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

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Abstract

In this study, we analyze how economic shocks affect six ASEAN Member States—Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam—in three dimensions: global, domestic, and uncertainty shocks. We collect macroeconomic indicators for 1990−2021 and calculate macroeconomic shocks based on the prediction errors of real GDP growth rates. First, we demonstrate that countries were significantly subjected to unforeseen negative economic shocks on average. Second, we show high synchronization of economic fluctuations and shocks within these countries and with the world. Third, by conducting regression analyses separately, we derive the following: (i) positive association between variations of the global real GDP growth rates and countries' economic shocks; (ii) different quantitative significance of previous estimates among countries; (iii) country-specific domestic shocks; and (iv) correlation of global- and country-level uncertainty indices with negative economic shocks in some AMS. Our results highlight the relative importance of global, domestic, and uncertainty shocks in the AMS as 56.3%, 39.6%, and 2.8%, respectively. Finally, based on this dataset and conducted analysis, 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 synchronization

I. Introduction

ASEAN Member States (AMS) have been subjected to economic shocks owing to external and unforeseen business fluctuations, such as the Asian financial crisis (1997–1998) and global financial crisis (2008–2009). AMS have also suffered economic shocks originating from internal

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and domestic systems and institutions by failing to control economic recessions or overheating. Moreover, AMS have been subjected to unforeseen and unavoidable exogenous shocks, including natural disasters, political disturbances, and pandemics. The COVID-19 pandemic represented a large negative economic shock in the ASEAN region and forced manufacturing and service industries to cease their operations for long periods, causing serious economic downturn. Increased economic or policy uncertainty could negatively and indirectly affect countries' real economy by weakening economic confidence and foresight, which eventually would reduce consumer consumption and firm investment.

In this study, we analyze how global, domestic, and uncertainty shocks affected six ASEAN countries: Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam.[1] We collected both actual and prediction values of annual macroeconomic indicators from 1990 to 2021 (e.g., domestic and global real gross domestic product (GDP) growth rates and merchandise export growth rates) and calculate their prediction errors. Many studies (reviewed in Section 2) have analyzed macroeconomic business cycle synchronization in East Asia and the ASEAN region based on econometric and macroeconomic models. Our study attempts to make another important contribution to ASEAN macroeconomic literature by providing a unique perspective on ASEAN macroeconomy through an in-depth examination of economic shocks that are evaluated by macroeconomic prediction errors and uncertainty indices. To date, AMS have faced 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. Using our original dataset, we will reveal how the economic shocks were distributed within each country, how they were synchronized within AMS and with the world, and the causes of the economic shocks so far.

Prediction error is calculated as "the actual value minus the prediction value" for annual macroeconomic indicators, similar to the Economic Surprise Index (Scotti, 2016). Prediction error directly measures unforeseen economic shocks and variations in past years from the present perspective. These types of prediction errors may reflect business fluctuations caused by "news" (i.e., exogenous changes in information about future economic activities) (Beaudry and Portier, 2006, 2014). In fact, firms' prediction errors on production or business confidence aggregated in the economy can measure firms' views on the business environments and their willingness to invest. Our study primarily focuses on using the former prediction errors as they become "proxy" variables for macroeconomic shocks that influenced country- and regional-level macroeconomies. We used data compiled by the Asian Development Bank (ADB) and the International Monetary Fund (IMF), which have both issued macroeconomic predictions for the selected AMS. As both the ADB and IMF are independent economic international organizations,

[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.

their predictions may be more objective than those of official government institutions, which tend to publish optimistic predictions. Additionally, macroeconomic predictions from both organizations are frequently cited in the mass media and used by professional investors, analysts, and economists.

A brief summary of the findings of this study is as follows. First, the prediction errors of real GDP growth rates for the selected AMS have been negative on average across the years from 1990 to 2021. Thus, these countries have been subjected to unforeseen negative economic shocks through global business recessions, export variations, and idiosyncratic domestic downturns. Second, simple correlation analyses relative to both actual values and prediction errors of real GDP growth rates demonstrated that these two correlation coefficients are significantly large in the total sample period. Hence, countries' business cycles highly synchronize with those of their region and the world, as confirmed by existing studies. Third, we conducted ordinary least squares (OLS) regression analyses of the prediction errors of real GDP growth rates separately for each AMS. Our OLS analyses confirmed that (i) variations of the global real GDP growth rate are positively associated with economic shocks; (ii) 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 some AMS. Hence, in AMS, 56.3%, 39.6%, and 2.8% of variations of economic shocks stemmed from global, domestic, and uncertainty shocks, respectively. Finally, we reviewed the effects of the COVID-19 pandemic on these countries based on this dataset and conducted analysis. By observing detailed factors of past economic shocks, we can thus derive useful implications for various types of economic shocks, recovery paths, and policy responses.

The remainder of this paper is organized as follows. Section 2 explores the relevant literature. Section 3 explains the dataset used in the analyses. Section 4 presents the results of the statistical and econometric analyses and provides interpretations. Section 5 shows our evaluation on the effects of the COVID-19 pandemic. Section 6 concludes the study.

II. Related Literature

II.I. Prediction Errors, Economic Shocks, and Uncertainty

While our study employs annual macroeconomic indicators compiled by international organizations to estimate economic shocks, other studies have relied on data compiled by firms showing monthly or quarterly predictions of production or business confidence (Bachmann et al., 2013; Arslan et al., 2015; Morikawa, 2016; Morikawa 2019). These studies considered the standard deviations of prediction errors between present and former indicators or average absolute values of prediction errors across firms as degrees of "uncertainty" specific to firms. However, our study interprets *ex post* prediction errors (i.e., the difference between prediction values and *ex post* ones in actual values) as unforeseen "economic shocks." Our method resembles the Economic Surprise Index (Scotti, 2016) to measure uncertainty caused by

macroeconomic fluctuations based on professional predictions. A negative prediction error represents a negative economic shock.[2]

Using the above-mentioned measure of prediction errors as economic shocks may incur "institution biases." Many studies have shown that macroeconomic growth predictions published by governments and international organizations are likely upward-biased or optimistic (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 confirm whether the prediction values of macroeconomic indicators (e.g., real GDP growth rates) may have been biased upward as an overall trend.

When negative prediction errors are observed, economic downturns often imply an increase in macroeconomic uncertainty. This may rise when economic shocks or recessions occur and tends to be higher in developing countries than in developed countries (Bloom, 2014). Natural disasters, war, terrorist attacks, political disturbances, and public health problems like the COVID-19 pandemic all increase uncertainty. These events may suppress economic activities by reducing consumption through precautionary saving and investment because of increased real option values and higher finance costs due to increased risk premiums. Baker et al. (2016) developed the Economic Policy Uncertainty Index to directly measure uncertainty, which calculates the frequency of words related to economic policy uncertainty in US newspapers.[3] Similarly, these authors constructed the World Uncertainty Index, which relies on texts of country reports published by the Economist Intelligence Unit.[4] We use the latter uncertainty measure to explain economic shocks more relevant for economic uncertainty, which the selected AMS received.

