Trade Volatility in the Association of Southeast Asian Nations Plus Three: Impacts and Determinants

Thi Nguyet Anh Nguyen, Thi Hong Hanh Pham, and Thomas Vallée*

This paper investigates trade volatility in the Association of Southeast Asian Nations Plus Three (ASEAN+3) and its links with output volatility, export diversification, and free trade agreements. To achieve this research objective, we apply several econometric estimators to data from all ASEAN+3 member states over the period 1990–2016. We first find evidence of a positive relationship between output volatility and trade volatility. Second, we reveal that the way export diversification is measured can influence its impacts on bilateral export volatility. Moreover, the relationship between income volatility, trade volatility, and export diversification seems to depend on country size and the level of economic development.

Keywords: ASEAN+3, export diversification, FTA, output volatility, trade volatility
JEL codes: F02, F14, F15, F21, F40

I. Introduction

International trade is considered one of the most volatile components of gross domestic product (GDP). According to Bennett et al. (2016), trade volatility and GDP volatility have tended to move together over the past 20 years—from slightly falling in the mid-1990s until 2008 to sharply increasing after the global crisis of 2008–2009. Obviously, trade has become a transmission mechanism of external shocks throughout the world economy. In addition, researchers have found a positive correlation between trade openness and volatility (Di Giovanni and Levchenko 2009), which suggests that trade openness has also played a role in explaining the volatility of economic growth (Rodrik 1997). Caselli et al. (2015) find that

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countries that suffer from big country-specific shocks experience a reduction in volatility as a result of opening up to international trade, because trade is a source of diversification.

Trade volatility also varies among countries at different levels of economic development. Developing countries are substantially more volatile than developed ones (Hakura 2009) because developing countries usually concentrate their exports in a small number of sectors that are particularly sensitive to external shocks. Therefore, diversification in trade should diminish volatility effects. Moreover, developing countries are characterized by underdeveloped financial markets and weak monetary and fiscal policies. Thus, diversification of the sectoral composition can enhance the development of financial markets and alleviate uncertainty in the economy.

ASEAN+3 is known as a successful model of economic cooperation between the Association of Southeast Asian Nations (ASEAN) and three East Asian countries—Japan, the People's Republic of China (PRC), and the Republic of Korea. Although trade integration and growth prospects from ASEAN enlargement over the last 2 decades have been investigated in the literature, trade volatility in the ASEAN+3 has attracted little attention. This paper contributes to empirical trade studies by analyzing the volatility of trade flows and its links with output volatility, international institutions, and trade diversification in ASEAN+3. In other words, our study aims to address the following three questions:

(i) Does output volatility move together with trade volatility in ASEAN+3?

(ii) What are the links between output volatility and export diversification in ASEAN+3?

(iii) How do export diversification and free trade agreements (FTAs) impact ASEAN+3's trade volatility?

To answer these questions, we conduct multivariate statistical tests using data from 13 ASEAN+3 countries from 1990 to 2016. First, we investigate the impacts of trade variables, notably trade volatility and export diversification, on ASEAN+3's output volatility by applying the generalized method of moments (GMM) estimator. Second, using a cross-sectional dataset covering ASEAN+3 bilateral exports, we explore the potential determinants of ASEAN+3's bilateral export volatility by applying fixed effect (FE) and instrumental variable (IV) techniques.

The rest of the paper is organized as follows. Section II summarizes the literature on the link between trade volatility and economic growth. Section III characterizes the trend in trade growth volatility, openness, and diversification over

the past 20 years in ASEAN+3. Section IV explains the impact of trade volatility on output volatility. Section V explores the determinants of trade volatility. The concluding remarks are in section VI.

II. Literature Framework

The theoretical and empirical links between international trade and economic growth have largely been investigated. Helpman and Krugman (1985) and Bhagwati (1988) find that export growth promotes economic growth and stimulates both the supply and demand sides of the economy. Easterly (2007) also argues that exports boost economic efficiency with better allocation of resources and raise economic growth in the long run. Our study relates to the literature that predicts the relationship between trade volatility, diversification, and output volatility. In an early paper, Rodrik (1997) considers whether trade openness increases macroeconomic volatility but finds that the effects of openness are still ambiguous. Bejan (2006) analyzes the relationship between trade openness and output volatility and finds that higher trade openness is associated with higher output volatility. Over the last decades, several empirical studies have investigated this trade openness–volatility relationship (Easterly, Islam, and Stiglitz 2001; Calderón, Loayza, and Schmidt-Hebbel 2005; Cavallo 2008; Jansen et al. 2009; Balavac and Pugh 2016), but openness remains the most controversial determinant of volatility. For this reason, we investigate the relationship between trade volatility and economic growth volatility in this study.

The existing literature has also examined the role of export diversification in controlling risks arising from trade volatility. On the one hand, several empirical studies find a negative but not always a significant effect of export diversification on volatility (e.g., Cavallo 2008 and Cavalcanti, Mohaddes, and Raissi 2012). Calderón and Schmidt-Hebbel (2008) discover a negative relationship between openness and volatility only when exports are diversified. Similarly, Haddad et al. (2013) find strong evidence that export diversification plays an important role in reducing the vulnerability of countries to global shocks. They also find that product diversification clearly moderates the effect of trade openness on growth volatility, while market concentration measures yield much more mixed results. Meanwhile, Bejan (2006) shows that the interaction term between openness and export product concentration is significant only in advanced economies. On the other hand, several scholars have found evidence of a positive effect of diversification on growth. According to Melitz (2003), an increase in export diversification can boost productivity given that exporters are more productive than nonexporters. Moreover, Melitz (2003) suggests that export diversification can reduce exposure to external shocks, thus reducing macroeconomic volatility and increasing economic growth.

Together with the link between trade volatility and export diversification, we also analyze the impact of international trade institutions on trade volatility,

particularly the impact of FTAs. Initial work by Keohane (1983) points out that various international regimes are explicitly designed to promote "orderly patterns of behavior among members," implying that they would enhance stability and reduce volatility in interactions among members. Martin and Simmons (1998) state that international institutions "lock in a particular equilibrium, providing stability." According to Abbott (2000), trade agreements are adopted to reduce the risk for private traders and investors. Bagwell and Staiger (2002) maintain that the purpose of trade agreements is to allow countries with market power to reach more efficient market access exchanges. Most recently, Mansfield and Reinhardt (2008) conducted the first large-scale, multivariate statistical tests and strongly confirmed that preferential trade agreements and the World Trade Organization regime significantly reduced export volatility and also increased export levels.

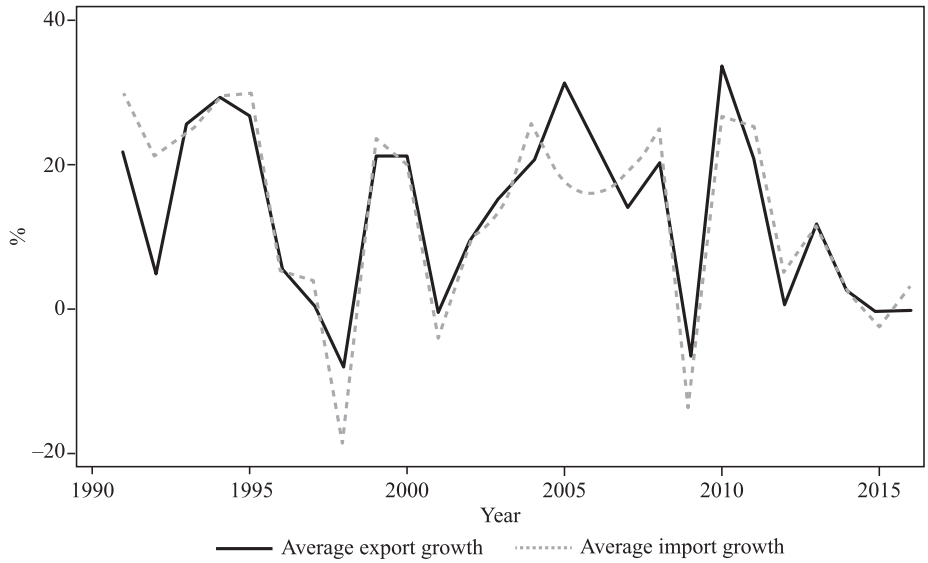
In sum, based on the theoretical background discussed above, we first investigate the impacts of trade volatility and export diversification on ASEAN+3's economic growth volatility. Second, we focus on trade volatility in ASEAN+3 by providing an empirical analysis on its determinants.

III. Trade Volatility, Openness, and Diversification in ASEAN+3

Over the last 2 decades, ASEAN+3 has witnessed fluctuating trade growth. Figure 1 plots the trend of ASEAN+3 trade growth, which is measured by the average growth rate of intra-ASEAN+3 exports and imports. As shown in Figure 1, ASEAN+3 experienced a significant decrease in intraregional trade during the 1997 Asian financial crisis and the 2008 global financial crisis. Trade flows in the region increased by around 20% after recovering from the 1997 Asian crisis but dropped again in 2002, before climbing by more than 30% in 2005. After a difficult period, due to the 2008 global financial crisis, intra-ASEAN+3 trade attained its highest growth rate in 2010, but has experienced a decreasing trend since 2011.

