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The impact of inflation on economic growth

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Abstract

This study investigated the correlation between inflation and economic growth in ASEAN-5 countries from 1990 to 2020. The main objective of this study is to explore the causal connection between inflation and economic growth. The results demonstrate variations in the relationship between economic growth and inflation in these countries. Of the five ASEAN countries, we found that inflation hurts economic growth in the Philippines and Indonesia, but not Singapore. This research revealed a stationary economic growth series in all countries except for the Philippines. The inflation rates were found to be stationary for all ASEAN-5 countries. Furthermore, Granger causality tests suggested either a feedback or one-way causal relationship between economic growth and inflation in all countries except Malaysia. Our panel estimation also provides interesting findings that complement time-series analysis. Our findings shed light on the complexities of the inflation-economic growth relationship within ASEAN-5 countries and contribute to a better understanding of their economic dynamics in the age of digitalisation.

Keywords:
inflation;
GDP;
economic growth;
ASEAN-5 countries

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1. Introduction

Inflation denotes a sustained increase in prices that results in a decrease in currency values. This phenomenon is characterised by a widespread and continuous rise in the price level of most goods and services over an extended period, rather than isolated price hikes in specific items. The Consumer Price Index (CPI) functions as a gauge for inflation, which often occurs when the expenses for labour and raw materials in production escalate (McKinsey & Company, 2022). According to the World Economic Outlook of the International Monetary Fund from October 2022, the global economy is undergoing an unforeseen decline accompanied by inflation rates that have reached heights unseen in many decades. Various factors, including challenges related to the cost of living, more restrictive financial conditions in numerous regions, Russia's incursion into Ukraine, and continued effects of the COVID-19 pandemic, have profoundly shaped economic forecasts. Global inflation is projected to escalate from 4.7 percent in 2021 to 8.8 percent in 2022, and then gradually recede to 6.5 percent in 2023 and 4.1 percent in 2024. These figures

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underscore the complex and volatile economic landscape that the world currently faces (Gourinchas, 2022).[1]

Global inflation saw atypical peaks in 1980 and 1990 but has since reached stability, averaging 3% to 5% annually (Khan & Senhadji, 2021). During the "Great Recession" of 2008, it touched 6.34% (Figure 1). After the recession, inflation remained stable until the onset of the COVID-19 pandemic in 2020, which led to a significant economic downturn and a drop in global inflation to 3.23%. It will later recover to 4.7% by 2021. Factors contributing to the new global recession include disruptions in supply chains, increases in oil and food prices, financial instability, and market uncertainty. The conflict between Russia and Ukraine further intensified inflation (see O'Neill, 2023), with the global rate projected to reach 8.75% in 2022, the highest since 1996.

The Association of Southeast Asian Nations (ASEAN)-5, which comprises Indonesia, Malaysia, the Philippines, Singapore, and Thailand, represents a diverse region with distinct economic traits. Given their global economic importance and interdependence within ASEAN-5 countries, understanding the relationship between inflation and economic growth in these countries is vital. Moderate inflation can be indicative of an expanding economy, encouraging investment and consumer spending (Bruno & Easterly, 1997). However, if inflation is too high, it can negatively impact economic growth by diminishing purchasing power and introducing market uncertainty. However, extremely low or negative inflation can suppress spending and investment, thereby slowing economic progress. The equilibrium between inflation and economic growth is vital for ASEAN-5 countries, as these emerging markets seek to achieve stability and growth simultaneously. The dynamics of this relationship can differ among individual nations and are influenced by variations in economic structure, fiscal governance, and monetary policy.