II.II. Business Cycle Synchronization in East and Southeast Asia

Many studies have examined business cycles in East and Southeast Asia based on short-term macroeconomic indicators using economic shocks estimated by prediction errors of real GDP growth rates. Previous studies have analyzed business cycle synchronization in East Asia, including Southeast Asia from the trade and financial connectivity perspective, given that regional economic integration has rapidly advanced since the 1990s.

Existing studies have shown that trade integration is the key factor for business cycle synchronization in East Asia. Studies have highlighted aspects including bilateral trade forming regional supply chains (Jiang et al., 2019; Allegret and Essaadi, 2011; Gong and Kim, 2013) and differences in trade structures across countries (Nguyen et al., 2020). In East Asia, major structural change in trade related to business cycle synchronization arises from product

[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). With respect to the detail of uncertainty measures, see the following in this section.

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

[4] See reports of Economic Intelligence Unit. https://www.eiu.com/default.aspx

fragmentations (Takeuchi, 2011) and intra-industry trade (Rena et al., 2012). Intra-industry trade has relatively significant impact on East Asian business cycle synchronization owing to the development of 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, the enhancement of trade integration in East Asia has contributed to reinforcing a region's business cycle synchronization.[5]

While the effect of financial integration has been explored, no consensus has been made on whether business cycle synchronization it has on is positive or negative. Some authors have asserted that the advancement of financial integration is positively associated with business cycle synchronization (Rena, 2007; Nguyen et al., 2020), particularly after the Asian financial crisis (Xie et al., 2013) and through international capital flow encouraged by capital market liberalization (Kim and Kim, 2013). However, other authors have shown that internal financial integration can negatively affect East Asian or Asia-Pacific business cycle synchronization (Gong and Kim, 2013; Pontines and Parulian, 2010). The alternative view is that financial integration may also cause synchronization 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 (e.g., changes in oil and commodity prices and exchange rates, and productivity improvements) could also be critical factors for export synchronization (Moneta and Rüffer, 2009; He and Liao, 2012; Park, 2013).[6]

III. Dataset

This section describes the dataset used in this study. We collect the main macroeconomic indicators from statistical tables listed in the *Asian Development Outlook* from 1989 to 2022. ADB publishes these reports annually between March and April, presenting the annual prediction values of the particular publication year and the following year and annual actual values of the past few years.[7] However, ADB (1999) did not report statistical tables, including predictions of macroeconomic indicators, as publishing point forecasts in the middle of the Asian financial crisis was challenging. Therefore, prediction values from ADB (1999) for the year 2000 are missing values and are extrapolated from the IMF dataset as necessary. We used two annual macroeconomic indicators based on ADB (1989−2022): real GDP growth rates and merchandise export growth rates. Both indicators are calculated in the percentage growth rate relative to the previous year.[8] For supplemental explanations, the GDP is valued at market prices and merchandise exports are evaluated in US million dollars from the balance-of-payments accounts

[5] Xie et al. (2013) consider that trade specialisation negatively affects business cycle synchronisation.
[6] Meanwhile, commodity price fluctuations, war, and political disturbances could weaken transmission of business cycles (Selover, 1999).
[7] For example, ADB (2020) exhibited prediction values of macroeconomic indicators both in 2020 and 2021.
[8] The inflation rate based on consumer price index are also available, and its prediction value is an important index particularly for central banks. But we do not use them for the main analysis of this study.

based on free on board.[9]

We use the prediction values of macroeconomic indicators published by other international organizations. We use the *World Economic Outlook Database* to collect data on global real GDP growth rates (i.e., a fixed-price base). This database is updated by the IMF in April and in September−October. To ensure consistency with the timing when ADB data was published, we only used data from April. IMF (1999) is the oldest available dataset relative to the selected AMS. One-year-later prediction values are available from 2000 to 2021. We use IMF (1999) to complement the missing prediction value in the year 2000 for the real GDP growth rate in ADB (1999) for part of the analyses. To examine the worldwide economic shocks affecting the AMS, we collect data on global real GDP growth rates (i.e., fixed-price base, without exchange rate adjustment) synthesized from the GDP data of 195 countries from IMF (1999−2022).[10] Its dataset on actual and prediction values are available from 1990 and 2000, respectively.

How the past actual values of macroeconomic indicators are obtained is a technical problem. As per the system of national accounts (SNA), the basis of the time series is periodically modified. Actual values are thus frequently revised from those of the past. However, the current actual values of macroeconomic indicators may diverge from the economic outlooks formulated by the international organizations or economists of that time. Immediate past values (e.g., those of the previous year) could significantly change in the following year owing to additional data becoming available for the SNA. Hence, we used 3-year-lagged actual values of macroeconomic indicators from the report publication year. This implies that, for example, the actual value for the year 2000 refers to that documented in the 2003 report (e.g., *Asian Development Outlook 2003*). Unfortunately, as obtaining actual indicator values for 2020 and 2021 is impossible through the mentioned methodology, we use those listed in the 2022 report.

For our analyses, we use ADB (1989−2022) for data on the actual values of real GDP growth rates as it covers the longest period (i.e., 1990–2021). Comparing the actual values of these two indicators between both ADB (1989−2022) and IMF (1999−2022) datasets shows no significant difference. If only ADB (1999) is used, actual values for 1996 are missing. Hence, we extrapolate actual values of real GDP growth rates and merchandise export growth rates from IMF (1999) and ADB (1998), respectively. We then 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 actual values, prediction values, and prediction errors of real GDP growth rates for the six selected AMS and the world. The table 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.

<Table 1>

[9] For further information, see the 'Statistical Notes and Tables' of *Asian Development Outlook* of each year.
[10] The World Bank also publishes global real GDP growth rates. However, since more samples are available from IMF, this study uses these.

In this study, we applied the World Uncertainty Index instead of the Economic Policy Uncertainty Index. The former index is consistent with our analysis as it includes data of six AMS country-level uncertainty indices from 1990. The latter index only contains data beginning from 1997. The World Uncertainty Index (i.e., weighted average of countries' GDPs) is based on individual country-level uncertainty indices calculated quarterly. We divide the World Uncertainty Index by 100 and multiply all country-level indices by 100 to obtain readable numerical values. Numerical expansion and contraction do not affect the statistical analyses, excluding numerical scales. Moreover, as the dataset has an annual base, annual uncertainty indices simply average the quarterly World Uncertainty Index and country-level uncertainty indices.

