Prediction Errors of Macroeconomic Indicators and Economic Shocks for ASEAN Member States, 1990–2021*

Masahito AMBASHI†
Associate Professor, Kyoto University, Research Fellow, ERIA,
and Consulting Fellow, RIETI
Fusanori IWASAKI
Executive Assistant to the President, ERIA
Keita OIKAWA
Economist, ERIA

Abstract

We analyse economic shocks on six selected ASEAN Member States (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam) in three dimensions: global, domestic, and uncertainty. We collect 1990−2021 macroeconomic indicators and calculate macroeconomic shocks based on prediction errors of the real GDP growth rates. We first demonstrate that the countries were, on average, significantly subjected to unforeseen negative economic shocks. Second, we show high synchronisation of economic fluctuations and shocks within the countries as well as with the world. Third, by conducting regression analyses separately for each country, we derive (i) positive association between variations of the global real GDP growth rates and countries' economic shocks; (ii) different quantitative significance of the previous estimates amongst the countries; (iii) country-specific, domestic shocks; and (iv) correlation of global and country-level uncertainty indices with negative economic shocks in the Philippines and Singapore, respectively. The calculation points to the relative importance of global, domestic, and uncertainty shocks in the AMS as 56.9%, 40.1%, and 3.0%, respectively. Finally, based on this dataset, we also review the effect of the COVID-19 pandemic on these countries.

JEL Classification: E32; F44; N15
Keywords: Prediction error; Economic shock; Uncertainty; Business cycle synchronisation

I. Introduction

The Association of Southeast Asian Nations (ASEAN) Member States (AMS) have been frequently subjected to economic shocks due to various global business fluctuations, such as the 1997–1998 Asian financial crisis and the 2008–2009 global financial crisis. They have suffered other economic shocks from within their domestic systems and institutions by failing to control

* The authors wish to thank the Economic Research Institute for ASEAN and East Asia (ERIA) and the Research Institute of Economy, Trade and Industry (RIETI), which provided great support including the research fund.
† Corresponding author: Masahito Ambashi (anbashi.masahito@gmail.com)

economic recessions or overheating. They have also sometimes faced unforeseen and unavoidable exogenous shocks, such as natural disasters, political disturbances, and pandemics. In recent years, the negative economic shock of the unanticipated COVID-19 pandemic has been quite substantial in the ASEAN region that manufacturing and service industries ceased operations for a long period, causing serious downturns of its economy. Moreover, increased uncertainty could negatively affect countries' economic growth in an indirect manner that weakens consumers' and firms' economic confidence and foresight.

In this study, we analyse the effects of past economic shocks on six selected ASEAN countries – Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam – by examining global, domestic, and uncertainty shocks.[1] We collect both actual and prediction values of annual macroeconomic indicators from 1990 to 2021 such as real gross domestic product (GDP) growth rates, and then calculate prediction errors. Whereas many studies (which will be reviewed in Section 2) have analysed macroeconomic business cycle synchronisation in East Asia and the ASEAN region based on econometric and macroeconomic models, we believe that we have made a unique contribution to ASEAN macroeconomic literature through the in-depth examination of economic shocks that are evaluated by macroeconomic prediction errors and uncertainty indices. Indeed, from 1990 to present, AMS have encountered various economic shocks, including global shocks that impacted the entire region, domestic shocks such as local economic and political disturbances (e.g. Indonesia in 1998) and natural disasters (e.g. Thailand in 2011), and uncertainty shocks that were sometimes accompanied by these two shocks. By using our original dataset, we will reveal how the economic shocks were distributed within each country, how they were synchronised within AMS and with the world, and what the cause of economic shocks they suffered so far was.

Prior to proceeding on to the details of the study, "prediction error" must be clearly defined. In brief, we calculate it as "the actual value minus the prediction value" concerning annual macroeconomic indicators. In fact, firms' prediction errors of production or business confidence aggregated in the economy is often used to measure their sentiment of business environments and willingness of investment activities. In place of this, we use the former prediction errors as they are likely to be "proxy" variables for macroeconomic shocks that influenced country- and regional-level macroeconomies – this is the primary focus of this study. Specifically, we use data compiled by the Asian Development Bank (ADB) and the International Monetary Fund (IMF), which have continually issued macroeconomic predictions from 1990 and 2000, respectively. Their predictions seem to be more objective than those of official government institutions that tend to establish optimistic economic predictions. Additionally, macroeconomic predictions made by them are frequently cited in the mass media and referred to by professional investors, analysts, and economists.

[1] Brunei Darussalam, Cambodia, the Lao People's Democratic Republic, and Myanmar also belong to ASEAN. However, these four countries are excluded from the study, as they account for a small share of the ASEAN economy, and published data are likely to lose their quality, particularly those of the past.

A brief summary of the findings of this study is as follows. First, given that prediction errors of real GDP growth rates for the selected AMS are negative on average across the years, these countries have been subjected to unforeseen negative economic shocks, including through global business recessions, export variations, and idiosyncratic domestic downturns. Second, simple correlation analyses with respect to both actual values and prediction errors of real GDP growth rates demonstrate that these two correlation coefficients are significantly large in the total sample period, implying that countries' business cycles are highly synchronised with those of the region and world, as existing studies have already presented. Third, ordinary least squares (OLS) regression analyses of the prediction errors of real GDP growth rates conducted separately for each AMS indicate that (i) variations of the global real GDP growth rate are positively associated with economic shocks; (ii) the previous estimates have different quantitative significance across countries; (iii) residual variations approximate country-specific, domestic shocks; and (iv) global and country-level uncertainty indices are associated with negative economic shocks in the Philippines and Singapore, respectively. The calculation indicates that 56.9%, 40.1%, and 3.0% of variations of economic shocks from 2001 to 2021 in AMS stem from global, domestic, and uncertainty shocks, respectively. Finally, based on this dataset, we also review the effects of the COVID-19 pandemic on these countries. We can thus derive useful implications for various types of economic shocks, recovery paths, and policy responses by observing detailed factors of past economic shocks.

This paper is organised as follows. Section 2 surveys existing studies relevant to the study. Section 3 details the dataset used in the analyses. Section 4 demonstrates the results of the statistical and econometric analyses and derives their interpretations. Section 5 exhibits a tentative evaluation regarding the effects of the COVID-19 pandemic. Section 6 concludes followed by full references.

II. Related Literature

II.I Prediction Errors, Economic Shocks, and Uncertainty

While we employ annual macroeconomic indicators compiled by international organisations to estimate economic shocks, other existing studies rely on data about monthly or quarterly predictions of production or business confidence compiled by firms (Bachmann et al., 2013; Arslan et al., 2015; Morikawa, 2016; Morikawa 2019). These studies regarded standard deviations of prediction errors between present and former indicators or average absolute values of prediction errors across firms as degrees of "uncertainty" that are specific to firms. However, in contrast to these studies, we simply interpret *ex post* prediction errors, viz. the difference between prediction values and *ex post* ones (actual values), as an unforeseen "economic shock". A negative economic shock is represented especially when the prediction error is negative.[2]

[2] Rigorously speaking, this kind of negative prediction errors should include negative economic effects due to a rise in uncertainty (second moment) in addition to direct economic shocks (first moment). As for the detail of uncertainty measures, see the following in this section.

When we use the above-mentioned measure of prediction errors as economic shocks, attention needs to be directed to the fact that many existing studies have already shown likely upward-biased (in other words, optimistic) macroeconomic growth predictions published by governments and international organisations (Ashiya, 2007; Frankel, 2011; Merola and Perez, 2013; Morikawa, 2020; Pain et al., 2014; Timmermann, 2007). Hence, while probing factors and relations of economic shocks in selected AMS, we also attempt to confirm whether prediction values of macroeconomic indicators, such as the real GDP growth rates, may have been influenced by upward biases.

Generally, economic downturns, when negative prediction errors are observed, often entail an increase in uncertainty. Macroeconomic uncertainty is likely to rise when economic shocks or recessions (e.g., bubble economy burst, financial crisis) occur; this tends to be higher in developing countries than in developed countries (Bloom, 2014). Natural disasters, war, terrorist attacks, political disturbances, and public health problems such as the current COVID-19 pandemic are also responsible for a rise in uncertainty. It may suppress economic activities such as investment because it makes a wait-and-see strategy seem to be more valuable for firms and results in higher finance costs due to a rise in required risk premium. Baker et al. (2016) developed the Economic Policy Uncertainty Index to grasp a direct measure of uncertainty, which calculates the frequency of words (e.g. uncertainty), related to economic policy uncertainty, appearing in US newspapers.[3] Similarly, these authors constructed the World Uncertainty Index that relies on texts published by the Economist Intelligence Unit. We use the latter uncertainty measure to explain economic shocks that the selected AMS received.

II.II Business Cycle Synchronisation in East and South-East Asia

Many studies have examined business cycles in East and South-East Asia using short-term macroeconomic indicators, which is also a focus of our study using economic shocks estimated by prediction errors of real GDP growth rates. These previous studies mostly analysed business cycle synchronisation in East Asia, including South-East Asia, mainly from the viewpoint of trade and financial connectivity, given the fact that regional economic integration has advanced since the 1990s.