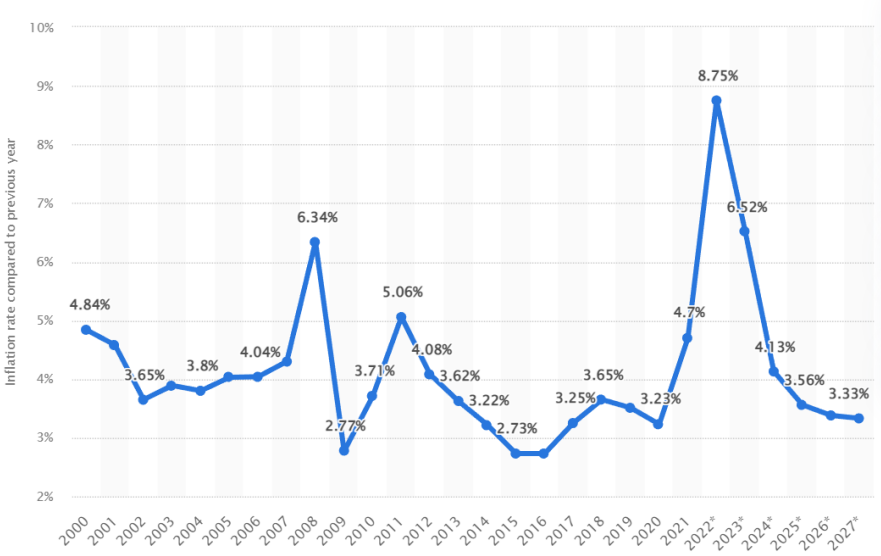

Figure 1: Global inflation rate from 2000 to 2021, with forecasts until 2027 from Statista

[1] The global economy suffered a significant blow in 2009 due to the Great Recession, marked by a considerable shrinkage in economic activity. This downturn originated in the financial crisis that erupted in August 2007, when a loss of confidence in mortgage assets triggered a liquidity crisis. Even with the extensive infusion of capital by central banks across the globe, the financial disaster was inescapable. The crisis escalated in September 2008, spreading to various economic sectors and exacerbating the overall condition. The emergence of the COVID-19 crisis presented the world with a multitude of challenges, including strained healthcare systems, commercial and tourism losses, diminished transfers, constrained capital flows, and financial strain due to escalating debt.