IV. Analytical Results

Section 4 presents (i) an overview of real GDP growth rates and prediction errors across 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. These analyses would help us better understand both the similarity and uniqueness of economic shocks these AMS have faced so far.

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

In Table 1, shaded cells denote negative prediction errors, wherein actual values have fallen below prediction values. This implies that some past prediction values overestimated macroeconomic environments impacted by unforeseen negative economic shocks. Concretely, the 1990−2021 sample period (32 years) shows overestimations for Indonesia (19 years), Malaysia (14 years), Philippines (19 years), Singapore (15 years), Thailand (19 years), and Vietnam (15 years). Standard deviations and coefficients of variation are larger for actual values than for prediction values relative to all countries. Hence, actual real GDP growth rates fluctuated more than their predictions. Moreover, it suggests that prediction values may trace long-term trends (i.e., potential real GDP growth rates).

Specifically, predictions for Indonesia, Philippines, and Thailand generally overestimated their macroeconomic environments heavily.[11] The Philippines recorded negative prediction errors mainly in the 1990s as many as 9 years over the decade. In the 1990s, the Philippines' economic deterioration was caused by huge external debt, overevaluation of the Philippine peso, high inflation, and sluggish exports due to low international competitiveness. Conversely, Indonesia and Thailand recorded negative prediction errors in greater frequency after the mid-2000s than in other countries. Thailand faced an adjustment phase after the demand expansion policy (2002−2004), the global financial crisis (2008), catastrophic floods around Bangkok

[11] The previous discussion paper version published by ERIA (Ambashi, et al., 2022) described the detailed historical backgrounds of economic shocks each AMS received from 1990 t0 2021.

(2011), and a military coup (2014). These events negatively affected domestic consumption and investment in Thailand, although exports continued growing steadily. While Indonesia has highly improved with its recent stable economic growth owing to strong domestic demand and steady resource and primary product exports, its prediction error has been negative for 10 consecutive years (2012–2021). Average negative prediction error (−0.46% point) is not large in the absolute value in the 2010s. However, in the mid-2010s, factors including rising in import costs, decrease in exports, and delay of infrastructure development dampened Indonesia's economy. Hence, Indonesia could not realize economic development on par with its expected economic potential despite the absence of large negative economic shocks. Figure 1 shows that negative prediction errors were greater especially for Indonesia, Philippines, and Thailand.

<Figure 1>

Using the simple average over these three values in 1990−2021, prediction errors are negative excluding Singapore among the AMS. This result broadly supports negative economic shocks in total as well as upward and arguably optimistic biases of prediction values reported by ADB (1989−2022). Notably, the average prediction errors of the global real GDP growth rate published by IMF are negative. This might be because ADB's prediction values frequently refer to upward-biased economic outlooks published by individual governments.[12] While the negative economic shocks estimated by ADB may be larger than real shocks under upward biases, ADB's prediction for macroeconomic indicators remains an authoritative reference professional investors and economists often cite. Hence, ADB's estimated prediction errors may be a reasonable "proxy" for economic shocks that agents and markets encounter.

Considering each AMS, we find that the average prediction error is positive for Singapore in the 1990s; almost zero for Indonesia in the 2000s; positive for Malaysia, Philippines, and Singapore in the 2010s; and that for Vietnam is almost zero in the 2010s. Recording a small negative prediction error (−0.43% points) and a standard deviation (1.90) despite displaying a high average real GDP growth rate (6.61%) for 32 years suggests that Vietnam has seen relatively stable economic growth since the 2010s. Singapore maintained solid growth before the COVID-19 pandemic, exhibiting a positive prediction error (0.27% points). Conversely, Thailand exhibits sizable, negative prediction errors in the 1990s (−2.41% points), 2000s (−0.82% points), and 2010s (−0.77% points). The average prediction error for 32 years is −1.59% points, while its standard deviation is the largest at 4.44. Therefore, Thailand could not fully exploit its growth potential despite its long-time centrality of manufacturing and export bases in Southeast Asia.

[12] Overall, across the selected AMS, the upward biases shown by data from ADB are larger than those of IMF, which suggests that IMF made more conservative economic predictions. Whereas ADB, as a regional development bank, tends to highlight country growth potential, IMF works to maintain the international financial system, such as emergency loans and monitoring of foreign exchange markets and debt situations.

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

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

Intriguingly, correlation is weaker among the six AMS in the 2010s than in the 2000s. The correlation coefficients for Malaysia–Thailand and Singapore–Thailand in the 2010s are not significant. While the first ASEAN economic integration occurred in 2010, autonomous business cycles may have been reinforced within each country during that period, wherein "slow trade" occurred. Vietnam does not exhibit significant correlation with the other AMS and the world in the 2010s, but it then realized relatively high growth.

<Table 2>

Similarly, Table 3 shows the correlation coefficients of prediction errors of real GDP growth rates relative to the six AMS and the world. As prediction values of global real GDP growth rates are available only from 2000, correlation coefficients regarding the prediction errors of those indicators in the 1990s are nonexistent. Correlation coefficients in the total period are calculated as per 2000−2021.

<Table 3>

Correlation coefficients for the total period are all highly statistically significant. All have a 1% significance, excluding only the correlation between Singapore and Vietnam (but at the 5% significance level).[13] Hence, economic shocks that the six AMS faced also seem to have been synchronized over the long-term due to the factors mentioned in Subsection 2.2.[14] On a country basis, correlation coefficients regarding Indonesia weaken from the 1990s to the 2000s and 2010s. In the 2010s, they are significantly correlated with those only for Malaysia and Singapore. Relative to Vietnam, while a positive correlation with the other AMS prediction errors was found in the 2000s, the correlation coefficients in the 2010s are not statistically significant. Additionally, those with the world are not significant, either. Therefore, Indonesia and Vietnam have not been exposed to economic shocks common within the ASEAN region by leveraging autonomous domestic demand. Conversely, correlation coefficients of prediction errors between Malaysia

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

[14] The correlation analysis using the prediction errors of inflation rates does not show strong synchronisation among the six AMS and the world.

and Singapore remain at very high levels possibly because of the economic and geographical proximity of the two countries. Moreover, Singapore shows large correlation coefficients with those of the other countries, excluding Thailand in the 2000s and Vietnam in the 1990s and 2010s. Therefore, economic shocks may have been transmitted by way of Singapore—the center of trade and finance in Southeast Asia—to other countries in the region.

