITC 8 are found to be more sensitive to exchange rate volatility. The impact of exchange rate volatility on export can be negative or positive. There is no strong evidence of exchange rate volatility on real export which could be due to the presence of the forward and futures markets and incomplete exchange rate pass-through (Devereux and Engel 2002; Gopinath et al. 2010; Bandt and Razafindrabe 2014; Bernini and Tomasi 2015; Choudhri and Hakura 2015). On the other hand, exchange rate volatility can have positive impact on export due to the dominance of the income effect over the substitution effect of exchange rate volatility (De Grauwe 1988).

The rest of this study is organized as follows. Section 2 is a literature review of the impact of exchange rate volatility on export. Section 3 provides some background of exports of Malaysia to Singapore, China, Japan, the USA and Korea and exports of Malaysia by SITC. Section 4 is the data and methodology and Sect. 5 is the empirical results and discussions. Finally, the last section summaries some concluding remarks.

2 Literature review

Bahmani-Oskooee and Hegerty (2007) provide a literature review of the impact of exchange rate volatility on international trade. For a more recent discussion of the impact of exchange rate volatility on international trade, can refer to Wong (2014). There are some studies assessing the impact of exchange rate volatility on exports in Malaysia (Wong and Tang 2008, 2011; Bahmani-Oskooee and Harvey 2011). Bahmani-Oskooee and Harvey (2011) explore the impact of real exchange rate volatility on trade between the USA and Malaysia. The 101 US exporting industries to Malaysia is examined using the export model, that is, real export is a function of real exchange rate, real gross domestic product (GDP) of foreign country and real exchange rate volatility. The 17 US importing industries from Malaysia are examined using the import model, that is, real import is a function of real exchange rate, real GDP of domestic country and real exchange rate volatility. The ARDL approach is used. The data are annual for the period from 1971 to 2006. Real exchange rate volatility is measured as the standard deviation of the 12 monthly real bilateral exchange rate in a year. The data are annual for the period from 1971 to 2006. The results show that exchange rate volatility is found to have short-run impact of about two-thirds of the industries and the impact of exchange rate volatility last into the long run in the 38 US exporting industries and in the 10 US importing industries. In the majority of the industries, the main long-run determinants are found to be the levels of economic activities in both countries.

Wong and Tang (2008) analyze the impact of exchange rate volatility on electrical exports of Malaysia. More specifically, the electrical exports of Malaysia are electrical apparatus, resistors, other than heating resistors, printed circuits, switchboard and control panels (SITC 772), air conditioning machinery comprising a motor drive fan and elements of changing temperature and humidity and parts (SITC 7415), equipment for distributing electricity (SITC 773), rotating electric plants and parts (SITC 716) and domestic electrical and non-electrical equipment (SITC 775). The ARDL approach is used. Exchange rate volatility is expressed by the moving standard deviation with order four of real effective exchange rate. The data are quarterly from quarter I, 1990, to quarter IV, 2001. The results show that exchange rate volatility is found to have an adverse impact on electrical exports of Malaysia. In another paper, Wong and Tang (2011) dispatch the impact of exchange rate volatility on semiconductor exports of Malaysia, namely thermionic valves and tubes, photocells and parts thereof (SITC 776). The results show that exchange rate volatility is found to have both the long-run and the short-run impact on semiconductor exports of Malaysia. The Johansen cointegration approach is used, and the sample period is from quarter I, 1990, to quarter IV, 2001. The same measure of exchange rate volatility is used, namely the moving standard deviation with order four of real effective exchange rate.

The impact of exchange rate volatility on export could be different for different countries because of different commodities of exports (Fang et al. 2009; Caglayan and Di 2010; Chit and Judge 2011). Fang et al. (2009) report that the impact of exchange rate volatility on bilateral exports of eight Asian countries, namely Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand to the USA using monthly data for the period from 1979 to 2003. The dynamic conditional correlation generalized autoregressive conditional heteroscedasticity in mean model is used. The results show that exchange rate volatility affects exports asymmetrically due to different sources such as exporter asymmetric risk perception, the US dollar invoicing, fear of floating, fear of appreciation, love of depreciation and lack of inappropriate exchange market intervention. Exchange rate volatility is found to be positive for Malaysia. Caglayan and Di (2010) investigate the impact of exchange rate volatility on sectoral bilateral trade flows between the USA and its 13 trading countries, including Malaysia using monthly for the period between 1996 and 2007. Generally, the results demonstrate that there is little impact of exchange rate volatility on sectoral trade flows. Conversely, Chit and Judge (2011) find that the impact of exchange rate volatility on exports depends on the level of financial sector development. The adverse impact of exchange rate volatility on export can be more easily affected by the less developed in financial sector. A stable exchange rate is a condition to promote export in five emerging East Asian countries, namely China, Indonesia, Malaysia, the Philippines and Thailand.

The recent studies of the impact of exchange rate volatility on exports in Malaysia use bilateral export data or export of a specific category of industry (Bahmani-Oskooee and Harvey 2011). Real exports which are expressed as export values divided by export unit values are widely used in the literature of the impact of exchange rate volatility on export (Wong and Tang 2008, 2011; Bahmani-Oskooee and Harvey 2011; Bahmani-Oskooee et al. 2014). The unit values of exports are not good proxies for export prices and can be biased because the bundles of export goods can change over time (Byrne et al. 2008; Bandt and Razafindrabe 2014). Also, some categories of exports to the whole world rather than bilateral exports are usually examined (Wong and Tang 2008, 2011). Exchange rate volatility is found to have significant impact on exports. However, the impact of exchange rate volatility on exports is relatively small compared with the impact of other explanatory variable such as the impact of real foreign demand on exports. The impact of exchange rate volatility on exports can be asymmetric across industries and countries. The exports of Malaysia to the USA and the world are mostly examined (Wong and Tang 2008, 2011; Bahmani-Oskooee and Harvey 2011). Not many studies examine other important export destination of Malaysia for example Korea. Moreover, they are not many studies used exchange rate volatility selected from a group of ARCH models to examine its impact on bilateral exports in Malaysia (Bahmani-Oskooee and Harvey 2011; Wong and Tang 2008, 2011). There is no general consensus of the impact of exchange rate volatility on exports in Malaysia.

3 Exports of Malaysia to Singapore, China, Japan, the USA and Korea and exports of Malaysia by SITC

Currently, Singapore is the main export of Malaysia. This is followed by China, Japan and the USA. Korea is relatively a small destination of export of Malaysia. In 2013, exports of Malaysia to Singapore, China, Japan, the USA and Korea were Malaysian ringgit (RM) 100,439 million or 14.0 % of total export of Malaysia, RM96,966 million or 13.5 % of total export of Malaysia, RM79,747 million or 11.1 % of total export of Malaysia, RM58,055 million or 8.1 % of total export of Malaysia and RM26,133 million or 3.6 % of total export of Malaysia, respectively. Exports of Malaysia to Singapore, China, Japan, the USA and Korea from 2010 to 2013 are given in Table 1 (Ministry of Finance Malaysia 2013). On the whole, the ranks of exports to these countries were about the same over the years from 2010 to 2013.

SITC 0 is food and live animals. SITC 1 is beverages and tobacco. SITC 2 is crude materials, inedible, except fuels. SITC 3 is mineral fuels, lubricants and related materials. SITC 4 is animal and vegetable oils, fats and waxes. SITC 5 is chemicals and related products. SITC 6 is manufactured goods classified chiefly by material. SITC 7 is machinery and transport equipment. SITC 8 is miscellaneous manufactured

Table 1 Exports of Malaysia to Singapore, China, Japan, the USA and Korea from 2010 to 2013 (RM million). *Source*: Ministry of Finance Malaysia (2013)

	2010	2011	2012	2013
Singapore	85,253 (13.3 %)	88,191 (12.6 %)	95,553 (13.6 %)	100,439 (14.0 %)
China	80,105 (12.5 %)	91,551 (13.1 %)	88,793 (12.6 %)	96,966 (13.5 %)
Japan	66,763 (10.5 %)	81,368 (11.7 %)	83,401 (11.9 %)	79,747 (11.1 %)
The USA	60,951 (9.5 %)	57,653 (8.3 %)	60,791 (8.7 %)	58,055 (8.1 %)
Korea	24,330 (3.8 %)	26,252 (3.8 %)	25,368 (3.6 %)	26,133 (3.6 %)
Total	638,822 (100 %)	697,862 (100 %)	702,188 (100 %)	719,815 (100 %)

articles. SITC 9 is commodities and transactions not classified elsewhere in SITC. In 2013, exports of Malaysia were about RM719,814 million. Exports of SITC from 0 to 9 were about RM22,104 million (3.1 % of total export of Malaysia), about RM3,881 million (0.5 % of total export of Malaysia), about RM19,508 million (2.7 % of total export of Malaysia), about RM159,912 million (22.2 % of total export of Malaysia), about RM49,056 million (6.8 % of total export of Malaysia), about RM52,012 million (7.2 % of total export of Malaysia), about RM67,721 million (9.4 % of total export of Malaysia), about RM273,629 million (38.0 % of total export of Malaysia), about RM67,285 million (9.3 % of total export of Malaysia) and about RM4,706 million (0.7 % of total export of Malaysia), respectively. SITC 7 was the most important export of Malaysia. This was followed by SITC 3, SITC 6, SITC 8, SITC 5, SITC 4, SITC 0, SITC 2, SITC 9 and SITC 1. The main components of exports of SITC 7 were thermionic valves and tubes, photocells and parts thereof, automatic data processing machines and units thereof, and telecommunications equipment. Exports of Malaysia by SITC from 2010 to 2013 are given in Table 2 (*Malaysia External Trade Statistics System*, Department of Statistics Malaysia).

Table 2 Exports of Malaysia by SITC from 2010 to 2013 (RM million). *Source*: *Malaysia External Trade Statistics System*, Department of Statistics Malaysia

SITC	2010	2011	2012	2013
0	18,168 (2.8 %)	20,555 (2.9 %)	20,692 (2.9 %)	22,104 (3.1 %)
1	2,815 (0.4 %)	3,136 (0.4 %)	3,726 (0.5 %)	3,881 (0.5 %)
2	1 9,129 (3.0 %)	25,026 (3.6 %)	20,610 (2.9 %)	19,508 (2.7 %)
3	101,958 (16 %)	125,752 (18 %)	143,388 (20.4 %)	159,912 (22.2 %)
4	54,139 (8.5 %)	73,119 (10.5)	63,394 (9.0 %)	49,056 (6.8 %)
5	40,618 (6.4 %)	46,211 (6.6 %)	46,102 (6.6 %)	52,012 (7.2 %)
6	56,391 (8.8 %)	65,400 (9.4 %)	63,624 (9.1 %)	67,721 (9.4 %)
7	280,416 (43.9 %)	269,763 (38.7 %)	266,685 (38 %)	273,629 (38.0 %)
8	61,407 (9.6 %)	64,707 (9.3 %)	68,704 (9.8 %)	67,285 (9.3 %)
9	3,781 (0.6 %)	4,193 (0.6 %)	74,421 (10.6 %)	4,706 (0.7 %)
Total	638,822 (100 %)	697,862 (100 %)	702,641 (100 %)	719,814 (100 %)

4 Data and methodology

Real total export is the sum of export values of SITC from 0 to 9 divided by total export price index (2005 = 100). Real exports of SITC from 0 to 9 are export values of SITC from 0 to 9 divided by export price indexes (2005 = 100) of SITC from 0 to 9, respectively. Real exchange rate is the RM against the foreign exchange rate multiplied by the ratio of consumer price index (CPI, 2005 = 100) of Malaysia over CPI (2005 = 100) of foreign country. Exchange rate volatility is real exchange rate volatility estimated by an ARCH model. Real foreign demand is expressed by industrial production index (IPI, 2005 = 100) of foreign country, except China, which real foreign demand is expressed by industrial value added of China (2005 = 100). Total export, export values of SITC from 0 to 9, export price indexes and export values of trading partner and Malaysia were obtained from various issues of *Malaysia External Trade Statistics System*, Department of Statistics Malaysia. The RM against the foreign exchange rates was obtained from the Web site of Central Bank of Malaysia or Bank Negara Malaysia. CPI of Malaysia was obtained from *Consumer Price Index*, Department of Statistics Malaysia. CPI of Singapore was obtained from *Economic Survey of Singapore,* Department of Statistics Singapore. IPI of Singapore was obtained from various issues of *Monthly Digest of Statistics Singapore,* Department of Statistics Singapore. CPI and industrial value added of China were obtained from the Web site of National Bureau of Statistics of China. CPI of Japan was obtained from Statistics Bureau of Japan. IPI of Japan was obtained from Ministry of Economy, Trade and Industry. CPI and IPI of the USA were obtained from United Nations Economic Commission for Europe Statistical Database. CPI of Korea was obtained from *Consumer Price Survey*, Statistics Korea. IPI of Korea was obtained from *Monthly Survey of Mining and Manufacturing*, Statistics Korea. All the data were seasonal adjusted using the census X11 multipilcative method, which is a standard method used by the US Bureau of Census to seasonally adjusted the data. The sample period is from January 2010 to May 2015. The sample period is mainly restricted by the availability of the monthly export price indexes in Malaysia, which is available beginning from January 2010.