We now turn our attention to the volatility of ASEAN+3 trade integration over the period 1990–2016. Figure 2 plots the volatility of total trade growth and of intra-ASEAN+3 and extra-ASEAN+3 trade growth for each member country. As seen in Figure 2, ASEAN+3 member states can be divided into two groups according to trade volatility levels. The first group includes the PRC, the Lao People's Democratic Republic (Lao PDR), Cambodia, Indonesia, and Viet Nam, which are characterized by a higher level of trade volatility. Moreover, in these countries, intra-ASEAN+3 and extra-ASEAN+3 trade volatilities do not move together. For instance, the volatility of trade flows between Viet Nam and extra-ASEAN+3 countries has an increasing trend, while a decreasing trend in volatility is observed for Viet Nam's intra-ASEAN+3 trade. The second group includes Brunei Darussalam, Japan, the Republic of Korea, the Lao PDR, Myanmar,

Figure 1. **Average Trade Growth Intra-ASEAN+3**



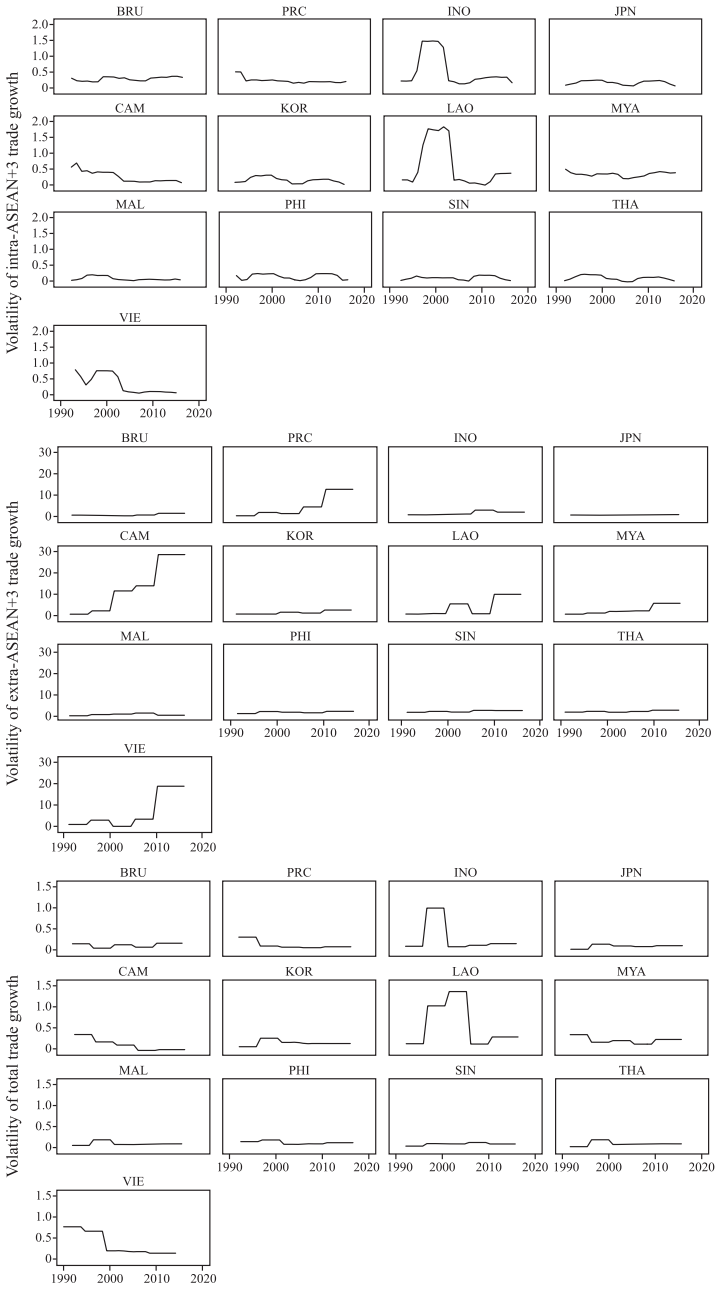
ASEAN+3 = Association of Southeast Asian Nations plus Japan, the People's Republic of China, and the Republic of Korea.
Source: Authors' illustration from UN COMTRADE data.

Malaysia, the Philippines, Singapore, and Thailand. These countries have a fairly stable evolution of trade volatility at different levels. Among all countries, Malaysia and Japan have the lowest trade volatility.

Together with a significant change in trade growth, ASEAN+3 has also experienced an important evolution in trade openness, which is measured by the ratio of total exports and imports to GDP. As reported in Table 1, the average of this ratio over the period 1990–2016 ranges from 7% for Japan to over 100% for Singapore in terms of intra-ASEAN+3 trade. In terms of total world trade, this ratio is much higher for all countries, in particular for Viet Nam, Malaysia, and Singapore (mostly over 100%).

Table 1 also shows that the intra-ASEAN+3 openness indicator increased in most countries in the 2000s, reflecting the growing importance of intraregional trade. This ratio continued to rise in the 2010s in many countries such as Cambodia, Japan, the Lao PDR, the Republic of Korea, Thailand, and Viet Nam, but slightly declined in other countries. Japan and the Republic of Korea, in particular, experienced a significant increase in this ratio over the study period, indicating greater trade integration with the region. We also observe a similar trend in ASEAN+3 trade integration in terms of total world trade.

Figure 2. **Volatility of Trade Growth by Country**



ASEAN+3 = Association of Southeast Asian Nations plus Japan, the People's Republic of China, and the Republic of Korea; BRU = Brunei Darussalam; CAM = Cambodia; INO = Indonesia; JPN = Japan; KOR = Republic of Korea; LAO = Lao People's Democratic Republic; MAL = Malaysia; MYA = Myanmar; PHI = Philippines; PRC = People's Republic of China; SIN = Singapore; THA = Thailand; VIE = Viet Nam.
Source: Authors' illustration.

Table 1. **ASEAN+3 Openness Indicator**

Country	Intra-ASEAN+3 Trade				Total World Trade			
	Full Period	1990–1999	2000–2009	2010–2016	Full Period	1990–1999	2000–2009	2010–2016
Brunei Darussalam	0.67	0.73	0.64	0.61	0.87	0.94	0.84	0.81
Cambodia	0.34	0.31	0.28	0.50	0.73	0.44	0.84	1.00
Indonesia	0.24	0.23	0.25	0.22	0.45	0.48	0.47	0.38
Lao PDR	0.36	0.35	0.35	0.38	0.47	0.49	0.47	0.45
Malaysia	0.79	0.76	0.86	0.73	1.56	1.56	1.71	1.33
Myanmar	0.27	0.21	0.33	0.29	0.39	0.30	0.50	0.35
Philippines	0.29	0.23	0.37	0.26	0.66	0.63	0.82	0.48
Singapore	1.30	1.17	1.48	1.22	2.78	2.69	3.05	2.53
Thailand	0.46	0.32	0.52	0.57	0.97	0.73	1.09	1.12
Viet Nam	0.57	0.34	0.61	0.85	1.08	0.66	1.15	1.56
People's Republic of China	0.14	0.13	0.17	0.12	0.43	0.36	0.52	0.42
Japan	0.07	0.04	0.08	0.12	0.21	0.15	0.23	0.28
Republic of Korea	0.24	0.17	0.25	0.34	0.62	0.49	0.63	0.79

ASEAN+3 = Association of Southeast Asian Nations plus Japan, the People's Republic of China, and the Republic of Korea; Lao PDR = Lao People's Democratic Republic.
Note: The openness indicator refers to the ratio of total exports and imports to gross domestic product.
Source: Authors' calculation.

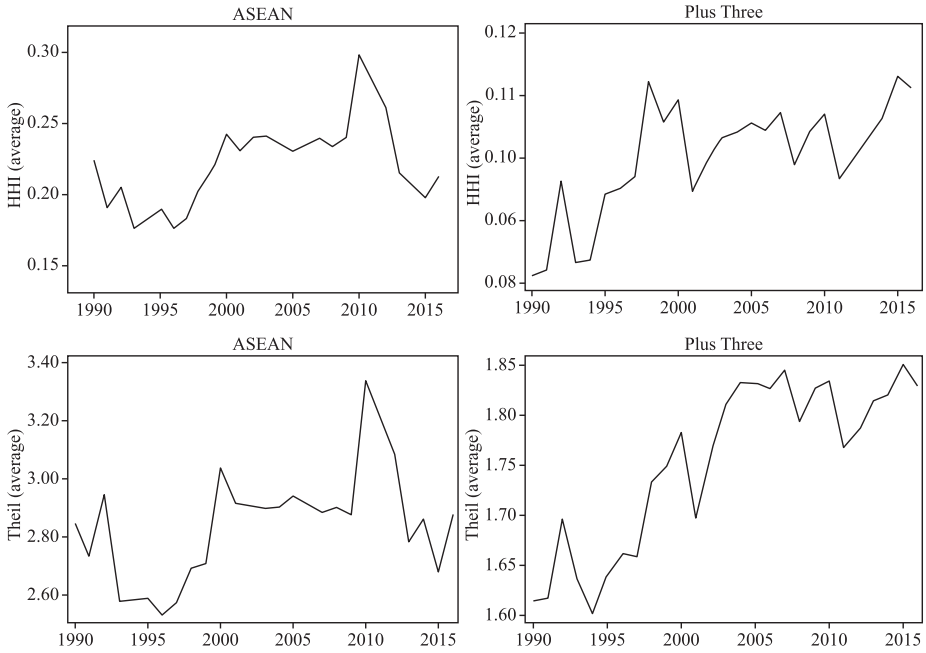
Regarding export diversification, Figure 3 shows how export diversification has evolved in the last 2 decades in the ASEAN+3 market.[1] Figure 3 also illustrates the difference in export concentration between ASEAN and the Plus Three countries (Japan, the PRC, and the Republic of Korea). As displayed in Figure 3, the evolution of both indicators, the Herfindahl–Hirschman Index (HHI) and the Theil index, is similar in each country group.[2] ASEAN has a higher concentration in exports with an average HHI of up to 0.3 and an average Theil index of up to 3.3, compared with 0.1 and 1.9, respectively, for the Plus Three countries. ASEAN experienced two significant upward trends in export concentration after 1997 and 2009. First, between 1997 and 2000, the HHI climbed from 0.17 to 0.25 and the Theil index increased from 2.1 to 3. This trend could be explained by an important change in trade policy of ASEAN countries due to the financial crisis. However, since 2010, these indicators have dramatically decreased, corresponding with the trend toward export diversification in ASEAN. For the Plus Three countries, both the HHI and the Theil index varied significantly over the study period. Compared to ASEAN countries, the Plus Three countries experienced a significant increase in both the HHI and the Theil index. During 1990–2016, the HHI ranged from 0.08 to 0.11, and the Theil index ranged from 1.62 to 1.83.

Figure 4 illustrates the evolution of export concentration in each ASEAN+3 country. A high value of HHI indicates a high level of export concentration.

[1] In line with our research objective, Figure 3 only displays trends in export concentration. For import concentration, see Figure A1.1 in Appendix 1.

[2] See section IV.A for details on computing the HHI and the Theil index.

Figure 3. **Export Concentration: ASEAN versus Plus Three**



ASEAN = Association of Southeast Asian Nations, HHI = Herfindahl–Hirschman Index.
Note: Plus Three refers to Japan, the People's Republic of China, and the Republic of Korea.
Source: Authors' illustration.

