Relationship Between Stock Market and Macroeconomic Variables Using Panel Data with Structural Breaks: ASEAN-5 Countries

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Abstract

This study looks at the ASEAN-5 countries and investigates how structural changes affect the relationship between the stock market index and selected macroeconomic variables (interest rate, exchange rate, and industrial production index) using panel data analysis from January 2012 to December 2022. Applying the panel date regression techniques, the results show that before the structural break period, the random effect model (REM) is appropriate for the estimate model. The stock market index is significantly affected by the interest rate and industrial production index, but the exchange rate is found to be insignificant. After structural break, a fixed effect model (FEM) is appropriate where all significant and only the exchange rate is found to be negative. The findings of this paper also conclude that the industrial production index has a greater effect on both the model before and after a break and is positively related to the stock market index. In this case, there is a need for amendments in monetary policy to ensure that the industrial production index is set at a high level, since the results would be able to boost the stock market in the selected ASEAN-5 countries.

Keywords: structural break, panel data model, stock market index, COVID-19, ASEAN-5

1. Introduction

Stock is highly responsive to economic situations. The link between macroeconomic conditions and stock returns has been a highly discussed issue in finance due to the potential detrimental impact of significant fluctuations in stock prices on the economy (Fama & French, 2004). Stock markets generally promote economic growth by increasing liquidity and supplying capital for industrialisation and economic progress. They also serve as intriguing investment hubs. Stock price fluctuations are inherently unpredictable, and prices quickly adapt to economic updates, including news about local and global disruptions. Stock market investors' daily profits and losses reflect how individual stock returns change due to unexpected occurrences. Supply and demand are the main factors affecting stock prices. Increased demand for a specific stock will cause its price to rise. A decrease in investor confidence in a certain stock led to a capital outflow as investors sell the shares, resulting in less demand and a lower stock price. Ultimately, the stock market fluctuates due to several variables, and there is no foolproof approach to predicting its precise fluctuations. Stock market influences can be categorised as systematic risk and unsystematic risk. The connections between macroeconomic factors and stock market fluctuations have been well-researched, particularly in developed and developing nations.

The stock market's attention was not only restricted to policymakers and academics but also drew the interest of economists and financial investors due to the link between macroeconomic factors and the stock market for three specific reasons. Initially, policymakers could anticipate the complete impact of existing and future policies and laws. Secondly, investors may make better decisions by fully comprehending this relationship, reducing their risk exposure. Furthermore, informing the public about potential economic or financial market developments might mitigate the element of surprise, enabling individuals to implement precautionary actions (Abu-Libdeh & Harasheh, 2011). Nevertheless, the focus was mostly on industrialised nations, with only a small number of studies exploring this connection in underdeveloped countries (Ali, 2011). In established nations, the correlation between the stock market and macroeconomic indicators may vary compared to emerging economies. The study aims to investigate the link between exchange rates, interest rates, the industrial production index, and the stock market in ASEAN-5 countries: Malaysia, Indonesia, Singapore, Thailand, and the Philippines. The most dependable macroeconomic indicators for explaining stock market movements are these three variables (Barakat *et al*., 2016; Gay, 2016; Celebi & Hönig, 2019; Mayur & Saravanan, 2017).

The ASEAN-5 nations were chosen for examination due to their similarities in location, circumstances, and the fact that their market indexes began simultaneously. Furthermore, ASEAN-5 nations experienced a revolution simultaneously. ASEAN-5 nations require a robust financial system, including a well-functioning stock market, to develop strong economies. This research will investigate the correlation between macroeconomic indicators and the stock market. Understanding the stock market's behavior can help corporations operate more effectively. Governments can stabilise the stock market and the economy by understanding the nature of this link, which can attract more investors and enterprises and help manage economic downturns. Furthermore, it will be the initial move to ease the transition to a more robust economy.

Figure 1 illustrates the stock market index trends for five ASEAN countries between January 2012 and December 2022. The trends differ significantly across countries. Malaysia and Singapore show almost identical and relatively flat trajectories, with their indices remaining stable around the 100-mark throughout the period, indicating minimal growth. Indonesia, on the other hand, experienced a consistent upward trend, with its index more than doubling from 120 to around 250 by the end of 2022, reflecting the strongest growth among the five countries. The Philippines saw rapid growth until early 2018, reaching a peak of over 250, but this was followed by a sharp decline due to external shocks like the U.S. market crash and COVID-19. Although it began to recover post-pandemic, the index did not regain previous highs. Thailand exhibited moderate growth, with its index rising from 100 to 160 by the end of the period, though it experienced notable dips in 2018 and 2020. Overall, Indonesia and the Philippines showed the most significant growth, though the Philippines' trend was more volatile, while Malaysia and Singapore displayed the least growth with almost no volatility. Thailand fell between these extremes, with moderate gains and some fluctuations.