Existing studies have demonstrated that trade integration is the most critical factor for business cycle synchronisation in East Asia. Concretely, they highlight some aspects including bilateral trade forming regional supply chains (Jiang et al., 2019; Allegret and Essaadi, 2011; Gong and Kim, 2013) and the difference in trade structures across countries (Nguyen et al., 2020). In particular, the major structural change in trade in East Asia that relates to business cycle synchronisation is the expansion of product fragmentations (Takeuchi, 2011) and resultant intra-industry trade (Rena et al., 2012). Studies have argued that the impact of intra-industry trade on East Asian business cycle synchronisation is relatively significant due to the development of

[3] See Economic Policy Uncertainty. https://www.policyuncertainty.com/index.html

regional supply chains, such as those involving electrical and electronic equipment (Shin and Wang, 2003; Cortinhas, 2007; Rena, 2007; Li, 2017; Sng et al., 2017). Overall, it is assessed that the enhancement of trade integration in East Asia has contributed to reinforcing business cycle synchronisation of the region.[4]

The effect of financial integration has also been explored, but there has not been any consensus on whether the effect is positive or negative. Some authors asserted that the advancement of financial integration, as well as trade integration, is associated with business cycle synchronisation (Rena, 2007; Nguyen et al., 2020) particularly after Asian financial crisis (Xie et al., 2013) and through international capital flow encouraged by capital market liberalisation (Kim and Kim, 2013). But contrastingly, other authors showed the negative effect of internal financial integration on East Asian or Asia-Pacific business cycle synchronisation (Gong and Kim, 2013; Pontines and Parulian, 2010) and pointed out financial integration as the reason for synchronisation between ASEAN and other countries/regions (e.g., US) (Sethapramote, 2015).

Furthermore, existing studies have also highlighted additional influential factors. Common external factors, mainly supply shocks, such as changes in oil and commodity prices and exchange rates, and productivity improvements could also be critical factors through export synchronisation (Moneta and Rüffer, 2009; He and Liao, 2012; Park, 2013).[5]

III. Dataset

This section describes the dataset used in this study. We collect the main macroeconomic indicators from the statistical tables listed in the *Asian Development Outlook* from 1989 to 2022. These reports, made public annually between March and April by ADB, demonstrate annual prediction values of the particular publication year and the following year, as well as annual actual values of the past five years.[6] It should be noted that ADB (1999) did not report statistical tables, including the prediction of macroeconomic indicators, due to the difficulty in exhibiting point forecasts in the middle of the Asian financial crisis. Therefore, the 2000 prediction values from ADB (1999) are treated as missing values; these are extrapolated from the IMF dataset, if appropriate. Two annual macroeconomic indicators based on ADB (1989−2022) are employed: real GDP growth rates and merchandise export growth rates, both of which are calculated in the percentage growth rate relative to the previous year. As for supplemental explanations, the GDP of each AMS is valued at market prices. Merchandise exports evaluated in US million dollars are obtained from the balance-of-payments accounts of each AMS economy, and export data are based on free on board.[7]

---

[4] However, Xie et al. (2013) consider that trade specialisation negatively affects business cycle synchronisation.

[5] Meanwhile, commodity price fluctuations, war, and political disturbances could weaken transmission of business cycles (Selover, 1999).

[6] For example, ADB (2020) exhibited prediction values of macroeconomic indicators both in 2020 and 2021.

[7] For further information, see the 'Statistical Notes and Tables' of *Asian Development Outlook* of each year.

We also reference prediction values of macroeconomic indicators published by other international organisations. We use *World Economic Outlook Database* to collect data on real GDP growth rates (i.e. a fixed-price base). The database is published by the IMF biannually, April and September−October, and we employ for our analysis only April data to be consistent with the timing when ADB data was published. IMF (1999), published in April 1999, is the oldest available dataset with respect to the selected AMS; one-year-later prediction values are available from 2000 to 2022. Specifically, we use IMF (1999) to complement the missing prediction value of the 2000 real GDP growth rate in ADB (1999) for part of the analyses. To examine the world-wide economic shocks that impacted AMS, we collect from IMF (1999−2022) data on global real GDP growth rates (i.e. fixed-price base, without exchange rate adjustment) synthesised from 195 countries' GDP data.[8] Its dataset on actual and prediction values are available from 1990 and 2000, respectively.

More importantly, past actual values of macroeconomic indicators are determined. With respect to the system of national accounts (SNA), the basis of the time series is periodically modified; thus, actual values are frequently revised from those of the past. There is a serious concern that actual values of macroeconomic indicators from the present viewpoint may diverge from economic outlooks formulated by relevant international organisations or economists of that time. That is, immediate past values such as those of the previous year could drastically change in the following year due to additional data becoming available for the SNA. Considering these difficulties, three-year lagged actual values of macroeconomic indicators from the report publication year are used, implying that, for example, the actual value of 2000 refers to that documented in the dataset of the 2003 report (e.g. *Asian Development Outlook 2003*). Unfortunately, since it is impossible to obtain 2020 and 2021 actual values of indicators by the above-mentioned methodology, we use those listed in the 2022 report.

To facilitate the analyses, we use ADB (1989−2022) for data on the actual values of real GDP growth rates, as it covers the longest time span from 1990 to 2021. Indeed, when the actual values of these two indicators are compared between ADB (1989−2022) and IMF (1999−2022), there is no critical difference between the two datasets. If ADB (1999) is only used, the actual 1996 values are missing. To address this problem, we extrapolate actual values of real GDP growth rates from IMF (1999), and merchandise export growth rates from ADB (1998). In addition, we obtain the actual value of the global real GDP growth rates from 1990 to 1995 by referring to the statistical table offered by IMF (1999).

Table 1 represents the actual values, prediction values, and prediction errors of real GDP growth rates for the six selected AMS and the world. It also consolidates the average growth rates, standard deviations, and coefficients of variation (i.e. standard deviation divided by sample mean) in the 1990s, 2000s, and 2010s.

---

[8] The World Bank also publishes global real GDP growth rates. However, since more samples are available from IMF, this study uses these.

<Table 1>

As an alternative to the Economic Policy Uncertainty Index, the World Uncertainty Index is applied. The reason is that the former index is available only from 1997, while the latter from 1990 including the six AMS country-level uncertainty indices, which is consistent with our analysis that begins in 1990. The World Uncertainty Index (i.e. weighted average of countries' GDPs) is based on individual country-level uncertainty indices that are calculated on a quarterly basis. We downsize the World Uncertainty Index by 100 and magnify all country-level indices 100-fold in order for numerical values to be readable. The numerical expansion and contraction do not affect the statistical analyses, excluding numerical scales. Furthermore, since the dataset has an annual base, the series of the annual uncertainty indices simply average the quarterly World Uncertainty Index and country-level uncertainty indices.

IV. Analytical Results

Section 4 details (i) an overview of real GDP growth rates and prediction errors across the six selected AMS; (ii) correlation analyses of these two series from 1990 to 2021 within the six AMS and with the world; and (iii) regression analyses of the prediction errors for each country.

IV.I Actual Values and Prediction Errors of Real GDP Growth Rates

In Table 1, the shaded cells signify negative prediction errors, wherein actual values fall below prediction values. This implies that past prediction values overestimated macroeconomic environments that were impacted by unforeseen negative economic shocks. Among the sample period of 1990−2021 (i.e. 32 years), overestimations can be observed in Indonesia (19 years), Malaysia (14 years), the Philippines (19 years), Singapore (15 years), Thailand (19 years), and Viet Nam (15 years).[9] Specifically, it appears that the predictions of Indonesia, the Philippines, and Thailand tended to heavily overestimate the macroeconomic environments. The Philippines recorded negative prediction errors mainly in the 1990s, while for Indonesia and Thailand in much greater frequency after 2005. Recent overestimations are more conspicuous in Indonesia and Thailand than in the other countries. Particularly, while Indonesia has highly appreciated with its recent stable, remarkable economic growth, its prediction error has been negative for ten consecutive years from 2012 to 2021. Moreover, while having a lower frequency of negative prediction values, Malaysia, Singapore, and Viet Nam also recorded them in around half of the total sample years. Moreover, Figure 1 shows that negative prediction errors tended to be greater especially for Indonesia, Malaysia, the Philippines, and Thailand.

<Figure 1>

[9] The standard deviations and coefficients of variation are larger for the actual values than for the prediction values with respect to all countries, which means that the actual real GDP growth rates fluctuated more than their predictions.

Taking the simple average over these three values across 32 years (i.e. 1990−2021), prediction errors are negative among the AMS excluding Singapore, which broadly supports negative economic shocks in total as well as upward, optimistic biases of prediction values.[10] Meanwhile, the average prediction error for Singapore is positive in the 1990s; that for Indonesia is almost zero in the 2000s; those for Malaysia, the Philippines, and Singapore are positive; and that for Viet Nam is almost zero in the 2010s. Notably, recording a small negative prediction error (−0.43% points) and a standard deviation (1.87) despite displaying a high average real GDP growth rate (6.61%) for 32 years suggests that Viet Nam has seen relatively stable economic growth since the 2010s. Singapore maintained solid growth before the onset of the COVID-19 pandemic, exhibiting the smallest but positive prediction error (0.27% points). In sharp contrast, Thailand shows sizable, negative prediction errors in the 1990s (−2.41% points), 2000s (−0.82% points), and 2010s (−0.77% points), and the average prediction error for 32 years is −1.59% points, while its standard deviation is the largest at 4.37. This implies that Thailand was not able to fully exploit its growth potential despite its long-time centrality of manufacturing and export bases in South-East Asia.

IV.II Correlation Analyses between the Six ASEAN Member States and the World

Table 2 calculates the correlation coefficients with respect to the six AMS and global real GDP growth rates in the 1990s, 2000s, 2010s, and total period (i.e. 1990−2021). Obviously, significantly positive correlations exist between all of them for the cumulative period, excluding the relationship between Indonesia and the world. Although this analysis is quite primitive, the finding is almost consistent with existing studies reviewed in Subsection 2.2 that observed business cycle synchronisation within South-East Asian countries.