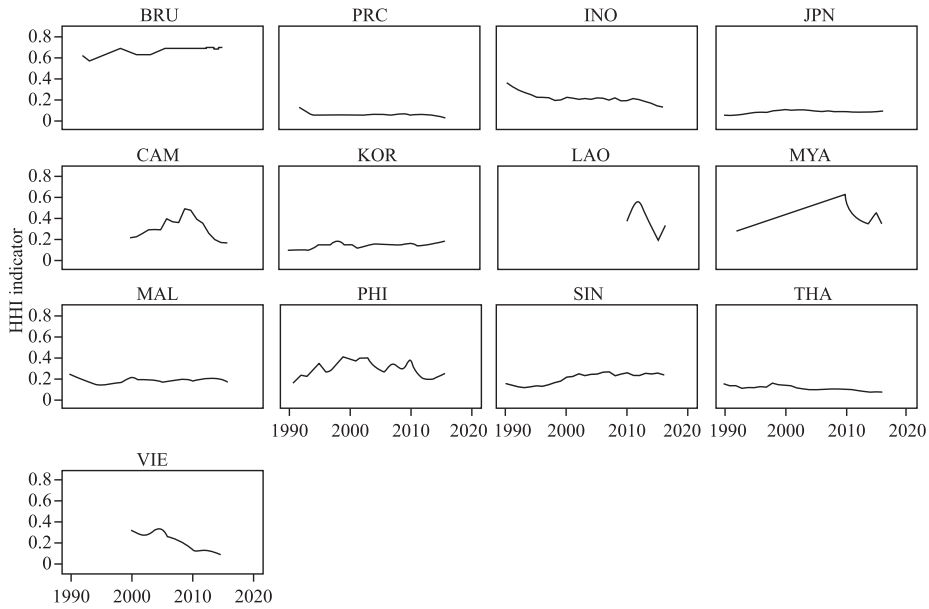
Accordingly, Brunei Darussalam, which mainly specializes in oil and natural resources, shows the highest concentration in exports with a value of 0.6. Low- and middle-income economies such as Cambodia, the Lao PDR, Myanmar, and Viet Nam maintained a high level of export concentration until 2010. However, since 2010, the HHIs in these countries have fallen, suggesting the start of a trade diversification policy. Compared to other countries, the PRC and Japan have maintained a low level of HHI throughout the period 1990–2016, clearly affirming their trade diversification policy.

In short, these stylized facts on trade volatility, openness, and export diversification provide more details about trade patterns in ASEAN+3, which partly support the research objectives of this paper.

IV. Impacts of Trade Volatility

This section addresses the question of whether trade volatility contributes to economic growth volatility in ASEAN+3. Moreover, we also investigate the potential role of export diversification in explaining output volatility.

Figure 4. **Export Diversification Trends by Country**



BRU = Brunei Darussalam, CAM = Cambodia, HHI = Herfindahl–Hirschman Index, INO = Indonesia, JPN = Japan, KOR = Republic of Korea, LAO = Lao People's Democratic Republic, MAL = Malaysia, MYA = Myanmar, PHI = Philippines, PRC = People's Republic of China, SIN = Singapore, THA = Thailand, VIE = Viet Nam.
Source: Authors' illustration.

A. Methodology

This paper aims to explain the pace in output volatility and its variation across ASEAN+3 by employing an empirical model, which will allow us to test the main hypothesis of interest. Given this objective, we try to make maximum use of both time and cross-country dimensions of our panel dataset, including data at an annual frequency. Based on an annual dataset, our empirical model will consider the possible slow adjustment of output volatility to changes in other variables in any given year. Therefore, we specify a dynamic equation, which includes a lagged dependent variable. The potential impacts of trade volatility and export diversification on output volatility are formulated as follows:

$$GDPvol_{i,t} = \alpha_0 + \beta_1 Tvol_{i,t-1} + \beta_2 DIV_{i,t-1} + \beta_3 CON_{i,t-1} + \beta_4 FTA_{i,t} + \beta_5 Z_{i,t} + u_{i,t} \quad (1)$$

where the dependent variable, $GDPvol_{i,t}$, is the volatility of the growth of real GDP per capita for country i in period t. As argued in many studies (Bejan 2006, Cavallo 2008, Jansen et al. 2009, and Haddad et al. 2013), we use the growth rate instead of output level, since it is of greater interest to policy makers to measure economic growth stability. $Tvol_{i,t-1}$ is the volatility of total trade (sum of exports

and imports) of country i in period $t-1$. In this paper, we use the 5-year rolling standard deviation to measure the volatility of output and trade.

In equation (1), u_{it} is an error term that contains country and time-specific fixed effects:

$$u_{it} = \mu_i + \varepsilon_t + \vartheta_{it} \tag{2}$$

where ϑ_{it} is independent and identically distributed with mean 0 and variance σ^2_{ϑ}. $DIV_{i,t-1}$ is the level of export diversification in country i in period $t-1$, which is proxied by different alternative concentration indicators including the HHI, the Theil index, and the similarity index (SI). Cadot, Carrère, and Strauss-Kahn (2013) decompose the Theil index into two indicators for the intensive and extensive product margins. The extensive Theil index captures concentration in the number of products (extensive product margin), whereas the intensive Theil index measures concentration in the sales volume of products (intensive product margin).

The Theil index is thus $T = T^{ext} + T^{int}$, where the intensive Theil index is given by

$$T^{int} = \frac{1}{N_x} \sum_{k \in N_x} \frac{R_k}{\bar{R}_x} ln \left(\frac{R_k}{\bar{R}_x} \right) \tag{3}$$

and the extensive Theil index is

$$T^{ext} = \ln \left(\frac{N}{N_x} \right) \tag{4}$$

where N_x denotes the number of exported products, R_k is the value of exports of product k, and $\bar{R}_x$ represents the mean value of exported products. Like the HHI, a higher value means higher export concentration.

The HHI, by construction, measures the changes in the distribution of export shares. In other words, this indicator is a measure of the degree of product concentration. The following normalized HHI is used in order to obtain values between 0 and 1:

$$H_j = \frac{\sqrt{\sum_{i=1}^{n} \left(\frac{x_{ij}}{X_j} \right)^2} - \sqrt{1/n}}{1 - \sqrt{1/n}}$$

$$X_j = \sum_{i=1}^{n} x_{ij} \tag{5}$$

where x_{ij} is the value of exports for country j and product i, and n is the number of products at the level of classification. An index value closer to 1 indicates that a country's exports or imports are highly concentrated on a few products. On the contrary, values closer to 0 mean that exports or imports are more homogeneously distributed among a series of products.

Different from the HHI and Theil index, the similarity index *SI* is considered the simplest measure for comparing export content across countries or across time. To calculate export *SI,* we use the original export similarity index first introduced by Finger and Kreinin (1979) and largely applied to trade data. The Finger and Kreinin similarity index between two countries *c* and *d* is given as follows:

$$SI_{c,d}^{FK} = \sum_{i=1}^{n} min\left(\frac{x_{c,i}}{X_c}, \frac{x_{d,i}}{X_d}\right) \tag{6}$$

where $\frac{x_{c,i}}{X_c}$ and $\frac{x_{d,i}}{X_d}$ are the shares of good *i* in the total exports of country *c* and *d,* respectively. This index ranges from 0 to 1—from completely different export shares to identical export shares. According to Finger and Kreinin (1979), this measure should not be affected by the relative sizes or scales of total exports as it is intended to compare only patterns of exports across product categories. All three concentration indexes are calculated at the 4-digit level of the Standard Industry Trade Classification Revision 3 from the United Nations Commodity Trade Statistics Database.

Apart from trade, Easterly, Islam, and Stiglitz (2000) find evidence of bivariate correlation between per capita growth volatility and financial sector development, and price policies. Following this work, we also introduce in equation (1) a set of control variables CON_{it}, which includes inflation volatility and the level of financial development, which is measured by the ratio of private sector banking credit to GDP and a financial openness indicator. The quality of domestic institutions has also been recognized as a cause of macroeconomic instability in the literature. For instance, research by Rodrik (1999) and Acemoglu et al. (2003) has found that corruption and conflict can lead to misleading trade policy. Similarly, Mobarak (2005) and Klomp and de Haan (2009) have found that a democracy or a stable political regime supports macroeconomic stability. Thus, we introduce in equation (1) an institution variable which is proxied by the index of political rights from Freedom House.[3] The index ranges from 1 to 7, with 1 indicating the most "free" country. We also include the variable $FTA_{i,t}$ to see the impact of a free trade agreement in ASEAN on the volatility of output. In addition, time dummies are included to control common output fluctuations during financial crises, notably the Asian economic crisis (1997–1999) and the global financial crisis (2007–2009).

The data are summarized in Table 2, which provides definitions and sources for all variables and their units of measurement, mean, standard deviations, and minimum and maximum values. This table also reports the correlation coefficients between output volatility, trade volatility, and independent variables. The signs, magnitudes, and significance of correlation coefficients help in modeling and confirming the choice of variables. However, the values of the correlation coefficients are diverse, ranging from negative to positive and small to large. This

[3] See Balavac and Pugh (2016).

Table 2. **Output Volatility Model: Summary Statistics**

Variable	Measurement	Source	Descriptive Statistics					Correlation with	
			Obs	Mean	SD	Min	Max	Income Volatility	Trade Volatility
Income volatility	5-year rolling standard deviation of GDP per capita growth	WDI	325	0.105	0.077	0.000	0.459	1.000	
Trade volatility	5-year rolling standard deviation of total exports and imports	UN COMTRADE	325	0.235	0.276	0.023	1.766	0.405*	1.000
HHI	Authors' computation	UN COMTRADE	274	0.212	0.145	0.055	0.707	0.211*	0.118
Intensive Theil index	Authors' computation	UN COMTRADE	274	2.400	0.838	1.203	5.566	0.249*	0.091
Extensive Theil index	Authors' computation	UN COMTRADE	274	0.307	0.536	0.035	4.301	−0.036	0.118
Theil index	Authors' computation	UN COMTRADE	274	2.707	1.120	1.276	6.132	0.168*	0.124*
Similarity index	Authors' computation	UN COMTRADE	274	7.348	2.787	0.770	14.616	−0.004	−0.093
Inflation volatility	5-year rolling standard deviation of inflation rate	WDI	334	5.521	7.849	0.019	53.629	0.513*	0.756*
Financial development	Ratio of private sector banking credit to GDP	WDI	321	6.469	5.615	0.060	31.081	0.011	−0.092
Financial openness	KAOPEN	Chinn and Ito (2008)	319	0.032	1.434	−1.904	2.374	−0.235*	−0.215*
Political rights	Score of 1–7, with 1 representing the greatest degree of freedom and 7 the smallest degree of freedom	Freedom House	351	4.749	2.214	1.000	7.000	0.081	0.207*
Free trade agreement	Dummy	ASEAN Secretariat	351	0.684	0.466	0.000	1.000	0.137*	0.111*

ASEAN = Association of Southeast Asian Nations, GDP = gross domestic product, HHI = Herfindahl–Hirschman Index, KAOPEN = Chinn–Ito index, SD = standard deviation, UN COMTRADE = United Nations Commodity Trade Statistics Database, WDI = World Development Indicators.
Note: * indicates significance at the 5% level.
Source: Authors' compilation based on various sources.

means we should expect different potential impacts of the independent variables on output volatility.