Ding et al. (1993) propose the asymmetric power generalized autoregressive conditional heteroscedasticity (APGARCH), which can be specified as follows:

$$\begin{aligned} \ln e_t &= \mu + \gamma \ln e_{t-1} + u_t \\ u_t &= \varepsilon_t \sqrt{\sigma_t},\ \varepsilon_t | I_{t-1} \sim \mathrm{N(0,1)} \\ \sigma_t^d &= \omega + \sum_{i=1}^{p} \alpha_i \left(|u_{t-i}| + \theta_i u_{t-i}\right)^d + \sum_{i=1}^{q} \beta_i \sigma_{t-i}^d \end{aligned} \tag{1}$$

where ln is logarithm, e is real exchange rate, u_t is a disturbance term, ε_t is a white noise stochastic process, I_{t-1} is the past information set, d is the power term, σ_t is the conditional variance and u_t is assumed to be normally distributed with mean zero and variance one. When $d = 2$, $p = 1$, $q = 0$ and $\theta_1 = 0$, the estimated model is the ARCH model or the ARCH (1) model. When $d = 2$, $p = 1$, $q = 1$ and $\theta_1 = 0$, the estimated model is the GARCH(1, 1) model. When $d =$ free, $p = 1$, $q = 1$ and $\theta_1 \neq 0$, the estimated model is the APGARCH(1, 1) model. When $d =$ free,

$p = 1, q = 1$ and $\theta_1 = 0$, the estimated model is the power generalized autoregressive conditional heteroscedasticity (PGARCH) or the PGARCH(1, 1) model (Brooks et al. 2000). When $d = 2$, $p = 1$, $q = 1$, $\theta_1 = 0$, $\sigma_t^d = \ln \sigma_t^d$ and $|u_{t-i}| = \varphi u_{t-i} + \varphi \left[|u_{t-i}| - \mathrm{E}\,|u_{t-i}|\right]$, whereE is expectation operator, the estimated model is the exponential GARCH (EGARCH) model or the EGARCH(1, 1) model. Finally, when $d = 2, p = 1, q = 1, \theta_1 = 0, \theta_i u_{t-i} = \delta D_{t-1} u_{t-1}^2$, where $D_{t-1} = 1$ if $u_{t-1}^2 < 0$ and 0 if $u_{t-1}^2 \geq 0$, the estimated model is the threshold generalized autoregressive conditional heteroscedasticity (TGARCH) model or the TGARCH(1, 1) model. The conditional variance models are estimated by the maximum likelihood estimators.

Exchange rate volatility is estimated by an ARCH model. The ARCH models to be considered are the ARCH(1) model, the GARCH(1, 1) model, the EAGRCH(1, 1) model, the TGARCH(1, 1) model, the APGARCH(1, 1) model and the PGARCH(1, 1) model, which each ARCH model is estimated with different assumptions of the disturbance term, namely normal, student's t and generalized. The different assumption of the distribution of the disturbance term could affect the estimation of exchange rate volatility. The powers for the APGARCH(1, 1) model and the PGARCH(1, 1) model to be considered are based on 0.5, 0.75, 1, 1.25, 1.5 and 1.75. The lag length of the mean equation of the ARCH model is selected based on the Akaike information criterion (AIC). The best ARCH model to be selected is based on significance of the estimated coefficients, the AIC, the Schwarz Bayesian criterion (SBC) and the log likelihood ratio. The ARCH test, that is, the F statistic for the disturbance term of the mean equation is reported to show the appropriation of the estimated model. For Singapore, the GARCH(1, 1) with generalized error distribution term is the best model. For the USA, the GARCH(1, 1) with normal distribution term is the best model. For Japan, the EGARCH(1, 1) with leverage effect and generalized error distribution term is the best model. For China, the EGARCH(1, 1) with generalized error distribution term is the best model. For Korea, PGARCH(1, 1) with power one and generalized error distribution term is the best model. The results of the best ARCH models are reported in Table 3 . The ARCH tests are all not rejected and therefore are said to be appropriate. The log likelihood ratios of the models are large. The absolute values of the AIC and SBC are also large. The coefficients of the mean equation and the variance equation of the model are all found to be statistically significant. The plots of exchange rate volatility are given in Fig. 1. Generally, exchange rate volatility was volatile throughout the period. The descriptive statistics of exchange rate volatility are given in Table 4. The Jarque–Bera normality test is found to be statistically significant.

The export model to be estimated is specified as follows:

$$\ln x_t = \beta_{11} \ln\ e_t + \beta_{12} \ln\ y_t + \beta_{13} v_t + u_{1,t} \tag{2}$$

where x_t is real export (real total export, real exports of SITC from 0 to 9), e_t is real exchange rate, y_t is real foreign demand, v_t is exchange rate volatility which is estimated by an ARCH model and $u_{1,t}$ is a disturbance term. The export model is usually estimated in logarithms, except the measure of exchange rate volatility, which is in its level (Fang et al. 2009; Bahmani-Oskooee and Harvey 2011).

Cointegration implies an error correction model (ECM), which can be expressed as follows:

Table 3 ARCH models, January 2010–May 2015

$$\ln e_t = + \sum_{i=1}^{r} \gamma_i \ln e_{t-i} + u_t$$

$$\sigma_t^d = \omega + \sum_{i=1}^{p} \alpha_i \left(|u_{t-i}| + \theta_i u_{t-i} \right)^d + \sum_{i=1}^{q} \beta_i \sigma_{t-i}^d$$

	Singapore	China	The USA	Japan	Korea
	GARCH(1, 1)	EGARCH(1, 1)	GARCH(1, 1)	EGARCH(1, 1)	PGARCH(1, 1)
Mean equation					
μ	0.0035	0.0069	0.0766**	0.0352	0.0196
γ_1	0.9977***	1.3688***	1.3033***	0.9716***	1.0099***
γ_2	–	−0.3606**	−0.3678***	–	–
Variance equation					
ω	0.00002*	−16.7079***	0.0004***	−6.7248***	0.0121***
α	0.1712	0.5084*	0.3087*	0.6909**	0.6988***
β	0.6740***	−0.9013***	−0.7643***	−0.4686***	−0.3479*
θ	–	–	–	0.1476***	–
Diagnostic tests					
AIC	−6.0889	−5.6663	−5.4480	−4.6332	−5.4814
SBC	−5.9202	−5.4622	−5.2438	−4.3971	−5.3127
LR	199.8439	184.4895	177.6105	155.2636	180.4051
ARCH test	0.0883	0.1140	1.6742	0.1450	0.4431

LR is the log likelihood ratio

*** (*) Denotes significance at the 1 % (10 %) level

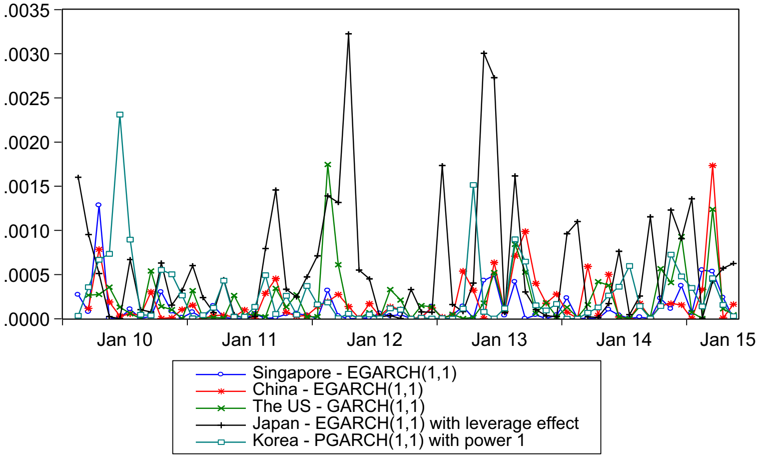

Fig. 1 Exchange rate volatility estimated by the ARCH models, January 2010–May 2015

$$\Delta \ln x_t = \beta_{20} + \sum \beta_{21i} \ln e_{t-i} + \sum \beta_{22i} \ln y_{t-i} + \sum \beta_{23i} v_{t-i} + \sum \beta_{24i} \ln x_{t-i} + \beta_{25} ec_{t-1} + u_{2,t} \quad (3)$$

Table 4 Descriptive statistics of exchange rate volatility, January 2010–May 2015

	Singapore	China	The USA	Japan	Korea
Mean	0.0001	0.0002	0.0002	0.0006	0.0003
Median	0.0000	0.0001	0.0001	0.0003	0.0001
Maximum	0.0013	0.0017	0.0017	0.0032	0.0023
Minimum	0.0000	0.0000	0.0000	0.0000	0.0000
SD	0.0002	0.0003	0.0003	0.0007	0.0004
Skewness	3.4216	2.9704	2.6658	1.9724	2.9802
Kurtosis	17.7512	14.1805	11.4824	7.0157	14.2988
Jarque–Bera	694.1193***	420.7771***	263.4869***	83.1784***	428.3701***

SD is standard deviation

*** Denotes significance at the 1 % level

where ec_{t-1} is an error correction term generated from the Johansen cointegration method for equation (2) and $u_{2,t}$ is a disturbance term. The coefficient of real exchange rate volatility is found to be significant and negative which implies that real exchange rate volatility is said to have significant negative impact on export.

The DOLS estimator is also used to estimate real exports, which can be specified as follows:

$$\ln x_t = \beta_{30} + \beta_{31} \ln e_t + \beta_{32} \ln y_t + \beta_{33} v_t + \sum_{i=-p}^{p} \beta_{34i} \Delta\ln e_{t+i} + \sum_{i=-p}^{p} \beta_{35i} \Delta\ln y_{t+i} + \sum_{i=-p}^{p} \beta_{36i} \Delta v_{t+i} + u_{3,t} \tag{4}$$

where $u_{3,t}$ is a disturbance term. The DOLS estimator corrects the problem of endogeneity by including the leads (p) and lags ($-p$) of the first difference and the problem of serial correlation by a generalized least squares procedure. The leads (p) and lags ($-p$) of the first differences are selected based on the SBC or AIC. The estimator provides good estimation in a finite sample (Stock and Watson 1993).

5 Results and discussions

The results of the Dickey and Fuller (DF) unit root test statistics are reported in Table 5. The lag length used to estimate the DF unit root test statistics is based on the SBC or modified SBC. Generally, the results of the DF unit root test statistics show that exchange rate volatility is stationary in their level and the rest of the variables are mostly a unit root variable or closely a unit variable. Therefore, exchange rate volatility is entered as a deterministic variable in the estimation.