IV.III. Regression Analysis of Prediction Error

To examine the factors for generating prediction errors of real GDP growth rates, we conduct the following simple OLS regression analyses[15]:

$$cgdp_{it} = \beta_0 + \beta_1 \times ggdp_t + \beta_2 \times exm_{it} + \beta_3 \times wui_t + \beta_4 \times clui_{it} + \beta_5 \times t + \varepsilon_{it},$$

where *i* and *t* represent country and year indices, respectively. This formulation regresses the prediction errors (*cgdp*) of the following macroeconomic indicators: global real GDP growth rates (*ggdp*) and merchandise export growth rates (*exm*), World Uncertainty Index (*wui*), country-level uncertainty indices (*clui*), and year trend (*t*). Note that while the independent variables of *ggdp* and *exm* are related to factors for global economic fluctuations, those of *clui* and *wui* are related to an increase in uncertainty. While macroeconomic indicators (e.g., domestic consumption and investment) should be added to the independent variables to explain domestic variations, these are not consistently available from ADB (1989−2022).[16] Rather, the error term reflects domestic variations that cannot be explained by global and uncertainty factors. Finally, the year trend reflects the change in potential economic growth and advancement of prediction accuracy given that the standard deviations of prediction errors of real GDP growth rates tend to decrease from the 1990s to the 2010s except Singapore.

These estimates represent correlation and do not mean causal relation. Country-level uncertainty could correlate with the error term (i.e., domestic shocks). Moreover, whether uncertainty affects the prediction error of real GDP growth rates or vice versa is unanswered. While uncertainty may have causal relations with real GDP growth rates (Bloom, 2009), the compiled prediction errors imply a reverse causal relation (Scotti, 2016). Hence, the simultaneous relation between them is the most plausible. Specifically, the endogeneity of domestic uncertainty (*clui*) is relevant as it may correlate with the error term (ε), the proxy of domestic shocks.[17] Ideally, possible upward bias accrued to the estimation of β_4 should be corrected using instruments. However, finding such valid instruments strongly correlated with

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[15] We also conducted the regression analysis, in which the prediction error of inflation rates is a dependent variable, and those of domestic and global real GDP growth rates, and domestic and global uncertainty are used as independent variables. These estimation results will be provided by the authors upon request.

[16] 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.

[17] The reverse causality from the prediction error of real GDP growth rates to global uncertainty is less plausible considering the economic scales of the six AMS.

domestic uncertainty and not with economic shocks is difficult.[18] Therefore, it is necessary to pay attention to some biases contained in the estimation, though they do not seem serious.

We obtained data on *cgdp* and *exm* from ADB (1989−2022). Data on *exm* cover 1990−1999 and 2001−2021 as data in 2000 *exm* are nonobtainable. Data on *ggdp*, ranging from 2000 to 2021, are obtained from IMF (1999−2022). As *ggdp* and *exm* may be generally mutually correlated—and as this correlation may cause multicollinearity—we also conduct regression analyses that included one of the two as independent variables. When only *exm* is used as an independent variable, this sample covers 31 years (1990−2021, excluding 2000) at most. In regression analyses, we apply heteroskedasticity- and autocorrelation-consistent standard errors (Newey and West, 1987) for ε_{it} by considering serial autocorrelation between error terms.[19] Table 4 shows the descriptive statistics used in the following regression analyses.

<Table 4>

Table 5 presents the time-series estimation results for the six AMS individually. Using Indonesia, Estimation (1) includes both *ggdp* and *exm* as independent variables, but they do not generate serious multicollinearity, considering their variance inflation factors (VIFs) of 1.312 and 1.473 for *ggdp* and *exm*, respectively. Nevertheless, as the concern of multicollinearity is not entirely resolved, Estimations (2) and (3) include only one of the two variables. Estimation (4), using the full sample (1990−1999 and 2001−2021), does not include *ggdp* as this variable is available only since the year 2000.[20]

<Table 5>

The estimates of *ggdp* are all significant at the 1% level across the relevant estimations of the six AMS. Thus, the economic shocks received are strongly associated with unforeseen variations of global economic growth. Conversely, estimates of *exm* are not necessarily significant according to country and sample periods. The estimates for Malaysia, Philippines, and Vietnam in Estimation (1), for Malaysia in Estimation (3), and for Indonesia in Estimation (4) are all insignificant. Hence, unforeseen variations in merchandise export growth rates may not be a significant factor of economic shocks to these economies. Relative to Philippines and Vietnam, estimates of *exm* are not significant in Estimation (1). However, those in Estimation (3) are significantly positive as the estimates of *exm* may absorb part of the effect of *ggdp*.[21]

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[18] We attempted to instrument domestic uncertainty by using the one-year lag of its index. However, the estimation result indicates the serious weak instrument problem that fails to control for that endogenous variable.

[19] Since the variables of real GDP and merchandise exports are first differenced in calculating a growth rate. a concern for problems of unit roots is more or less alleviated.

[20] Actually, the indicators of 2000 are excluded, so the sample ranges from 2001 to 2021.

[21] Note that the adjusted R^2 is drastically smaller in Estimation (3).

Meanwhile, the estimates of *exm* in Estimations (1), (3), and (4) for Singapore and Thailand are significantly positive. Since the estimates of both *ggdp* and *exm* are simultaneously significant, unforeseen global economic and merchandise exports shocks can be separated for these two countries. That is, Singapore and Thailand have crucial export sectors in the Southeast Asia region, so unforeseen merchandise export growth variations have linkages to economic shocks when the global economic shocks are appropriately controlled.

Table 6 presents the mentioned estimation results of the six AMS, extracted from Table 5. To compare the relevant estimates, estimates of *ggdp* for 2001−2021 correspond to Estimation (2) and estimates of *exm* for 2001−2021 and 1990−2021 (excluding 2000) correspond to Estimations (3) and (4), respectively. As previously described, estimates of *exm* can absorb a part of the effect of *ggdp*. Hence, these estimates may not completely represent the effect of *exm*, but this simplification is convenient and useful to compare the two periods.

<Table 6>

First, we compare the estimates of *ggdp*: Philippines (1.737), Singapore (1.710), Thailand (1.555), Malaysia (1.435), Indonesia (0.709), and Vietnam (0.490). These numerical values represent the degree of the countries' linkages to the global economy. The Philippines has the largest estimate, which contrasts with its *exm* result. This is because the remittances of Filipino overseas workers (i.e., about 10% of nominal GDP in 2021) are affected by variations in the global economy. These impose economic shocks towards the Philippine economy through domestic consumption. Next, Thailand's thriving tourism sector (i.e., about 20% of nominal GDP in 2021) attracts many foreign tourists, which may be connected to the relatively large *ggdp* estimate. Moreover, as Singapore is the largest economic, financial, and trade hub in Southeast Asia, the country obviously has stronger connectivity to the global economy.