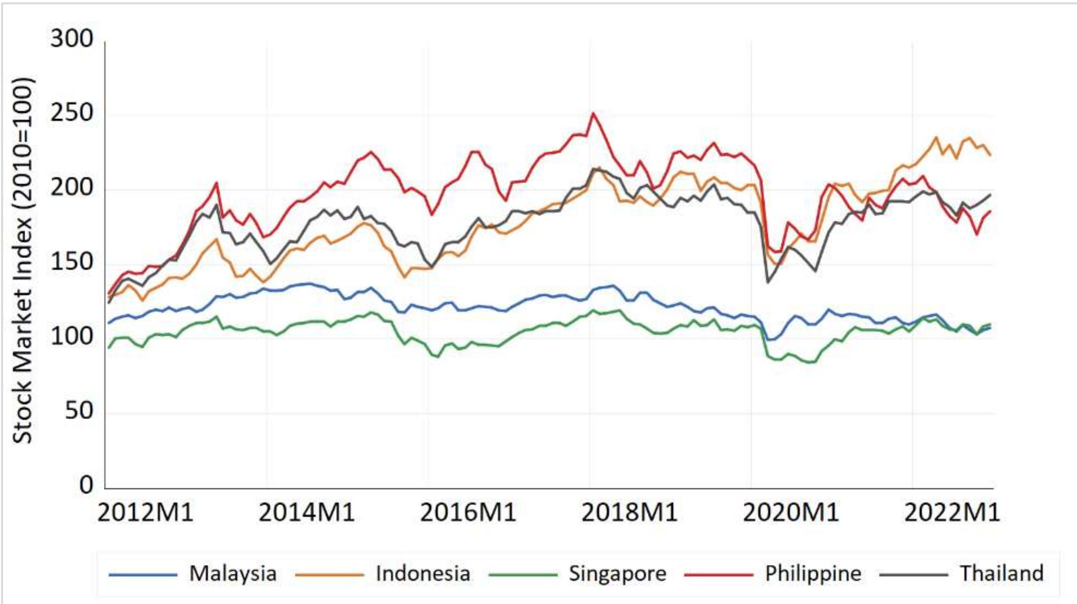

Figure 1: ASEAN-5 Stock Market Indices

When examining the stock markets in the ASEAN-5, it is important to consider the potential occurrence of a structural break in our data. Addressing structural breakdowns is a crucial aspect of nearly all empirical economic studies. This is especially true for panel data made up of a variety of cross-sectional units, such as people, companies, or countries, all of which are subject to major economic events. If not addressed, existing breaks may result in missing variables, causing contradictory estimations of the model's slope coefficients. It is crucial to determine the occurrence of structural fractures and their timing. Such knowledge is typically not readily accessible and must be deduced from the existing data. We need to determine the presence of breaks and, if they exist, identify both the dates of the breaks and the slope coefficients relevant to each regime. Many papers have overlooked the impact of structural breaks. To get around this problem, some decide to divide the sample into two subsamples on either side of a possible break point. This technique was used to analyse twelve Asia-Pacific stock markets (Sheng & Tu, 2000). Prior to 1997, no lasting ties were found, but during and following the crisis, there was a noticeable degree of integration. There could be differences in the results of a structural rupture before and after a crisis (Mueller, 2019). In light of the potential for structural disruptions in the markets, this article seeks to improve earlier studies on the degree of market integration in the ASEAN-5 and assesses how diversification can help investors reduce risk.

This work's subsequent section is organised as follows: The second section offers a summary of studies that investigate the relationship between macroeconomic variables and the stock market. The research variables, technique, hypothesis, and research strategy are described in section three. The article's findings are presented in Section Four, and suggestions for more research are summarised and presented in Section Five.

2. Literature Review

The interest rate can influence the stock market, but it does not have the power to dictate its movements (Kadir *et al.,* 2011). Higher interest rates will make borrowing more challenging. The company's ability to develop its operations will be limited due to decreased funds, resulting in a negative impact on profits. Bonuses and dividends will be reduced, impacting investors in the long run. Subsequently, the stock market will lose its appeal as an investment vehicle. The interest rate is not the sole factor influencing the stock market. Other variables such as economic development, political difficulties, and monetary policies might cause the stock market index to trend upward, even in the presence of a high interest rate.

The Malaysian stock market return is inversely correlated with interest rates, as indicated by several studies (Vejzagic & Zarafat, 2013; Heng & Niblock, 2014; Vaz *et al.,* 2008). This outcome is in line with a Chinese study, which also found a similar effect when they examined how China stock returns react to changes in the official interest rate under several economic scenarios (bull, medium, and bear) (Vejzagic & Zarafat, 2013). According to their research, bear markets are more severely impacted negatively by changes in the official interest rate than are the other two market scenarios. Furthermore, in contrast to moderate markets, the stock market typically responds to these developments more forcefully during bull markets.

The stock market is impacted by interest rates in two primary ways (Ferre *et al*., 2016). Changes in interest rates impact the discount rate utilised in contemporary valuation methods. Subsequently, it changes the borrowing costs, impacting the expected cash flow of a company. On the contrary, any statistically significant changes in returns in the days leading up to and following the announcement of interest rate changes (Yakob *et al*., 2014). This is consistent with research by Bernanke and Kuttner (2005) who found that the stock market only responds to news that is unexpected.

The relationship between exchange rates and stock market indices in ASEAN-5 countries has been a subject of interest, particularly during the COVID-19 pandemic. Studies such as Arisandhi and Robiyanto (2022) and Hamil *et al*., (2023) have delved into the dynamic correlation of exchange rates and stock prices in the ASEAN-5 region during the pandemic, shedding light on the impact of external factors like the pandemic on financial markets. Additionally, Liang *et al.* (2015) emphasized the importance of monitoring the linkages between stock prices and exchange rates in ASEAN-5 countries for policymakers and investors to make informed decisions. Furthermore, researchers like Robiyanto (2018) and Qizam *et al.* (2020) have examined the integration of capital markets within the ASEAN-5 countries, highlighting the interconnectedness of these markets despite external shocks like the global financial crisis. These studies provide insights into the strengths and vulnerabilities of Islamic capital markets within the ASEAN-5 region. Additionally, Prowanta *et al.* (2017) investigated the influence of macroeconomic variables on stock price indices in ASEAN-5 countries, illuminating how variables like GDP, inflation, interest rates, and exchange rates affect stock market movements. Understanding these relationships is crucial for comprehensively analysing stock market behaviors in the region.