The results of the Johansen likelihood ratio test statistics, namely the *maximum eigenvalue* statistic (λ_{Max}) and the trace statistic (λ_{Trace}), are computed with unrestricted intercepts and no trends in the vector autoregressive model are reported in

Table 5 Results of the Dickey and Fuller unit root test statistics

	No trend	Trend	No trend	Trend
	Singapore		China	
ln $x_{t,t}$	−2.4881 (1)	−2.7655 (1)	−2.4881 (1)	−2.7655 (1)
Δln $x_{t,t}$	−6.3350*** (1)	−6.3163 *** (1)	−6.3350*** (1)	−6.3163*** (1)
ln $x_{0,t}$	−0.1594 (3)	−1.8575 (3)	−1.1068 (3)	−3.3969* (3)
Δln $x_{0,t}$	−13.3840*** (0)	−13.2772*** (3)	−10.2163*** (0)	−10.1178*** (0)
ln $x_{1,t}$	−1.4240 (2)	−2.7588 (2)	−1.7852 (3)	−2.1216 (3)
Δln $x_{1,t}$	−16.0340*** (0)	−15.9955*** (0)	−14.1947*** (0)	−14.0590*** (0)
ln $x_{2,t}$	−1.9754 (2)	−1.9575 (2)	−2.9123* (1)	−3.5938** (1)
Δln $x_{2,t}$	−12.4448*** (0)	−12.3412*** (0)	−10.8906*** (0)	−10.8026*** (0)
ln $x_{3,t}$	−2.0045 (3)	−1.9572 (3)	−1.1637 (2)	−3.2054* (2)
Δln $x_{3,t}$	−13.8867*** (0)	−13.8750*** (0)	−19.2276*** (0)	−19.2541*** (0)
ln $x_{4,t}$	−0.7982 (9)	−1.6646 (9)	−2.6031* (3)	−2.6520 (3)
Δln $x_{4,t}$	−11.4805 (0)	−11.3914*** (0)	−9.9508*** (0)	−9.9056*** (0)
ln $x_{5,t}$	−1.3504 (4)	−1.7918 (5)	−1.6330 (3)	−1.8078 (6)
Δln $x_{5,t}$	−16.5522*** (0)	−16.6419*** (0)	−12.7704*** (0)	−12.6706*** (0)
ln $x_{6,t}$	−7.7681*** (0)	−8.0017*** (0)	−2.2300 (1)	−2.2546 (1)
Δln $x_{6,t}$	−13.2308*** (0)	−13.1170*** (0)	−2.2502 (5)	−2.1660 (5)
ln $x_{7,t}$	−2.0502 (2)	−1.9908 (2)	−1.8462 (3)	−1.9683 (3)
Δln $x_{7,t}$	−12.6404*** (0)	−12.7212*** (0)	−15.7735*** (0)	−15.6431*** (0)
ln $x_{8,t}$	−1.4894 (2)	−2.0951 (2)	−3.5092** (1)	−3.4581* (1)
Δln $x_{8,t}$	−13.2938*** (0)	−13.1843*** (0)	−13.2214*** (0)	−13.1093*** (0)
ln $x_{9,t}$	−2.0405 (0)	−2.4715 (0)	−1.3381 (2)	−2.1298 (2)
Δln $x_{9,t}$	−3.2093** (4)	−3.2093* (4)	−10.7418*** (0)	−10.6614*** (0)
ln e_t	0.4271 (0)	−2.0874 (0)	0.5682 (1)	−2.5390 (0)
Δln e_t	−3.0712** (4)	−7.6000*** (0)	−5.4021*** (0)	−5.7407*** (0)
ln y_t	−2.3148 (4)	−2.3005 (4)	−1.7457 (10)	−5.7389*** (1)
Δln y_t	−12.8160*** (0)	−12.7467*** (0)	−1.8737 (0)	−2.9881 (4)
v_t	−5.5694*** (2)	−5.9402*** (2)	−1.8338 (6)	−3.8802** (2)
Δ v_t	−14.1177*** (0)	−13.9943*** (0)	−12.9856*** (0)	−12.8754*** (0)
	The USA		Japan	
ln $x_{t,t}$	−1.7251 (2)	−1.8598 (3)	−2.2056 (1)	−3.0764 (0)
Δln $x_{t,t}$	−1.4772 (10)	−11.4215*** (0)	−11.5421*** (0)	−11.4809*** (0)
ln $x_{0,t}$	−1.8264 (0)	−2.6600 (0)	−1.3856 (6)	−1.0412 (6)
Δln $x_{0,t}$	−8.8148*** (0)	−8.7424*** (0)	−16.0238*** (0)	−15.9190*** (0)
ln $x_{1,t}$	0.2836 (8)	−1.4597 (9)	−1.4275 (2)	−1.3957 (2)
Δln $x_{1,t}$	−13.5311*** (0)	−13.4358*** (0)	−13.0627*** (0)	−12.9805*** (0)
ln $x_{2,t}$	−7.3222*** (0)	−7.2694*** (0)	−2.0067 (2)	−2.3644 (2)
Δln $x_{2,t}$	−12.2917 (0)	−12.1920*** (0)	−5.0047*** (0)	−4.9607*** (2)
ln $x_{3,t}$	−7.6096*** (0)	−8.1307*** (0)	−2.9786** (1)	−2.9555 (1)
Δln $x_{3,t}$	−13.3755*** (0)	−13.2552*** (0)	−11.2242*** (0)	−11.3492*** (0)

Table 5 continued

	No trend	Trend	No trend	Trend
$\ln x_{4,t}$	−1.3082 (5)	−2.6801 (5)	−2.6259* (2)	−2.8884 (2)
$\Delta\ln x_{4,t}$	−17.0373*** (0)	−16.9940*** (0)	−12.1036*** (0)	−12.0014*** (0)
$\ln x_{5,t}$	−0.7825 (4)	−1.6098 (4)	−2.3653 (3)	−2.1312 (5)
$\Delta\ln x_{5,t}$	−12.7232*** (0)	−12.6119*** (0)	−17.6339*** (0)	−9.8073*** (9)
$\ln x_{6,t}$	−0.4653 (7)	−4.0993** (2)	−4.9581*** (0)	−1.4256 (2)
$\Delta\ln x_{6,t}$	−14.4417*** (0)	−14.3470*** (0)	−9.7329*** (0)	−14.7909*** (0)
$\ln x_{7,t}$	−2.5152 (3)	−2.5931 (3)	−1.4337 (2)	−2.7292* (1)
$\Delta\ln x_{7,t}$	−13.1417*** (0)	−13.2516*** (0)	−14.6771*** (0)	−6.2026*** (1)
$\ln x_{8,t}$	−2.0777 (1)	−2.0742 (1)	−2.7292* (1)	−2.7617 (1)
$\Delta\ln x_{8,t}$	−3.2173** (3)	−3.2104* (3)	−6.2026*** (1)	−6.1737*** (1)
$\ln x_{9,t}$	−1.6480 (2)	−1.1983 (2)	−2.4900 (4)	−2.4768 (4)
$\Delta\ln x_{9,t}$	−1.6046 (10)	−12.7258*** (0)	−9.9496*** (0)	−9.8709*** (0)
$\ln e_t$	−0.6116 (1)	−1.3637 (0)	−0.7980 (0)	−1.6843 (0)
$\Delta\ln e_t$	−5.6570*** (0)	−6.2803*** (0)	−3.9839*** (2)	−4.9293*** (1)
$\ln y_t$	−1.2557 (1)	−3.8805** (1)	−4.1317*** (0)	−4.1163*** (0)
$\Delta\ln y_t$	−10.1616*** (0)	−10.1854*** (0)	−9.5300*** (0)	−9.4610*** (0)
v_t	−7.2024*** (0)	−7.2609*** (1)	−6.1865*** (0)	−6.1982*** (0)
Δv_t	−11.6666*** (0)	−11.5682*** (0)	−11.1905*** (0)	−11.1016** (0)
	Korea			
$\ln x_{t,t}$	−3.0763** (2)	−3.1940* (2)		
$\Delta\ln x_{t,t}$	−18.4662*** (0)	−18.3344*** (0)		
$\ln x_{0,t}$	−2.3528 (6)	−1.7139 (6)		
$\Delta\ln x_{0,t}$	−11.5525*** (0)	−11.4710*** (0)		
$\ln x_{1,t}$	−1.3334 (7)	−1.5933 (7)		
$\Delta\ln x_{1,t}$	−10.9307*** (0)	−10.8762*** (0)		
$\ln x_{2,t}$	−2.4948 (2)	−2.2212 (2)		
$\Delta\ln x_{2,t}$	−2.0992 (9)	−16.9550*** (0)		
$\ln x_{3,t}$	−3.0188** (2)	−2.4364 (5)		
$\Delta\ln x_{3,t}$	−13.9492*** (0)	−19.0074*** (0)		
$\ln x_{4,t}$	−1.3449 (10)	−2.4364 (5)		
$\Delta\ln x_{4,t}$	−13.9492*** (0)	−13.8349*** (0)		
$\ln x_{5,t}$	−1.9984 (3)	−2.9581 (2)		
$\Delta\ln x_{5,t}$	−14.0687*** (0)	−14.0322*** (0)		
$\ln x_{6,t}$	−1.5217 (2)	−2.7409 (2)		
$\Delta\ln x_{6,t}$	−15.2187*** (0)	−15.0758*** (0)		
$\ln x_{7,t}$	−1.8963 (2)	−2.0762 (2)		
$\Delta\ln x_{7,t}$	−11.8962*** (0)	−11.8019*** (0)		
$\ln x_{8,t}$	−3.2998** (1)	−4.6870*** (0)		
$\Delta\ln x_{8,t}$	−10.8847*** (0)	−10.7953*** (0)		
$\ln x_{9,t}$	−0.5776 (4)	−1.3331 (8)		

Table 5 continued

	No trend	Trend
$\Delta \ln x_{9,t}$	−12.7084*** (0)	−12.6170*** (0)
$\ln e_t$	0.1002 (1)	1.9671 (0)
$\Delta \ln e_t$	−3.5316** (2)	−6.3357*** (0)
$\ln y_t$	−3.7374*** (3)	−2.7372 (5)
$\Delta \ln y_t$	−14.3894*** (0)	−14.5885*** (0)
v_t	−2.9657** (3)	−5.6505*** (0)
Δv_t	−10.0059*** (0)	−9.9235*** (0)

$x_{t,t}$ is real total export at time t. $x_{i,t}$ is real export of SITC i at time t ($i = 0, \ldots, 9$). e_t is real exchange rate at time t. y_t is real foreign demand at time t. v_t is exchange rate volatility at time t estimated by an ARCH model. No Trend is the ERS t-statistic and is estimated based on the model including an intercept. Trend is the ERS t-statistic and is estimated based on the model including an intercept and a time trend. Values in the parentheses are the lags used in the estimations

*** (**, *) Denotes significance at the 1 % (5 %, 10 %) level

Table 6. The lag lengths used to compute the vector autoregressive model are based on the SBC or AIC. The results show that the null hypothesis of no cointegration among real exports, real exchange rate and real foreign demand is mostly rejected. As a result, there is evidence of cointegrating vector among those variables.

The results of the normalized cointegrating vectors are reported in Table 7. The likelihood ratio test statistics, which test that the coefficients of real exchange rate and real foreign demand are zero, respectively, are mostly rejected at the 1, 5 or 10 % level. An appreciation of real exchange rate will lead to an increase or a decrease in real exports. Also, an increase in real foreign demand will lead to an increase or a decrease in real exports. Real exchange rate and real foreign demand are mostly found to be important determinants of real exports in the long run. Nonetheless, more real foreign demand than real exchange rate is found to have a significant impact on real export.

This study uses the general-to-specific modeling strategy to find the error correction representation. Initially, three lags of each first difference variable are used, and then, the dimensions of the parameter space are reduced to a final parsimonious specification by sequentially excluding less statistically insignificant variables. The results of the error correction models (ECMs) are displayed in Table 8.[1] On the whole, the results show the ECMs to have a high adjusted R^2. For Singapore, the high adjusted R^2 ranges from 0.0581 to 0.5854. For China, the high adjusted R^2 ranges from 0.2007 to 0.6560. For the USA, the high adjusted R^2 ranges from 0.0894 to 0.6128. For Japan, the high adjusted R^2 ranges from 0.0849 to 0.5838. Finally for Korea, the high adjusted R^2 ranges from 0.2839 to 0.6772. The one-period lags of error correction terms are mostly found to be statistically significant. The results show exchange rate volatility to have significant impact on real exports. For Singapore, exchange rate volatility is found to have significant impact on real total export and real exports of SITC 0, SITC

[1] The plots of cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ), which are not reported, generally show no evidence of instability of the ECMs. The estimations of the models are said to be appropriate.