Second, if the 2001−2021 estimates are compared across six AMS, these estimates are Singapore (0.265), Thailand (0.211), the Philippines (0.146), Malaysia (0.133, insignificant), Indonesia (0.039), and Vietnam (0.033). This order points to the magnitude of economic shocks that these countries receive through variations of merchandise export growth. Hence, while the estimates for Singapore and Thailand are relatively large, those for Indonesia and Vietnam are minimal. Specifically, the latter result shows that Indonesia and Vietnam may still be improving their connectivity with the global economy via exports and may have larger shares of domestic demand in variations in their economies (Subsection IV.II). Finally, Malaysia's estimation result being insignificant is particularly surprising. However, this may be because of the inclusion of the year trend; the regression without the time trend exhibits a significant estimate (0.124, significant at the 10% level).

Third, comparing *exm* between 2001−2021 and 1990−2021 (excluding 2000) demonstrates that while the estimate for Singapore has almost remained the same, estimates for Indonesia,

Malaysia, Thailand, and Vietnam in the former period are smaller than in the latter period.[22] Such "attenuation" of the linkage with merchandise export growth rates (*exm*) particularly for Malaysia and Thailand in the more recent time period seems caused by diversification of export items. These include 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, exports on these countries' economies reduce as manufacturing products proliferate 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 have been bolstered, owing to the advancement of information and communication technologies and globalization (Baldwin, 2016).

Relative to Estimation (1) for Singapore, which includes a full set of regressors, both world and domestic uncertainty indices (*wui* and *clui*, respectively) are negatively related to economic shocks. As these two estimates are significant in Estimations (1) and (4) (especially both significant at the 1% level in the former), this result on uncertainty shocks 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 stock and asset price decreases. These negative estimates may 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 Estimation (4) is not. Therefore, the negative correlation of domestic uncertainty in the Philippine economy is clearer in 2001−2021.[23]

Estimation (1) aims to show the impact of the variation related to *ggdp*, *exm*, *wui*, *clui*, and *t* (i.e., regression variation) on the overall variation of the economy (i.e., total variation). Hence, the adjusted R^2 represents the share of the variation mostly attributable to external and uncertainty shocks besides the year trend to the total variation. While R^2 is high for Indonesia (0.700), Malaysia (0.712), Philippines (0.793), Singapore (0.830), and Thailand (0.840), it is quite small for Vietnam (0.373). On the other hand, $1-R^2$ accounts for the residual variation that cannot be explained by the regression variation (i.e., it is deemed the domestic shock). Table 7 shows the fitted 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, as external variations are eliminated, the residual values rarely have any positive correlations between each other across AMS.[24] Thus, domestic economic shocks seem mainly idiosyncratic (i.e., country-specific). For instance, in Thailand in 2011, a large

[22] The estimate of *exm* for Indonesia (1990−2021) is insignificant. However, the estimate derived from the regression without the year trend is 0.027 and statistically significant at the 10% level.
[23] The estimates of *wui* and *clui* in Estimation (1) for Thailand are significantly positive, opposite to expected negative signs.
[24] The exceptions are combinations of only Malaysia−Viet Nam, which is significant at the conventional 5% level.

negative value of the residual (−2.25% points) seemed 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.

<Table 7 >

Moreover, to compare the degree of the global, domestic, and uncertainty shocks and the year trend affecting AMS's macroeconomic shocks, we evaluate the relative importance in the linear regression of Estimation (1). Concretely, we calculate metrics based on unweighted average over orders of sequential R^2s, as per Grömping (2003).[25] We allot the share of R^2 to global and uncertainty shocks and derive domestic shocks from the error sum of squares, $1\text{-}R^2$. Table 8 presents them according to both individual and whole AMS. To obtain coefficients in the latter estimation, we conduct a pooled OLS regression by gathering all variables across countries and years and dividing samples into 2001−2009 and 2010−2019.[26] Evidently, while the global shock contributes most to economic shocks excluding Vietnam, the uncertainty shock (and the year trend) does relatively little. Overall, AMS in 2001−2021 accounted for 56.3%, 39.6%, and 2.8% as well as 1.3% of variations of economic shocks in global, domestic, and uncertainty shocks, and year trend, respectively. By comparing sample periods between 2001−2009 and 2010−2019, we find that global share decreases, while domestic share increases in the latter period. This observation is consistent with the analysis in Subsection IV.II, which suggests an increased contribution of idiosyncratic domestic shocks amid the globalization progress.

<Table 8>

V. Effects of the COVID-19 Pandemic

This section summarizes the effects of the COVID-19 pandemic through the lens of prediction errors. While this analysis is not comprehensive, it can help examine whether such pandemic effects are *ex ante* anticipated, how global and domestic factors affect the economies, and how different economic shocks are distributed across six AMS.

First, we examined the prediction errors of the 2020 real GDP growth rates: Indonesia (−7.4% points), Malaysia (−10.3% points), Philippines (−16.0% points), Singapore (−6.7% points), Thailand (−9.9% points), and Vietnam (−3.8% points). In 2020, all six AMS experienced the largest negative economic shock as Asian or global financial crises. Given the prediction error of the 2020 global real GDP growth rate of −6.7% points, the six AMS did not suffer the

[25] We use the method of 'lmg' provided by R package, 'relaimpo'.
[26] These estimation results will be provided by the authors upon request.

most severe economic downturns compared to others at the onset of the COVID-19 pandemic. In fact, fitted and residual values of Table 7 indicate that these prediction errors are caused primarily by external shocks (and with slight uncertainty shocks). These external shocks include a decrease in external demand and disruption of global supply chains.[27] For details, ratios of fitted values to prediction errors (i.e., the extent that negative global factors account for negative economic shocks) are as follows: Indonesia (0.744), Malaysia (0.935), Philippines (0.791), Singapore (0.861), Thailand (0.897), and Vietnam (1.028). Only in Singapore and Vietnam, a positive residual value of 1.23% points and 0.11% points in 2020 compensated for negative external shocks to the economies, respectively.

In 2021, the COVID-19 pandemic affected countries differently. While negative prediction errors diminished in 2021 for all countries, they remained negative except for Singapore: Indonesia (−1.3% points), Malaysia (−2.4% points), Philippines (−0.9% points), Singapore (5.6% points), Thailand (−0.9% points), and Vietnam (−4.2% points). Hence, unforeseen negative economic shocks have had a profound influence on the economies of the five AMS even in 2021. However, the prediction error of the 2021 global real GDP growth rate is positive at 0.3% points, and the global economy mainly comprised of developed countries began recovering from the devastating impact of the COVID-19 pandemic by easing economic and social regulations. Conversely, many AMS helped prevent COVID-19 outbreaks by enforcing lockdowns and lagged developed countries in expanding its citizens' vaccination procedures. Table 7 reveals that domestic shocks represented by residual values are negative in other ASEAN countries except Singapore and Thailand. The ratios of residual values to prediction errors (i.e., the extent that negative domestic factors account for negative economic shocks) are as follows: Indonesia (0.139), Malaysia (1.304), Philippines (0.181), and Vietnam (0.729). Moreover, unreported calculations show that prediction errors of the 2021 merchandise export growth rates are nevertheless enormous: Indonesia (35.5%), Malaysia (17.9%), Philippines (6.1%), Singapore (16.5%), Thailand (8.8%), and Vietnam (11.2%). Thus, negative economic shocks in 2021 stemmed mostly from domestic shocks in these countries.