Due to the inclusion of lagged dependent variables in equation (1), the combination of fixed effects and lagged dependent variables introduces serious econometric bias. According to Nerlove (1967) and Nickell (1981), the ordinary least squares estimates of the lagged dependent variable's coefficient in a dynamic panel model are biased due to the correlation between the fixed effects and the lagged dependent variable.[4] Judson and Owen (1999) also suggest that the bias is inversely related to panel length ("T"), but potentially severe biases remain even at T = 30. In this case, the preferred estimator is the GMM suggested by Arellano and Bond (1991), which was then developed and extended by Arellano and Bover (1995) and Blundell and Bond (1998) for two reasons. First, the GMM differences the model of interest to remove country-specific effects or any time-invariant country-specific variable. Second, this method eliminates possible correlation between the country-specific effects and the regressors. In the GMM estimator, moment conditions utilize the orthogonality conditions between differenced errors and the dependent variable's lagged values. This means that the disturbances ϑ_{it} are serially uncorrelated and that the differenced error is a moving average with 1 lag (MA[1]). Therefore, two diagnostics are computed to test for first-order and second-order serial correlation in the disturbances. We expect to reject the null of the absence of first-order serial correlation and not reject the absence of second-order serial correlation. In the GMM procedure, the number of moment conditions increases with time span t. As a result, the Sargan test is performed to test for overidentification restrictions.

B. Results and Discussion

Our empirical estimations are organized in two steps. First, the benchmark dynamic GMM estimation treats all right-hand side variables other than the lagged dependent variable as if they were exogenous. In this benchmark estimation, we lag all independent variables by one period. Second, we run the dynamic GMM estimator in which the export volatility is treated as endogenous by using an additional instrument suggested by related literature. We follow Frankel and Romer (1999) who developed "natural openness" instruments for openness. According to Wei (2000), natural openness is found by estimating the level of trade openness depending on a country's size and geographic and linguistic characteristics. In particular, we estimate the following equation:

$$\log(Openness) = \beta_{21} Remoteness + \beta_{22} \log(Population) + \beta_{23} Lang + \beta_{24} Geo + \varepsilon_{21} \quad (7)$$

[4] See further Baltagi (2008).

where $Remoteness = \sum_j \frac{distance_{ij}}{GDP_j/GDP_w}$, a formula that measures a country's average weighted distance from its trading partners (Head 2003), where the weights are the partner countries' shares of total GDP (denoted by GDP_w). "Lang" is proxied by two dummies of language, "English" and "Chinese," each of which takes the value of 1 if the country speaks the respective language and 0 otherwise. "Geo" is constructed from the land area and a dummy called "landlock" if the country is landlocked. All data are adopted from Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) data. The method to construct an IV is based on the same concept as the gravity model. Appendix 2 reports a succession of regressions on ASEAN+3 openness over the period 1990–2016. The predicted value of the log of openness (trade-to-GDP ratio) from equation (7) is used as an IV for trade volatility to deal with the biases.

All empirical results are summarized in Table 3. We estimate equation (1) separately for each of our five export diversification indexes. It is also worth noting that in all the output volatility regressions reported in Table 3, all diagnostics are satisfactory, irrespective of whether the trade volatility terms are treated as exogenous or endogenous. First, the presence of first-order serial correlation is not rejected, while the presence of second-order serial correlation is rejected. Second, the Sargan test does not reject the overidentification restrictions. In addition, the lagged dependent variable in all regressions is positive and statistically significant. These results allow us to conclude that the dynamic GMM is an appropriate estimator.

Going straight to the hypothesis of interest, we note that the estimated coefficients of trade volatility have the expected sign with a high level of significance. This result suggests that an increase in intra-ASEAN+3 trade volatility leads to an increase in income volatility of member countries. In addition, when the trade volatility terms are treated as endogenous, the sign and significance of their estimates are qualitatively similar to those obtained in the benchmark GMM models. However, due to the endogeneity treatment, the empirically estimated coefficients are somewhat smaller. The positive link between trade and income volatility is also illustrated in Figure 5.

In sum, our empirical results confirm that trade has a quantitatively large and robust positive effect on income (Frankel and Romer 1999). This result is also consistent with that of Cavallo (2008) who argues that output volatility naturally relates to the frequency and size of the shocks affecting an economy and to the manner in which the economy handles the shocks. Accordingly, trade openness is associated with greater output volatility. In other words, the more exposed a country is to trade, the more vulnerable it is to shocks coming from abroad.

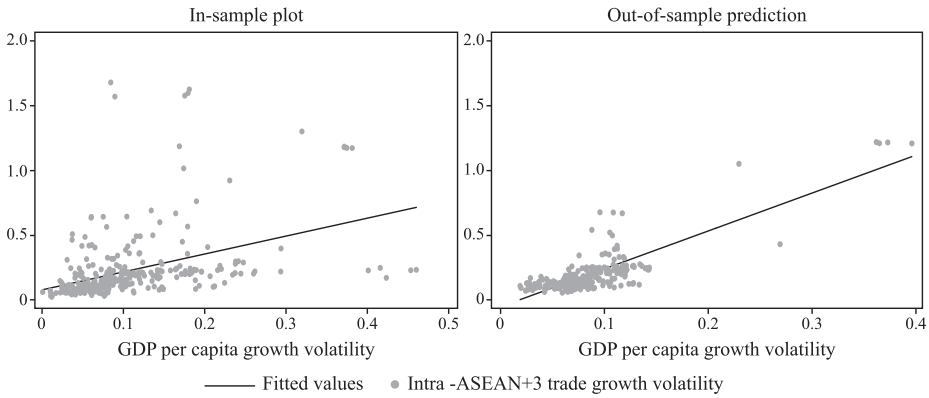
Examining the estimated coefficients associated with export diversification variables, we first note that their signs depend on the way export diversification is measured. For instance, estimates of the extensive Theil index have a negative value, while those of the intensive Theil index have a positive value. Second, in

Table 3. **Generalized Method of Moments Estimator Results of the Output Volatility Model**

	Measure of Export Diversification									
	HHI		Extensive		Intensive		Theil		SI	
Lagged dependent variable	0.942**	0.519**	0.873*	0.461*	0.886**	0.512**	0.922**	0.512**	0.781*	0.464**
	(0.394)	(0.208)	(0.404)	(0.217)	(0.395)	(0.188)	(0.372)	(0.195)	(0.369)	(0.166)
Trade volatility (lagged)	0.112*	0.073*	0.101*	0.069*	0.108*	0.078**	0.110*	0.075*	0.126*	0.081**
	(0.058)	(0.035)	(0.057)	(0.038)	(0.060)	(0.036)	(0.059)	(0.035)	(0.063)	(0.037)
Export diversification (lagged)	−0.031	−0.071	−0.035	−0.050	0.016	0.001	0.007	−0.004	0.011*	0.004
	(0.124)	(0.130)	(0.027)	(0.035)	(0.019)	(0.012)	(0.014)	(0.012)	(0.005)	(0.006)
Inflation volatility (lagged)	0.005	0.012**	0.007	0.011**	0.007	0.011**	0.006	0.010**	0.008	0.011**
	(0.009)	(0.004)	(0.010)	(0.005)	(0.010)	(0.004)	(0.009)	(0.004)	(0.010)	(0.005)
Financial development (lagged)	−0.001	0.000	−0.001	0.000	−0.001	0.000	−0.001	0.000	−0.001	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Financial openness (lagged)	0.030	0.009	0.028	0.005	0.029	0.007	0.028	0.007	0.019	0.005
	(0.025)	(0.021)	(0.026)	(0.018)	(0.024)	(0.015)	(0.023)	(0.017)	(0.023)	(0.013)
Political rights (lagged)	0.014**	0.020*	0.017	0.021*	0.011	0.018	0.014**	0.019	0.006	0.016*
	(0.007)	(0.011)	(0.010)	(0.011)	(0.007)	(0.011)	(0.007)	(0.013)	(0.008)	(0.008)
Free trade agreement	−0.020	−0.040	−0.023	−0.046	−0.052	−0.053	−0.041	−0.045	−0.046	−0.058
	(0.040)	(0.037)	(0.029)	(0.034)	(0.037)	(0.046)	(0.035)	(0.043)	(0.029)	(0.043)
Crisis	0.029***	0.026**	0.029**	0.025**	0.026**	0.024**	0.027***	0.025**	0.017	0.021**
	(0.008)	(0.011)	(0.011)	(0.011)	(0.009)	(0.010)	(0.008)	(0.010)	(0.011)	(0.009)
Treatment of trade volatility	Exogeneous	Endogenous	Exogeneous	Endogenous	Exogeneous	Endogenous	Exogeneous	Endogenous	Exogeneous	Endogenous
First-order serial correlation test (*p*-value)	−2.2	−1.65	−2.27	−1.62	−2.18	−1.72	−2.2	−1.7	−1.97	−1.65
	(0.028)	(0.099)	(0.023)	(0.105)	(0.029)	(0.085)	(0.028)	(0.089)	(0.049)	(0.099)
Second-order serial correlation test (*p*-value)	−1.46	−1.25	−1.53	−1.27	−1.57	−1.19	−1.47	−1.2	−1.24	−1.09
	(0.143)	(0.211)	(0.126)	(0.204)	(0.117)	(0.236)	(0.142)	(0.231)	(0.215)	(0.277)
Sargan test of overidentification restrictions (*p*-value)	15.35	40.68	14.75	38.03	14.74	39.56	15.40	40.15	14.05	38.03
	(0.700)	(0.615)	(0.739	(0.724)	(0.739)	(0.662)	(0.697)	(0.637)	(0.781)	(0.724)

HHI = Herfindahl–Hirschman Index, SI = similarity index.
Notes: Figures in parentheses are standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimates.

Figure 5. **Output Volatility versus Trade Volatility**



ASEAN+3 = Association of Southeast Asian Nations plus Japan, the People's Republic of China, and the Republic of Korea; GDP = gross domestic product.
Note: Out-of-sample predictions are from the generalized method of moments estimator with the Herfindahl–Hirschman Index.
Source: Authors' illustration.

most regressions, the impact of export diversification on output volatility is not statistically significant. Exceptionally, we find a significant and positive estimated coefficient on the similarity index in the GMM model that considers trade volatility as an exogenous regressor. However, this coefficient loses its significance when trade volatility is treated as an endogenous variable. Third, the empirical results relating to export diversification are not sensitive to whether the trade volatility terms are treated as endogenous. Overall, we do not find evidence of a significant and direct link between export diversification and output volatility. Despite the absence of a direct impact, export diversification could still affect output volatility through its potential link with export volatility. This mechanism will be studied in the next section.