<Table 2>

Albeit the limitations presented by relatively small samples, what follows reviews correlation coefficients in the individual periods. First, in the 1990s, there is no statistically significant correlation between the countries (excluding the Philippines) and the world. Meanwhile, after the 2000s, significantly positive correlations exist in relation to the world: Malaysia and Singapore in the 2000s and 2010s; and Thailand, the Philippines, and Viet Nam in the 2000s. This seems to reflect the fact that economic integration with the global economy has advanced since the 2000s in East Asia. On the other hand, the correlation is weaker amongst the six AMS in the 2010s than in the 2000s. For example, the correlation coefficients for Malaysia−Thailand and Singapore−Thailand in the 2010s are not significant. The 2010s is exactly when ASEAN economic integration first occurred, but at the same time, autonomous

[10] The average prediction error of the global real GDP growth rate is also negative. One possible reason for upward biases in ADB (1989−2022) is that its prediction values are frequently made in reference to upward-biased economic outlooks that individual governments published.

business cycles may have been reinforced within each country during that period. Viet Nam does not exhibit significant correlation with the other AMS and the world in the 2010s, although it realised relatively high growth. Third, Indonesia tends to be influenced by its large domestic demand, so its correlation coefficient with the world in the total period is small (0.294) and statistically insignificant (10.2%).

Next, Table 3 shows the correlation coefficients of prediction errors of real GDP growth rates with respect to the six AMS and the world. It also examines the relationship between prediction errors and the World Uncertainty Index. Since prediction values of global real GDP growth rates are available only from 2000, the correlation coefficients regarding the prediction errors of those indicators in the 1990s are non-existent, and those in the total period are calculated based on 2000−2021.

<Table 3>

The correlation coefficients for the total period are all highly statistically significant; all have 1% significance, excluding only the correlation between Singapore and Viet Nam (but at the 5% significant level).[11] For this reason, economic shocks that the six AMS faced seem to have been synchronised over the long-term. On a country basis, the correlation coefficients regarding Indonesia weaken from the 1990s to the 2000s and 2010s. Particularly in the 2010s, they are significantly correlated with those only for Malaysia and Singapore. With respect to Viet Nam, while there is positive correlation with the other AMS prediction errors in the 2000s, the correlation coefficients in the 2010s are not statistically significant; in addition, those with the world are not significant, either. Therefore, it is likely that Indonesia and Viet Nam have not been exposed to economic shocks common within the ASEAN region by leveraging autonomous domestic demand. In contrast, the correlation coefficients of the prediction errors between Malaysia and Singapore remain at very high levels possibly due to the economic and geographical proximity of the two countries. Furthermore, Singapore shows large correlation coefficients with those of the other countries, excluding Thailand in the 2000s and Vietnam in the 1990s and 2010s. This finding suggests that economic shocks and increased uncertainty may have been transmitted via Singapore, the centre of trade and finance in South-East Asia, to the other countries in the region.

IV.III Regression Analysis of Prediction Error

To probe the factors for generating prediction errors of real GDP growth rates, we undertake the following OLS regression analyses:

$$cgdp_{it} = \beta_0 + \beta_1 \times ggdp_{it} + \beta_2 \times exm_{it} + \beta_3 \times wui_{it} + \beta_4 \times clui_{it} + \varepsilon_{it},$$

[11] Moreover, the correlation coefficients in the 2000s and 2010s, excluding Indonesia and Viet Nam in the 2010s, are strongly significant.

where *i* and *t* represent the country and year indices, respectively. This formulation regresses the prediction errors (*cgdp*) of the following macroeconomic indicators: global real GDP growth rates (*ggdp*), merchandise export growth rates (*exm*), World Uncertainty Index (*wui*), and country-level uncertainty indices (*clui*). Note that while the independent variables of *ggdp* and *exm* are related to factors for global economic fluctuations, those of *clui* and *wui* for an increase in uncertainty. Although such macroeconomic indicators as domestic consumption and investment should be added to the independent variables to explain domestic variations, these are not consistently available from ADB (1989−2022).[12] Rather, the error term is deemed to reflect domestic variations that cannot be explained by the global and uncertainty factors.[13]

Data on *cgdp* and *exm* are obtained from ADB (1989−2022). As noted, data of 2000 *exm* are non-obtainable, unlike *cgdp* by extrapolation from IMF (1999). Thus, the data on *exm* cover 1990−1999 and 2001−2021. Data on *ggdp*, which range from 2000 to 2021, are obtained from IMF (1999−2022). Since *ggdp* and *exm* may be generally mutually correlated – and as this correlation may cause serious multicollinearity – we also conduct regression analyses that included one of the two as independent variables. When only *exm* is employed as an independent variable, the sample covers 31 years (1990−2021, excluding 2000). In regression analyses, we apply heteroskedasticity- and autocorrelation-consistent standard errors (Newey and West, 1987) for ε_{it} by considering serial autocorrelation between the error terms.[14]

Table 4 presents the time-series estimation results for the six AMS individually. Using Indonesia as an example, Estimation (1) includes both *ggdp* and *exm* as independent variables, but they do not generate serious multicollinearity, considering their variance inflation factors (VIFs), 1.312 for *ggdp* and 1.473 for *exm*. This VIF result – that multicollinearity does not exist – is the case in Estimations (2)−(6). Nevertheless, since the concern of multicollinearity is not entirely resolved, Estimations (3) and (4) include only one of the two variables and exclude *clui*. However, Estimations (5) and (6), using the full sample (1990−1999 and 2001−2021), do not include *ggdp*, because this variable is available only from 2000 on.[15]

<Table 4>

The estimates of *ggdp* are all significant across the relevant estimations in Table 4. Thus, economic shocks that the six AMS received are strongly associated with unforeseen variations of global economic growth. On the other hand, the estimates of *exm* are not necessarily

[12] ADB published data on the ratio of domestic investment to GDP until 2011. However, these data cannot be used because the sample size is not adequate for this study.
[13] However, these estimates do not mean causal relation but mere correlation. Specifically, we should keep in mind that country-level uncertainty could be correlated with the error term, that is, domestic shocks.
[14] Since this dataset comprises time series, it may have unit roots that potentially cause spurious correlation in the regression analyses. However, all variables used are first differenced in calculating a growth rate. Hence, such concern for problems concerning unit roots is more or less alleviated.
[15] Actually, the indicators of 2000 are excluded, so the sample ranges from 2001 to 2021.

significant according to the country and sample periods. These estimates for Indonesia in Estimations (1)−(6) are all insignificant, which implies that unforeseen variations in merchandise export growth rates may not be a significant cause of economic shocks to the Indonesian economy. The same tendency can be observed in Estimations (1)−(4) for Viet Nam (the estimate in Estimation [1] is slightly significantly negative, which is inconsistent with the theoretically expected sign), but the estimates in Estimations (5) and (6) are significantly positive. With respect to Malaysia and the Philippines, while the estimates of *exm* are not significant in Estimations (1) and (2), those in Estimation (4) are significantly positive, because the estimates of *exm* may absorb a part of the effect of *ggdp*.[16] Meanwhile, the estimates of *exm* in Estimations (1)−(6) for Singapore and Thailand are significantly positive. As the estimates of both *ggdp* and *exm* are simultaneously significant, unforeseen global economic and merchandise exports shocks can be separated for these two countries. In other words, Singapore and Thailand have crucial export sectors in the South-East Asia region, so unforeseen merchandise export growth variations have linkages to economic shocks when the global economic shocks are appropriately controlled.

The above-mentioned estimation results of the six AMS are summarised in Table 5, which are extracted from Table 4. More precisely, for relevant estimates to be comparable, the estimates of *ggdp* for 2001−2021 correspond to Estimation (3), and the estimates of *exm* for 2001−2021 and 1990−2021 (excluding 2000) to Estimations (4) and (6), respectively. Recall that the estimates of *exm* are likely to absorb a part of the effect of *ggdp*. In this context, these estimates are not likely to completely represent the effect of *exm*, but this simplification is convenient and useful for a comparison between the two different periods.

<Table 5>

First, we begin by comparing the estimates of *ggdp*: the Philippines (1.762), Singapore (1.748), Thailand (1.582), Malaysia (1.435), Indonesia (0.702), and Viet Nam (0.494). These numerical values represent the degree of the countries' linkages to the global economy. Intriguingly, the estimate for the Philippines is the largest, and this result contrasts with the result regarding *exm*. A plausible reason is that remittances of Filipino overseas workers (i.e. 34.9 US billion dollars accounting for about 10% of nominal GDP in 2021) are affected by variations of the global economy, thus cause economic shocks to the Philippine economy through domestic consumption. Next, Thailand's thriving tourism sector (i.e. representing 20.1% of nominal GDP in 2021) attracts many foreign tourists, which may have a connection to the relatively large estimate of *ggdp*. Moreover, since Singapore is the largest economic, financial, and trade hub in South-East Asia, the country obviously has strong connectivity to the global economy.

Second, if the estimates of *exm* for 2001−2021 are compared across the six AMS, the estimates are Singapore (0.264), Thailand (0.210), the Philippines (0.133), Malaysia (0.122),

[16] Note that the adjusted R^2 is drastically smaller in Estimation (4).

Viet Nam (0.032, insignificant), and Indonesia (0.021, insignificant). This order points to the magnitude of economic shocks that the countries receive through variations of merchandise export growth. In relative terms, whereas the estimates for Singapore and Thailand are large, those for Indonesia and Viet Nam are minimal and statistically insignificant. Specifically, the latter result shows that Indonesia and Viet Nam may still be in the process of enhancing connectivity with the global economy via exports and may have larger shares of domestic demand in variations in their economies.