Table 6 Results of the Johansen likelihood ratio test statistics

	λ_{Max} Test statistic			λ_{Trace} Test statistic		
H_0:	$r = 0$	r <= 1	r <= 2	$r = 0$	r <= 1	r <= 2
H_a:	$r = 1$	$r = 2$	$r = 3$	r ≥ 1	r ≥ 2	$r = 3$
Singapore						
ln $x_{t,t}$	20.06	8.77	0.29	29.12	9.06	0.29
ln $x_{0,t}$	20.38	8.69	0.56	29.64	9.26	0.56
ln $x_{1,t}$	21.64*	7.11	0.57	29.32	7.68	0.57
ln $x_{2,t}$	36.27*	14.12	0.39	50.78*	14.51	0.39
ln $x_{3,t}$	30.38*	8.52	0.63	39.5*	9.16	0.63
ln $x_{4,t}$	42.75*	30.76*	0.02	73.53*	30.78*	0.02
ln $x_{5,t}$	23.04*	13.56	0.24	36.84*	23.80*	0.24
ln $x_{6,t}$	20.97*	7.86	3.92	32.75*	11.78	3.92
ln $x_{7,t}$	32.72*	20.61*	0.38	53.72*	20.99*	0.38
ln $x_{8,t}$	21.18*	16.48*	0.12	37.78*	16.60	0.12
ln $x_{9,t}$	39.62*	6.02	0.08	45.71*	6.10	0.08
China						
ln $x_{t,t}$	35.86*	8.22	2.48	46.57*	10.71	2.48
ln $x_{0,t}$	40.99*	16.06*	1.97	59.02*	18.03*	1.97
ln $x_{1,t}$	20.54*	4.91	4.13	29.58	9.04	4.13
ln $x_{2,t}$	34.31*	10.57	3.90	48.77*	14.47	3.90
ln $x_{3,t}$	29.27*	11.74	4.58	45.59*	16.32	4.58
ln $x_{4,t}$	51.53*	14.82	2.49	68.83*	17.30	2.49
ln $x_{5,t}$	23.20*	11.23	3.25	37.68*	14.49	3.25
ln $x_{6,t}$	28.80*	13.26	2.46	44.51*	15.71	2.46
ln $x_{7,t}$	35.96*	8.85	2.83	47.64*	11.68	2.83
ln $x_{8,t}$	53.94*	8.98	2.50	65.42*	11.48	2.50
ln $x_{9,t}$	27.21*	10.29	1.29	38.79*	11.58	1.29
The USA						
ln $x_{t,t}$	22.80*	12.99	0.007	35.79*	13.0	0.007
ln $x_{0,t}$	10.80	6.94	0.05	17.79	6.99	0.05
ln $x_{1,t}$	50.93*	13.63	0.004	64.56*	13.63	0.004
ln $x_{2,t}$	22.82*	11.13	0.07	34.02*	11.20	0.07
ln $x_{3,t}$	51.91*	13.85	0.005	65.76*	13.85	0.005
ln $x_{4,t}$	19.09	8.12	0.14	27.35	8.26	0.14
ln $x_{5,t}$	24.53*	7.57	1.26	33.37*	8.83	1.26
ln $x_{6,t}$	63.25*	12.67	0.007	75.92*	12.67	0.007
ln $x_{7,t}$	27.83*	14.10	0.002	41.93*	14.10	0.002
ln $x_{8,t}$	35.98*	9.62	0.08	45.67*	9.70	0.08
ln $x_{9,t}$	21.55*	9.45	0.02	31.02	9.47	0.02

Table 6 continued

	λ_{Max} Test statistic			λ_{Trace} Test statistic		
H_0:	$r = 0$	r <= 1	r <= 2	$r = 0$	r <= 1	r <= 2
H_a:	$r = 1$	$r = 2$	$r = 3$	r ≥ 1	r ≥ 2	$r = 3$
Japan						
ln $x_{t,t}$	46.02*	11.87	0.68	58.57*	12.55	0.68
ln $x_{0,t}$	17.34	9.86	7.98	35.18*	17.84	7.98
ln $x_{1,t}$	20.86*	14.14	0.92	35.92*	15.06	0.92
ln $x_{2,t}$	33.24*	16.90*	0.65	50.79*	17.56	0.65
ln $x_{3,t}$	19.19	13.70	0.47	33.37*	14.17	0.47
ln $x_{4,t}$	39.94*	18.09*	0.54	58.58*	18.63*	0.54
ln $x_{5,t}$	40.46*	15.57*	0.49	56.51*	16.05	0.49
ln $x_{6,t}$	26.66*	18.16*	0.48	45.30*	18.64*	0.48
ln $x_{7,t}$	26.77*	17.16*	1.28	45.22*	18.44*	1.28
ln $x_{8,t}$	27.10*	18.24*	0.71	46.06*	18.96*	0.71
ln $x_{9,t}$	24.62*	14.67	0.67	39.96*	15.35	0.67
Korea						
ln $x_{t,t}$	26.08*	13.54	0.17	39.80*	13.72	0.17
ln $x_{0,t}$	23.45*	8.91	0.27	32.64*	9.18	0.27
ln $x_{1,t}$	37.61*	18.37*	0.58	56.56*	18.95*	0.58
ln $x_{2,t}$	35.08*	8.00	0.01	43.10*	8.01	0.01
ln $x_{3,t}$	18.52	11.31	0.32	30.16	11.64	0.32
ln $x_{4,t}$	41.67*	24.37*	0.62	66.67*	24.99*	0.62
ln $x_{5,t}$	46.19*	19.04*	0.44	65.68*	19.48*	0.44
ln $x_{6,t}$	25.28*	8.47	0.31	34.06*	8.78	0.31
ln $x_{7,t}$	28.17*	12.38	0.61	41.17*	13.00	0.61
ln $x_{8,t}$	27.11*	18.75*	0.94	46.80*	19.69*	0.94
ln $x_{9,t}$	34.19*	22.39*	0.60	57.20*	23.00*	0.60
c.v.	21.12	14.88	8.07	31.54	17.86	8.07

$x_{t,t}$ is real total export at time t. $x_{i,t}$ is real export of SITC i at time t (i = 0–9). c.v. is the 5 % critical value
* Denotes significance at the 5 % level

1, SITC 4, SITC 5, SITC 6, SITC 7 and SITC 8. For China, exchange rate volatility is found to have significant impact on real total export and real exports of SITC 3, SITC 4 and SITC 6. For the USA, exchange rate volatility is found to have significant impact on real total export and SITC 0, SITC 1, SITC 2, SITC 5, SITC 7 and SITC 8. For Japan, exchange rate volatility is found to have significant impact on real total export and real exports of SITC 0, SITC 2, SITC 3, SITC 5, SITC 7 and SITC 8. Lastly for Korea, exchange rate volatility is found to have significant impact on real exports of SITC 2, SITC 3 and SITC 8. An increase in exchange rate volatility would lead to a decrease or an increase in real exports in the short run.

The results of the DOLS estimator are presented in Table 9. The leads (p) and lags ($-p$) of the first difference are selected based on the SBC or AIC with the

Table 7 Results of the normalized cointegrating vectors

Singapore	China
$\ln x_{t,t} = 0.5501 \ln e_t + 2.4508 \ln y_t$	$\ln x_{t,t} = -4.1841 \ln e_t + 3.9625 \ln y_t$
(0.4029) (10.8982)***	(15.6746)*** (27.1501)***
$\ln x_{0,t} = 2.7774 \ln e_t - 1.9103 \ln y_t$	$\ln x_{0,t} = -0.7780 \ln e_t + 1.8577 \ln y_t$
(4.3712)** (11.1516)***	(0.9470) (16.5790)***
$\ln x_{1,t} = 4.9594 \ln e_t - 5.9182 \ln y_t$	$\ln x_{1,t} = 13.5720 \ln e_t - 20.5927 \ln y_t$
(3.1262)* (13.0703)***	(2.3451) (9.3923)***
$\ln x_{2,t} = -1.0828 \ln e_t - 4.7358 \ln y_t$	$\ln x_{2,t} = -2.4210 \ln e_t + 3.7262 \ln y_t$
(0.6012) (20.2860)***	(4.5986)** (15.8220)***
$\ln x_{3,t} = 4.2213 \ln e_t - 6.3845 \ln y_t$	$\ln x_{3,t} = 2.0467 \ln e_t + 3.1823 \ln y_t$
(6.3710)* (21.2844)***	(0.9907) (6.4737)**
$\ln x_{4,t} = -2.2644 \ln e_t - 0.2306 \ln y_t$	$\ln x_{4,t} = -5.9288 \ln e_t + 4.4265 \ln y_t$
(4.2408)** (0.04785)	(30.3479) (32.3855)***
$\ln x_{5,t} = 1.3774 \ln e_t - 1.2024 \ln y_t$	$\ln x_{5,t} = -0.3245 \ln e_t - 1.5187 \ln y_t$
(2.3612)*** (3.4946)**	(0.0694) (2.1172)
$\ln x_{6,t} = 0.4144 \ln e_t + 0.3879 \ln y_t$	$\ln x_{6,t} = -4.4780 \ln e_t + 6.0631 \ln y_t$
(3.2107)* (4.9038)**	(7.3704)*** (12.5529)***
$\ln x_{7,t} = 1.1823 \ln e_t + 2.4734 \ln y_t$	$\ln x_{7,t} = -3.7468 \ln e_t + 3.4150 \ln y_t$
(1.6007) (11.2797)***	(16.0589)*** (25.8137)***
$\ln x_{8,t} = 1.4204 \ln e_t + 0.4578 \ln y_t$	$\ln x_{8,t} = 3.5511 \ln e_t + 2.5259 \ln y_t$
(3.4935)* (0.8400)	(38.2729)*** (39.2514)***
$\ln x_{9,t} = -1.6226 \ln e_t + 57.6053 \ln y_t$	$\ln x_{9,t} = -3.3471 \ln e_t - 2.0888 \ln y_t$
(0.0129) (33.3553)***	(3.5671)* (4.8296)**
The USA	**Japan**
$\ln x_{t,t} = 1.4483 \ln e_t - 0.9457 \ln y_t$	$\ln x_{t,t} = 0.3271 \ln e_t + 4.9080 \ln y_t$
(9.5190)*** (4.5856)**	(1.3166) (7.4002)***
$\ln x_{0,t} = -4.3334 \ln e_t + 9.1779 \ln y_t$	$\ln x_{0,t} = -1.1403 \ln e_t + 28.1888 \ln y_t$
(0.7140) (1.0148)***	(0.2382) (7.0398)***
$\ln x_{1,t} = 2.6634 \ln e_t + 4.4641 \ln y_t$	$\ln x_{1,t} = -1.1514 \ln e_t - 36.8105 \ln y_t$
(5.0421)** (8.7715)***	(0.1540) (6.4881)***
$\ln x_{2,t} = -2.2370 \ln e_t + 0.9424 \ln y_t$	$\ln x_{2,t} = -0.1134 \ln e_t + 3.4284 \ln y_t$
(6.3574)** (0.6918)	(0.0907) (5.2966)**
$\ln x_{3,t} = 5.6028 \ln e_t - 8.2440 \ln y_t$	$\ln x_{3,t} = -0.1745 \ln e_t + 11.1151 \ln y_t$
(4.9958)** (6.6493)**	(0.0243) (4.3146)**
$\ln x_{4,t} = -3.1212 \ln e_t + 0.9254 \ln y_t$	$\ln x_{4,t} = -0.9359 \ln e_t - 1.2825 \ln y_t$
(10.1738)*** (0.6129)	(12.6853)*** (2.7074)
$\ln x_{5,t} = 4.8435 \ln e_t - 0.5948 \ln y_t$	$\ln x_{5,t} = 0.0871 \ln e_t - 0.9593 \ln y_t$
(7.0523)*** (0.3099)	(0.3058) (3.1934)*
$\ln x_{6,t} = 0.3137 \ln e_t + 1.3438 \ln y_t$	$\ln x_{6,t} = 0.1793 \ln e_t - 1.1355 \ln y_t$
(0.9909) (9.1638)**	(0.7523) (1.3711)

Table 7 continued

The USA	Japan
$\ln x_{7,t} = 1.2382 \ln e_t - 0.8578 \ln y_t$	$\ln x_{7,t} = 0.1521 \ln e_t + 2.7876 \ln y_t$
(9.8830)*** (4.6134)**	(0.3608) (5.4429)**
$\ln x_{8,t} = 0.4365 \ln e_t - 1.7280 \ln y_t$	$\ln x_{8,t} = 0.5322 \ln e_t - 0.4524 \ln y_t$
(1.7633) (21.4542)***	(6.8028)*** (0.3619)
$\ln x_{9,t} = -6.3433 \ln e_t + 10.5405 \ln y_t$	$\ln x_{9,t} = 0.1773 \ln e_t + 4.6910 \ln y_t$
(9.7792)*** (10.9334)***	(0.2170) (4.3498)**