We now turn our attention to the impact of institutional variables, represented by political rights and FTAs. First, as expected, we find that the estimated coefficients for political rights all have a positive value. These coefficients are generally significant, except in the intensive Theil index model. This finding means that a "freer" country experiences less volatile output growth. In other words, ASEAN+3 countries with a higher level of political rights and democracy have a lower level of output volatility. Second, the estimates associated with FTAs are negative but statistically insignificant. In fact, it is noteworthy that there are two economic aspects of FTA. On the one hand, an FTA could divert trade away from more efficient suppliers outside the area toward less efficient ones within the area. On the other hand, an FTA could create trade that may not have otherwise existed and thus raise a country's national welfare. Reducing the output volatility of a country should also be considered a trade creation effect of an FTA. According

to our empirical results, this effect potentially exists, but ASEAN+3 countries have not yet realized it. In other words, the potential trade creation effects of FTAs are not working in ASEAN+3 in precisely the way that is described by the relevant literature, suggesting that more nuanced political economy explanations may be needed. This result can motivate policy makers in ASEAN+3 to conduct further analysis to find out exactly what makes FTAs beneficial, whether by enhancing growth or lowering income volatility. The resulting inferences could then be applied to future FTA negotiations in order to effectively achieve an expected long-run outcome from FTAs.

On the set of control variables, we find that inflation volatility plays a significant role in explaining output volatility when trade volatility is treated as endogenous. This means that a stable macroeconomic environment, which is captured by the level of inflation volatility, could promote output stability. By contrast, financial variables in all regressions have insignificant estimated coefficients. For instance, as expected, the sign of the coefficients on the level of financial development is negative, meaning a more developed financial system is associated with more stable output growth, although the results are not statistically significant. Looking at the financial openness variable, the estimates of this variable are positive in all regressions. This positive sign supports the theoretical relationship between financial openness and income volatility—the more integrated a financial system the more sensitive a country is to external shocks and the more volatile its income growth. Notwithstanding, this potential effect is not statistically significant.

V. Determinants of Trade Volatility

In this section, we use a cross-sectional dataset of intra-ASEAN+3 bilateral exports over the period 1990–2016 to investigate the potential determinants of ASEAN+3 trade volatility.

A. Methodology

The potential determinants of ASEAN+3 trade volatility are modeled in the following equation:

$$\log(Xvol)_{i,j,t} = \alpha_2 + \theta_0 \log(INCOMEvol)_{i,t} + \theta_1 \log(INCOMEvol)_{j,t} + \theta_2 DIVX_{i,j,t} + \theta_3 TARIFF_{i,j,t} + \theta_4 FTA_{i,j,t} + \theta_5 W_{i,j,t} + \mu_{i,j} + \delta_t + \varepsilon_{3i,t} \quad (8)$$

where we use the 5-year rolling standard deviation of bilateral exports $Xvol_{i,j,t}$ between countries i and j as a proxy of trade volatility. Export diversification, $DIVX_{i,j,t}$, is proxied by five alternative indicators: the HHI, the SI, the Theil index, and the intensive and extensive Theil indexes. $INCOMEvol_{i,t}$ and $INCOMEvol_{j,t}$ are the income volatilities of the reporter country and its trading partner, respectively.

$FTA_{i,j,t}$ is a dummy variable indicating whether countries i and j are members of the same FTA in year t. $TARIFF_{i,j,t}$ is the tariff applied on imported products from country i to country j in year t, which is measured by the most favored nation (MFN) and the effectively applied (AHS) weighted averages. $W_{i,j,t}$ is a vector of control variables, which are proxied by the bilateral exchange rate and political rights.[5] $\mu_{i,j}$ is a country-specific fixed effect, and δ_t is a year-specific fixed effect. The statistical summary of all variables in equation (8) is reported in Table 4.

According to the Hausman test results, the fixed-effects estimator is the appropriate technique to estimate equation (8).[6] In addition, we also reestimate equation (6) by using the IV technique, which allows us to tackle the potential endogeneity of the income volatility variable. We use *country's infant mortality rate* and the *corruption perception index* as two external instrumental variables of the income volatility variable.[7] According to Kalemli-Ozcan (2002), birth rate is indeed a determinant of economic growth. Lower child mortality results in higher educational investment and lower fecundity by parents, which in turn causes lower population growth and higher economic growth. The other variable, corruption control, is an essential instrument of governance, which has a sizable long-run effect on economic growth (Kaufmann, Kraay, and Mastruzzi 2007).

Furthermore, we distinguish the impact of each ASEAN+1 FTA (between ASEAN and the PRC, Japan, or the Republic of Korea) on trade volatility by estimating equation (8) with the presence of three dummies—ACFTA, AJFTA, and AKFTA—which represent ASEAN's FTA with the PRC, Japan, and the Republic of Korea, respectively.

B. Results and Discussion

We summarize the empirical results of FE and IV estimators in Table 5. In particular, the IV results that treat income volatility as endogenous indicate the validity of the instruments, which is shown by several diagnostic tests. First, the p-values for Anderson's canonical correlation test confirm the adequate explanatory power of our instruments. Second, the Cragg–Donald Wald F-statistics allow us to reject the null hypothesis of a weak instrument. Third, the overidentification restriction test (the Sargan statistics) accepts the null hypothesis of the instruments' validity.

The estimated results in Table 5 allow us to confirm a positive and significant impact of income volatility of the reporter country on its bilateral export volatility.

[5] The bilateral real exchange rate is calculated as the product of the nominal exchange rate and the relative GDP deflator in each country: $RER_{ij} = e_{ijt}*(p_{jt}/p_{it})$, where e_{ijt} is the nominal exchange rate (IMF, International Financial Statistics), p_{jt} is the GDP deflator of the exporter, and p_{it} is the GDP deflator of the importer.

[6] The Hausman test results are not reported here to save space.

[7] Infant mortality rate is extracted from World Bank data. Corruption perception index is adopted from Transparency International.

Table 4. **Export Volatility Model: Summary Statistics**

Variable	Measurement	Source	Obs	Mean	SD	Min	Max	Correlation with Export Volatility
Export volatility	5-year rolling standard deviation of ASEAN+3's bilateral export volatility	UN COMTRADE	2,544	0.352	0.362	0.001	5.236	1.000
Income volatility (reporter)	5-year rolling standard deviation of GDP per capita growth (reporter country)	WDI	2,860	0.160	0.117	0.000	0.971	0.112*
Income volatility (partner)	5-year rolling standard deviation of GDP per capita growth (partner country)	WDI	2,860	0.161	0.115	0.000	0.971	0.066*
HHI	Authors' computation	UN COMTRADE	2,542	0.267	0.193	0.042	1.000	0.301*
Intensive Theil index	Authors' computation	UN COMTRADE	2,554	2.331	0.782	0.000	5.311	−0.037
Extensive Theil index	Authors' computation	UN COMTRADE	2,554	0.963	1.128	0.044	6.940	0.460*
Theil index	Authors' computation	UN COMTRADE	2,554	3.295	1.264	1.240	6.940	0.371*
Similarity index	Authors' computation	UN COMTRADE	2,554	34.420	19.110	0.001	75.986	−0.406*
MFN tariff	Weighted most favored nation tariffs	WITS	2,155	7.828	8.714	0.000	88.941	0.091*
AHS tariff	Weighted effectively applied tariffs	WITS	2,155	6.108	7.958	0.000	65.915	0.068*
Exchange rate volatility	Authors' computation	IMF	2,860	0.117	0.137	0.000	0.936	0.187*
Free trade agreement	Dummy	ASEAN Secretariat	2,970	0.620	0.486	0.000	1.000	0.098*
ACFTA	Dummy	ASEAN Secretariat	2,970	0.291	0.454	0.000	1.000	0.008
AJFTA	Dummy	ASEAN Secretariat	2,970	0.215	0.411	0.000	1.000	−0.077*
AKFTA	Dummy	ASEAN Secretariat	2,970	0.242	0.429	0.000	1.000	−0.018
Political rights (reporter)	Score of 1–7, with 1 representing the greatest degree of freedom and 7 the smallest degree of freedom	Freedom House	2,970	4.354	2.179	1.000	7.000	0.197*
Political rights (partner)	Score of 1–7, with 1 representing the greatest degree of freedom and 7 the smallest degree of freedom	Freedom House	2,970	4.354	2.179	1.000	7.000	0.183*

ACFTA = ASEAN–China Free Trade Area; AHS = effectively applied tariff; AJFTA = ASEAN–Japan Free Trade Area; AKFTA = ASEAN–Korea Free Trade Area; ASEAN+3 = Association of Southeast Asian Nations plus Japan, the People's Republic of China, and the Republic of Korea; HHI = Herfindahl–Hirschman Index; IMF = International Monetary Fund; MFN = most favored nation; SD = standard deviation; UN COMTRADE = United Nations Commodity Trade Statistics Database; WDI = World Development Indicators; WITS = World Integrated Trade System.

Note: * indicates significance at the 5% level.

Source: Authors' compilation based on various sources.