Third, a comparison of *exm* between 2001−2020 and 1990−2021 (excluding 2000) demonstrates while the estimates for the Philippines and Singapore have almost remained the same, estimates for Malaysia and Thailand in the former period are smaller than in the latter period; and the estimate for Viet Nam is significantly positive only in the latter period, although the numerical value is still small.[17] Such 'attenuation' of the linkage with *exm*, particularly for Malaysia, Thailand, and Viet Nam in the more recent time period, seems due to the diversification of export items, such as the export transformation from resource and primary products (e.g. crude oil, natural rubber) to manufacturing products (e.g. automobile products, electrical equipment). While resource and primary products are generally vulnerable to price fluctuations and productivity shocks, the effects of exports on these countries' economies become smaller as manufacturing products play greater roles in their merchandise exports. Another possible reason is an increase in service exports, which data on merchandise exports do not cover. In the 21st century, economic activities related to global service trade has been bolstered, owing to the advancement of information and communication technologies and globalisation (Baldwin, 2016).

The estimates of *wui* for the Philippines in Estimations (1) and (4) in Table 4 are significantly negative, implying that the Philippine economy may have been affected by world uncertainty since the 2000s. As previously discussed, this is also possibly because the Philippine economy depends on overseas remittances, which are susceptible to world uncertainty. However, since the relevant estimates in Estimations (2), (3), (5), and (6) are not significant, this finding is not robust.[18] Another interesting finding is the robustness of the negative estimates of *clui* for Singapore. Since the estimates are highly significant at the 1% level in both Estimations (1) and (5) and do not vary, this result on country-level uncertainty is fairly robust. One possible interpretation is that Singapore's well-maintained financial and capital markets may be indirectly linked with domestic negative economic shocks by reflecting increased domestic uncertainty on decreases in stock and asset prices. In other words, these negative estimates seem to represent the characteristics of the Singaporean economy as a developed country. Furthermore, while the estimate of *clui* in Estimation (1) for the Philippines is also significantly negative, that in

[17] Note that although the estimate for Indonesia in the latter period is also larger, the estimates in both periods are not significant.

[18] The estimates of *wui* in Estimations (1)−(6) for Thailand are positive, opposite to a negative expectation. However, the estimate in only Estimation (1) is slightly significant at the 10% level, and this result is not robust.

Estimation (5) is not; therefore, the negative correlation of country-level uncertainty with the Philippine economy is not decisive.

Estimation (1) attempts to estimate the impact of the variation related to *ggdp*, *exm*, *wui*, and *clui* (i.e. regression variation) on the variation of the economy as a whole (i.e. total variation). Therefore, the adjusted R^2 signifies the share of the variation attributable to external and uncertainty shocks to the total variation. While the R^2 is high for Malaysia (0.741), the Philippines (0.770), Singapore (0.729), and Thailand (0.749), it is quite small for Viet Nam (0.278) and moderate for Indonesia (0.617). Put differently, $1-R^2$ accounts for the residual variation that cannot be explained by the regression variation, that is, the domestic shock. Table 6 shows the fitted values and residual values of the prediction errors of real GDP growth rates for the six AMS for 21 years [2001−2021] based on the estimated coefficients of Estimation (1). According to unreported calculations, since external variations are eliminated, the residual values rarely have any positive correlations between each other across AMS.[19] Thus, domestic economic shocks seem to be mainly idiosyncratic (i.e. country-specific). In citing examples of Thailand, a large negative value of the residual, −2.86% points, in 2011 seem to include a domestic economic shock caused by the catastrophic floods around Bangkok from September to November 2011 and the Great East Japan earthquake on 11 March 2011. These disasters forced local Thai firms including Japanese-affiliated firms to shut down domestic operations because supply chains and logistics were seriously disrupted.[20]

<Table 6 >

Furthermore, to compare the degree of the global, domestic, and uncertainty shocks that affect AMS's macroeconomic shocks, we evaluate the relative importance in linear regression of Estimation (1). Concretely, we calculate the metrics based on unweighted average over orders of sequential R^2s, the method of which is recommended by Grömping (2003).[21] By using this metrics, we allot the share of R^2 to the global and uncertainty shocks and derive the domestic shock from the error sum of squares, $1-R^2$. Table 7 presents them according to both the individual and whole AMS. In obtaining the coefficients in the latter estimation, we conduct a pooled OLS regression gathering all variables across countries and years and divide samples into 2001−2009 and 2010−2019.[22] It clearly shows that while the global shock contributes most to economic shocks excluding Vietnam, the uncertainty shock does relatively little. When it comes to the AMS as a whole in 2001−2021, the global, domestic, and uncertainty shocks account for 56.9%, 40.1%, and 3.0% of variations of economic shocks, respectively. Notably, comparing the sample

[19] The exceptions are combinations of only Malaysia−Thailand and Thailand−Vietnam, which are significant at the conventional 5% level.
[20] The previous discussion paper version (Ambashi, et al., 2022) described the detailed historical backgrounds of economic shocks each AMS received from 1990 to 2021.
[21] We use the method of 'lmg' provided by R package, 'relaimpo'.
[22] These estimation results will be provided by the authors upon request.

periods between 2001−2009 and 2010−2019, we find that the global share decreases while the domestic share increases in the latter period. This observation is consistent with the correlation analysis in Subsection IV.II, which suggests an increased contribution of idiosyncratic domestic shocks amid the progress of globalisation.

<Table 7>

V. The Effect of the COVID-19 Pandemic

This section summarises the effects of the COVID-19 pandemic through the lens of prediction errors, especially based on the estimation results of Table 6. This analysis is not necessarily comprehensive, but it is helpful in examining whether such effects are *ex ante* anticipated, how global and domestic factors affect the economies, and how different economic shocks are distributed across the six AMS.

Prediction errors of the 2020 real GDP growth rates are examined: Indonesia (−7.4% points), Malaysia (−10.3% points), the Philippines (−16.0% points), Singapore (−6.7% points), Thailand (−9.9% points), and Viet Nam (−3.8% points). Clearly, in 2020, all six AMS experienced the largest negative economic shock since the Asian financial crisis or global financial crisis. Given the prediction error of the 2020 global real GDP growth rate of −6.7% points, the six AMS did not suffer the most severe economic downturns in comparison to others at the onset of the COVID-19 pandemic. In fact, the fitted and residual values of Table 6 indicate that these prediction errors are caused primarily by external (and with slight uncertainty) shocks, such as a decrease in external demand and the disruption of global supply chains.[23] For details, the ratios of fitted values to prediction errors are as follows: Indonesia (0.753), Malaysia (0.933), the Philippines (0.777), Singapore (1.202), Thailand (0.843), and Vietnam (0.977). Only in Singapore, a positive residual value of 1.36% points in 2020 compensates for external shock to the economy.

There are also a number of differences in the effects of the COVID-19 pandemic in 2021. While negative prediction errors diminish in 2021 for all countries, they remain negative except for Singapore: Indonesia (−1.3% points), Malaysia (−2.4% points), the Philippines (−0.9% points), Singapore (5.6% points), Thailand (−0.9% points), and Viet Nam (−4.2% points). This implies that unforeseen negative economic shocks have had a profound influence on the economies of the five AMS even in 2021. Yet the prediction error of the 2021 global real GDP growth rate is positive at 0.3% points, and the global economy centred on developed countries began to recover from the devastating impact of the COVID-19 pandemic by easing economic and social regulations. In contrast, many AMS worked to prevent outbreaks of COVID-19 by enforcing lockdowns and lagged developed countries in expanding vaccination procedures of its

[23] In Table 6, the uncertainty shock is absorbed in fitted values. Nevertheless, as Table 7 suggests, it seems trivial relative to the global and domestic shocks.

citizens. Table 6 reveals that global shocks represented by the fitted values in 2021 are positive, excluding Viet Nam (−0.07%, but nearly null), while domestic shocks represented by the residual values are highly negative in the other five ASEAN countries except Singapore. The ratios of residual values to prediction errors are as follows: Indonesia (1.007), Malaysia (1.139), the Philippines (1.466), Singapore (0.558), Thailand (1.446), and Vietnam (0.982). Moreover, unreported calculation indicates that prediction errors of the 2021 merchandise export growth rates are enormous: Indonesia (35.5% points), Malaysia (17.9% points), the Philippines (6.1% points), Singapore (16.5% points), Thailand (8.8% points), and Viet Nam (11.2% points). Thus, the negative economic shocks in 2021 stemmed mostly from domestic shocks in these countries.

The recovery from the negative economic shocks of the COVID-19 pandemic differ amongst the six AMS. Only Singapore relished a positive economic shock in 2021, as both its global and domestic shocks are positive. In contrast, Viet Nam experienced a large domestic shock represented by the residual value of −4.09% in 2021, possibly due to the prevalence of COVID-19 in the latter half of 2021 and the resulting delay in eliminating regulations and expanding vaccinations. While the negative shocks of the COVID-19 pandemic originated mainly from global shocks in 2020, they originated from domestic shocks in 2021.