A certain amount of study has been done to evaluate the correlation between a few macroeconomic indicators and the stock market index. Table 1 enumerates relevant research along with the name of the author, the year the study was published, the period it covered, the proxies used to measure the macroeconomic variables included in the stock market index, and the anticipated impact of each study. Conversely, the industrial output index exhibits a positive impact on the stock market index, while most interest rates have a negative or negligible impact. The exchange rate, on the other hand, has a maximum impact that can even be positive.

3. Methodology Design

The proper analysis procedure to ascertain the correlation between the stock market index and specific macroeconomic variables is covered in this section. The sequential steps in panel data analysis are shown in Figure 2. The first step is to define the panel data specification, which is necessary in order to perform tests for cointegration and unit root. The objective is to ascertain if the panel data model's slope coefficients are homogenous or heterogeneous, as well as whether cross-sectional dependence exists in the data. The study then proceeds to the second phase, which involves determining if the variables under investigation have a unit root. Using the first stage results as a foundation, a suitable panel unit root test process is used to assess the level of variable integration. In this step, any possible structural fractures in the panel data are considered. Examining if a long-term relationship exists between the variables in the relationship model is the goal of the third phase. A suitable panel cointegration test is selected to investigate the cointegration connection, making use of the data gathered in the first phase. The modelling process now moves on to the fourth step, which is locating and fixing structural flaws in the model. Structural interruptions in panel data analysis can be caused by a variety of events, including economic crises, recessions, natural disasters, and political changes. In panel data analysis, there are two main methods that are frequently used to model structural fractures. The first method assumes abrupt structural changes and splits the data into many regime models. Conversely, the second method uses a panel data regression estimation model. Each of these steps in the panel data analysis process will have thorough methodological and technical explanations given in the sections that follow.

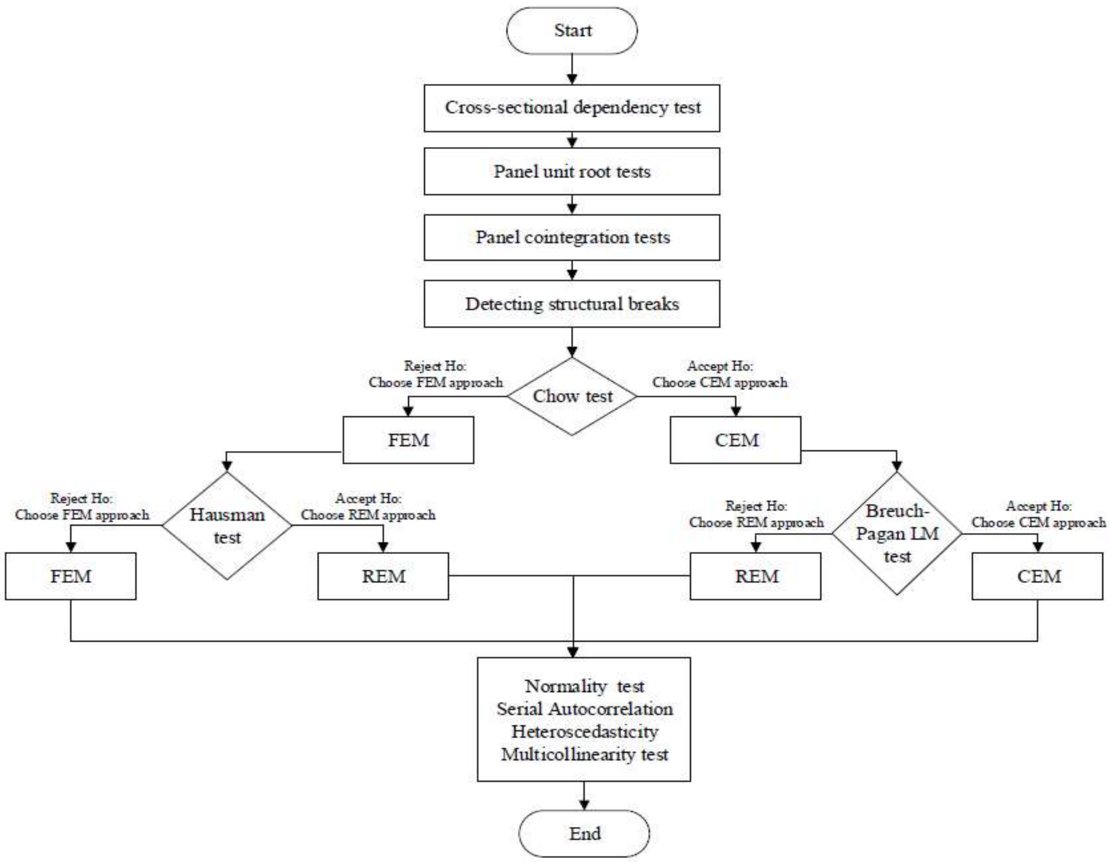

Figure 2: Methodology Design

3.1 Identifying the characteristics of panel data

This study's initial effort is to examine a panel dataset and comprehend its features, with an emphasis on slope homogeneity and cross-sectional dependence (Yerdelen & Gul, 2020). With this knowledge, we will be able to select the proper panel unit root tests, panel cointegration tests, and the crucial panel data estimator for the next phases of the analysis. Using the CD test, which Pesaran (2021) devised, the dependence relationship between the cross-sections in the panel data is examined. When determining the correlation factors, the mean values are not considered. The test's null hypothesis is that the data show no evidence of cross-section dependence. The following is how the CD test is shown:

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{y}_{ij}\right) \qquad CD = 1, 2, 3, \dots, N \tag{1}$$

Here, $\hat{y}_{ij}$ is the residual pairwise correlation coefficient of the OLS residuals.

The slope homogeneity test, as suggested by Pesaran and Yamagata (2008) is used in this investigation. The homogeneity of the slope coefficients of the cointegration equation across cross-sections can be ascertained by applying the slope homogeneity test, which was devised by Swamy in 1970. Swamy's slope homogeneity test was improved upon by Pesaran and Yamagata (2008), who created the following two test statistics:

$$\tilde{\Delta} = \sqrt{N}\left(\frac{N^{-1}\bar{S} - k}{\sqrt{2k}}\right) \quad (2)$$

$$\tilde{\Delta}_{adj} = \sqrt{N}\,\frac{1}{\sqrt{\frac{2k(T-k-1)}{T+1}}}\left(N^{-1}\bar{S} - k\right) \quad (3)$$

where k stands for the independent variables, S for the Swamy's test statistic, and N for the total number of cross-sections. Atasoy (2017) claims that because this test prevents the CD, it is superior to other conventional homogeneity tests such as the SURE form, which seems to have nothing to do with the regression equation.

3.2 Panel unit root tests

Panel unit root tests are more common than ordinary unit root tests on individual time series among academics who analyst panel data because of their higher statistical power. There are two generations of unit root tests in the literature on non-stationary panels. The cross-sectional units are assumed to be independent in the tests from the first generation. The LLC (2002), IPS (2003), MW (2012), CH (2002), and Hadri (2000) had stationarity panel unit tests are a few of these tests. When correlation exists between the panel units, as in the case of regional data, these tests are hampered by substantial size distortion and restricted power. In order to account for cross-sectional dependence, the second-generation tests loosen the assumption of independence. The cross-sectionally augmented IPS (CIPS) test developed by Pesaran (2007) is added to the unit root test in order to address any cross-section dependence.

According to Nelson and Plosser (1982), a unit root exists for practically all macroeconomic time series that are commonly used. Certain characteristics of the underlying data-generating mechanism of a series can be identified based on the existence or lack of unit roots. The series oscillates around a stable long-run mean when there is no unit root (stationary), suggesting that the series has a finite variance that is independent of time. Conversely, non-stationary series have a time-dependent variance and do not exhibit a tendency to revert to a long-run deterministic path. Random shocks have long-term consequences on non-stationary series.

3.3 Panel cointegration tests

The panel's cross-section dependence is not assumed by the first-generation cointegration tests. A Fisher-type test utilising the underlying Johansen methodology, Pedroni (1999), Pedroni (2004), and Kao (1999) are often employed tests to determine whether panel cointegration exists. These tests, however, are predicated on the notion of cross-sectional independence. Pedroni (1999) suggests using three groups of mean tests and four pooled tests to evaluate the stationarity of the error term, considering the small sample qualities of the data. For these seven tests, the null hypothesis is that there is no cointegration in any of the nations. The group mean tests show that a sizable portion of the countries show cointegration if the null hypothesis is rejected. Conversely, if the pooled tests show that the null hypothesis is false, then all the countries must be cointegrated. Developed by Westerlund (2007), the second-generation cointegration test is resistant to serial correlation, heteroscedasticity, and cross-section dependence. Determine whether the error-correction term in a conditional panel error-correction model equals zero to support the null hypothesis of no cointegration. All the new tests have a normal distribution and are sufficiently general to consider cross-sectional dependencies, unit-specific trend and slope parameters, and short-run dynamics peculiar to a given unit.

3.4 Structural break analysis

New tests were provided by Ditzen *et al.* (2021) to identify common structural breaks in panel data models. Their test can be applied to panel data even when the model errors are heteroskedastic and dependent on time as well as cross-sectional units. It is assumed that cross-sectional dependency has a strong kind of reliance due to an interaction impact or shared factor structure. The model that was taken into consideration had N units, T periods, and s structural breaks.

$$y_{i,t} = \alpha + \beta x'_{i,t} + \delta_j w'_{i,t} + e_{i,t} \quad (4)$$

For N= 1, this is a time series model, while for N> 1, it is a panel data model. The regime-wise of the structural break for Equation (5) can be written as Equation (6):

$$y_{i,t} = \beta x'_{i,t} + \delta_1 w'_{i,t} + e_{i,t} \text{ for } t = T_0, \dots, T_1 \quad (5)$$
$$y_{i,t} = \beta x'_{i,t} + \delta_2 w'_{i,t} + e_{i,t} \text{ for } t = T_1, \dots, T_2$$
$$\vdots$$
$$y_{i,t} = \beta x'_{i,t} + \delta_{s+1} w'_{i,t} + e_{i,t} \text{ for } t = T_s, \dots, T_{s+1} \quad (6)$$