Recovery from the negative economic shocks of the COVID-19 pandemic differed among the six AMS. Only Singapore enjoyed a positive economic shock in 2021, as both its global and domestic shocks are positive. Conversely, Malaysia and Vietnam experienced large domestic shocks represented by the residual values of −3.13% points and −4.09% points in 2021, possibly because of the prevalence of COVID-19 in the latter half of 2021. To summarize, while the negative shocks of the COVID-19 pandemic originated largely from global shocks for six AMS in 2020, the contribution of domestic shocks became larger for Malaysia and Vietnam in 2021.

[27] In Table 7, the uncertainty shock and the year trend are absorbed in fitted values. Nevertheless, as Table 8 suggests, it seems trivial relative to the global and domestic shocks.

VI. Conclusion

In this study, we analyzed how economic shocks in 1990−2021 affected six AMS from global, domestic and uncertainty perspectives. To construct the analyses, we calculated prediction errors as deviations between actual and prediction values of annual macroeconomic indicators. Based on the broad overview of prediction errors of real GDP growth rates, we showed that countries have experienced negative economic shocks overall during the total sample period caused by 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 synchronized, we conducted simple correlation analyses of actual real GDP growth rates and their prediction errors. Correlation coefficients of the two analyses exhibited significantly large numerical values in the total sample period. This suggests that, as extant studies demonstrated, business cycles and economic shocks were strongly synchronized within the region and 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. For some countries, estimates of the world and domestic uncertainty indices are related to negative economic shocks. We separated 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. Moreover, we introduced speculation on the economic effects of the COVID-19 pandemic from the perspective of global and domestic variations using fitted and residual values.

We derive the following policy implication. As the ASEAN economy has already achieved a high level of trade and financial integration (see Section II), a negative economic shock delivered to one country caused by an external factor may broadly spread to the entire ASEAN region. Therefore, ASEAN and each AMS need to prepare for policy measures to manage unforeseen production and trade variations, as well as financial crises. Moreover, this may require economic policy cooperation and coordination between AMS.

We note the following challenges that future researchers may face. First, we measured variations of domestic demand as residuals that cannot be explained by variations of the global economy. Data sources other than ADB (1989−2022) must be further examined to determine the feasibility of incorporating them into data. Second, our sample coverage on annual macroeconomic indicators was so limited that only rough sketches of macroeconomic shocks of countries could be observed. Based on detailed monthly or quarterly prediction data that increases samples, we can analyze mutual dependence in Southeast Asia by formulating structural VAR models. Finally, like Morikawa (2016, 2019), microeconomic research that directly observes firms' uncertainty through microstatistics and questionnaire surveys can be conducted to sufficiently explore the relationship between economic shocks or uncertainty and firms' investment activities or performance.

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Table 1 Actual Values, Prediction Values, and Prediction Errors 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.
	6.51	2.02	6.87	5.10	1.30	5.47	2.39	0.89	2.70	2.90	1.20	3.50	6.50	2.33	6.38	2.00	1.99	2.63	0.79	n.a.	n.a.
	1.48	0.32		0.75	0.17		0.86	0.17		0.40	0.18		1.32	0.32		0.27	0.26		0.24	n.a.	
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
	0.84	1.28	1.27	3.03	1.21	3.85	1.67	0.89	2.08	4.26	0.87	5.04	2.67	1.09	3.08	1.17	1.17	1.39	1.81	0.79	1.64
	0.17	0.26		0.67	0.23		0.37	0.19		0.91	0.17		0.67	0.23		0.17	0.16		0.50	0.18	
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
	0.59	0.62	0.84	0.89	0.36	1.04	1.08	1.08	1.57	3.81	0.98	3.86	2.34	0.76	2.81	0.67	0.42	0.75	0.63	0.72	1.29
	0.11	0.11		0.17	0.07		0.17	0.19		0.82	0.27		0.67	0.18		0.11	0.07		0.17	0.19	
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
	3.80	1.46	4.06	3.91	1.51	4.09	3.34	1.01	3.60	4.06	1.74	4.26	4.45	2.05	4.44	1.69	1.37	1.90	1.70	0.86	1.94
	0.81	0.26		0.77	0.26		0.81	0.19		0.77	0.35		1.19	0.38		0.26	0.20		0.50	0.21	

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

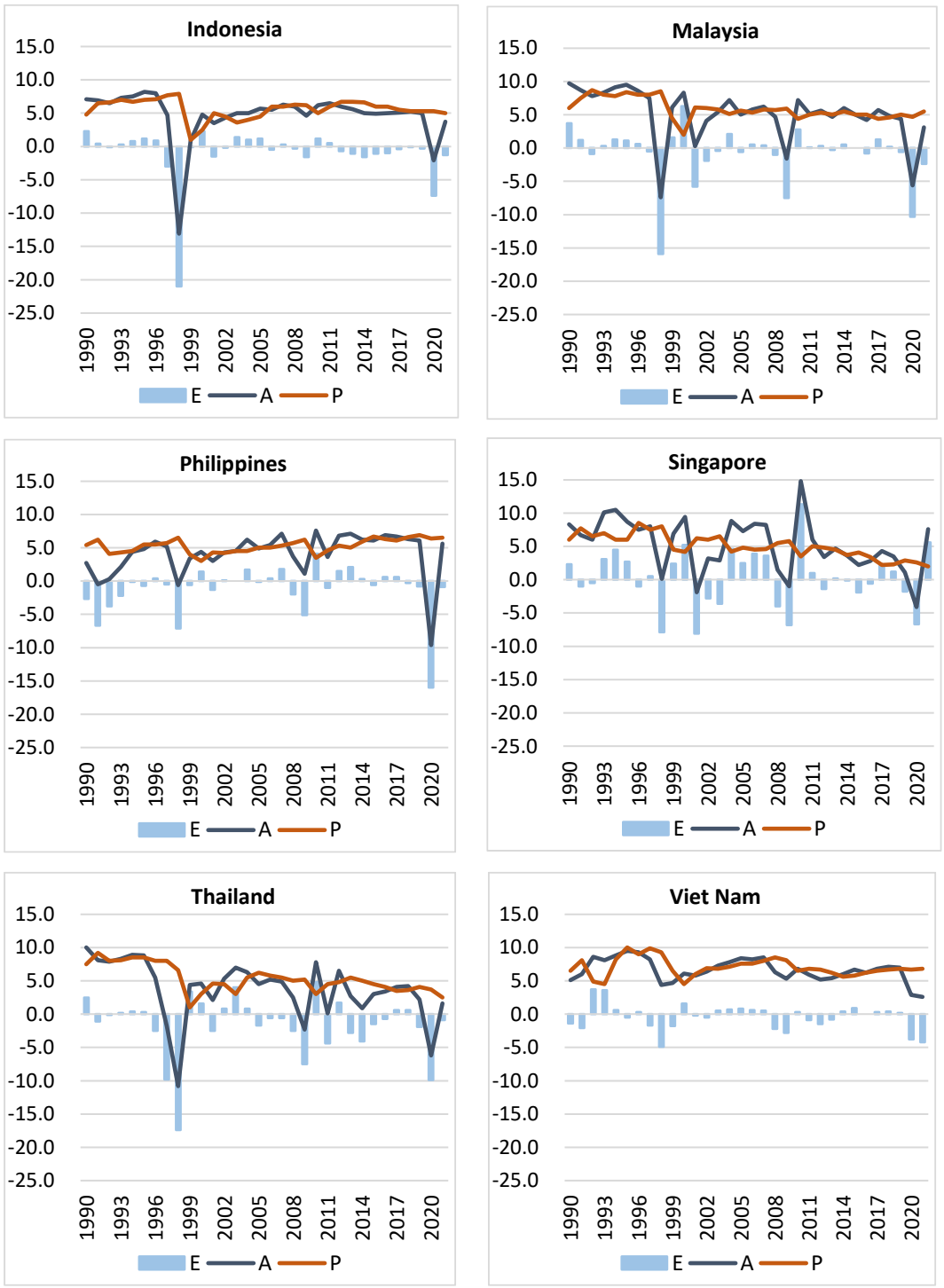
Notes: 1. The first, second, and third rows of each period represent the simple mean, standard deviation, and coefficient of variation.