Table 5. **Estimation Results of the Export Volatility Model**

	Linear Regression						Quantile Regression					
	HHI		SI		Theil		HHI		SI		Theil	
	FE	IV	FE	IV	FE	IV	1st	5th	1st	5th	1st	5th
Income volatility	0.548***	0.355*	0.548***	0.509**	0.566***	0.477**	0.558***	0.539***	0.553***	0.543***	0.573***	0.559***
(reporter)	(0.057)	(0.216)	(0.058)	(0.204)	(0.056)	(0.222)	(0.058)	(0.111)	(0.065)	(0.077)	(0.064)	(0.083)
Income volatility	0.086	0.093	0.091	0.182	0.075	0.154	0.099	0.072	0.102	0.080	0.091	0.058
(partner)	(0.063)	(0.189)	(0.062)	(0.192)	(0.064)	(0.198)	(0.070)	(0.132)	(0.079)	(0.093)	(0.075)	(0.098)
Bilateral exchange	−0.175**	−0.085	−0.207**	−0.255	−0.180**	−0.219	−0.187**	−0.161	−0.222**	−0.192	−0.195**	−0.163
rate volatility	(0.080)	(0.201)	(0.079)	(0.196)	(0.079)	(0.205)	(0.090)	(0.171)	(0.101)	(0.120)	(0.096)	(0.125)
Export diversification	0.400***	0.358***	0.001	0.000	0.082***	0.032***	0.200*	0.617**	0.001	0.000	0.047*	0.120*
index	(0.107)	(0.042)	(0.001)	(0.001)	(0.020)	(0.010)	(0.104)	(0.294)	(0.001)	(0.002)	(0.026)	(0.034)
AHS tariff	0.002	0.004***	0.002	0.004***	0.001	0.004***	−0.001	0.005*	−0.001	0.006**	−0.002	0.005*
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
MFN tariff	0.000	−0.003***	−0.001	−0.003**	0.000	−0.003***	0.002	−0.002**	0.002	−0.004*	0.002	−0.005*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)
Free trade agreement	−0.007	−0.010	−0.014	−0.009	−0.005	−0.008	−0.005	−0.021	0.000	−0.029	0.007	−0.018
	(0.020)	(0.011)	(0.021)	(0.011)	(0.020)	(0.012)	(0.022)	(0.043)	(0.026)	(0.031)	(0.024)	(0.031)
ACFTA	−0.071***	−0.038*	−0.078**	−0.059***	−0.068**	−0.049**	−0.055*	−0.090*	−0.065*	−0.091**	−0.053*	−0.084*
	(0.027)	(0.021)	(0.030)	(0.021)	(0.027)	(0.022)	(0.032)	(0.050)	(0.038)	(0.045)	(0.034)	(0.044)
AJFTA	−0.025	−0.014	−0.025	−0.018	−0.022	−0.014	−0.018	−0.033	−0.018	−0.033	−0.016	−0.028
	(0.022)	(0.014)	(0.024)	(0.014)	(0.022)	(0.014)	(0.020)	(0.039)	(0.024)	(0.028)	(0.022)	(0.028)
AKFTA	0.034	0.009	0.033	0.009	0.038	0.010	0.031	0.037	0.036	0.029	0.033	0.043
	(0.024)	(0.018)	(0.024)	(0.018)	(0.024)	(0.019)	(0.023)	(0.044)	(0.026)	(0.031)	(0.025)	(0.032)
Political rights	0.000	−0.009**	−0.003	−0.012**	−0.003	−0.012**	−0.004	0.004	−0.005	0.000	−0.006	0.001
(reporter)	(0.008)	(0.005)	(0.007)	(0.005)	(0.008)	(0.005)	(0.006)	(0.012)	(0.007)	(0.008)	(0.007)	(0.008)
Political rights	−0.005	−0.001	−0.004	−0.002	−0.005	−0.001	−0.007	−0.002	−0.007	−0.002	−0.007	−0.003
(partner)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)	(0.012)	(0.008)	(0.009)	(0.007)	(0.009)
Constant	0.158***		0.261***		0.007		–	–	–	–	–	–
	(0.044)		(0.061		(0.072)							
Observations	1,891	1,630	1,893	1,630	1,893	1,643	1,891	1,630	1,893	1,630	1,893	1,643
R-squared	0.116	0.1850	0.002				–	–	–	–	–	–

Continued.

Table 5. *Continued.*

	Linear Regression						Quantile Regression					
	HHI		SI		Theil		HHI		SI		Theil	
	FE	IV	FE	IV	FE	IV	1st	5th	1st	5th	1st	5th
Anderson canonical correlation		48.784		55.393		52.389	–	–	–	–	–	–
LM statistic (*p*-value)		(0.000)		(0.000)		(0.000)						
Cragg–Donald Wald F-statistic		9.979		11.382		10.742	–	–	–	–	–	–
(10% maximal IV relative bias)		(8.78)		(8.78)		(8.78)						
Sargan statistic (*p*-value)		6.089		2.764		3.180	–	–	–	–	–	–
		(0.1074)		(0.4295)		(0.3647)						

ACFTA = ASEAN–China Free Trade Area, AHS = effectively applied tariff, AJFTA = ASEAN–Japan Free Trade Area, AKFTA = ASEAN–Korea Free Trade Area, ASEAN = Association of Southeast Asian Nations, FE = fixed effect, HHI = Herfindahl–Hirschman index, IV = instrumental variable, LM = Lagrange multiplier, MFN = most favored nation, SI = similarity index.

Notes: We report only results for regressions using the Theil index to save space. Figures in parentheses are standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' estimates.

This impact seems to be slightly sensitive to the endogeneity treatment. In particular, when the reporter's income volatility is treated as endogenous, the level of its significance drops from 1% to 5% and 10%. In general, a percentage point rise in the reporter country's income volatility is likely to increase its export volatility from 0.355% to 0.509%. By contrast, the reporter's export volatility does not depend on the income volatility of its trading partner. This means that the intraregional export volatility of an ASEAN+3 country seems to be insensitive to a domestic economic shock of its partners in the same region. This may be good news for policy makers in low-income countries that are relatively closed in ASEAN+3, such as the Lao PDR, Myanmar, and the Philippines, since opening up their economies to regional trade will not necessarily make their exports more volatile nor weaken their domestic economy due to external turmoil.

Examining now the estimates of three export diversification indicators, we obtain two different findings. First, the estimated coefficients of the HHI and the Theil index in all regressions are positive and significant. For instance, after resolving the endogeneity problem of the dependent variable, a percentage point rise in export concentration (the HHI) would, all things being equal, increase export volatility by approximatively 0.358%. Accordingly, an ASEAN+3 country with a higher level of export concentration could experience a higher level of bilateral export volatility. In other words, to reduce intraregional export volatility, ASEAN+3 countries should diversify their exports to other ASEAN+3 member states. This finding is of major relevance for low-income and less open ASEAN+3 countries, notably the Lao PDR, Myanmar, and the Philippines, which do not have very diversified export baskets. Therefore, we recommend that policy makers of these countries increase export diversification. Higher export diversification corresponds with lower export volatility, which in turn fosters stability of economic growth. This argument is also supported by Haddad et al. (2013) who argue that irrespective of whether the effect of trade openness on output volatility is positive or negative on average, openness lowers output volatility in sufficiently diversified economies, while it increases volatility in those with more concentrated export baskets. Second, we find no evidence of a link between the similarity index and bilateral export volatility. We can thus conclude that the nature of export diversification's impact on ASEAN+3 bilateral export volatility strongly depends on the way export diversification is measured.

We now turn our attention to the potential effect of bilateral tariffs on ASEAN+3's bilateral export volatility. On the one hand, estimates of both tariff indicators, AHS and MFN, are statistically significant only in the model in which the export volatility term is treated as endogenous. On the other hand, these two tariff indicators experience conflicting effects on export volatility. Specifically, the impact of an AHS tariff on bilateral export volatility is positive, while that of an MFN tariff is negative: a percentage rise in the AHS tariff would create a 0.004% increase in export volatility, while the same increase in the MFN tariff would

reduce export volatility by around 0.003%. According to these results, granting the most favored nation status reduces the volatility of bilateral exports. Inversely, the bilateral intraregional exports of ASEAN+3 member states can become more volatile if their trading partners apply protective tariffs. However, these two impacts are quite small.

Looking now at the impact of FTAs, we first note that estimates of the FTA variable in all regressions are negative as expected but statistically insignificant. This suggests that sharing a common FTA does not allow two ASEAN+3 country partners to decrease their export volatility. Second, on the three FTAs signed between ASEAN and one of the Plus Three countries, we find that only the ASEAN–China Free Trade Area (ACFTA) plays a significant role in reducing the level of bilateral export volatility. This can be explained by the fact that the PRC's important position in world trade can help its ASEAN trading partners to maintain a low volatility of bilateral exports between them and the PRC. In other words, joining a regional trade block with the PRC reduces the variability of trade flows among ASEAN member states and the PRC. This finding is consistent with the hypothesis that "joint membership in a reciprocal trade agreement—a preferential trade agreement or the General Agreement on Tariffs and Trade/World Trade Organization—should decrease the volatility of a country's exports to a trade partner," according to Mansfield and Reinhardt (2008) in their study of 162 countries over the period 1951–2001. The authors also argue that institutions could precipitate fluctuations in trade due to commitments and protectionist barriers and reduce the volatility of cross-border transactions.

Similar to equation (1), we also consider political rights as a control variable in equation (8). After treating the export volatility terms, estimates of a reporter country's political rights become negative and significant. This suggests that intra-ASEAN+3 exports of an economy with a higher level of political rights appear to be more volatile. However, this negative impact of political rights is quite small. The second control variable in equation (8), bilateral exchange rate's volatility, also has a significantly negative impact on bilateral export volatility. However, this unexpected effect should not be considered since it becomes statistically insignificant due to the export volatility's treatment in the IV estimation. Indeed, the exchange rate variable plays a key role in international trade but the nature of its impact on trade has been a controversial issue in the literature. Therefore, we leave this issue for further research.

All empirical results mentioned above show how the main determinants affect export volatility on average. While these results allow us to address the question about the role of each main determinant in explaining export volatility, they do not allow us to answer another important question—does each determinant influence export volatility differently for exports with low volatility than for exports with average volatility? A more comprehensive picture of the effect of the predictors on export volatility can be obtained by using quantile regression analysis,

which allows us to model the relationship between the potential determinants and specific quantiles of export volatility. In other words, quantile regression specifies the change in the quantiles of export volatility's reaction to the change in its determinants. Therefore, to complete our empirical results reported in Table 5, we reestimate equation (8) by applying the regression quantiles approach developed by Machado and Santos Silva (2019). The authors consider two settings: panel data models with individual effects and models with endogenous explanatory variables. Coefficient estimates for the 1st and the 5th quintiles are presented in Table 5.

As reported in Table 5, the empirical results provided by the quantile regressions largely support those obtained in the linear regression. However, we observe that the effect of the main determinants on export volatility slightly changes from the 5th quintile to the 1st quintile. First, the effect of an increase in the reporter country's income on its export volatility is likely larger on exports with low volatility and smaller on exports with high volatility, while we find the opposite result for export diversification's impact on export volatility. Second, the positive impact of an AHS tariff and the negative impact of an MFN tariff on export volatility are not maintained in the 1st quintile, the group with the lowest export volatility. By contrast, the negative effect of bilateral exchange rate volatility is not significant in the 5th quintile, the group with the highest export volatility. Third, we also find that the role of the ACFTA in reducing export volatility is more important in the 5th quintile. In sum, the effect of each determinant is not the same for all levels of export volatility. This heterogeneity should be considered as an important factor in public policy.