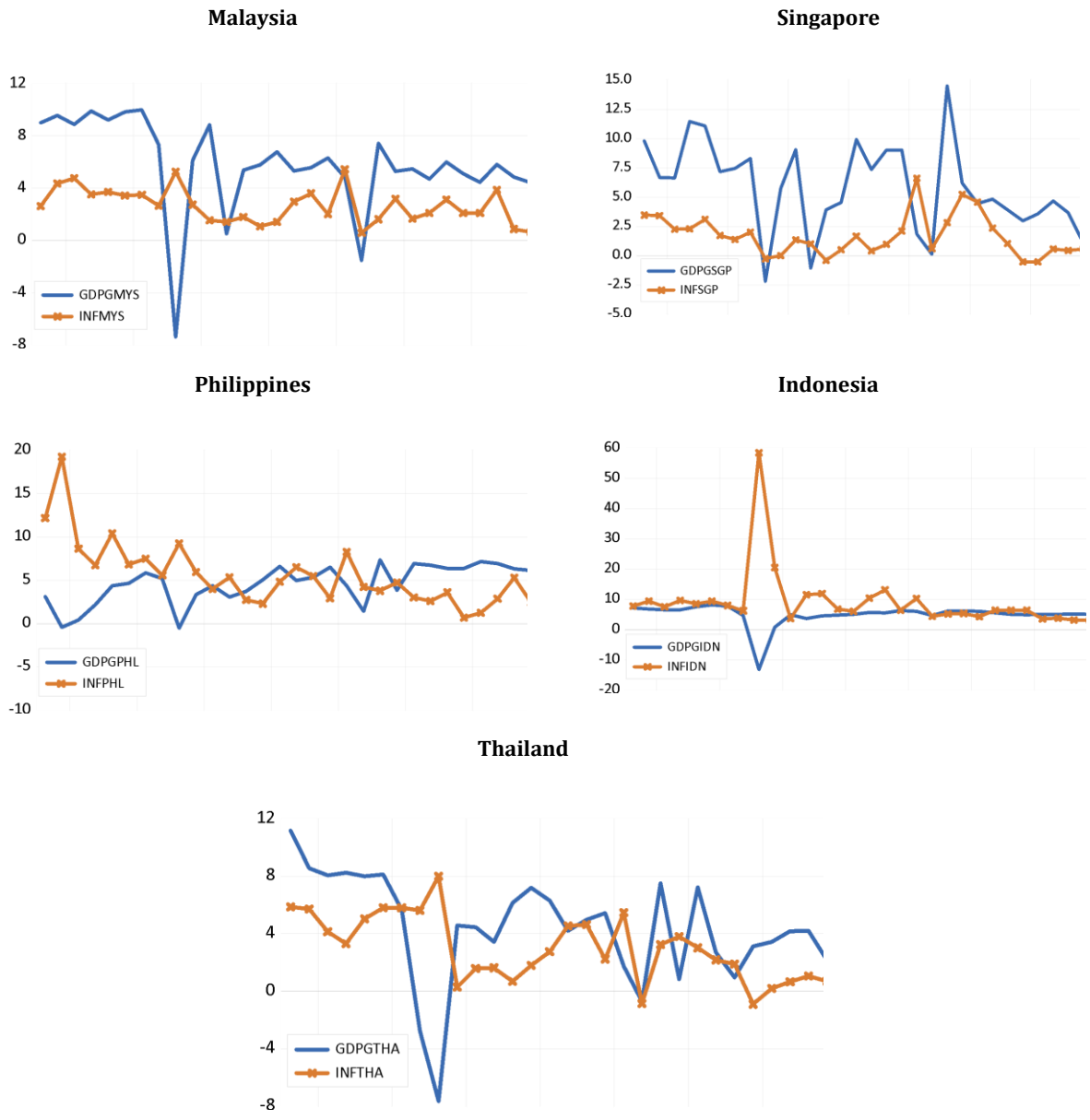

Figure 2: Inflation Rate and GDP growth for ASEAN-5

In Malaysia, inflation and the cost of living continue to rise annually, indicating a general increase in prices and a decrease in the purchasing power of money, both of which are considered inflation indicators. The Department of Statistics Malaysia (DOSM) reports that inflation surpassed the 3.4% recorded in June 2022 (International Monetary Fund (IMF), 2022). Malaysia's inflation rate rose by 4.4 percent to 127.9 from the previous year's 122.5, mainly due to increasing food prices. Various factors drove up expenses in Malaysia, contributing to an increased inflation rate. Ongoing increases in input costs and prolonged disruptions to global supply chains, along with geopolitical unrest and China's border closure efforts, exacerbate this situation. These global events may lead to increased consumer costs and a reduction in people's purchasing power,

further impacting Malaysia's inflation rate. Figure 2 shows the relationship between GDP growth and inflation for ASEAN-5 countries. In general, both series were severely affected by the 1997 Asian financial crisis and the late 2000s global financial crisis.

In general, this correlation is considered negative. Research by Barro (1995, 2013), Easterly and Bruno (1999), and Gokal and Hanif (2004) supports the notion that high inflation adversely affects economic growth by increasing production costs and diminishing consumer purchasing power. Conversely, some studies have proposed that moderate inflation may foster economic growth by encouraging investment and enhancing output. Most research on the impact of inflation on economic growth has primarily focused on developed countries, such as the United States and European nations. There is a conspicuous absence of studies on the ASEAN-5 countries. This lack of research is troubling given these nations' swift development and growing importance in the global economy. Previous studies on ASEAN-5 countries have not thoroughly examined the causal link between inflation and economic growth, often constrained by data coverage and timeframe limitations. Hence, there is a pressing need for an updated study that considers recent developments over an extended period. Therefore, this study seeks to bridge the knowledge gap, rectify previous research deficiencies, and offer empirical insights to enhance comprehension of the topic.

This study explores the effect of inflation on economic growth in the age of digitalisation. Our focus is on ASEAN-5 countries, which have substantial relevance to diverse stakeholders. The position of ASEAN-5 countries as key contributors to the global economy heightens the necessity for an in-depth analysis of inflation and economic growth within these nations. The insights derived from such a study can provide essential lessons for managing inflation and fostering growth in other regions. Additionally, the close economic ties between these countries imply that inflationary shifts in one nation may lead to ripple effects throughout the region. Therefore, a thorough understanding of the dynamics between inflation and economic growth is crucial for ensuring the stability and continued prosperity of the ASEAN-5 region. From an academic standpoint, it fills a vital gap in the existing literature by scrutinising the causal link between inflation and economic growth within the specific context of ASEAN-5 nations. This study enhances the comprehension of the inflation-growth nexus in emerging economies by offering an updated and thorough analysis, thereby enriching macroeconomic analysis. Second, the results of this investigation have essential ramifications for policymakers in the ASEAN-5 region. These stakeholders depend on empirically grounded insights to craft effective monetary and fiscal policies to encourage sustainable growth. By examining the correlation between inflation and economic growth, this study provides invaluable guidance for policymakers, central banks, and governmental bodies in shaping suitable inflation-targeting strategies, managing inflation expectations, and nurturing economic stability. The following section reviews the literature, followed by the methodology section. Section 4 discusses the results, and the paper concludes the paper.