VI. Conclusion

In this study, we conducted analyses of economic shocks in 1990−2021 to the six selected AMS from the perspective of global, domestic, and uncertainty factors. In constructing the analyses, we calculated prediction errors as the deviations between actual and prediction values of annual macroeconomic indicators. From the broad overview of prediction errors of real GDP growth rates, we demonstrated that the countries have experienced, on average, negative economic shocks over the total sample period through unforeseen global economic recessions, domestic downturns, and increased uncertainty. To confirm whether business cycles and economic shocks within the six AMS and with the world were synchronised, we conducted simple correlation analyses of the actual real GDP growth rates and their prediction errors. The correlation coefficients of the two analyses exhibited significantly large numerical values in the total sample period, which suggests that, as existing literature have already demonstrated, business cycles and economic shocks were strongly synchronised within the region and with the world. Moreover, by implementing OLS regression analyses that regressed the prediction errors of real GDP growth rates, we found that variations of the global real GDP growth rates are positively associated with economic shocks on the six AMS. Another interesting observation was that the estimates of the world and domestic uncertainty indices are related to negative economic shocks for the Philippines and Singapore, respectively. We separated the relative contributions to economic shocks into global, domestic, and uncertainty shocks based on the estimations, and then derived implications for individual variations of the real GDP growth rates. We also introduced to an extent speculations on the economic effects of the COVID-19 pandemic from the viewpoint of global and domestic variations using the fitted and residual values.

Challenges facing future research must be noted. First, variations of domestic demand were measured as 'residuals' that cannot be explained by variations in the global economy. Data sources other than ADB (1989−2022) must be further examined to determine the feasibility of incorporating them into data. Second, as the sample coverage was quite limited on annual macroeconomic indicators, it was only possible to understand an overview of macroeconomic year trends of countries. Based on monthly or quarterly prediction data that increases samples (it may be difficult to obtain, though), we will be able to analyse mutual dependence in South-East Asia by formulating structural VAR models. Finally, like Morikawa (2016, 2019), we can also conduct microeconomic research that directly observes firms' uncertainty through microstatistics and questionnaire surveys to adequately probe the relationship between economic shocks or uncertainty and firms' investment activities or performance.

References

Allegret, J.P. and E. Essaadi (2011), Business Cycles Synchronization in East Asian Economy: Evidence from Time-Varying Coherence Study. *Economic Modeling*, 28(1−2), pp.351−65.

Ambashi, M., Iwasaki, H., and Oikawa, K. (2022), Prediction Errors of Macroeconomic Indicators and Economic Shocks for ASEAN Member States, 1990–2021. ERIA Discussion Paper Series, No.431.

Arslan, Y., A. Atabek, T. Hulagu, and S. Şahinöz (2015), Expectation Errors, Uncertainty, and Economic Activity. *Oxford Economic Papers*, 67(3), pp.634−60.

Ashiya, M. (2007), Forecast Accuracy of the Japanese Government: Its Year-Ahead GDP Forecast Is Too Optimistic. *Japan and the World Economy*, 19(1), pp.68−85.

Asian Development Bank (ADB), *Asian Development Outlook*. Manila (33 years: 1989−2022).

Bachmann, R., S. Elstner, and E.R. Sims (2013), Uncertainty and Economic Activity: Evidence from Business Survey Data. *American Economic Journal: Macroeconomics*, 5(2), pp.217−49.

Baker, S.R., N. Bloom, and S.J. Davis (2016), Measuring Economic Policy Uncertainty. *Quarterly Journal of Economics*, 131(4), pp.1593−636.

Baldwin, R. (2016), *The Great Convergence: Information Technology and the New Globalization*. Cambridge, MA: Harvard University Press.

Bloom, N. (2014), Fluctuations in Uncertainty. *Journal of Economic Perspectives*, 28(2), pp.153−76.

Cortinhas, C. (2007), Intra-Industry Trade and Business Cycles in ASEAN. *Applied Economics*, 39(7), pp.893−902.

Frankel, J. (2011), Over-Optimism in Forecasts by Official Budget Agencies and Its Implications. *Oxford Review of Economic Policy*, 27(4), pp.536−62.

Gong, C., and S. Kim (2013), Economic Integration and Business Cycle Synchronization in Asia. *Asian Economic Papers*, 12(1), pp.76−99.

Grömping, U. (2006), Relative Importance for Linear Regression in R: The Package relaimpo. Journal of Statistical Software, 17(1), 1−27.

He, D. and W. Liao (2012), Asian Business Cycle Synchronization. *Pacific Economic Review*, 17(1), pp.106−35.

International Monetary Fund (IMF), *World Economic Outlook Database*. Washington, DC (23 years: 1999−2022).

Jiang, W., Y. Li, and S. Zhang (2019), Business Cycle Synchronisation in East Asia: The Role of Value-Added Trade. *The World Economy*, 42(1), pp.226−41.

Kim, S. and S.H. Kim (2013), International Capital Flows, Boom–Bust Cycles, and Business Cycle Synchronization in the Asia Pacific Region. *Contemporary Economic Policy*, 31(1), pp.191−211.

Li, L. (2017), The Impact of Intra-Industry Trade on Business Cycle Synchronization in East Asia. *China Economic Review*, 45, pp.143–54.

Merola, R. and J.J. Perez (2013), Fiscal Forecast Errors: Governments versus Independent Agencies? *European Journal of Political Economy*, 32, pp.285−99.

Moneta, F. and R. Rüffer (2009), Business Cycle Synchronisation in East Asia. *Journal of Asian Economics*, 20(1), pp.1−12.

Morikawa, M. (2016), Business Uncertainty and Investment: Evidence from Japanese Companies. *Journal of Macroeconomics*, 49, pp.224−36.

Morikawa, M. (2019), Uncertainty over Production Forecasts: An Empirical Analysis Using Monthly Quantitative Survey Data. *Journal of Macroeconomics*, 60, pp.163−79.

Morikawa, M. (2020), Uncertainty in Long-Term Macroeconomic Forecasts: *Ex Post* Evaluation of Forecasts by Economics Researchers. Quarterly Review of Economics and Finance, 85, pp.8−15.

Newey, W.K. and K.D. West (1987), A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica*, 55(3), pp.703−08.

Nguyen, V., T. Hoang, and M.S. Nguyen (2020), The Effect of Trade Integration on Business Cycle Synchronization in East Asia. *Journal of Asian Finance Economics and Business*, 7(8), pp.225−31.

Pain, N., C. Lewis, T.T. Dang, Y. Jin, and P. Richardson (2014), OECD Forecasts during and after the Financial Crisis. OECD Economics Department Working Papers, No.1107.

Park, Y.J. (2013), Regional Business Cycle in East Asia: Synchronization and Its Determinants. *Journal of East Asian Economic Integration*, 18(2), pp.103−28.

Pontines, V. and F. Parulian (2010), Business Cycle Synchronization and Financial Integration in the Asia-Pacific Region, in C. Findlay, F. Parulian, and J. Corbett (eds.), *Linkages between Real and Financial Aspects of Economic Integration in East Asia*. Jakarta: Economic Research Institute for ASEAN and East Asia (ERIA), pp.94−129.

Rena, P.B. (2007), Economic Integration and Synchronization of Business Cycles in East Asia. *Journal of Asian Economics*, 18(5), pp.711−25.

Rena, P.B., T. Cheng, and W.M. Chia (2012), Trade Intensity and Business Cycle Synchronization: East Asia versus Europe. *Journal of Asian Economics*, 23(6), pp.701−6.

Selover, D.D. (1999), International Interdependence and Business Cycle Transmission in ASEAN. *Journal of Japanese and International Economics*, 13(3), pp.230−53.

Sethapramote, Y. (2015), Synchronization of Business Cycles and Economic Policy Linkages in ASEAN. *Journal of Asian Economics*, 39(6), pp.126–36.

Shin, K. and Y. Wang (2003), Trade Integration and Business Cycle Synchronization in East Asia. *Asian*

Economic Papers, 2(3), pp.1−20.

Sng, H.Y., L. Dou, and P.B. Rana (2017), Catalyst of Business Cycle Synchronization in East Asia. *The Singapore Economic Review*, 62(3), pp.703−19.

Takeuchi, F. (2011), The Role of Production Fragmentation in the International Business Cycle Synchronization in East Asia. *Journal of Asian Economics*, 22(6), pp.441−59.

Timmermann, A. (2007), An Evaluation of the World Economic Outlook Forecasts. *IMF Staff Papers*, 54(1), pp.1−33.

Xie, S., T. Cheng, and W.M. Chia (2013), Trade, Finance, Specialization and Synchronization in the Asia-Pacific. *Journal of the Asia Pacific Economy*, 18(2), pp.253−70.

Table 1 Actual Values, Prediction Values, and Prediction Errs of Real GDP Growth Rates (%)