C. Bilateral Export Volatility in the Association of Southeast Asian Nations and Plus Three Countries: A Comparison

In this subsection, we reestimate equation (8) by applying the FE and IV estimators again for two separate data subsamples—ASEAN countries and Plus Three countries. We aim to address the question of whether differences in size and levels of economic development between ASEAN countries and Plus Three countries can influence the relationship between bilateral export volatility and its potential determinants. We report the empirical results in Table 6.

First, looking at the impact of income volatility on bilateral export volatility, the empirical results are significantly altered. Specifically, in the ASEAN subsample, we fail to maintain the significant impact of the reporter country's income volatility on its bilateral export volatility after treating income volatility as an endogenous variable. By contrast, in the Plus Three subsample, estimates of the reporter country's income volatility are quite high and statistically significant in both FE and IV estimations, suggesting a considerable effect of income volatility on bilateral export volatility. For instance, on the estimated coefficients of the reporter's income volatility in the HHI, SI, and the Theil index models after treating the

Table 6. **Export Volatility Estimation: ASEAN versus Plus Three**

	ASEAN Panel						Plus Three Panel					
	HHI		SI		Theil		HHI		SI		Theil	
	FE	IV	FE	IV	FE	IV	FE	IV	FE	IV	FE	IV
Income volatility (reporter)	0.557***	−0.032	0.566***	0.072	0.577***	−0.034	0.400***	1.343***	0.455***	1.628***	0.419***	1.415***
	(0.066)	(0.202)	(0.064)	(0.196)	(0.065)	(0.198)	(0.100	(0.412)	(0.107)	(0.414)	(0.099)	(0.407)
Income volatility (partner)	0.051	−0.267	0.056	−0.165	0.037	−0.263	0.126	0.369	0.162**	0.335	0.129	0.363
	(0.083)	(0.257)	(0.077)	(0.249)	(0.084)	(0.261)	(0.077	(0.233)	(0.078)	(0.245)	(0.078)	(0.238)
Exchange rate volatility	−0.204*	0.366	−0.271***	0.231	−0.210**	0.364	−0.085	−0.351*	−0.174	−0.425*	−0.102	−0.361*
	(0.104)	(0.230)	(0.101)	(0.232)	(0.101)	(0.229)	(0.120	(0.210)	(0.129)	(0.232)	(0.121)	(0.214)
Export diversification index	0.393***	0.213***	0.002	0.000	0.081***	0.035***	0.488***	0.463***	−0.002*	−0.004***	0.093***	0.075***
	(0.119)	(0.056)	(0.002)	(0.001)	(0.023)	(0.012)	(0.131	(0.087)	(0.002)	(0.001)	(0.029)	(0.014)
AHS tariff	0.001	0.003**	0.003	0.004***	0.001	0.003**	0.005	0.000	0.004	−0.002	0.004	0.000
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.007	(0.005)	(0.006)	(0.006)	(0.007)	(0.005)
MFN tariff	0.000	−0.004***	0.001	−0.004***	0.000	−0.004***	−0.003	0.004	−0.003	0.004	−0.002	0.004
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.007	(0.005)	(0.007)	(0.006)	(0.007)	(0.006)
Free trade agreement	−0.036	−0.006	−0.042	−0.008	−0.033	−0.007	0.016	−0.007	0.005	−0.019*	0.021	−0.005
	(0.034)	(0.006)	(0.035)	(0.005)	(0.034)	(0.006)	(0.017	(0.010)	(0.017)	(0.010)	(0.018)	(0.010)
ACFTA	−0.075**	0.001**	−0.083**	0.000*	−0.074**	0.001**	–	–	–	–	–	–
	(0.034)	(0.000)	(0.036)	(0.000)	(0.034)	(0.000)						
AJFTA	−0.014	−0.031*	−0.018	−0.032*	−0.008	−0.028	–	–	–	–	–	–
	(0.033)	(0.019)	(0.033)	(0.018)	(0.032)	(0.019)						
AKFTA	0.024	−0.021	0.025	−0.037	0.027	−0.021	–	–	–	–	–	–
	(0.033)	(0.026)	(0.033)	(0.025)	(0.033)	(0.026)						
Political rights (reporter)	0.001	0.006	−0.002	0.002	−0.002	0.007	−0.022	0.002	−0.024	−0.002	−0.022	0.000
	(0.008)	(0.023)	(0.008)	(0.021)	(0.008)	(0.023)	(0.015	(0.005)	(0.016)	(0.006)	(0.016)	(0.005)
Political rights (partner)	−0.008	−0.029	−0.005	−0.024	−0.008	−0.029	0.000	0.009	−0.004	−0.011	0.000	0.007
	(0.009)	(0.026)	(0.010)	(0.025)	(0.009)	(0.026)	(0.004	(0.015)	(0.005)	(0.017)	(0.004)	(0.015)
Constant	0.212***		0.283***		0.053		0.153***	–	0.406***	–	0.009	–
	(0.050)	–	0.066	–	(0.085)	–	(0.047)		(0.078)		(0.069)	
Observations	1,320	1,116	1,322	1,116	1,322	1,103	527	527	571	–	571	–
R-squared	0.089	–	0.0072	–	0.124	–	0.1290	–	0.0936	–	0.1261	–

Continued.

Table 6. *Continued.*

	ASEAN Panel						Plus Three Panel					
	HHI		SI		Theil		HHI		SI		Theil	
	FE	IV	FE	IV	FE	IV	FE	IV	FE	IV	FE	IV
Anderson canonical correlation		65.541		63.937		61.200		19.983		22.682		20.552
LM statistic (*p*-value)	–	(0.000)	–	(0.000)	–	(0.000)	–	(0.000)	–	(0.000)	–	(0.000)
Cragg–Donald Wald F-statistic		13.788	–	13.429	–	12.822	–	6.779[a]	–	7.736[a]	–	6.980[a]
(10% maximal IV relative bias)	–		–		–		–		–		–	
Sargan statistic (*p*-value)		5.587		5.370		7.119		0.308		0.065		0.409
	–	(0.133)	–	(0.146)	–	(0.106)	–	(0.579)	–	(0.798)	–	(0.522)

ACFTA = ASEAN–China Free Trade Area, AHS = effectively applied tariff, AJFTA = ASEAN–Japan Free Trade Area, AKFTA = ASEAN–Korea Free Trade Area, ASEAN = Association of Southeast Asian Nations, FE = fixed effect, HHI = Herfindahl–Hirschman Index, IV = instrumental variable, LM = Lagrange multiplier, MFN = most favored nation, SI = similarity index.

Notes: Figures in parentheses are standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

[a]20% maximal IV relative size.

Source: Authors' estimates.

endogeneity problem, the results reveal that a percentage point increase in income volatility would, all things being equal, raise export volatility by approximately 1.343%, 1.628%, and 1.415%, respectively. We therefore conclude that the role of income volatility in explaining the volatility of bilateral exports between ASEAN+3 countries depends on the size and level of economic development of each member country. Precisely, in strong economies, particularly the Plus Three countries, the positive impacts of income volatility on export volatility are much more pronounced.

Second, our empirical results on the effects of export diversification are not affected very much after splitting the data. It is worth noting that the effects of export diversification on export volatility appear to be qualitatively similar to those obtained for the ASEAN+3 as a whole. Exceptionally, the impact of the similarity index becomes negative and significant but only in the Plus Three sample. In addition, the estimates of the HHI and Theil index in the Plus Three sample are substantially higher than those in the ASEAN sample. For instance, the IV estimation results show that a percentage point rise in the degree of export concentration (the HHI), would increase the export volatility of the Plus Three countries by approximately 0.463%, while export volatility in ASEAN countries would go up by only 0.213%. This means that the Plus Three countries seem to be more cautious than the ASEAN members in terms of considering export diversification as a tool for controlling export volatility.

Third, the empirical results on the impact of tariffs on ASEAN+3 as a whole can only be found in the results for the ASEAN panel. This means that in smaller and less powerful economies, export volatility depends on the variation of tariffs applied by their trading partners. However, this impact is quite small. A percentage point increase in the AHS tariff would increase ASEAN export volatility by around 0.003%, while a percentage point increase in the MFN tariff would reduce ASEAN export volatility by approximately 0.004%. Thus, negotiating preferential tariffs with trading partners should be considered an essential tool for controlling export volatility. On the other hand, the empirical results reported in Table 6 also confirm that becoming a member of ACFTA allows an ASEAN country to slightly lower its bilateral export volatility. By contrast, due to their meaningful position in world trade, the bilateral export volatility of the Plus Three countries is not significantly affected by tariffs applied by ASEAN countries.

Similar to the previous section, we once again apply the quantile regression's estimator to investigate the possible heterogeneity of each determinant's impact on export volatility in ASEAN and Plus Three countries, as reported in Table 7. As expected, the link between each determinant and export volatility changes when export volatility moves from the highest to the lowest levels. First, in ASEAN, the change in export volatility from the 5th quintile to the 1st quintile results in a slight increase in the positive impact of the reporter country's income volatility by approximatively 0.03%. However, the reverse result is found for Plus Three