2. Literature review

2.1 Theory of inflation and economic growth

The connection between inflation and economic growth is of keen interest to economists and policymakers. Phillips Curve posits that an increase in inflation can fuel economic growth by reducing unemployment and enhancing aggregate demand (Team, 2023). From a Keynesian perspective, a moderate level of inflation may encourage spending and investment, thereby stimulating economic growth (see Blinder, 2020). Conversely, the real business cycle theory emphasises that inflation may indicate growing economic activity, thus encouraging investment and fostering growth (Pettinger, 2018). The endogenous growth theory underscores the role of technological advancement and innovation in long-term economic growth, with moderate inflation acting as a catalyst for investment, innovation, productivity gains, and growth. However,

excessively high, and fluctuating inflation can obstruct investment, misallocate resources, and compromise economic efficiency (see also CFI Team, 2020). The monetarist theory anticipates a more negative correlation between inflation and growth at lower inflation rates. In contrast, the monetary theory of inflation asserts that an expansion in money supply is both a cause and accelerator of inflation (see Kenton, 2021). This concept is grounded in the Quantitative Theory of Money, which maintains that the overall price level is inversely related to the money supply. The intricate interplay between inflation and economic growth is influenced by a multitude of factors, such as inflation rates, the structure of the economy, and prevailing policy conditions.

2.2 Impact of inflation on economic growth

High inflation can be detrimental to a country's economy, whereas controlled and reasonable inflation can contribute to economic success. A nation experiencing lower inflation rates is often associated with positive trends such as increased employment and enhanced consumer purchasing power. When inflation reduces, individuals typically have more disposable income to spend on goods and services. This increased spending can lead to positive economic outcomes and foster national growth (see Davis, 2022). Several studies have identified a negative relationship between inflation and economic growth. This includes the works of Barro (1995, 2013), Easterly and Bruno (1999), Gokal and Hanif (2004), Akinsola and Odhiambo (2017), Ahmed and Mortaza (2010), Ayyoub et al. (2011), and Tien (2021). These studies generally conclude that higher inflation levels are often correlated with lower economic growth rates. However, some studies have also found that inflation can at times stimulate economic growth.

De Gregorio (1992) explored the relationship between inflation and economic growth across twelve Latin American countries, uncovering a negative link between inflation and growth within this region. In a broader study encompassing roughly 100 nations from 1960 to 1990, Barro (1995, 2013) found that a 10-percentage-point annual increase in average inflation corresponded to a decrease in the annual growth rate of real per capita GDP by approximately 0.2 to 0.3 percentage points. These results underscore the considerable negative impact of high inflation rates on economic growth, highlighting the critical role of inflation reduction in policy objectives. In a separate study, Easterly and Bruno (1999) examined the determinants of economic growth in 26 countries that had faced inflation crises, defined as having an inflation rate of 40% or higher between 1961 and 1992. Their analysis reveals a strong negative correlation between inflation and growth, particularly during discrete periods of high inflation. They also observed that growth tends to decline sharply during these high-inflation periods, but rebounds once inflation subsides.

Gokal and Hanif (2004) examined various economic theories, such as supply side, Keynesian, monetary, and neoclassical and endogenous growth theories, to determine whether there was a consensus regarding the relationship between inflation and economic growth. Their study, focusing on Fiji from 1970 to 2003, includes a review of empirical evidence from prior research and an analysis of the specific connection between inflation and growth in that context. The results reveal a slight negative correlation between inflation and growth, with significant effects stemming from alterations in the production gap. The study also found unidirectional causality between GDP growth and inflation originating from GDP growth. In a separate study, Paul et al. (1997) have explored the causal link between inflation and economic growth in 70 countries, utilising the Granger causality test across diverse regions. This included 22 industrialised countries, 13 African countries, 13 Asian countries, three European countries, and 19 Latin American countries. The findings highlight the regional variations in the relationship between inflation and growth. Approximately 28 countries exhibited no causality, one-third showed unidirectional causality, and approximately one-fifth showed bidirectional causality. Notably, the majority of countries with unidirectional or bidirectional causality have been identified as industrialised nations.