where $T_1, \dots, T_s$ are the dates of the s structural breaks and additionally define $T_0 = 0$ and $T_{s+1} = T$ (Dizten *et al.*, 2021). The coefficients of $x_{i,t}$ are unaffected by the breaks, while those of $w_{i,t}$ are affected by the breaks. It is possible that all coefficients break, in which case $\beta x'_{i,t}$ is defined to be zero. The break dates are common for all units. This is very common assumption that is reasonable in settings where the frequency of the data is not high. It is also possible that different coefficients break at different times by allowing subsets of δ_j to remain constant across regimes and assume that β and δ_1, ..., δ_{s+1} are equal across the cross-section. Pesaran (2006) assume that the coefficients are random but with common means. If each series has its own breakpoints, estimating the mean of the individual breakpoints. The implementation of xtbreak model and stability tests by Dizten *et al.,* (2021) involves two processes. First, to test for the presence of breaks, and, if breaks are detected, to estimate the location of the breaks and construct confidence intervals for the true breakpoints. Second, the parameters are estimated before and after the potential break with utilize the ordinary least squares estimation method. In this paper, a sequential test procedure is used which H_0: no breaks versus H_1: s breaks.

3.5 Panel regression analysis

3.5.1 Common Effect Model

The common-effect model (CEM), also known as pooled least square, is the simplest approach. The assumption contained in this model is that there is no correlation between the regressors and the disturbance or error term (Gujarati & Porter, 2009). The coefficient is constant for both cross-sectional and time periods. The Ordinary Least Square (OLS) method is used to estimate parameters in the CEM method. The following is the regression equation that may be expressed using the CEM approach:

$$Y_{it} = \alpha + \beta_1 X_{it} + \beta_2 X_{it} + \cdots + \beta_k X_{it} + \varepsilon_{it} \quad (7)$$

3.5.2 Fixed Effect Model

In the fixed effect model (FEM), the intercept in the regression model is allowed to differ among individuals in recognition of the fact that each individual, or cross-sectional, unit may have some special characteristics of its own (Gujarati & Porter, 2009). The one-way fixed effect model postulates that time-invariant characteristics are distinct to each individual entity and are anticipated to exhibit no correlation with other individual attributes. Given the inherent variability among entities (countries), it is imperative that the error term and the constant, which encapsulate individual-specific traits, remain uncorrelated with those of other entities. Although the one-way fixed effects model accommodates covariance with unmeasured between-unit effects, it operates under the assumption of the absence of unobserved time heterogeneity (Halaby, 2004; Morgan & Winship, 2007; Wooldridge, 2010). This foundational premise is compromised when an unmeasured period effect influences temporal trends across all units. The one-way FEM model equation in this paper is written as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 X_{it} + \cdots + \beta_k X_{it} + \varepsilon_{it} \quad (8)$$

3.5.3 Random Effect Model

An alternative to FEM is the random effects model (REM). In REM, it is assumed that the intercept of an individual unit is a random drawing from a much larger population with a constant mean value (Gujarati & Porter, 2009). The individual intercept is expressed as a deviation from this constant mean value. REM is economical in degrees of freedom because no estimation of N cross-sectional intercepts is needed, just to estimate the mean value of the intercepts and their variance. REM is appropriate in situations where the random intercept of each cross-sectional unit is uncorrelated with the regressors. A one-way individual-specific random effects model is also known as a random constant term (Greene, 2003). One way to handle the ignorance or error is to assume that the intercept is a random outcome variable. The composite error term ε_{it} consists of two components, μ_i, which is the cross-section, or individual specific, error component, and v_{it}, which is the combined time series and cross-section error component and is sometimes call the idiosyncratic term because it varies over cross-section (in this study is country) as well as time (Gujarati & Porter, 2009). The ε_{it} is not correlated with any of the explanatory variables included in the model. The one-way REM model equation in this paper is written as follows:

$$Y_{it} = \alpha + \beta_1 X_{it} + \beta_2 X_{it} + \cdots + \beta_k X_{it} + \varepsilon_{it} + \mu_i \quad (9)$$

where μ_i is the error component of the cross-section data. To estimate the random effects model parameters can use Generalized Least Squares (GLS).

3.5.4 Model Selection
3.5.4.1 Chow Test

The Common Effect Model and the Fixed Effect Model are the two models that are chosen using the Chow test. The following equation represents the Chow test statistics:

$$F = \frac{(RRSS - URSS)/(N-1)}{URSS\ /(NT - N - k)} \quad (10)$$

RRSS is the restricted residual sums of squares, URSS is the unrestricted residual sums of squares, N is the number of individuals, NT is the number of multiplications of the time series by cross section, and k represents the number of independent variables. The hypothesis used is:

H_0 : $\alpha_1 = \alpha_2 = \cdots = \alpha_n = 0$ (indicates that CEM is appropriate)
H_1 : $\alpha_1 \neq 0; i = 1,2,\ldots,n$ (indicates that FEM is appropriate)

At a usual significance level of 5%, the null hypothesis is rejected when the probability value is less than 0.05.