Korea
$\ln x_{t,t} = 0.5211 \ln e_t - 0.9213 \ln y_t$
(5.3135)** (1.6218)
$\ln x_{0,t} = -0.0327 \ln e_t + 5.8850 \ln y_t$
(0.0039) (10.7630)***
$\ln x_{1,t} = 2.4984 \ln e_t + 16.1355 \ln y_t$
(3.0714)* (14.0259)***
$\ln x_{2,t} = -3.2143 \ln e_t + 41.7877 \ln y_t$
(2.9413)* (25.7377)***
$\ln x_{3,t} = 0.8292 \ln e_t - 4.3254 \ln y_t$
(1.8451) (10.6930)***
$\ln x_{4,t} = -0.6509 \ln e_t + 0.1737 \ln y_t$
(1.1397) (0.0074)
$\ln x_{5,t} = 1.0775 \ln e_t + 4.7339 \ln y_t$
(9.1707)*** (22.4836)***
$\ln x_{6,t} = 1.3518 \ln e_t - 0.7607 \ln y_t$
(9.0070)*** (0.4959)
$\ln x_{7,t} = -0.1977 \ln e_t - 9.4881 \ln y_t$
(0.0626) (22.6999)***
$\ln x_{8,t} = -0.0989 \ln e_t - 18.8986 \ln y_t$
(0.0013) (15.4838)***
$\ln x_{9,t} = -1.1776 \ln e_t - 10.0983 \ln y_t$
(1.1023) (7.1425)***

$x_{t,t}$ is real total export at time t. $x_{i,t}$ is real export of SITC i at time t ($i = 0, \ldots, 9$). e_t is real exchange rate at time t. y_t is real foreign demand at time t. Values in parentheses are the likelihood ratio test statistics
*** (**, *) Denotes significance at the 1 % (5 %, 10 %) level

maximum lags being set for six. The results of the Hansen parameter instability test, which is a test of the null hypothesis of cointegration against the alternative of no cointegration, are all not rejected at the 5 % level. Thus, all the estimated equations are stable in the long run. Real exchange rate and real foreign demand are mostly found to be important in influencing export in the long run. On the whole, exchange rate volatility is mostly found to have significant impact on sub-categories of real exports. For Singapore, exchange rate volatility is found to have significant impact

Table 8 Results of the error correction models

	$\Delta\ln x_{t,t}$	$\Delta\ln x_{0,t}$	$\Delta\ln x_{1,t}$	$\Delta\ln x_{2,t}$	$\Delta\ln x_{3,t}$	$\Delta\ln x_{4,t}$
Singapore						
Constant	−0.2183	2.4182	3.5835	3.6218	7.3451	7.7810
	(−2.8945)	(1.9499)*	(1.9254)*	(1.8940)*	(1.9044)*	(5.6054)***
$\Delta\ln e_t$	–	–	–	–	–	−11.0426
						(−3.9133)***
$\Delta\ln e_{t-1}$	1.2896	–	−2.7964	–	–	–
	(1.3003)		(−1.9786)*			
$\Delta\ln e_{t-2}$	–	–	–	−3.0728	–	–
				(−1.9747)*		
$\Delta\ln e_{t-3}$	–	0.0192	–	–	−3.2106	−4.7505
		(0.0332)			(−1.5588)	(−1.8191)*
$\Delta\ln y_t$	0.6517	–	–	–	–	0.3157
	(3.1343)***					(0.6213)
$\Delta\ln y_{t-1}$	–	–	0.5709	–	0.9010	–
			(1.7737)*		(1.9554)*	
$\Delta\ln y_{t-2}$	–	0.2901	0.9317	0.3213	–	–
		(2.7032)***	(3.2537)***	(1.9405)*		
$\Delta\ln y_{t-3}$	−0.1671	–	0.5539	–		–
	(−1.0788)		(2.4252)**			
Δv_t	–	–	–	–	109.7173	−281.6350
					(1.0786)	(−2.6864)**
Δv_{t-1}	−72.6886	–	173.4876	–	–	–
	(−2.3331)**		(2.9698)***			
Δv_{t-2}	–	–	–	−69.3010	–	–
				(−1.0872)		
Δv_{t-3}	–	−61.1992	−97.6902	–	–	–
		(−3.6282)***	(−1.8027)*			
$\Delta\ln x_{t-1}$	–	–	−0.5603	–	−0.4104	–
			(−5.3261)***		(−4.0358)***	
$\Delta\ln x_{t-2}$	–	−0.3112	–	–	–	–
		(−2.5864)**				
ec_{t-1}	−0.2619	−0.1686	−0.1195	−0.1248	−0.2069	−0.8056
	(−2.9565)***	(−1.9437)*	(−1.9162)*	(−1.8921)*	(−1.9029)*	(−5.5413)***

on real exports of SITC 1, SITC 4 and SITC 7. For China, exchange rate volatility is found to have significant impact on real total export and real exports of SITC 1, SITC 2, SITC 7, SITC 8 and SITC 9. For the USA, exchange rate volatility is found to have significant impact on real total export and real exports of SITC 2, SITC 7 and SITC 8. For Japan, exchange rate volatility is found to have significant impact

Table 8 continued

	$\Delta \ln x_{t,t}$	$\Delta \ln x_{0,t}$	$\Delta \ln x_{1,t}$	$\Delta \ln x_{2,t}$	$\Delta \ln x_{3,t}$	$\Delta \ln x_{4,t}$
Diagnostic tests						
Adj. R^2	0.2135	0.2589	0.4833	0.1083	0.3074	0.4724
LM	16.4948	22.8443**	11.5223	20.9983*	19.6514*	19.9674*
Reset	3.7628*	0.0138	0.0028	0.6597	0.8442	1.6848
Normal	0.5044	11.9556***	0.5631	0.9341	8.5808*	1.9287
Hetero	4.4430**	4.7150**	0.0659	2.2421	0.0135	0.0072

	$\Delta \ln x_{5,t}$	$\Delta \ln x_{6,t}$	$\Delta \ln x_{7,t}$	$\Delta \ln x_{8,t}$	$\Delta \ln x_{9,t}$
Constant	0.4088	5.3485	−0.2893	2.7314	−6.4820
	(2.7739)***	(6.1384)***	(−1.8884)*	(3.3610)***	(−1.7838)*
$\Delta \ln e_t$	1.5310	–	–	–	–
	(1.3055)				
$\Delta \ln e_{t-1}$	–	–	0.7788	–	15.6996
			(1.3091)		(1.3513)
$\Delta \ln e_{t-2}$	–	–	–	1.0143	–
				(1.3947)	
$\Delta \ln e_{t-3}$	–	−0.3368	–	–	–
		(−0.3048)			
$\Delta \ln y_t$	–	0.6141	0.1365	–	3.9897
		(3.9036)***	(0.9916)		(2.3606)**
$\Delta \ln y_{t-1}$	−0.3352	–	–	–	–
	(−2.1727)**				
$\Delta \ln y_{t-3}$	–	–	–	−0.2410	–
				(−1.7342)*	
Δv_t	−16.5657	–	54.1372	–	–
	(−0.3376)		(1.8831)*		
Δv_{t-2}	–	80.3189	–	–	−100.8089
		(1.8438)*			(−0.2221)
Δv_{t-3}	−89.3676	–	–	−45.7906	–
	(−2.1648)**			(−2.0331)**	
$\Delta \ln x_{t-1}$	−0.4086	–	–	−0.3233	–
	(−3.4416)***			(−2.2350)**	
$\Delta \ln x_{t-2}$	–	–	–	−0.3930	–
				(−3.0765)***	
ec_{t-1}	−0.3486	−0.8231	−0.1352	−0.5108	−0.1107
	(−2.7901)***	(−6.1365)***	(−1.8586)*	(−3.3531)***	(−1.7804)*

on real exports of SITC 0, SITC 1, SITC 2, SITC 5, SITC 6, SITC 7 and SITC 8. For Korea, exchange rate volatility is found to have significant impact on real exports of SITC 1 and SITC 8. The conclusion, which exchange rate volatility to have

Table 8 continued

	$\Delta\ln x_{5,t}$	$\Delta\ln x_{6,t}$	$\Delta\ln x_{7,t}$	$\Delta\ln x_{8,t}$	$\Delta\ln x_{9,t}$	
Diagnostic tests						
Adj. R^2	0.4462	0.5338	0.0797	0.5854	0.0581	
LM	8.0680	10.8708	20.3423*	9.1171	15.0080	
Reset	0.0583	0.0746	0.0416	10.2552***	0.3614	
Normal	1.7478	45.1061***	21.1277***	6.4202**	561.5794***	
Hetero	2.2585	0.2014	0.0728	13.4393***	2.2511	
	$\Delta\ln x_{t,t}$	$\Delta\ln x_{0,t}$	$\Delta\ln x_{1,t}$	$\Delta\ln x_{2,t}$	$\Delta\ln x_{3,t}$	$\Delta\ln x_{4,t}$
China						
Constant	−2.1288	−2.2052	15.6950	−2.8566	−5.3053	−10.3170
	(−3.5843)***	(−3.5374)***	(2.0927)**	(−2.2646)**	(−3.4657)***	(−4.0459)***
$\Delta\ln e_t$	2.0384	2.9137	10.7050	4.7807	–	–
	(3.2665)***	(2.4035)**	(2.2564)**	(3.1634)***		
$\Delta\ln e_{t-1}$	–	–	–	–	–	5.4150
						(2.5520)**
$\Delta\ln e_{t-2}$	–	–	–	–	−6.7769	–
					(−2.2629)**	
$\Delta\ln e_{t-3}$	–	–	–	–	–	−4.6044
						(−2.1955)**
$\Delta\ln y_t$	9.9041	11.1592	–	–	–	34.0944
	(3.7476)***	(3.6439)***				(3.8200)***
$\Delta\ln y_{t-1}$	–	–	–	13.6632	–	–
				(2.6886)**		
$\Delta\ln y_{t-2}$	–	–	−43.1784	–	27.5918	–
			(−2.0031)*		(3.0222)***	
Δv_t	–	5.9332	–	–	–	–
		(0.1381)				
Δv_{t-1}	–	–	−270.3441	97.7586	–	–
			(−1.2454)	−1.5828		
Δv_{t-2}	69.6549	–	−408.8647	131.0448	–	317.0306
	(2.7154)***		(−1.4811)	(1.7778)*		(3.5833)***
Δv_{t-3}	–	–	−497.0277	–	−256.5560	–
			(−1.8255)*		(−1.7169)*	
$\Delta\ln x_{t-1}$	−0.6146	–	−0.7785	−0.3576	−0.5767	−0.2280
	(−6.4413)***		(−7.7325)***	(−2.9154)***	(−5.4425)***	(−1.9101)*
$\Delta\ln x_{t-2}$	–	–	−0.5576	–	–	−0.2920
			(−5.8029)***			(−2.6144)**

Table 8 continued

	$\Delta \ln x_{t,t}$	$\Delta \ln x_{0,t}$	$\Delta \ln x_{1,t}$	$\Delta \ln x_{2,t}$	$\Delta \ln x_{3,t}$	$\Delta \ln x_{4,t}$
$\Delta \ln x_{t-3}$	–	–	–	–	0.2101	–
					(2.4969)**	
ec_{t-1}	−0.1164	−0.3482	−0.1035	−0.1514	−0.4322	−0.4173
	(−3.5379)***	(−3.4857)***	(−2.0932)**	(−2.2008)**	(−3.5564)***	(−4.0455)***
Diagnostic tests						
Adj. R^2	0.5177	0.2155	0.5671	0.2808	0.6560	0.4489
LM	8.4570	17.6737	16.2881	12.6686	7.0564	16.1092
Reset	0.0136	2.3812	1.1938	0.0544	0.1269	0.3252
Normal	12.4590***	2.0992	6.9291	8.0765**	9.6602***	2.1133
Hetero	0.1279	1.9345	1.1430	0.1938	1.2387	0.1309

	$\Delta \ln x_{5,t}$	$\Delta \ln x_{6,t}$	$\Delta \ln x_{7,t}$	$\Delta \ln x_{8,t}$	$\Delta \ln x_{9,t}$
Constant	3.5152	−3.6788	−2.4948	10.5297	3.3952
	(2.7757)***	(−1.7751)*	(−3.9349)***	(4.1491)***	(3.3327)***
$\Delta \ln e_t$	1.4884	4.2019	1.2434	2.1618	–
	(−1.4056)	(2.0567)**	(1.8615)*	(1.7427)*	
$\Delta \ln e_{t-1}$	–	–	–	−2.9371	1.1294
				(−2.1400)**	(0.9369)
$\Delta \ln y_t$	–	15.3213	12.6564	–	–
		(1.9557)*	(4.1547)***		
$\Delta \ln y_{t-1}$	–	–	–	−17.2370	−12.9099
				(−3.8901)***	(−3.1870)***
$\Delta \ln y_{t-2}$	−8.0693	–	–	–	–
	(−2.7970)***				
Δv_{t-1}	–	188.4347	–	–	–
		(2.2237)**			
Δv_{t-2}	34.6019	245.6240	–	–	103.2109
	(0.777)	(2.4802)**			−1.2744
Δv_{t-3}	–	–	−17.3694	−97.3706	–
			(−0.5172)	(−1.6256)	
$\Delta \ln x_{t-1}$	−0.4132	−0.2694	−0.7987	–	−0.3774
	(−3.2071)***	(−2.1332)**	(−6.6286)***		(−3.3948)***
$\Delta \ln x_{t-2}$	−0.2270	–	−0.4880	–	−0.3857
	(−1.7531)*		(−3.2969)***		(−3.5141)***
$\Delta \ln x_{t-3}$	–	–	−0.2407	–	–
			(−1.9745)*		
ec_{t-1}	−0.1827	−0.1032	−0.1669	−0.3990	−0.1971
	(−2.7659)***	(−1.7421)*	(−3.8788)***	(−4.1518)***	(−3.3322)***