	Indonesia			Malaysia			Philippines			Singapore			Thailand			Viet Nam			World		
	A	P	E	A	P	E	A	P	E	A	P	E	A	P	E	A	P	E	A	P	E
1990	7.1	4.8	2.3	9.7	6.0	3.7	2.7	5.4	-2.7	8.3	6.0	2.3	10.0	7.5	2.5	5.1	6.5	-1.4	2.6	n.a.	n.a.
1991	6.9	6.5	0.4	8.7	7.5	1.2	-0.5	6.2	-6.7	6.7	7.7	-1.0	8.1	9.2	-1.1	6.0	8.1	-2.1	1.8	n.a.	n.a.
1992	6.5	6.6	-0.1	7.8	8.7	-0.9	0.3	4.1	-3.8	6.0	6.5	-0.5	7.9	8.0	-0.1	8.6	4.9	3.7	2.7	n.a.	n.a.
1993	7.3	7.0	0.3	8.3	8.0	0.3	2.1	4.3	-2.2	10.1	7.0	3.1	8.3	8.1	0.2	8.1	4.5	3.6	2.7	n.a.	n.a.
1994	7.5	6.7	0.8	9.1	7.8	1.3	4.4	4.5	-0.1	10.5	6.0	4.5	8.9	8.5	0.4	8.8	8.2	0.6	4.0	n.a.	n.a.
1995	8.2	7.0	1.2	9.5	8.4	1.1	4.8	5.5	-0.7	8.7	6.0	2.7	8.8	8.5	0.3	9.5	10.0	-0.5	3.7	n.a.	n.a.
1996	8.0	7.1	0.9	8.6	8.0	0.6	5.9	5.5	0.4	7.5	8.5	-1.0	5.5	8.0	-2.5	9.3	9.0	0.3	4.3	n.a.	n.a.
1997	4.7	7.7	-3.0	7.5	8.0	-0.5	5.2	5.7	-0.5	8.0	7.5	0.5	-1.8	8.0	-9.8	8.2	9.9	-1.7	4.1	n.a.	n.a.
1998	-13.1	7.9	-21.0	-7.4	8.5	-15.9	-0.6	6.5	-7.1	0.1	8.0	-7.9	-10.8	6.6	-17.4	4.4	9.3	-4.9	2.8	n.a.	n.a.
1999	0.9	1.0	-0.1	6.1	4.5	1.6	3.4	4.0	-0.6	6.9	4.5	2.4	4.4	1.0	3.4	4.7	6.5	-1.8	3.6	n.a.	n.a.
2000	4.8	2.5	2.3	8.3	2.0	6.3	4.4	3.0	1.4	9.4	4.2	5.2	4.6	3.0	1.6	6.1	4.5	1.6	4.7	3.4	1.3
2001	3.5	5.0	-1.5	0.3	6.1	-5.8	3.0	4.3	-1.3	-1.9	6.2	-8.1	2.1	4.6	-2.5	5.8	6.0	-0.2	2.5	3.9	-1.4
2002	4.3	4.5	-0.2	4.1	6.0	-1.9	4.3	4.2	0.1	3.2	6.0	-2.8	5.3	4.5	0.8	6.4	6.9	-0.5	3.0	3.9	-0.9
2003	5.0	3.6	1.4	5.4	5.8	-0.4	4.5	4.5	0.0	2.9	6.5	-3.6	7.0	3.0	4.0	7.3	6.8	0.5	4.0	4.0	0.0
2004	5.0	4.0	1.0	7.2	5.1	2.1	6.2	4.5	1.7	8.8	4.2	4.6	6.3	5.5	0.8	7.8	7.1	0.7	5.3	4.1	1.2
2005	5.7	4.5	1.2	5.0	5.6	-0.6	4.9	5.0	-0.1	7.3	4.8	2.5	4.5	6.2	-1.7	8.4	7.6	0.8	4.4	4.9	-0.5
2006	5.5	6.0	-0.5	5.8	5.3	0.5	5.4	5.0	0.4	8.4	4.5	3.9	5.2	5.8	-0.6	8.2	7.6	0.6	5.1	5.6	-0.5
2007	6.3	6.0	0.3	6.2	5.8	0.4	7.1	5.3	1.8	8.2	4.6	3.6	4.9	5.5	-0.6	8.5	8.0	0.5	5.2	5.7	-0.5
2008	6.0	6.3	-0.3	4.7	5.7	-1.0	3.7	5.7	-2.0	1.5	5.5	-4.0	2.5	5.0	-2.5	6.3	8.5	-2.2	2.9	4.9	-2.0
2009	4.6	6.2	-1.6	-1.6	5.9	-7.5	1.1	6.2	-5.1	-1.0	5.8	-6.8	-2.3	5.2	-7.5	5.3	8.1	-2.8	-0.6	3.8	-4.4
2010	6.2	5.0	1.2	7.2	4.4	2.8	7.6	3.5	4.1	14.8	3.5	11.3	7.8	3.0	4.8	6.8	6.5	0.3	5.2	1.9	3.3
2011	6.5	6.0	0.5	5.1	5.0	0.1	3.6	4.6	-1.0	6.0	5.0	1.0	0.1	4.5	-4.4	5.9	6.8	-0.9	3.9	4.3	-0.4
2012	6.0	6.7	-0.7	5.6	5.3	0.3	6.8	5.3	1.5	3.4	4.8	-1.4	6.5	4.8	1.7	5.2	6.7	-1.5	3.4	4.5	-1.1
2013	5.6	6.7	-1.1	4.7	5.0	-0.3	7.1	5.0	2.1	4.7	4.5	0.2	2.7	5.5	-2.8	5.4	6.2	-0.8	3.3	4.1	-0.8
2014	5.0	6.6	-1.6	6.0	5.5	0.5	6.2	5.9	0.3	3.6	3.7	-0.1	0.9	5.0	-4.1	6.0	5.6	0.4	3.5	4.0	-0.5
2015	4.9	6.0	-1.1	5.0	5.0	0.0	6.1	6.7	-0.6	2.2	4.1	-1.9	3.0	4.5	-1.5	6.7	5.8	0.9	3.5	3.9	-0.4
2016	5.0	6.0	-1.0	4.2	5.0	-0.8	6.9	6.3	0.6	2.8	3.4	-0.6	3.4	4.1	-0.7	6.2	6.2	0.0	3.4	3.8	-0.4
2017	5.1	5.5	-0.4	5.7	4.4	1.3	6.7	6.1	0.6	4.3	2.2	2.1	4.1	3.5	0.6	6.8	6.5	0.3	3.9	3.5	0.3
2018	5.2	5.3	-0.1	4.8	4.6	0.2	6.3	6.6	-0.3	3.5	2.3	1.2	4.2	3.6	0.6	7.1	6.7	0.4	3.6	3.6	-0.1
2019	5.0	5.3	-0.3	4.4	5.0	-0.6	6.1	6.9	-0.8	1.1	2.9	-1.8	2.2	4.1	-1.9	7.0	6.8	0.2	2.9	3.9	-1.1
2020	-2.1	5.3	-7.4	-5.6	4.7	-10.3	-9.6	6.4	-16.0	-4.1	2.6	-6.7	-6.2	3.7	-9.9	2.9	6.7	-3.8	-3.1	3.6	-6.7
2021	3.7	5.0	-1.3	3.1	5.5	-2.4	5.6	6.5	-0.9	7.6	2.0	5.6	1.6	2.5	-0.9	2.6	6.8	-4.2	6.1	5.8	0.3

Table 1 (continued)

	Indonesia			Malaysia			Philippines			Singapore			Thailand			Viet Nam			World		
	A	P	E	A	P	E	A	P	E	A	P	E	A	P	E	A	P	E	A	P	E
1990s	4.40	6.23	-1.83	6.79	7.54	-0.75	2.77	5.17	-2.40	7.28	6.77	0.51	4.93	7.34	-2.41	7.27	7.69	-0.42	3.22	n.a.	n.a.
	6.18	1.92	6.52	4.83	1.24	5.19	2.27	0.84	2.56	2.75	1.14	3.32	6.16	2.21	6.05	1.90	1.89	2.49	0.79		
	1.40	0.31		0.71	0.16		0.82	0.16		0.38	0.17		1.25	0.30		0.26	0.25		0.24		
2000s	5.07	4.86	0.21	4.54	5.33	-0.79	4.46	4.77	-0.31	4.68	5.23	-0.55	4.01	4.83	-0.82	7.01	7.11	-0.10	3.65	4.40	-0.76
	0.80	1.21	1.21	2.87	1.15	3.65	1.58	0.84	1.98	4.04	0.83	4.78	2.54	1.04	2.92	1.11	1.11	1.32	1.72	0.75	1.56
	0.16	0.25		0.63	0.22		0.36	0.18		0.86	0.16		0.63	0.21		0.16	0.16		0.47	0.17	
2010s	5.45	5.91	-0.46	5.27	4.92	0.35	6.34	5.69	0.65	4.64	3.64	1.00	3.49	4.26	-0.77	6.31	6.38	-0.07	3.65	3.76	-0.12
	0.56	0.59	0.79	0.84	0.34	0.99	1.02	1.03	1.49	3.62	0.93	3.66	2.22	0.72	2.67	0.64	0.40	0.71	0.60	0.69	1.22
	0.10	0.10		0.16	0.07		0.16	0.18		0.78	0.26		0.64	0.17		0.10	0.06		0.16	0.18	
Total	4.71	5.63	-0.92	5.11	5.88	-0.77	4.12	5.29	-1.17	5.30	5.03	0.27	3.74	5.33	-1.59	6.61	7.04	-0.43	3.38	4.14	-0.69
	3.74	1.43	4.00	3.85	1.49	4.02	3.29	1.00	3.55	4.00	1.71	4.19	4.38	2.01	4.37	1.67	1.35	1.87	1.68	0.84	1.90
	0.79	0.25		0.75	0.25		0.80	0.19		0.75	0.34		1.17	0.38		0.25	0.19		0.50	0.20	