3.5.4.2 Hausman Test

After completing the Chow test, this test is meant to determine which FEM model or REM model is the best suitable. The test results are as follows:

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})'\left[Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE})\right]^{-1}(\hat{\beta}_{FE} - R_{RE}) \sim \chi_k^2 \quad (11)$$

where, $\hat{\beta}_{FE}$ vectors of the estimated FEM parameters, $\hat{\beta}_{RE}$ is vectors of the estimated REM parameters, $Var(\hat{\beta}_{FE})$ is variance of the estimated FEM parameters, $Var(\hat{\beta}_{RE})$ is variance of the estimated REM parameters, χ_k^2 is chi-square distribution with k degrees of freedom, and k is numbers of factors or degrees of freedom. Reject the null hypothesis if the calculated Hausman statistic exceeds the critical value for (χ_k^2), indicating that the fixed effect model is more appropriate. If the estimated Hausman statistic is smaller than the crucial value of (χ_k^2), then H_0 cannot be rejected, indicating that the random effect model is more appropriate. The hypothesis used is:

H_0 : $Cov\ (\mu_i, x_{it}) = 0$ (indicates that REM is appropriate)

H_1 : $Cov\ (\mu_i, x_{it}) \neq 0$ (indicates that FEM is appropriate)

4. Results and Discussion

The methodical analyses align with the analytical flow depicted in Figure 2. Every analysis that has been done has been done so with reference to the goal, which is to look at how certain macroeconomic variables affect the stock market index and to see if there has been a structural break during the study's duration. Considering the correlation between a few chosen macroeconomic factors and the stock market index, the econometric model is constructed as follows:

$$lnSMI_{it} = \beta_0 + \beta_1 lnINT_{it} + \beta_2 lnEXR_{it} + \beta_3 lnIPI_{it} + \varepsilon_{it} \quad (12)$$

SMI is stock market index (2010=100), INT is interest rate (in %), EXR is the exchange rate, based on currency Against US Dollar, and IPI is industrial production index (in 2010=100), with the subscript *i* denoting each of the ASEAN-5 countries and *t* denoting time. The variables are all expressed in logarithmic form, which is represented by the ln acronym. This analysis uses monthly panel data from 2012 to 2022. The information came from the database of Euromonitor International.

The descriptive statistics (overall, between, and within) calculated for the variables used in this paper are summarised in Table 2. The dependent variable, stock market index (SMI), shows that the overall average in ASEAN-5 countries is increased by 56% relative to its value in 2010, with a minimum has decreased by 15.9% relative to its value in 2010 and a maximum increased by 151.4% relative to its value in 2010. The overall mean interest rate (INT) is 3.61%, with a minimum of 0.19% and a maximum 9.64%. The mean overall of the exchange rate (EXR) is 2633.89, with a minimum of 1.22 USD Singapore and a maximum of 15867.43 Indonesian Rupiah (IDR). The industrial production index (IPI), the overall mean has increased by 23.22% relative to its value in 2010, with a minimum value has decreased by 73.6% relative to its value in 2010 and a maximum has increased by 97.50% relative to its value in 2010.

Table 1: Panel Summary Statistics of Variables

Variable	Statistics	Mean	Std. dev.	Min	Max	Observations
SMI	overall	156.00	41.04	84.10	251.40	N = 660
	between		40.28	105.12	197.40	n = 5
	within		19.61	89.29	212.85	T = 132
INT	overall	3.61	2.06	0.19	9.64	N = 660
	between		2.08	2.01	7.17	n = 5
	within		0.89	1.27	7.62	T = 132
EXR	overall	2633.89	5287.06	1.22	15867.43	N = 660
	between		5841.47	1.34	13083.37	n = 5
	within		783.15	-1424.19	5417.95	T = 132
IPI	overall	123.22	24.54	26.40	197.50	N = 660
	between		17.76	92.16	136.37	n = 5
	within		18.69	13.26	184.36	T = 132

Notes: Descriptive statistics is calculated form level (original)

4.1 Panel Specification Test

First, the degree of slope homogeneity and cross-sectional dependence in the panel data are examined. Table 3 reports the results of the slope homogeneity test and the panel cross-sectional dependence test. Cross-sectional dependence (CD) is investigated using the Pesaran (2021) CD test. For every variable, the cross-sectional independent null hypothesis is rejected. Thus, it may be inferred that the variables lnSMI, lnINT, lnEXR, and lnIPI exhibit cross-sectional dependence. Furthermore, as can be shown in Table 3, the $\tilde{\Delta}_{CSA}$ slope homogeneity test by Bersvendsen and Ditzen (2020) is a strong variant of the $\tilde{\Delta}$ test by Pesaran and Yamagata (2008), and it accounts for the presence of autocorrelation, heteroskedasticity, and cross-sectional dependency in the model. Based on the obtained values of $\tilde{\Delta}_{CSA}$ and $\tilde{\Delta}_{CSA-adj}$, the null hypothesis that the slope coefficients are homogenous at the 5% significance level is not rejected (p-value > 0.05). Thus, it can be said that the panel has heterogeneous slopes and cross-sectional dependencies.

Table 2: Panel Specification Tests Results

Cross-sectional dependence tests				
Variables	lnSMI	lnINT	lnEXR	lnIPI
CD	17.34**	13.41**	25.75**	15.92**
Slope homogeneity tests				
Test	Statistics		p-value	
$\tilde{\Delta}_{CSA}$	47.086**		<0.001	
$\tilde{\Delta}_{CSA-adj}$	48.004**		<0.001	

Note: *indicates a 10% significance level and ** indicates a 5% significance level.