Table 8 continued

	$\Delta \ln x_{5,t}$	$\Delta \ln x_{6,t}$	$\Delta \ln x_{7,t}$	$\Delta \ln x_{8,t}$	$\Delta \ln x_{9,t}$	
Diagnostic tests						
Adj. R^2	0.2357	0.2007	0.5448	0.2395	0.2779	
LM	13.8275	9.1234	8.0905	12.9768	19.5912*	
Reset	0.0010	0.0012	2.0369	1.6555	0.6018	
Normal	31.8641***	1.1444	0.5515	2.7458	4.2505	
Hetero	0.6620	0.1345	0.0006	0.0110	1.2807	
	$\Delta \ln x_{t,t}$	$\Delta \ln x_{0,t}$	$\Delta \ln x_{1,t}$	$\Delta \ln x_{2,t}$	$\Delta \ln x_{3,t}$	$\Delta \ln x_{4,t}$
The USA						
Constant	5.0307	−1.6458	−23.2483	3.5039	39.0127	4.7737
	(2.8634)***	(−1.8273)*	(−8.5084)***	(7.1164)***	(8.2779)**	(3.0583)***
$\Delta \ln e_t$	0.9135	−2.2351	–	–	–	−4.2225
	(2.1906)**	(−1.9005)*				(−1.8787)*
$\Delta \ln e_{t-1}$	–	–	2.3339	–	–	–
			−0.64330			
$\Delta \ln e_{t-2}$	–	–	–	7.4378	−5.9461	–
				(3.1365)***	(−0.7847)	
$\Delta \ln y_t$	–	–	–	–	–	−9.0023
						(−1.4542)
$\Delta \ln y_{t-1}$	–	–	–	−3.6725	–	–
				(−0.5628)		
$\Delta \ln y_{t-2}$	1.8379	1.0267	9.5689	–	26.3431	–
	(1.6533)	(0.3425)	(0.9829)		(1.2590)	
Δv_t	34.0596	–	–	–	–	–
	(2.2062)**					
Δv_{t-1}	27.1112	–	–	–	–	–
	(1.7080)*					
Δv_{t-2}	–	−113.9770	240.8525	–	252.5919	–
		(−2.7964)***	(1.6964)*		(0.8819)	
Δv_{t-3}	–	–	248.7476	−284.8535	–	−106.6382
			(1.6146)	(−3.0287)***		(−1.2063)
$\Delta \ln x_{t-1}$	−0.2512	–	–	–	–	−0.5015
	(−1.9310)*					(−2.6220)**
$\Delta \ln x_{t-2}$	–	–	–	–	–	−0.3292
						(−2.5699)**
ec_{t-1}	−0.3790	−0.0678	−1.1164	−0.8476	−1.0723	−0.7073
	(−2.8680)***	(−1.8183)*	(−8.5021)***	(−7.1737)***	(−8.2884)***	(−3.0497)***

Table 8 continued

	$\Delta \ln x_{t,t}$	$\Delta \ln x_{0,t}$	$\Delta \ln x_{1,t}$	$\Delta \ln x_{2,t}$	$\Delta \ln x_{3,t}$	$\Delta \ln x_{4,t}$
Diagnostic tests						
Adj. R^2	0.3135	0.1275	0.5577	0.5402	0.5318	0.6128
LM	16.9337	10.2966	12.9342	15.4045	11.5675	8.49
Reset	0.0488	0.7375	0.0830	0.0878	2.6567	2.3329
Normal	0.8683	0.7790	30.0736***	156.7766***	3.2448	34.6686***
Hetero	0.4139	0.8317	0.0047	0.0466	0.1210	0.1183

	$\Delta \ln x_{5,t}$	$\Delta \ln x_{6,t}$	$\Delta \ln x_{7,t}$	$\Delta \ln x_{8,t}$	$\Delta \ln x_{9,t}$
Constant	0.9087	1.1606	4.7077	2.3244	−10.2099
	(2.1465)**	(9.1938)***	(2.4910)**	(1.8640)*	(−1.8660)*
$\Delta \ln e_t$	–	0.9130	1.0577	0.6477	–
		(0.7965)	(2.5751)**	(1.1702)	
$\Delta \ln e_{t-2}$	−3.2184	–	–	–	−4.6002
	(−1.9001)*				(−2.2357)**
$\Delta \ln y_t$	–	–	2.0403	–	7.5965
			(1.7447)*		(1.1421)
$\Delta \ln y_{t-1}$	–	–	–	1.3779	–
				(0.9290)	
$\Delta \ln y_{t-2}$	4.7713	6.5682	–	–	–
	(1.0216)	(2.1189)**			
$\Delta \ln y_{t-3}$	–	–	2.1680	–	–
			(1.8411)*		
Δv_t	114.646	−31.7741	71.9827	–	–
	(1.8981)*	(−0.7899)	(3.8482)***		
$\Delta v_{\tau-1}$	–	–	82.9125	–	–
			(3.6315)***		
Δv_{t-2}	–	–	46.5125	–	71.4583
			(1.9483)*		(1.2208)
Δv_{t-3}	–	–	55.8716	38.5329	–
			(2.7242)***	(1.7831)*	
$\Delta \ln x_{t-1}$	−0.3276	–	−0.5040	–	–
	(−2.6841)**		(−3.2479)***		
$\Delta \ln x_{t-2}$	–	–	−0.3090	–	–
			(−2.0056)*		
$\Delta \ln x_{t-3}$	–	–	−0.3374	–	–
			(−2.7002)**		
ec_{t-1}	−0.2224	−1.1944	−0.3703	−0.1404	−0.2758
	(−2.1417)**	(−9.4263)***	(−2.5004)**	(−1.8681)*	(−1.8609)*

Table 8 continued

	$\Delta\ln x_{5,t}$	$\Delta\ln x_{6,t}$	$\Delta\ln x_{7,t}$	$\Delta\ln x_{8,t}$	$\Delta\ln x_{9,t}$
Diagnostic tests					
Adj. R^2	0.2823	0.5985	0.5024	0.0894	0.1592
LM	12.8588	12.4162	14.6483	17.5287	13.5633
Reset	0.0222	0.5681	4.9256**	1.1999	0.0675
Normal	1.9242	69.2880***	0.9279	0.7000	3.0023
Hetero	1.0097	0.2193	0.3213	0.2198	6.7692***

	$\Delta\ln x_{t,t}$	$\Delta\ln x_{0,t}$	$\Delta\ln x_{1,t}$	$\Delta\ln x_{2,t}$	$\Delta\ln x_{3,t}$	$\Delta\ln x_{4,t}$
Japan						
Constant	−1.6101	−3.8349	18.3189	−2.4833	−4.5315	10.1278
	(−3.0698)***	(−1.8245)*	(2.3353)**	(−2.6435)**	(−2.1658)**	(6.8878)***
$\Delta\ln e_t$	−0.7756	−1.6971	–	–	–	–
	(−2.1258)**	(−2.3457)**				
$\Delta\ln e_{t-1}$	–	–	–	–	–	0.9041
						(1.2240)
$\Delta\ln e_{t-2}$	–	–	–	−0.9236	−1.2140	–
				(−0.8592)	(−1.4164)	
$\Delta\ln e_{t-3}$	–	–	4.4603	–	–	–
			(1.9520)*			
$\Delta\ln y_t$	–	–	−3.1632	1.2936	–	–
			(−1.7888)*	(2.1378)**		
$\Delta\ln y_{t-1}$	−0.3861	–	–	–	−1.4726	−1.0998
	(−1.3722)				(−2.1239)**	(−1.9943)*
$\Delta\ln y_{t-2}$	–	−1.2216	–	–	–	–
		(−2.2979)**				
Δv_{t-1}	–	–	–	−51.3268	–	32.1061
				(−1.8972)*		(1.6099)
Δv_{t-2}	–	27.6840	91.5723	–	58.8901	–
		(1.4025)	(1.4678)		(2.4361)**	
Δv_{t-3}	29.7867	36.6536	–	–	42.9715	–
	(1.8025)*	(1.8377)*			(1.7506)*	
$\Delta\ln x_{t-1}$	–	−0.6308	−0.5527	−0.5111	−0.4149	–
		(−6.4303)***	(−4.6342)***	(−3.9057)***	(−3.2420)***	
$\Delta\ln x_{t-2}$	–	–	−0.3176	–	–	–
			(−2.6517)**			
$\Delta\ln x_{t-3}$	–	–	–	0.2188	–	–
				(1.8251)*		
ec_{t-1}	−0.1424	−0.0548	−0.1091	−0.2951	−0.1141	−0.9029
	(−3.1874)***	(−1.8221)*	(−2.3294)**	(−2.6517)**	(−2.1628)**	(−6.8861)***

Table 8 continued

	$\Delta\ln x_{t,t}$	$\Delta\ln x_{0,t}$	$\Delta\ln x_{1,t}$	$\Delta\ln x_{2,t}$	$\Delta\ln x_{3,t}$	$\Delta\ln x_{4,\tau}$
Diagnostic tests						
Adj. R^2	0.0849	0.4438	0.3522	0.4814	0.2503	0.4454
LM	24.1814**	13.3380	14.7650	14.2271	15.4570	11.7207
Reset	0.4067	0.8591	3.2948*	2.8398*	0.7622	0.5593
Normal	126.1293***	0.1350	2.4080	1.6505	4.3115	1.5960
Hetero	1.4916	0.0012	0.8227	6.4002**	0.0537	1.0352

	$\Delta\ln x_{5,t}$	$\Delta\ln x_{6,t}$	$\Delta\ln x_{7,t}$	$\Delta\ln x_{8,t}$	$\Delta\ln x_{9,t}$
Constant	7.2534	6.9066	−1.2603	2.9729	−11.3965
	(4.1228)***	(5.2446)***	(−4.2577)***	(2.2916)**	(−5.6132)***
$\Delta\ln e_t$	–	–	0.7915	0.6562	–
			(1.7892)*	(1.6983)*	
$\Delta\ln e_{t-1}$	1.3381	1.3340	–	–	–
	(2.7428)***	(3.1576)***			
$\Delta\ln e_{t-2}$	0.9015	–	−0.4610	–	2.5892
	(1.8241)*		(−0.9670)		(1.8454)*
$\Delta\ln e_{t-3}$	–	–	0.7195	–	−2.6215
			(1.6265)		(−1.8578)*
$\Delta\ln y_t$	–	–	0.7662	–	1.7300
			(2.2255)**		(1.7779)*
$\Delta\ln y_{t-1}$	0.5106	–	–	–	−2.0390
	−1.4891				(−2.0146)**
$\Delta\ln y_{t-2}$	–	–	−0.7655	–	–
			(−2.3422)**		
$\Delta\ln y_{t-3}$	–	−0.5948	–	0.2587	–
		(−1.9374)*		−0.9777	
Δv_t	32.7746	–	–	–	−67.7865
	(2.4317)**				(−1.7774)*
Δv_{t-1}	36.5920	−14.7063	−22.8970	−22.4043	−54.8666
	(2.6666)**	(−1.3055)	(−1.8489)*	(−2.2192)**	(−1.2592)
Δv_{t-2}	–	–	–	−18.4015	−54.2276
				(−1.7984)*	(−1.3295)
$\Delta\ln x_{t-1}$	−0.4140	–	–	−0.3721	–
	(−3.6689)***			(−2.9437)***	
ec_{t-1}	−0.6037	−0.5244	−0.3989	−0.3152	−0.6803
	(−4.1214)***	(−5.2447)***	(−4.2542)***	(−2.2922)**	(−5.6091)***

significant impact on sub-categories of real exports and not real total exports is the same as the conclusion obtained by the Johansen method although there are some minor differences.