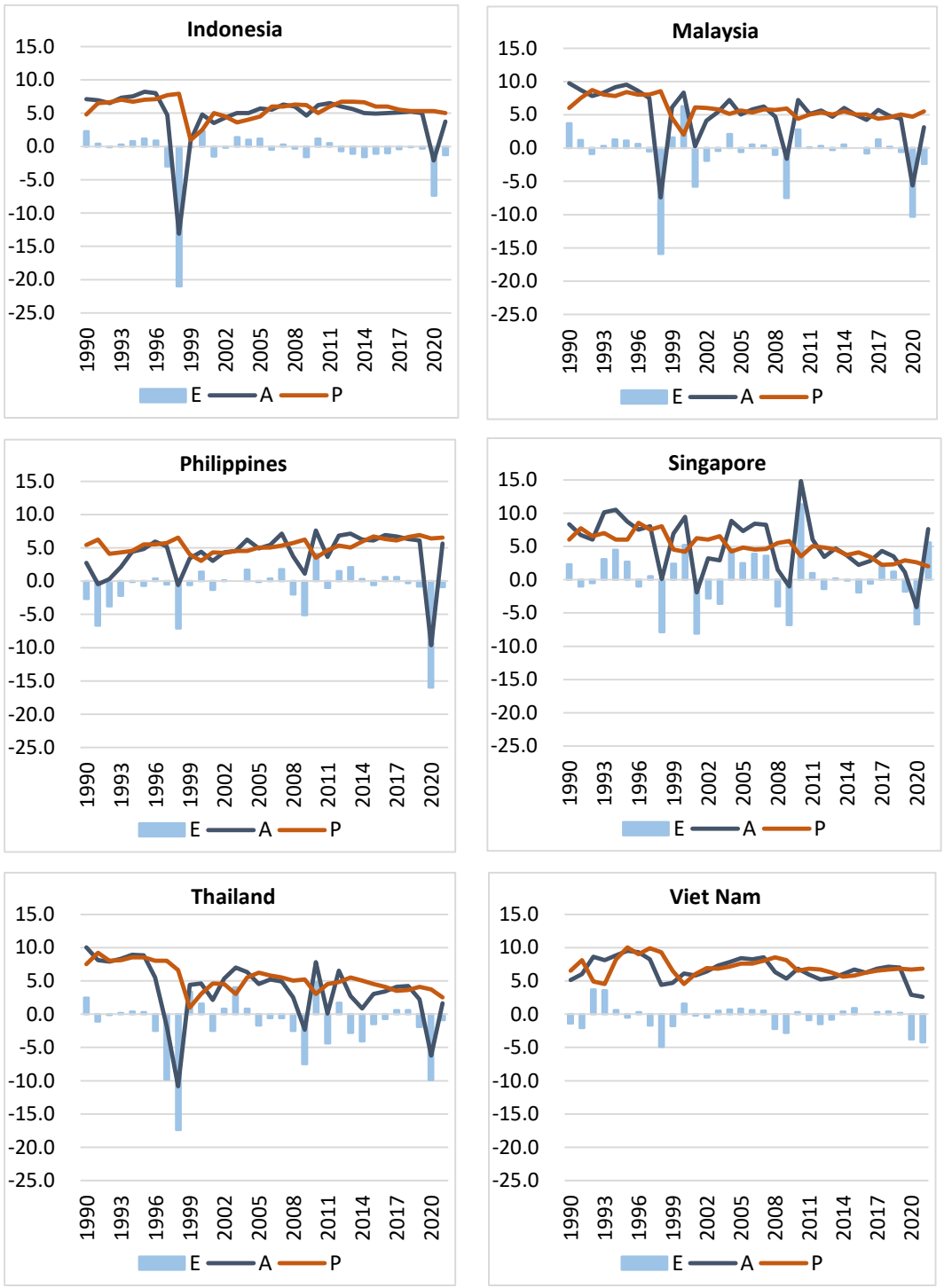
A = actual value, E = prediction error (A – P), P = prediction value.

Notes: 1. The first, second, and third rows of each period represent the simple mean, standard deviation, and coefficient of variation.

2. The prediction values of the 2000 real GDP growth rates for the six ASEAN Member States are extrapolated from IMF (1999).

Sources: ADB (1989−2022), IMF (1999).

Figure 1 Actual Values, Prediction Values, and Prediction Errors of the Real GDP Growth Rate



A = actual value, E= prediction error (A − P), P = prediction value.

Sources: ADB (1989–2022), IMF (1999).

Table2 Correlation Coefficients of Real GDP Growth Rates

	Malaysia	Philippines	Singapore	Thailand	Viet Nam	World
Indonesia	0.984 ***	0.471	0.884 ***	0.897 ***	0.650 **	0.131
	0.510	0.564 *	0.539	0.246	0.668 **	0.453
	0.433	-0.287	0.647 **	0.233	-0.428	0.570 *
	0.819 ***	0.471 ***	0.479 ***	0.793 ***	0.537 ***	0.294
Malaysia		0.493	0.896 ***	0.901 ***	0.549	0.142
		0.813 ***	0.878 ***	0.825 ***	0.605 *	0.906 ***
		0.274	0.796 ***	0.520	0.036	0.829 ***
		0.534 ***	0.766 ***	0.867 ***	0.613 ***	0.552 ***
Philippines			0.603 *	0.230	0.562 *	0.893 ***
			0.814 ***	0.813 ***	0.866 ***	0.929 ***
			0.244	0.724 **	0.062	0.160
			0.446 **	0.421 **	0.402 **	0.814 ***
Singapore				0.801 ***	0.575 *	0.285
				0.654 **	0.725 **	0.853 ***
				0.535	0.078	0.953 ***
				0.640 ***	0.481 ***	0.683 ***
Thailand					0.409	-0.109
					0.671 **	0.883 ***
					0.104	0.525
					0.528 ***	0.411 **
Viet Nam						0.509
						0.795 ***
						0.201
						0.400 **

Notes: 1. The values in the correlation table are the Pearson correlation coefficients. The first, second, third, and fourth rows represent the correlation coefficients of the 1990s, 2000s, 2010s, and the total period, respectively.

2. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3 Correlation Coefficients of Prediction Errors of Real GDP Growth Rates

	Malaysia	Philippines	Singapore	Thailand	Viet Nam	World
Indonesia	0.986 ***	0.581 *	0.855 ***	0.898 ***	0.599 *	n.a.
	0.868 ***	0.692 **	0.688 **	0.744 **	0.732 **	0.819 ***
	0.609 *	0.310	0.752 **	0.524	-0.059	0.706 **
	0.862 ***	0.535 ***	0.526 ***	0.832 ***	0.572 ***	0.815 ***
Malaysia		0.589 *	0.869 ***	0.880 ***	0.489	n.a.
		0.812 ***	0.853 ***	0.711 **	0.745 **	0.873 ***
		0.665 **	0.891 ***	0.667 **	0.191	0.886 ***
		0.673 ***	0.736 ***	0.811 ***	0.591 ***	0.869 ***
Philippines			0.699 **	0.438	0.359	n.a.
			0.785 ***	0.805 ***	0.885 ***	0.932 ***
			0.739 **	0.673 **	-0.177	0.684 **
			0.593 ***	0.597 ***	0.481 ***	0.885 ***
Singapore				0.823 ***	0.542	n.a.
				0.454	0.733 **	0.746 **
				0.653 **	0.160	0.973 ***
				0.600 ***	0.392 **	0.797 ***
Thailand					0.558 *	n.a.
					0.748 **	0.859 ***
					0.085	0.693 **
					0.555 ***	0.851 ***
Viet Nam						n.a.
						0.915 ***
						0.328
						0.631 ***
World						

Notes: 1. The values in the correlation table are the Pearson correlation coefficients. The first, second, third, and fourth rows represent the correlation coefficients of the 1990s, 2000s, 2010s, and the total period, respectively. The total period of the matrix relating to 'World' ranges from 2000 to 2021.

2. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4 OLS Regression Analysis of the Prediction Error of Real GDP Growth Rates

Dependent variable: *cgdp*

	Indonesia					
	(1)	(2)	(3)	(4)	(5)	(6)
ggdp	0.714 **	0.730 **	0.702 **			
	(0.305)	(0.292)	(0.271)			
exm	-0.004	-0.009		0.021	0.110	0.104
	(0.021)	(0.025)		(0.022)	(0.075)	(0.069)
wui	-0.005	-0.005	-0.004	-0.008	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.005)	(0.010)	(0.009)
clui	0.024 **				0.032	
	(0.010)				(0.028)	
F-stat.	9.36 ***	11.72 ***	18.16 ***	2.35	1.49	2.19
Adj. R^2	0.626	0.617	0.632	0.119	0.047	0.073
#Obs.	21	21	21	21	31	31
	Malaysia					
	(1)	(2)	(3)	(4)	(5)	(6)
ggdp	1.457 ***	1.457 ***	1.435 ***			
	(0.146)	(0.140)	(0.092)			
exm	-0.006	-0.006		0.122 **	0.196 ***	0.184 **
	(0.028)	(0.039)		(0.049)	(0.066)	(0.070)
wui	0.0004	0.0004	0.001	-0.004	-0.0004	-0.002
	(0.003)	(0.003)	(0.003)	(0.009)	(0.008)	(0.008)
clui	-0.0002				-0.060	
	(0.027)				(0.063)	
F-stat.	14.14 ***	20.03 ***	31.74	3.68 **	4.92 ***	6.79 ***
Adj. R^2	0.724	0.741	0.755	0.211	0.281	0.278
#Obs.	21	21	21	21	31	31
	Phlippines					
	(1)	(2)	(3)	(4)	(5)	(6)
ggdp	1.903 ***	1.957 **	1.762 ***			
	(0.522)	(0.759)	(0.487)			
exm	-0.036	-0.041		0.133 **	0.133 ***	0.136 ***
	(0.038)	(0.052)		(0.034)	(0.041)	(0.042)
wui	-0.006 **	-0.003	-0.004	-0.018 *	-0.001	-0.001
	(0.003)	(0.004)	(0.003)	(0.009)	(0.011)	(0.011)
clui	-0.062 **				-0.025	
	(0.024)				(0.058)	
F-stat.	19.20 ***	23.34 ***	34.57 ***	4.42 **	2.21	3.33 *
Adj. R^2	0.784	0.770	0.770	0.255	0.108	0.135
#Obs.	21	21	21	21	31	31

Table 4 (continued)