4.2 Panel Unit Root Test Results

Prior to estimating the regression analysis, the stationarity of the variables is verified using the panel unit root test. A false regression problem may arise from a series that is deemed nonstationary, meaning that its variance and mean do not remain constant over time. To make sure the results are reliable and prevent this problem, several unit root tests are employed. This work employs the second-generation panel unit root test, the CADF and CIPS test of Pesaran (2007), because CD is present in our models (see Table 4). At the 1% level of significance at the first difference, the outcome is insufficient to reject the unit root (non-stationary) null hypothesis for any of the variables. All measures are integrated of order one I (1), as all variables are highly statistically significant at the first difference. As a result, the model might predict that these factors together have a long-term relationship.

Table 3: Second-Generation Panel Unit Root Test Panel

Variable	Level		First Difference		Decision
	Constant	Constant & Trend	Constant	Constant & Trend	
CADF test results					
lnSMI	-1.132	-2.387	-3.786**	-4.212**	I (1)
lnINT	-1.332	-2.237	-3.616**	-3.693**	I (1)
lnEXR	-2.301	-2.181	-3.085**	-3.162**	I (1)
lnIPI	-0.873	-2.389	-3.545**	-3.513**	I (1)
CIPS test results					
lnSMI	-1.628	-2.929**	-6.190**	-6.420**	I (1)
lnINT	-1.567	-2.167	-6.190**	-6.420**	I (1)
lnEXR	-2.509**	-2.45	-6.190**	-6.420**	I (1)
lnIPI	-0.655	-2.322	-5.148**	-5.245**	I (1)

Note: *indicates a 10% significance level and ** indicates a 5% significance level.

4.3 Panel Cointegration Test Results

Panel cointegration tests are employed in this section's study. First, the panel cointegration test of Westerlund (2007) is computed as the benchmark, assuming cross-section dependence. Table 3 demonstrates the cross-section dependence, heteroscedasticity, and serial correlation that this cointegration test is resistant to. The next stage is to determine whether there is a long-term link between the variables after the order of integration has been established. The panel cointegration test results from Westerlund (2007) are displayed in Table 5. The test statistics support the null hypothesis and show that there is no cointegration. We can therefore conclude that there are short-term relationships between these variables. In the model, the error correction parameter (α′) is computed as -0.095. This indicates that there is a variable of 9.5% inaccuracy between the stock market index and its determinants. Therefore, any long-term disequilibrium is expected to be remedied soon. The subsequent phases will identify the important structural breaks for the short-run relationship model.

Table 4: ECM panel cointegration test: Westerlund (2007)

Statistic	Value	Z-value	P-value
Gt	-2.142	1.442	0.925
Ga	-10.268	1.463	0.928
Pt	-5.116	0.417	0.662
Pa	-12.544	0.111	0.456

4.4 Detection Structural Break

The Bai and Perron (2003) and Ditzen *et al.* (2021) methodology is used to test all the series for structural breaks while keeping in mind the unit root features of the series. We start by testing the null of no breaks against to test the alternative up to 5 breaks. Bai and Perron (2003) recommend to always test this hypothesis before applying estimating the number of breaks using the sequential test. The null hypothesis could have up to five breaks according to the UDmax statistics. It is not possible to have more than five breaks because doing so would violate the trimming parameter's minimum segment size specification. Put otherwise, if more than five breaks were permitted, the resulting section would be too small for the existing technique. The outcomes are displayed in Table 6. There is evidence of up to five breaks if the test is rejected at the 1%, 5%, and 10% levels. Subsequently, we examine the hypothesis of no break versus 1 break, which is the primary goal of this investigation to determine whether breaks occur during the panel data's time span. In light of the undetermined break dates, the sup Wald test statistic is applied. Table 6 shows that at all levels (1%, 5%, and 10%), the null of no breaks may be rejected.

Table 5: Sequential Test Results

Test	Test Statistics	Bai & Perron Critical Values		
		1%	5%	10%
Udmax(tau)	19.91	6.09	4.74	4.13
supW(tau)	19.91	6.09	4.66	4.03

With 1 break under the alternative, which we take as evidence in support that there are structural breaks in the study and proceed to estimate the locations. Table 7 shows the results. The estimated breaks take place in November 2018. The confidence intervals for the breaks are narrow.

Table 6: Estimation of break points

Test Hypothesis F(s+1, s)	Statistics	Break Dates	[95% Conf. Interval]	
F(1, 0)	19.91***	2018m11	2018m10	2018m12

Note: *indicates a 10% significance level and ** indicates a 5% significance level.

4.5 Result of Panel Regression Analysis

Since there exists at least 1 break (November 2018) in the relationship between stock market index and the selected macroeconomic variable, then the overall data was split into two. The first of the data to find the appropriate model to estimate panel data is from January 2012 to November 2018 and the second part is from December 2018 to December 2022. Testing to identify the best approach method is the first stage in developing a panel data regression model. Tables 8 and 9 display the outcomes of the Chow and Hausman tests that were previously discussed. Tables 10 and 11 present the estimation findings.

Table 7: Selection Results of Panel Data Model (2012m1–2018m11)

Test Statistics	Statistic	Criterion
Chow Test	693.7641**	Reject H_0: implies that FEM is appropriate model
Hausman Test	6.6500*	Accept H_0: implies that REM is appropriate model

Note: *indicates a 10% significance level and ** indicates a 5% significance level.