Table 8 continued

	$\Delta \ln x_{5,t}$	$\Delta \ln x_{6,t}$	$\Delta \ln x_{7,t}$	$\Delta \ln x_{8,t}$	$\Delta \ln x_{9,t}$
Diagnostic tests					
Adj. R^2	0.5838	0.3906	0.2761	0.3382	0.4137
LM	5.5700	4.1226	16.4622	6.5084	18.3465
Reset	0.9284	0.0442	0.1153	5.9180**	1.1510
Normal	12.2893***	1.6720	1.6160	4.1674	2.0968
Hetero	0.0589	0.2765	1.7763	0.0116	0.2901

	$\Delta \ln x_{t,t}$	$\Delta \ln x_{0,t}$	$\Delta \ln x_{1,t}$	$\Delta \ln x_{2,t}$	$\Delta \ln x_{3,t}$	$\Delta \ln x_{4,t}$
Korea						
Constant	13.1792	−11.4282	−32.6588	−125.1149	23.5161	3.9673
	(4.4045)***	(−2.5491)**	(−4.2545)***	(−3.6824)***	(3.7666)***	(6.9980)***
$\Delta \ln e_t$	2.7665	–	−6.9518	–	8.1396	–
	(3.1617)***		(−1.7630)*		(3.6041)***	
$\Delta \ln e_{t-1}$	–	–	15.1193	–		–
			(1.8733)*			
$\Delta \ln e_{t-2}$	–	1.4063	–	–	–	−3.2922
		(0.83934)				(−1.2698)
$\Delta \ln y_t$	–	–	0.5176	11.4951	–	–
			(0.2491)	(2.2323)**		
$\Delta \ln y_{t-1}$	0.9247	–	–	–	1.3092	–
	(2.1679)**				(1.1967)	
$\Delta \ln y_{t-2}$	–	−1.2712	–	–	–	−2.2736
		(−1.3246)				(−1.8101)*
Δv_t	–	–	35.1883	782.5426	–	–
			(0.2582)	(2.7737)***		
Δv_{t-1}	27.7213	–	–	492.2959	159.7424	93.1572
	(0.8862)			(1.6784)*	(1.9496)*	(1.0298)
Δv_{t-2}	–	40.1251	–	–	154.3046	–
		(0.7363)			(1.8588)*	
Δv_{t-3}	–	–	–	–	209.6454	–
					(2.5556)**	
$\Delta \ln x_{t-1}$	−0.2516	–	–	−0.3811	−0.3108	–
	(−2.0962)**			(−3.1574)***	(−2.3894)**	
ec_{t-1}	−0.8767	−0.4851	−0.4389	−0.6015	−0.7490	−0.8967
	(−4.4091)***	(−2.5528)**	(−4.2611)***	(−3.6836)***	(−3.7730)***	(−6.9968)***

This study finds that different exchange rate can be best to be estimated by a different ARCH model with different assumption of the disturbance term. This implies and simply assumes that exchange rate volatility to be estimated by a certain ARCH model could produce misleading conclusion. There is some evidence of exchange

Table 8 continued

	$\Delta\ln x_{t,t}$	$\Delta\ln x_{0,t}$	$\Delta\ln x_{1,t}$	$\Delta\ln x_{2,t}$	$\Delta\ln x_{3,t}$	$\Delta\ln x_{4,t}$
Diagnostic tests						
Adj. R^2	0.6772	0.2839	0.2358	0.5633	0.6510	0.4707
LM	11.7981	16.2950	15.2201	17.6268	11.2943	13.7527
Reset	2.1529	7.3632***	2.1851	0.1070	0.0112	0.1618
Normal	0.3168	9.1297***	0.6639	59.6485***	0.0311	78.3433***
Hetero	0.5603	6.5592***	0.1515	2.4955	0.0981	0.0640

	$\Delta\ln x_{5,t}$	$\Delta\ln x_{6,t}$	$\Delta\ln x_{7,t}$	$\Delta\ln x_{8,t}$	$\Delta\ln x_{9,t}$
Constant	−8.4040	12.0971	11.7873	17.5005	−2.1775
	(−3.5340)***	(6.9394)***	(3.0593)***	(4.4173)***	(−3.8603)***
$\Delta\ln e_t$	–	1.9129	2.4425	2.8589	−4.5424
		−1.5356	(2.5654)**	(1.7442)*	(−2.1696)**
$\Delta\ln e_{t-2}$	−3.0000	–	–	–	–
	(−2.1171)**				
$\Delta\ln e_{t-3}$	2.3898	–	–	–	–
	(1.9030)*				
$\Delta\ln y_t$	1.6882	–	−1.0103	–	−0.9258
	(2.0773)**		(−1.9016)*		(−2.2273)**
$\Delta\ln y_{t-2}$	–	−1.1189	−1.4447	−2.1597	–
		(−1.8843)*	(−2.7255)***	(−2.3299)**	
$\Delta\ln y_{t-3}$	–	–	−1.3018	−2.5370	–
			(−2.4052)**	(−2.6842)**	
Δv_{t-1}	29.1448	−18.4784	–	–	–
	−1.0698	(−0.4312)			
Δv_{t-2}	–	–	48.2584	−126.5612	−66.2543
			−1.5289	(−2.2995)**	(−1.6406)
Δv_{t-3}	–	–	–	–	−91.7193
					(−1.7571)*
$\Delta\ln x_{t-1}$	−0.3160	–	−0.3298	–	–
	(−2.6908)***		(−2.9255)***		
ec_{t-1}	−0.5553	−0.9072	−0.2119	−0.3143	−0.7646
	(−3.5403)***	(−6.9369)***	(−3.0595)***	(−4.4184)***	(−3.8664)***

rate volatility to have significant impact on real total exports of Malaysia in the long run, but more evidence of exchange rate volatility is found to have significant impact on sub-categories of real total exports of Malaysia in the short run. This conclusion seems to be applied for mostly all the countries examined. There is some evidence that country which is less important to export of Malaysia is less affected by exchange rate volatility. However, further investigation should be carried out to confirm this hypothesis. The stochastic volatility model can be used to estimate exchange rate volatility

Table 8 continued

	$\Delta\ln x_{5,t}$	$\Delta\ln x_{6,t}$	$\Delta\ln x_{7,t}$	$\Delta\ln x_{8,t}$	$\Delta\ln x_{9,t}$
Diagnostic tests					
Adj. R^2	0.5036	0.4548	0.3199	0.295	0.4314
LM	11.3089	14.736	13.0201	9.2085	12.1123
Reset	0.4847	0.0123	0.0377	0.8626	6.4851**
Normal	0.4154	1.1780	57.9959***	5.0292*	14.3947***
Hetero	6.7064**	0.3325	0.0037	1.6518	11.2580***

$x_{t,t}$ is real total export at time t. $x_{i,t}$ is real export of SITC i at time t ($i = 0, \ldots, 9$). e_{t-i} is real exchange rate at time $t - i$ ($i = 0, 1, 2, 3$). y_{t-i} is real foreign demand at time at time $t - i$ ($i = 0, 1, 2, 3$). v_t is exchange rate volatility at time at time $t - i$ ($i = 0, 1, 2, 3$) estimated by an ARCH model. The ordinary least squares (OLS) estimator with the Newey–West standard errors is used when the Lagrange multiplier statistic is found to be significant. The OLS estimator with White's heteroscedasticity standard errors is used when the heteroscedasticity test is found to be significant. Adj. R^2 is the adjusted R^2. LM is the Lagrange multiplier test of the disturbance term serial correlation. Reset is the test of functional form. Normal is the test of the normality of the disturbance term. Hetero is the test of heteroscedasticity. Values in parentheses are the t-statistics

*** (**, *) Denotes significance at the 1 % (5 %, 10 %) level

to examine its impact on export to clarify this claim. Policy implication can be specifically designed to assist those affected industries or sectors. For example, industries are significantly affected and may be given some incentive for their exports. The finding that exchange rate volatility to have significant impact on exports is consistent with the findings such as Bahmani-Oskooee and Harvey (2011) and Wong and Tang (2008), Wong and Tang (2011). Furthermore, the impact of exchange rate volatility differs across sectors of exports. Some industries are found to be more sensitive to exchange rate volatility. Real exports of SITC 7 and SITC 8 tend to sensitive to exchange rate volatility as mostly found to be significance in all bilateral exports examined.

The impact of exchange rate volatility on export can be negative or positive. De Grauwe (1988) demonstrates that an increase in exchange rate volatility has both the substitution and income effects. The substitution effect is that an increase in exchange rate volatility will lead to a decrease in export. The income effect is that an increase in exchange rate volatility will lead to an increase in export. The explanation is that an increase in exchange rate volatility, which is a risk, and thus, the expected utility of export revenue declines. The decline in export revenue can be offset by increasing in export. For an exporting firm, which is risk averse, perceives export revenue less attractive given increase in exchange rate volatility and therefore the exporting firm reduces its export and focuses on sale in domestic market. The substitution effect dominates the income effect, that is, an increase in exchange rate volatility will lead to a decrease in export. Conversely an exporting firm, which is very risk averse or risk neutral, worries the lower export revenue given the increase in exchange rate volatility, and hence, the exporting firms increase its export. The income effect dominates the substitution effect, that is, an increase in exchange rate volatility will lead to an increase in export.

There are some reasons exchange rate volatility has no impact on export (Devereux and Engel 2002; Gopinath et al. 2010; Bandt and Razafindrabe 2014: 64; Bernini

Table 9 Long-run coefficients of the dynamic ordinary least squares (DOLS) estimator

	$\ln x_{t,t}$	$\ln x_{0,t}$	$\ln x_{1,t}$	$\ln x_{2,t}$	$\ln x_{3,t}$	$\ln x_{4,t}$
Singapore						
Constant	8.3988	9.0664	23.4988	20.3296	25.0889	6.6138
	(7.9837)***	(7.3303)***	(9.4723)***	(4.1481)***	(6.9287)***	(2.0118)**
$\ln e_t$	0.8926	3.2537	6.2460	−0.7572	5.9666	−2.4193
	(2.3210)**	(8.6781)***	(6.9356)***	(−0.4876)	(5.5109)***	(−2.3183)**
$\ln y_t$	0.3965	−0.8637	−4.7979	−2.9280	−4.4748	0.4600
	(1.8754)*	(−3.1319)***	(−9.0450)***	(−2.6834)**	(−5.5578)***	(0.6806)
v_t	−3.4293	−87.4650	406.8338	−1.5388	−145.8296	−366.9700
	(−0.0501)	(−1.0739)	(2.4311)**	(−0.0047)	(−1.0189)	(−2.0435)**
Lc	0.0207	0.0277	0.0430	0.0205	0.0328	0.0309
	$\ln x_{5,t}$	$\ln x_{6,t}$	$\ln x_{7,t}$	$\ln x_{8,t}$	$\ln x_{9,t}$	
Constant	7.5639	5.7547	8.4534	7.1528	−157.4997	
	(4.9970)***	(6.2659)***	(7.0875)***	(6.4936)***	(−3.9983)***	
$\ln e_t$	1.6276	0.3694	0.8631	1.7318	−19.0366	
	(3.3873)***	(1.1001)	(2.2796)**	(4.7710)***	(−1.7276)*	
$\ln y_t$	−0.2199	0.5558	0.2497	0.0110	38.8865	
	(−0.7064)	(3.0112)***	(1.0182)	(0.0448)	(4.4529)***	
v_t	32.2718	−13.2405	118.0366	−98.6348	−1093.1270	
	(0.3903)	(−0.2216)	(1.8117)*	(−1.3522)	(−0.6588)	
Lc	0.0330	0.0460	0.0192	0.0628	0.0191	
	$\ln x_{t,t}$	$\ln x_{0,t}$	$\ln x_{1,t}$	$\ln x_{2,t}$	$\ln x_{3,t}$	$\ln x_{4,t}$
China						
Constant	9.0882	6.1161	−195.4034	95.4691	11.2664	−22.6803
	(2.6905)**	(7.4493)***	(−5.8091)***	(8.7078)***	(2.0488)**	(−2.5882)**
$\ln e_t$	1.1735	1.3748	−43.2267	16.8736	3.3944	−7.0576
	(2.0414)*	(3.8065)***	(−7.3321)***	(8.7811)***	(2.9816)***	(−4.6206)***
$\ln y_t$	0.3635	0.1878	26.5436	−11.7356	−0.1906	4.0514
	(0.7917)	(1.8381)*	(5.7765)***	(−7.8357)***	(−0.2556)	(3.4058)***
v_t	−164.4942	24.0821	974.4413	−424.8831	122.0570	−55.2418
	(−4.7680)***	(0.3563)	(4.9875)***	(−6.6721)***	(0.6780)	(−0.4373)
Lc	0.0729	0.0389	0.0604	0.0227	0.0339	0.0464

and Tomasi 2015; Choudhri and Hakura 2015). One explanation is the incomplete transmission between exchange rate volatility and export price because an exporting firm is facing a choice between profit maximization and market share in the export market. An exporting firm will reduce its profit or absorb loss temporarily because of exchange rate volatility to maintain its market share in foreign country. Therefore, there is no significant impact of exchange rate volatility on export. Also, there is no