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

3. The prediction values of shaded cells signify negative values.

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 the 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 the 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 ***

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 Descriptive Statistics

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam
cgdp	-0.922	-0.769	-1.172	0.267	-1.588	-0.434
	(0.718)	(0.723)	(0.637)	(0.753)	(0.785)	(0.337)
exm	-2.158	-2.926	-3.145	-0.900	-2.332	4.061
	(2.674)	(2.155)	1.816	(2.263)	(1.673)	(2.221)
clui	19.693	12.188	17.476	8.863	20.171	8.429
	(2.092)	(1.968)	(1.732)	(1.173)	(1.933)	(1.193)
	World					
ggdp	-0.685					
	(0.414)					
wui	174.247					
	(13.789)					

Notes: 1. The first and second rows represent simple means and standard errors, respectively.

2. In each country, 32 observations (1990−2021) for *cgdp*, *clui*, and *wui*; 31 observations (1990−1999, 2001−2021) for *exm*; and 22 observations (2000−2021) for *ggdp*.

Table 5 OLS Regression Analysis of the Prediction Error of the Real GDP Growth Rates

Dependent variable: *cgdp*

	Indonesia				Malaysia			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ggdp	0.688 ***	0.709 ***			1.487 ***	1.435 ***		
	(0.113)	(0.211)			(0.111)	(0.087)		
exm	0.007 **		0.039 ***	0.127	-0.015		0.133	0.205 **
	(0.003)		(0.009)	(0.087)	(0.019)		(0.415)	(0.079)
wui	0.003 *	0.003	0.002	0.016	-0.002	-0.001	-0.001	0.006
	(0.002)	(0.003)	(0.004)	(0.013)	(0.004)	(0.006)	(0.046)	(0.009)
clui	-0.018	-0.017 *	-0.018	0.005	0.002	-0.001	-0.012	-0.056
	(0.011)	(0.009)	(0.011)	(0.023)	(0.025)	(0.042)	(0.226)	(0.055)
t	-0.147 ***	-0.138 ***	-0.177 ***	-0.131	0.042	0.032	-0.053	-0.070
	(0.004)	(0.008)	(0.016)	(0.097)	(0.052)	(0.101)	(1.464)	(0.153)
F-stat.	10.34 ***	13.58 ***	2.32	1.35	10.87 ***	14.35 ***	1.71	3.73 **
Adj. R^2	0.700	0.716	0.101	0.044	0.712	0.728	0.124	0.267
#Obs.	21	21	21	31	21	21	21	31
	Philippines				Singapore			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ggdp	1.850 ***	1.737 ***			1.035 ***	1.710 ***		
	(0.408)	(0.364)			(0.178)	(0.375)		
exm	-0.024		0.146 ***	0.128 ***	0.164 ***		0.265 ***	0.265 ***
	(0.028)		(0.047)	(0.042)	(0.034)		(0.043)	(0.035)
wui	-0.001	-0.002	-0.014 **	-0.012	-0.012 ***	-0.023 ***	-0.011	-0.013 *
	(0.003)	(0.003)	(0.006)	(0.010)	(0.003)	(0.007)	(0.007)	(0.007)
clui	-0.065 ***	-0.067 ***	-0.099 *	-0.037	-0.120 ***	-0.053	-0.179 ***	-0.150 ***
	(0.021)	(0.023)	(0.054)	(0.059)	(0.032)	(0.038)	(0.047)	(0.045)
t	-0.102 ***	-0.112 **	-0.170 *	0.108	0.204 ***	0.298 ***	0.146 **	0.092
	(0.032)	(0.044)	(0.082)	(0.065)	(0.047)	(0.074)	(0.058)	(0.055)
F-stat.	16.37 ***	21.25 ***	3.08 **	1.95	20.57 ***	13.18 ***	13.65 ***	19.09 ***
Adj. R^2	0.793	0.802	0.294	0.113	0.830	0.709	0.717	0.707
#Obs.	21	21	21	31	21	21	21	31
	Thailand				Viet Nam			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
ggdp	1.273 ***	1.555 ***			0.568 ***	0.490 **		
	(0.090)	(0.082)			(0.101)	(0.227)		
exm	0.087 ***		0.211 ***	0.263 ***	-0.024		0.033 **	0.063 ***
	(0.006)		(0.041)	(0.052)	(0.019)		(0.015)	(0.021)
wui	0.022 **	0.018 *	0.021 **	0.029 **	0.004	0.005	0.003	0.008
	(0.009)	(0.009)	(0.008)	(0.011)	(0.003)	(0.004)	(0.007)	(0.006)
clui	0.024 ***	0.032 *	0.035	0.064	-0.037	-0.027	-0.022	0.016
	(0.008)	(0.016)	(0.039)	(0.046)	(0.040)	(0.087)	(0.172)	(0.034)
t	-0.194 ***	-0.181 **	-0.212 ***	-0.192 ***	-0.091	-0.097	-0.102	-0.087
	(0.043)	(0.071)	(0.045)	(0.035)	(0.074)	(0.258)	(0.409)	(0.124)
F-stat.	21.96 ***	19.63 ***	5.19 ***	5.23 ***	3.38 **	4.20 **	1.13	1.88
Adj. R^2	0.840	0.788	0.456	0.361	0.373	0.390	0.025	0.105
#Obs.	21	21	21	31	21	21	21	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, t = *year trend*, *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 6 Summary of Estimation Results

	Time period	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam
ggdp	2001–2021	0.709 ***	1.435 ***	1.737 ***	1.710 ***	1.555 ***	0.490 **
exm	2001–2021	0.039 ***	0.133	0.146 ***	0.265 ***	0.211 ***	0.033 **
	1990–2021 (excluding 2000)	0.127	0.205 **	0.128 ***	0.265 ***	0.263 ***	0.063 ***

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

2. *ggdp* for 2001−2021, *exm* for 2001−2021, and *exm* for 1990−2021 (excluding 2000) correspond to Estimations (3), (4), and (6) in Table 4, respectively.