Table 7. **Export Volatility Quantile Regression: ASEAN versus Plus Three**

	ASEAN Panel						Plus Three Panel					
	HHI		SI		Theil		HHI		SI		Theil	
	1st	5th	1st	5th	1st	5th	1st	5th	1st	5th	1st	5th
Income volatility	0.571***	0.543***	0.581***	0.551***	0.590***	0.562***	0.394***	0.406**	0.446*	0.464*	0.396***	0.445*
(reporter)	(0.000)	(0.126)	(0.077)	(0.111)	(0.072)	(0.116)	(0.002)	(0.186)	(0.283)	(0.272)	(0.106)	(0.254)
Income volatility	0.086	0.013	0.078	0.033	0.080	−0.009	0.114	0.141	0.140	0.187	0.105	0.155
(partner)	(0.373)	(0.166)	(0.103)	(0.149)	(0.094)	(0.151)	(0.198)	(0.131)	(1.039)	(0.260)	(0.076)	(0.254)
Exchange rate	−0.189*	−0.222	−0.270**	−0.271	−0.201*	−0.222	−0.104	−0.065	−0.190	−0.157	−0.114	−0.089
volatility	(0.100)	(0.214)	(0.134)	(0.195)	(0.120)	(0.193)	(0.389)	(0.179)	(1.376)	(0.362)	(0.103)	(0.346)
Export diversification	0.211*	0.591**	0.003	0.001	0.051*	0.115***	0.176	0.839**	−0.003	−0.003*	0.039	0.255**
index	(0.112)	(0.289)	(0.002)	(0.002)	(0.026)	(0.043)	(0.454)	(0.347)	(0.184)	(0.002)	(0.031)	(0.104)
AHS tariff	−0.001	0.004	0.000	0.006	−0.002	0.003	0.003	0.007	0.003	0.005	0.004	0.005
	(0.661)	(0.005)	(0.003)	(0.004)	(0.003)	(0.004)	(0.582)	(0.008)	(0.764)	(0.018)	(0.005)	(0.016)
MFN tariff	0.002	−0.002	0.002	−0.004	0.002	−0.003	−0.003	−0.003	−0.003	−0.002	−0.003	−0.001
	(0.367)	(0.004)	(0.002)	(0.003)	(0.002)	(0.003)	(0.641)	(0.009)	(0.786)	(0.018)	(0.005)	(0.017)
Free trade agreement	0.002	−0.078	−0.008	−0.078	0.002	−0.071	0.007	0.027	0.000	0.011	0.009	0.033
	(0.959)	(0.067)	(0.041)	(0.059)	(0.037)	(0.060)	(0.740)	(0.029)	(2.447)	(0.058)	(0.017)	(0.056)
ACFTA	−0.048	−0.105	−0.055	−0.112*	−0.048	−0.103*	–	–	–	–	–	–
	(0.260)	(0.073)	(0.045)	(0.065)	(0.041)	(0.066)						
AJFTA	−0.018	−0.010	−0.023	−0.012	−0.016	0.000	–	–	–	–	–	–
	(0.554)	(0.052)	(0.030)	(0.044)	(0.029)	(0.047)						
AKFTA	0.026	0.022	0.032	0.018	0.029	0.023	–	–	–	–	–	–
	(0.433)	(0.057)	(0.034)	(0.049)	(0.032)	(0.051)						
Political rights	−0.004	0.005	−0.005	0.001	−0.006	0.002	−0.027	−0.016	−0.034	−0.013	−0.028	−0.015
(reporter)	(0.558)	(0.011)	(0.006)	(0.009)	(0.006)	(0.010)	(0.365)	(0.044)	(3.550)	(0.084)	(0.025)	(0.084)
Political rights	−0.012	−0.003	−0.011	0.000	−0.012	−0.003	0.002	−0.002	0.001	−0.009	0.003	−0.004
(partner)	(0.209	(0.017)	(0.011)	(0.015)	(0.009)	(0.015)	(0.755)	(0.010)	(0.889)	(0.021)	(0.006)	(0.020)
Observations	1,320	1,116	1,322	1,116	1,322	1,103	527	527	571	571	571	571

ACFTA = ASEAN–China Free Trade Area, AHS = effectively applied tariff, AJFTA = ASEAN–Japan Free Trade Area, AKFTA = ASEAN–Korea Free Trade Area, ASEAN = Association of Southeast Asian Nations, HHI = Herfindahl–Hirschman Index, MFN = most favored nation, SI = similarity index.

Notes: Figures in parentheses are standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: Authors' estimates.

countries. Second, the negative impact of exchange rate volatility on ASEAN export volatility is only significant in the lowest quintile (1st), while this impact is not significant for Plus Three countries. Third, the empirical results at the quintile level support the significant and strong effects of export diversification on export volatility, particularly in the highest quintile (5th), in both ASEAN and Plus Three countries. Lastly, the very small impact of AHS and MFN tariffs on ASEAN's export volatility obtained by using linear regression (Table 6) is not found in the quantile regression. This means that ASEAN's exports, on average, weakly depend on AHS and MFN tariffs. However, this fragile dependence could be lost at the quintile level.

All the empirical results listed above also allow us to provide ranking properties among the determinants of interest. We reveal that income volatility of the reporter country plays the most important role in explaining ASEAN+3 export volatility (for both the full sample and the two separate samples). Following income volatility, export diversification and exchange rate volatility play the next important roles in explaining export volatility in ASEAN+3. By contrast, changes in trading tariffs, unexpectedly, have a very weak impact on export volatility.

VI. Conclusion

The objective of this paper is twofold. First, we investigate the potential role of trade variables, notably trade volatility and export diversification, on income volatility of ASEAN+3 member states. Second, we provide an empirical analysis on the potential determinants of ASEAN+3's bilateral export volatility. To this end, we apply a set of panel and cross-sectional econometric techniques including the GMM and the FE and IV estimators. We carry out our empirical tests for a panel dataset covering aggregate income and trade volatility of each ASEAN+3 member state and a cross-sectional data sample of intra-ASEAN+3 bilateral export volatility. A set of important findings on the relationship between income volatility, trade volatility, and trade diversification can be drawn from our paper.

First, we reveal that the volatility of trade has a positive effect on output volatility in ASEAN+3. This result confirms trade's key role in explaining economic growth. Second, we find no evidence that export diversification reduces output volatility in ASEAN+3. Similarly, becoming a member of an FTA does not allow ASEAN+3 member states to better control economic growth volatility. Exceptionally, the ACFTA seems to be creating stability in terms of intra-ASEAN+3 exports. Third, income volatility, in turn, positively influences intra-ASEAN+3 bilateral export volatility. Fourth, the nature of the link between export diversification and export volatility strongly depends on the measurement of export diversification. Fifth, the type of tariffs applied by a trading partner is also a considerable factor in determining bilateral export volatility in ASEAN+3,

particularly in ASEAN countries. Lastly, by separating data for ASEAN and Plus Three countries, we find that the nature of the relationship between export volatility, income volatility, and trade diversification could depend on country size and the level of economic development.

Our findings also provide a set of important policy implications. First, the trade–economic growth volatility nexus supports the compensation hypothesis as economic growth becomes susceptible to external shocks from trading partners. In the case of ASEAN+3, particularly in ASEAN countries in which trade openness is still considered an economic growth promoter, policy makers should implement efficient tools for controlling trade volatility that, in turn, could shield an economy against the detrimental impact of idiosyncratic global shocks on volatility. Another important finding of this paper concerns the role of export diversification in reducing bilateral export volatility in ASEAN+3. This finding supports the fact that trade openness can reduce economic growth volatility in ASEAN+3 when countries are well diversified. The relation between export concentration and trade openness is also illustrated in Figure A1.2 in Appendix 1. Lastly, we cannot confirm the theoretical impact of an FTA on export volatility in our empirical analysis since the FTA estimates we find are negative but statistically insignificant. This finding suggests that ASEAN+3 policy makers have to review the implementation of existing intraregional FTAs in order to better benefit from these agreements in terms of lessening bilateral export volatility.

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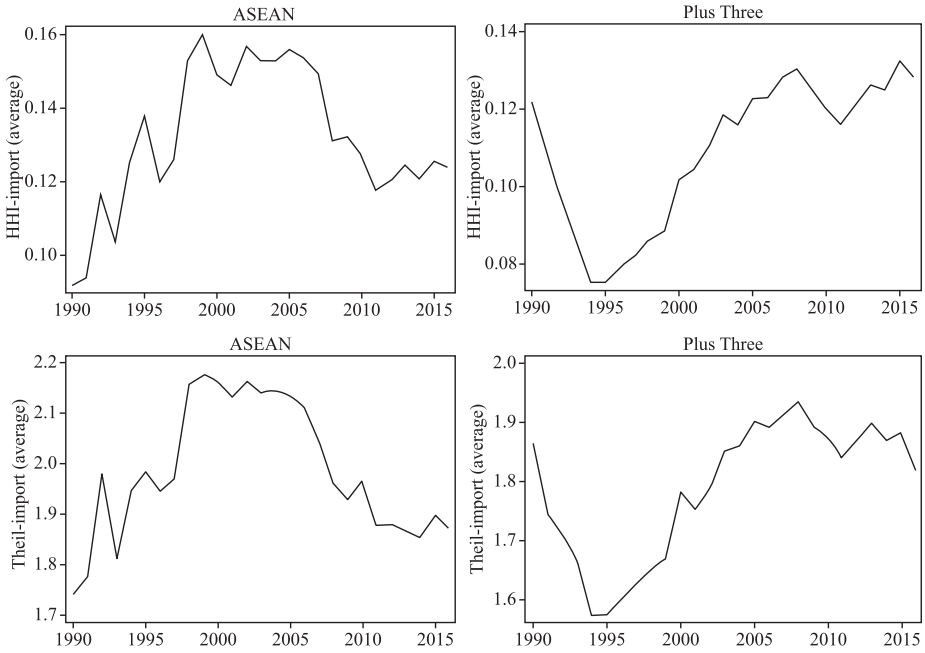
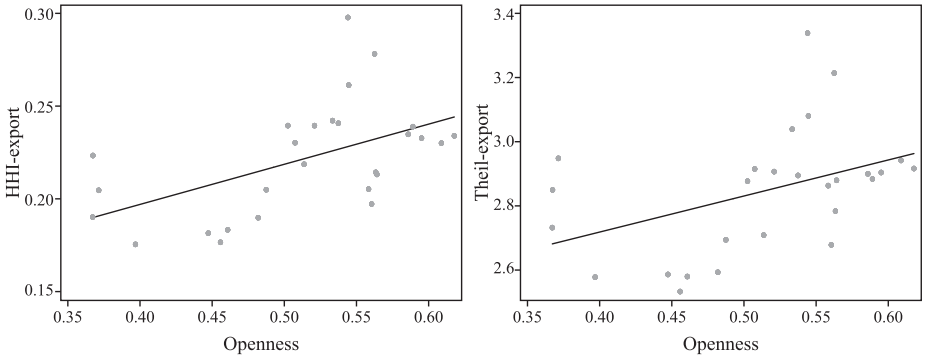
Appendix 1

Figure A1.1. **Import Concentration, 1990–2016**



ASEAN = Association of Southeast Asian Nations, HHI = Herfindahl–Hirschman Index.
Note: Plus Three refers to Japan, the People's Republic of China, and the Republic of Korea.
Source: Authors' illustration from calculated indexes.

Figure A1.2. **Export Concentration and Trade Openness**



HHI = Herfindahl–Hirschman Index.
Source: Authors' illustration from calculated indexes.

Appendix 2

Estimation of Trade Openness Model (equation 7)

Dependent Variable: Trade Openness ([Exports + Imports]/GDP)	
Regressors	**Fixed Effects**
Log (Population)	−0.129***
	(0.015)
Landlocked	−0.451***
	(0.086)
Area	−0.000***
	(0.000)
Language: English	0.156**
	(0.065)
Language: Chinese	0.870***
	(0.066)
Remoteness	−0.000***
	(0.000)
Constant	1.649***
	(0.255)
Observations	351
R-squared	0.76
Number of years	27

GDP = gross domestic product.
Notes: Robust standard errors in parentheses. *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.10$.
Source: Authors' estimates.