Table 8: Selection Results of Panel Data Model (2018m12–2022m12)

Test Statistics	Statistic	Criterion
Chow Test	437.2610**	Reject H_0: implies that FEM is appropriate model
Hausman Test	36.2406**	Reject H_0: implies that FEM is appropriate model

Note: ** indicates a 5% significance level.

Table 9: Panel Estimation Results of REM model (2012m1–2018m11)

Variable	Constant	lnINT	lnIPI	lnEXR
lnSMI	1.2715**	-0.0365**	0.8039**	-0.0147
Adjusted R-squared		0.419516		
F-statistic		100.7327		
Standard error		0.083855		

Note: ** indicates a 5% significance level.

The suitable REM model was chosen based on the outcomes of the Chow and Hausman tests. The model is

$$\widehat{lnSMI}_{it} = 1.2715 - 0.0365lnINT_{it} + 0.8039lnIPI_{it} - 0.0147\, lnEXR_{it} \tag{13}$$

The resulting model shows that a change in interest rate (INT) of one percent will reduce the stock market index (SMI) by 0.0365 percent. Every change in the industrial production index (IPI) of one percent will increase the stock market index (SMI) by 0.8039 percent. For change in exchange rate (EXR) by one percent will reduce the stock market index (SMI) in 0.0147 percent.

Table 10: Panel Estimation Results of FEM model (2018m12–2022m12)

Variable	Constant	lnINT	lnIPI	lnEXR
lnSMI	7.1936**	0.1433**	0.1113**	-0.7614**
Adjusted R-squared		0.9334		
F-statistic		489.9654		
Standard error		0.0780		

Note: ** indicates a 5% significance level.

Based on the results of the analysis in Table 11, it can be concluded that the panel data regression model with Fixed Effect Model approach can explain the effect of predictor variables on the response variable. Therefore, the model equation is:

$$\widehat{lnSMI}_{it} = 7.1936_i + 0.1433lnINT_{it} + 0.1113lnIPI_{it} - 0.7614\, lnEXR_{it} \tag{14}$$

From Equation 15 above, the value of R2 = 0.9334 shows that the percentage of all three predictor variables can affect the number of stock market indexes (SMI) by 93.34%, while the other 6.66% are influenced by other variables outside of this study. All three variables significantly influence the increase in the number of SMI. The change in interest rate (INT) of one percent will change the stock market index (SMI) by 0.1433 percent. Every change in the industrial production index (IPI) of one percent will change the stock market index (SMI) by 0.1113 percent. A change in the exchange rate (EXR) of one percent will reduce the stock market index (SMI) by 0.7614 percent.

After obtaining the appropriate model in this study, which is the REM for Panel Model A, and FEM for Panel Model B—a series of diagnostic tests was conducted, addressing multicollinearity, heteroscedasticity, and serial correlation to ensure the validity and robustness of the estimated models. First, the Variance Inflation Factor (VIF) and tolerance values were used to test for multicollinearity across both panel models. The results indicated no serious multicollinearity issues in Panel A and Panel B as all VIF values were below 5. Next, the Modified Wald Test was applied to detect heteroscedasticity. Panel A and B exhibited no signs of heteroscedasticity. Finally, the Wooldridge Test was used to test for serial correlation (autocorrelation) in all models. The test results were insignificant for both panel models, confirming no serial correlation. The model assumptions are satisfied, meaning that the regression estimates are unbiased, consistent, and efficient. Therefore, the regression models are valid and suitable for interpreting the relationships between the macroeconomic variables and the stock market indices. These results can be confidently used to draw conclusions and make inferences regarding the research questions.

5. Conclusion

For the panel data covering the period from January 2012 to December 2022, the study examined the effects of interest rates, currency rates, and the industrial production index on the stock market index in ASEAN-5 with unknown structural breaks. The panel data regression approach has been utilised to assess the effects of macroeconomic variables on the stock market index. The order of integration of the variables has been tested using the panel unit root test and the xtbreak structural break by Ditzen *et al.* (2021) tests. According to our findings, the variables were stationary following the initial differencing but non-stationary at other levels. The cointegration results verified that there was cointegration between the variables. However, our main concern from this analysis is the potential break that may occur during the period under investigation. The structural break (November 2018) showed a significant positive impact on the ASEAN-5 stock market index. This indicated that the ASEAN-5 stock market index responded to the US-China Trade War led by the US, where the United States imposed tariffs on $200 billion worth of Chinese goods, initially set at a rate of 10%. China responded with tariffs on $60 billion worth of US goods in September 2018. The escalating trade tensions between the United States and China had significant implications for global trade and economic growth. As major trading partners and export-oriented economies, the ASEAN-5 countries were not immune to the effects of tariffs and trade restrictions imposed by the two largest economies in the world.

However, when the data is separated into two periods, different results appear, which must be paid attention to. For the first period, which is before the strquctural break, the model that is appropriate to estimate the relationship between the stock market index and interest rate, exchange rate, and industrial production index is the random effect model (REM). From here, we can see that the interest rate is negatively significant, while the industrial production index is positively significant, but the exchange rate is insignificant. In the second period, which is after the structural break, the fixed effect model is appropriate to use to estimate the relationship between the stock market index and selected macroeconomic variables. The interest rate and industrial production index have a positive and significant impact on the stock market index, while the exchange rate is negatively significant.

Recommendations for further research to address the study's limitations. Expanding the research term and including other additional elements might enhance the study's outcomes. The analysis may be expanded by including additional macroeconomic drivers such as the consumer price index, bank credit, and crude palm oil price.

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