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

Table 7 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	-0.44	-1.06	-5.80	-2.30	-3.50	-1.30	-0.03	-1.27
2002	-0.20	0.48	-0.68	-1.90	-1.57	-0.33	0.10	0.12	-0.02
2003	1.40	0.97	0.43	-0.40	-0.27	-0.13	0.00	1.32	-1.32
2004	1.00	1.27	-0.27	2.10	1.47	0.63	1.70	1.65	0.05
2005	1.20	0.21	0.99	-0.60	-0.86	0.26	-0.10	0.22	-0.32
2006	-0.50	0.14	-0.64	0.50	-0.73	1.23	0.40	0.13	0.27
2007	0.30	-0.01	0.31	0.40	-0.74	1.14	1.80	-0.14	1.94
2008	-0.30	-1.35	1.05	-1.00	-3.04	2.04	-2.00	-2.69	0.69
2009	-1.60	-2.87	1.27	-7.50	-6.13	-1.37	-5.10	-6.84	1.74
2010	1.20	2.60	-1.40	2.80	4.63	-1.83	4.10	6.83	-2.73
2011	0.50	-0.25	0.75	0.10	-0.63	0.73	-1.00	0.85	-1.85
2012	-0.70	-1.09	0.39	0.30	-1.60	1.90	1.50	-1.17	2.67
2013	-1.10	-1.00	-0.10	-0.30	-0.91	0.61	2.10	0.35	1.75
2014	-1.60	-1.10	-0.50	0.50	-0.57	1.07	0.30	0.10	0.20
2015	-1.10	-0.90	-0.20	0.00	-0.14	0.14	-0.60	0.10	-0.70
2016	-1.00	-0.88	-0.12	-0.80	-0.29	-0.51	0.60	-0.93	1.53
2017	-0.40	-0.28	-0.12	1.30	0.65	0.65	0.60	0.22	0.38
2018	-0.10	-0.81	0.71	0.20	0.03	0.17	-0.30	0.40	-0.70
2019	-0.30	-1.58	1.28	-0.60	-1.51	0.91	-0.80	-2.01	1.21
2020	-7.40	-5.51	-1.89	-10.30	-9.63	-0.67	-16.00	-12.65	-3.35
2021	-1.30	-1.12	-0.18	-2.40	0.73	-3.13	-0.90	-0.74	-0.16
	Singapore			Thailand			Viet Nam		
	E	F	R	E	F	R	E	F	R
2001	-8.10	-5.02	-3.08	-2.50	-1.47	-1.03	-0.20	0.35	-0.55
2002	-2.80	-4.57	1.77	0.80	-0.43	1.23	-0.50	0.52	-1.02
2003	-3.60	-2.13	-1.47	4.00	3.17	0.83	0.50	0.61	-0.11
2004	4.60	4.86	-0.26	0.80	1.84	-1.04	0.70	0.79	-0.09
2005	2.50	0.96	1.54	-1.70	-1.36	-0.34	0.80	-0.29	1.09
2006	3.90	2.54	1.36	-0.60	-0.49	-0.11	0.60	-0.38	0.98
2007	3.60	1.30	2.30	-0.60	0.02	-0.62	0.50	0.01	0.49
2008	-4.00	-1.04	-2.96	-2.50	-3.22	0.72	-2.20	-1.69	-0.51
2009	-6.80	-6.97	0.17	-7.50	-8.36	0.86	-2.80	-1.98	-0.82
2010	11.30	9.87	1.43	4.80	5.20	-0.40	0.30	1.03	-0.73
2011	1.00	0.31	0.69	-4.40	-2.15	-2.25	-0.90	-0.83	-0.07
2012	-1.40	-2.76	1.36	1.70	-0.95	2.65	-1.50	-0.48	-1.02
2013	0.20	0.11	0.09	-2.80	-3.51	0.71	-0.80	-1.15	0.35
2014	-0.10	0.98	-1.08	-4.10	-2.97	-1.13	0.40	-1.30	1.70
2015	-1.90	-2.68	0.78	-1.50	-1.65	0.15	0.90	-0.48	1.38
2016	-0.60	-0.37	-0.23	-0.70	-0.72	0.02	0.00	-0.25	0.25
2017	2.10	3.49	-1.39	0.60	0.42	0.18	0.30	-0.25	0.55
2018	1.20	4.45	-3.25	0.60	-0.82	1.42	0.40	-0.36	0.76
2019	-1.80	-2.15	0.35	-1.90	-0.13	-1.77	0.20	-0.13	0.33
2020	-6.70	-7.93	1.23	-9.90	-8.88	-1.02	-3.80	-3.91	0.11
2021	5.60	4.94	0.66	-0.90	-1.84	0.94	-4.20	-1.14	-3.06

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 8 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	56.0%	74.6%	71.3%	70.2%	72.5%	37.1%	56.3%	49.2%	40.0%
ggdp	50.6%	61.8%	59.5%	33.7%	50.5%	33.0%	43.9%	28.5%	24.2%
exm	5.4%	12.9%	11.9%	36.5%	21.9%	4.1%	12.5%	20.6%	15.7%
Uncertainty	7.9%	3.1%	8.1%	12.3%	8.6%	4.9%	2.8%	4.9%	5.6%
wui	6.0%	2.9%	5.4%	7.9%	6.2%	1.8%	2.5%	3.7%	1.4%
clui	2.0%	0.3%	2.8%	4.5%	2.4%	3.1%	0.2%	1.2%	4.1%
Year trend	13.6%	0.6%	5.0%	4.7%	6.9%	11.0%	1.3%	3.3%	2.7%
Domestic	22.5%	21.6%	15.5%	12.7%	12.0%	47.0%	39.6%	42.6%	51.8%
R^2	0.775	0.784	0.845	0.873	0.880	0.530	0.604	0.574	0.483

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 (%).