Dependent variable: *cgdp*

	Singapore					
	(1)	(2)	(3)	(4)	(5)	(6)
ggdp	0.893 ***	1.072 ***	1.748 ***			
	(0.226)	(0.249)	(0.420)			
exm	0.199 ***	0.171 ***		0.264 ***	0.275 ***	0.264 ***
	(0.039)	(0.034)		(0.042)	(0.039)	(0.037)
wui	-0.002	-0.003	-0.009	-0.005	-0.004	-0.005
	(0.003)	(0.004)	(0.007)	(0.005)	(0.004)	(0.004)
clui	-0.156 ***				-0.159 ***	
	(0.046)				(0.052)	
F-stat.	18.83 ***	18.96 ***	15.67 ***	16.91 ***	24.14 ***	27.88 ***
Adj. R^2	0.781	0.729	0.595	0.614	0.698	0.642
#Obs.	21	21	21	21	31	31
	Thailand					
	(1)	(2)	(3)	(4)	(5)	(6)
ggdp	1.308 ***	1.316 ***	1.582 ***			
	(0.160)	(0.171)	(0.071)			
exm	0.077 **	0.080 **		0.210 ***	0.239 ***	0.254 ***
	(0.028)	(0.028)		(0.039)	(0.054)	(0.068)
wui	0.013 *	0.012	0.009	0.010	0.011	0.010
	(0.007)	(0.007)	(0.007)	(0.011)	(0.008)	(0.009)
clui	0.015				0.057	
	(0.015)				(0.048)	
F-stat.	15.04 ***	20.94 ***	26.29 ***	7.32 ***	5.45 ***	7.87 ***
Adj. R^2	0.737	0.749	0.717	0.387	0.308	0.314
#Obs.	21	21	21	21	31	31
	Viet Nam					
	(1)	(2)	(3)	(4)	(5)	(6)
ggdp	0.589 ***	0.565 ***	0.494 ***			
	(0.076)	(0.088)	(0.082)			
exm	-0.032 *	-0.021		0.032	0.056 ***	0.057 **
	(0.015)	(0.013)		(0.030)	(0.020)	(0.021)
wui	-0.001	0.001	0.002	-0.001	0.0000	0.0003
	(0.007)	(0.005)	(0.004)	(0.003)	(0.004)	(0.004)
clui	-0.049				-0.026	
	(0.054)				(0.027)	
F-stat.	3.07 **	3.57 **	5.32 **	1.54	1.52	2.21
Adj. R^2	0.293	0.278	0.302	-0.028	0.050	0.075
#Obs.	21	21	21	21	31	31

Notes: 1. *cgdp* = country-level real GDP growth rate, *clui* = Country-Level Uncertainty Index, *exm* = merchandise exports growth rate, *ggdp* = global real GDP growth rate, *wui* = World Uncertainty Index.

2. The estimate of the intercept is omitted.

3. The numerical values in the parentheses denote the heteroskedasticity and autocorrelation consistent standard error.

4. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5 Summary of Estimation Results

	Time period	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam
ggdp	2001–2021	0.702 **	1.435 ***	1.762 ***	1.748 **	1.582 ***	0.494 ***
exm	2001–2021	0.021	0.122 **	0.133 **	0.264 ***	0.210 ***	0.032
	1990–2021 (excluding 2000)	0.104	0.184 **	0.136 ***	0.264 ***	0.254 ***	0.057 **

Notes: 1. *exm* = merchandise exports growth rate, *ggdp* = global real GDP growth rate.

2. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6 Fitted and Residual Values of the Prediction Errors of *cgdp*

	Indonesia			Malaysia			Philippines		
	E	F	R	E	F	R	E	F	R
2001	-1.50	-0.14	-1.36	-5.80	-1.98	-3.82	-1.30	-0.78	-0.52
2002	-0.20	-0.59	0.39	-1.90	-1.24	-0.66	0.10	-0.87	0.97
2003	1.40	0.10	1.30	-0.40	0.07	-0.47	0.00	0.43	-0.43
2004	1.00	1.44	-0.44	2.10	1.66	0.44	1.70	1.38	0.32
2005	1.20	0.03	1.17	-0.60	-0.71	0.11	-0.10	-0.05	-0.05
2006	-0.50	-0.09	-0.41	0.50	-0.71	1.21	0.40	-0.03	0.43
2007	0.30	-0.21	0.51	0.40	-0.69	1.09	1.80	-0.37	2.17
2008	-0.30	-1.11	0.81	-1.00	-3.00	2.00	-2.00	-2.69	0.69
2009	-1.60	-3.26	1.66	-7.50	-6.21	-1.29	-5.10	-6.76	1.66
2010	1.20	2.04	-0.84	2.80	4.73	-1.93	4.10	6.73	-2.63
2011	0.50	-0.45	0.95	0.10	-0.63	0.73	-1.00	1.07	-2.07
2012	-0.70	-0.88	0.18	0.30	-1.51	1.81	1.50	-1.67	3.17
2013	-1.10	-0.71	-0.39	-0.30	-1.10	0.80	2.10	0.66	1.44
2014	-1.60	-0.30	-1.30	0.50	-0.77	1.27	0.30	0.45	-0.15
2015	-1.10	-0.60	-0.50	0.00	-0.46	0.46	-0.60	0.60	-1.20
2016	-1.00	-0.69	-0.31	-0.80	-0.47	-0.33	0.60	-0.54	1.14
2017	-0.40	-0.37	-0.03	1.30	0.47	0.83	0.60	0.60	0.00
2018	-0.10	-0.65	0.55	0.20	-0.13	0.33	-0.30	1.04	-1.34
2019	-0.30	-1.51	1.21	-0.60	-1.43	0.83	-0.80	-2.07	1.27
2020	-7.40	-5.57	-1.83	-10.30	-9.61	-0.69	-16.00	-12.44	-3.56
2021	-1.30	0.01	-1.31	-2.40	0.33	-2.73	-0.90	0.42	-1.32
	Singapore			Thailand			Viet Nam		
	E	F	R	E	F	R	E	F	R
2001	-8.10	-3.35	-4.75	-2.50	-3.27	0.77	-0.20	-0.43	0.23
2002	-2.80	-3.47	0.67	0.80	-2.01	2.81	-0.50	-0.16	-0.34
2003	-3.60	-0.66	-2.94	4.00	1.14	2.86	0.50	-0.29	0.79
2004	4.60	5.96	-1.36	0.80	1.26	-0.46	0.70	0.52	0.18
2005	2.50	1.52	0.98	-1.70	-1.75	0.05	0.80	-0.55	1.35
2006	3.90	2.75	1.15	-0.60	-0.79	0.19	0.60	-0.31	0.91
2007	3.60	1.94	1.66	-0.60	-0.58	-0.02	0.50	-0.07	0.57
2008	-4.00	-0.97	-3.03	-2.50	-3.24	0.74	-2.20	-1.83	-0.37
2009	-6.80	-6.91	0.11	-7.50	-8.28	0.78	-2.80	-1.90	-0.90
2010	11.30	10.52	0.78	4.80	5.23	-0.43	0.30	0.86	-0.56
2011	1.00	-0.28	1.28	-4.40	-1.64	-2.76	-0.90	-0.73	-0.17
2012	-1.40	-2.24	0.84	1.70	-1.46	3.16	-1.50	-0.83	-0.67
2013	0.20	-0.44	0.64	-2.80	-2.79	-0.01	-0.80	-1.03	0.23
2014	-0.10	0.02	-0.12	-4.10	-2.04	-2.06	0.40	-1.02	1.42
2015	-1.90	-4.01	2.11	-1.50	-1.10	-0.40	0.90	-0.19	1.09
2016	-0.60	-1.16	0.56	-0.70	-0.28	-0.42	0.00	0.10	-0.10
2017	2.10	2.57	-0.47	0.60	1.27	-0.67	0.30	0.28	0.02
2018	1.20	3.78	-2.58	0.60	0.27	0.33	0.40	0.27	0.13
2019	-1.80	-1.79	-0.01	-1.90	-0.28	-1.62	0.20	-0.18	0.38
2020	-6.70	-8.06	1.36	-9.90	-8.35	-1.55	-3.80	-3.71	-0.09
2021	5.60	2.48	3.12	-0.90	0.40	-1.30	-4.20	-0.07	-4.13

E = prediction error, F = fitted value, R = residual value.

Notes: 1. *cgdp* = country-level real GDP growth rate.

2. Fitted and residual values are calculated by the estimated coefficients of Estimation (1) in Table 4.

Table 7 Global, Domestic, and Uncertainty Shares of Economic Shocks in the Selected and Whole AMS

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam	ASEAN-6 (2001-2021)	ASEAN-6 (2001-2009)	ASEAN-6 (2010-2019)
Global	58.3%	74.7%	73.3%	71.5%	73.4%	38.8%	56.9%	51.1%	42.1%
ggdp	53.4%	62.0%	61.8%	32.6%	51.6%	34.3%	44.6%	28.9%	25.8%
exm	5.0%	12.7%	11.5%	38.9%	21.8%	4.5%	12.3%	22.2%	16.3%
Uncertainty	11.7%	3.2%	9.5%	10.9%	5.6%	4.6%	3.0%	4.5%	5.5%
wui	8.6%	2.9%	7.0%	5.6%	3.4%	0.9%	2.9%	3.2%	1.4%
clui	3.1%	0.3%	2.4%	5.3%	2.2%	3.7%	0.2%	1.3%	4.1%
Domestic	29.9%	22.1%	17.2%	17.5%	21.0%	56.6%	40.1%	44.4%	52.4%
R^2	0.701	0.779	0.828	0.825	0.790	0.434	0.599	0.556	0.476

Notes: R^2 is the residual variation that is derived from the OLS regression. The shares of the global and uncertainty shocks are calculated based on the metric of relative importance of coefficients. The domestic shock is derived from 1-R^2 (%).