Table 9 continued

	$\ln x_{5,t}$	$\ln x_{6,t}$	$\ln x_{7,t}$	$\ln x_{8,t}$	$\ln x_{9,t}$	
Constant	67.4656	79.9423	−5.5148	18.7183	5.1680	
	(5.2344)***	(3.8299)**	(−0.6871)	(3.0553)***	(0.9681)	
$\ln e_t$	10.3483	13.2404	−0.5446	1.4947	−4.3444	
	(4.5809)**	(3.6192)**	(−0.4058)	(1.4643)	(−4.9164)***	
$\ln y_t$	−7.9555	−9.5578	2.2729	−1.5282	−0.3809	
	(−4.5183)**	(−3.3519)**	(2.0794)*	(−1.8312)*	(−0.5217)	
v_t	−67.3682	−159.3780	−287.6141	−193.0950	276.6800	
	(−0.8999)	(−1.3146)	(−3.8155)***	(−2.2092)**	(2.5862)**	
Lc	0.0396	0.0570	0.0295	0.0333	0.0339	
	$\ln x_{t,t}$	$\ln x_{0,t}$	$\ln x_{1,t}$	$\ln x_{2,t}$	$\ln x_{3,t}$	$\ln x_{4,t}$
The USA						
Constant	5.4726	21.0431	−19.7697	6.0634	40.9911	17.2446
	(3.5907)***	(4.2085)***	(−3.9099)***	(0.4789)	(3.7197)***	(5.3688)***
$\ln e_t$	0.3746	1.4343	2.7749	7.6583	6.2308	−1.5463
	(1.3384)	(1.3055)	(2.5307)**	(2.4662)**	(2.6073)**	(−2.2200)**
$\ln y_t$	1.0018	−3.4474	4.2069	−1.6228	−9.4144	−1.7442
	(2.7328)**	(−2.8733)***	(3.4184)***	(−0.5580)	(−3.5100)***	(−2.2311)**
v_t	95.1395	−67.0011	212.2248	470.8719	450.5768	8.6932
	(5.2054)***	(−0.4476)	(1.3732)	(2.1158)*	(1.3378)	(0.0886)
Lc	0.0312	0.0162	0.0519	0.0433	0.0655	0.0581
	$\ln x_{5,t}$	$\ln x_{6,t}$	$\ln x_{7,t}$	$\ln x_{8,t}$	$\ln x_{9,t}$	
Constant	−12.4708	0.1821	12.5608	−7.2666	−54.2288	
	(−2.0610)**	(0.0889)	(10.3478)***	(−1.7199)	(−5.8109)***	
$\ln e_t$	2.3048	0.1950	1.9189	1.1871	−4.2693	
	(1.6621)	(0.4270)	(5.7779)***	(1.5412)	(−2.5094)*	
$\ln y_t$	3.6493	1.5439	−0.9841	3.3273	14.0593	
	(2.4923)**	(3.1442)***	(−3.1851)***	(3.3682)**	(6.44341)***	
v_t	91.4808	−84.7523	74.8110	155.5738	−35.6285	
	(0.6274)	(−1.5303)	(3.1946)***	(3.0454)**	(−0.3158)	
Lc	0.0191	0.0582	0.0433	0.0275	0.0308	

connection between exchange rate volatility and the real economy which may be due to local currency pricing, heterogeneous international distribution of commodities and noise traders in the foreign exchange rate markets (Devereux and Engel 2002). Bandt and Razafindrabe (2014) examine the impact of currency invoicing choice of exporting firms and find that the degree of exchange rate pass-through is incomplete in the short run, but complete in the long run. Bernini and Tomasi (2015) find that the imports of high-quality immediate input can reduce exchange rate pass-through to the price of

Table 9 continued

	$\ln x_{t,t}$	$\ln x_{0,t}$	$\ln x_{1,t}$	$\ln x_{2,t}$	$\ln x_{3,t}$	$\ln x_{4,t}$
Japan						
Constant	40.5288	−17.6818	66.6474	−3.3738	−14.6324	9.0237
	(4.7900)***	(−2.2662)**	(2.0406)**	(−0.5842)	(−1.3273)	(3.1977)***
$\ln e_t$	−0.5634	1.0162	0.0959	−0.1343	0.1075	0.9267
	(−1.4490)	(4.0366)***	(0.0655)	(−0.3426)	(0.2997)	(4.2845)***
$\ln y_t$	−6.3473	5.0518	−14.0639	2.3011	5.4457	−0.7904
	(−3.4424)***	(2.9769)***	(−1.9733)*	(1.8070)*	(2.2724)**	(−1.2717)
v_t	13.2004	−63.8169	264.9544	93.8398	24.5104	−6.7494
	(0.2898)	(−2.4986)**	(1.6965)*	(1.9778)*	(0.6836)	(−0.2564)
Lc	0.0179	0.0439	0.0164	0.0320	0.0228	0.0460
	$\ln x_{5,t}$	$\ln x_{6,t}$	$\ln x_{7,t}$	$\ln x_{8,t}$	$\ln x_{9,t}$	
Constant	71.7410	10.5764	1.9000	−34.2393	−201.3482	
	(9.2291)***	(4.5655)***	(0.5550)	(−1.7289)	(−9.0711)***	
$\ln e_t$	−1.3388	0.1556	0.2115	1.0731	1.5964	
	(−8.0169)***	(0.8762)	(1.2665)	(2.5223)*	(3.3479)**	
$\ln y_t$	−13.7996	−0.5445	1.6499	9.1092	45.2380	
	(−8.2135)***	(−1.0673)	(2.1996)**	(2.1282)	(9.4295)***	
v_t	19.4589	−43.5354	−39.3698	−47.2761	11.8576	
	(2.3525)*	(−2.0143)**	(−2.0377)**	(−2.2434)*	(0.5020)	
Lc	0.0495	0.0330	0.0242	0.0122	0.0124	
	$\ln x_{t,t}$	$\ln x_{0,t}$	$\ln x_{1,t}$	$\ln x_{2,t}$	$\ln x_{3,t}$	$\ln x_{4,t}$
Korea						
Constant	−30.9660	−27.2862	−113.2609	−135.2044	21.1419	6.3242
	(−1.5118)	(−2.7066)**	(−2.1902)**	(−3.7351)***	(3.0215)***	(0.7832)
$\ln e_t$	1.5983	0.7257	3.7719	−4.2183	0.8758	−0.6924
	(2.3814)*	(2.1490)**	(2.5584)**	(−1.9626)*	(1.7180)*	(−1.0626)
$\ln y_t$	8.5335	6.8073	24.0697	26.9996	−2.2625	−0.2194
	(2.0451)	(3.3749)***	(2.3048)**	(3.8171)***	(−1.6635)	(−0.1393)
v_t	198.5885	−33.6846	897.7594	312.4184	37.2171	51.7205
	(2.0336)	(−0.6248)	(2.9889)***	(0.7755)	(0.3693)	(0.3921)
Lc	0.0197	0.0534	0.0303	0.0604	0.0587	0.0347

high-quality export good. Moreover, export can be insensitive or inelastic to exchange rate volatility. This can be an avenue for the future research. Generally, there are many factors that can contribute to the no significant link between exchange rate volatility and export.

The impact of exchange rate volatility on export is more important in the short run than in the long run. Hence, the adverse impact of exchange rate volatility is much

Table 9 continued

	$\ln x_{5,t}$	$\ln x_{6,t}$	$\ln x_{7,t}$	$\ln x_{8,t}$	$\ln x_{9,t}$
Constant	−8.2265	0.9957	23.1308	126.5638	60.7861
	(−2.1938)**	(0.2573)	(3.8647)***	(5.5201)***	(4.7127)***
$\ln e_t$	1.0850	1.1958	−0.0346	−4.4507	−2.0946
	(3.5857)***	(3.8295)***	(−0.0794)	(−5.9241)***	(−4.9558)***
$\ln y_t$	3.3520	1.6586	−2.9610	−25.0253	−11.7923
	(4.5832)***	(2.1976)**	(−2.5452)**	(−5.3579)***	(−4.4879)**
v_t	50.9560	57.5606	−78.0979	−480.7995	114.1801
	(0.8318)	(0.9105)	(−0.9060)	(−4.3986)**	(1.8568)
Lc	0.0368	0.0359	0.0180	0.0253	0.0190

$x_{t,t}$ is real total export at time t. $x_{i,t}$ is real export of SITC i at time t ($i = 0$–9). e_t is real exchange rate at time t. y_t is real foreign demand at time t. v_t is exchange rate volatility at time t estimated by an ARCH model. Lc is the Hansen parameter instability test. The standard errors are the Newey–West standard errors. *** (**, *) denotes significance of the t-statistic at the 1 % (5 %, 10 %) level

more a short-run phenomenon than in the long run. On the other hand, real exchange rate and real foreign demand are mostly found to be important in influencing export in the long run. The conclusions are about the same for the results obtained by the Johansen method and the results obtained by the DOLS estimator. An appreciation of real exchange rate or real foreign demand will lead to an increase or a decrease in real exports. Generally, an increase in real foreign demand will lead to an increase in real export. However, an increase in real foreign demand mainly due to an increase in the output for import or the output for import substitution, export to the country can be adversely affected (Fu et al. 2012). An appreciation of real exchange rate would lead to an a decrease in real export, but an appreciation of real exchange rate would lead to an increase in real export for good, which is not easily substitutable (Auboin and Ruta 2013).

A stable exchange rate is important to stimulate exports. There is no strong evidence of exchange rate volatility on real export which could be due to the exchange rate policy and its management implemented in Malaysia is satisfactory to avoid the adverse impact of exchange rate volatility on export. Malaysia adopts a managed floating exchange rate. Bank Negara Malaysia might intervene in the exchange rate market in the short run but in the long run likely would let the exchange rate market to determine the value of RM, which is pegged against a basket of currencies. In the short run, small and medium exporters shall be encouraged to take position in the forward and futures markets. In the long run, the forward and futures markets shall be further developed with the use of the state-of-the-art technology and more instruments shall be introduced. The costs of involvement in the forward and futures markets shall be minimized. In the short run, an effective marketing approach shall be adopted to promote exports of Malaysia. In the long run, exporters of Malaysia shall continue to improve their products through innovation and high technology. Moreover, exporters of Malaysia shall focus on the export market in Association of Southeast Asian Nations Economic Community (AEC), which was launched in 2010 with the aims to promote free flow of goods, services, investment, capital and skilled labor to attract investment and trade in the region (Ministry of Finance Malaysia 2013). AEC would provide an extensive potential export market to exporters of Malaysia.

6 Concluding remarks

This study investigates the impact of exchange rate volatility on real total export and its sub-categories, namely real exports of SITC from 0 to 9 of Malaysia to Singapore, China, the USA, Japan and Korea. Exchange rate volatility is good to be selected from a group of ARCH model with different assumptions of the disturbance terms rather than simply assumes that exchange rate volatility to be estimated by a certain ARCH model could produce misleading conclusion. There is long-run relationship among real export, real exchange rate and real foreign demand. Generally, more evidence of the significant impact of exchange rate volatility on sub-categories of real total exports is found in the short run, that is, about half of the cases examined that exchange rate volatility is found to have significant impact on real exports in the short run. However, there are only a few significant impact of exchange rate volatility on real total exports is found in the long run. The impact of exchange rate volatility differs across sectors of exports and can be negative or positive, which imply that different sectors of exports response to exchange rate volatility differently. Country which is less important to export of Malaysia would be likely less affected by exchange rate volatility. Exporters of Malaysia shall improve their products through innovation and high technology. A better marketing strategy shall be adopted to promote exports of Malaysia. Exports shall be further diversified with more focus on exports to AEC. Exports can improve economic growth and can help Malaysia to transform its economy and to achieve its vision to be a high-income country in the near future. Export sector creates more high-paying employment opportunities. This can help to achieve the vision of a high-income country.

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