Faria and Carneiro (2001) explored the case of Brazil and concluded that inflation does not have a lasting impact on real output, although they found a short-term negative effect of inflation on output. In a study focusing on Malaysia from 1971 to 2007, Datta and Mukhopadhyay (2011) discovered that short-term inflation significantly contributes to negative economic growth, while long-term economic growth results in a positive shift in inflation. Mallik and Chowdhury (2001) noted a long-term positive correlation between the GDP growth rate and inflation. On the other hand, Ahmed and Mortaza (2010) have examined the relationship between inflation and economic growth in Bangladesh from 1980 to 2005. Their research findings indicate a statistically significant long-term negative relationship between inflation and economic growth in the country. Adaramola and Dada (2020) employed the autoregressive distributed lag (ARDL) model to investigate Nigeria's economic development from 1980 to 2018. Their research indicated that increasing inflation may hinder economic growth because of its substantial negative effect. Similarly, Khan and Khan (2018) observed that inflation exerted a negative and statistically significant influence on economic growth in Bangladesh, Iran, Indonesia, Malaysia, and Pakistan between 1973 and 2016, as determined through least squares estimation and panel data techniques.

Jayathilake and Rathnayaka (2013) conducted a study covering 1980 to 2010 in three Asian developing countries: China, India, and Sri Lanka. Their findings showed a significant and negative long-term relationship between economic growth and inflation in Sri Lanka, whereas no statistically significant relationships were found between China and India. Interestingly, a short-term inverse relationship between economic growth and inflation has been found in China. In a separate study, Mallik and Chowdhury (2001) investigate the relationship between inflation and GDP growth in four South Asian countries: Bangladesh, India, Pakistan, and Sri Lanka. Utilising integration and error correction models, they identified a consistent, long-term positive link between GDP growth rate and inflation across all four nations. Akinsola and Odhiambo (2017) reviewed the existing literature to examine the correlation between inflation and economic growth. Utilising qualitative methods, they explored this relationship in industrialised and developing countries. Their findings offer substantial evidence to counter the notion that inflation and growth are negatively correlated, especially in industrialised nations. Azam and Khan (2022) conducted an empirical study spanning 1975 to 2018 in which they analysed 27 countries, including 16 developing and 11 developed economies. Utilising the techniques of fixed effects and feasible generalised least squares (FGLS), they identify a negative correlation between inflation and economic growth.

In summary, empirical evidence on the relationship between inflation and economic growth remains mixed. The literature can be divided into three distinct views, applicable to both the short and long run. First, some studies have found that inflation has a negative impact on economic growth. Second, other studies suggest that inflation has a positive influence on economic growth. Third, some studies conclude that there is no evidence to support that inflation has a discernible impact on economic growth.

3. Methodology

This research aims to study the impact of inflation on economic growth in the age of digitalisation. The sample consisted of five ASEAN-5 countries (n=5). The dataset covers these five countries from 1990 to 2020 (annually) and is drawn from the World Development Indicator. The econometric model is as follows:

$$\Delta GDP_t = \varphi_0 + \varphi_1 Inflation_t + u_t, \quad (1)$$

where the dependent variable is ΔGDP, which refers to the GDP growth, Inflation is the independent variable, and u is the error or residual. The ordinary least squares (OLS) method has been used to obtain the model coefficients by minimising the sum of the squared differences

between the observed values of the dependent variable and the predicted values from the linear model (see Gujarati & Porter, 2009). The estimated coefficients explain the relationship between the GDP growth rate and inflation. A set of diagnostic tests is utilised to diagnose the empirical model.

We then conduct further analysis to test the stationarity of the series using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The unit root test is a statistical method employed to determine whether the GDP growth and inflation rates are stationary or non-stationary (see Kumar, 2021). Stationarity refers to the characteristics of a series, such as GDP growth or inflation rate, in which its statistical properties, such as mean and variance, remain constant over time. Conversely, a nonstationary series exhibits changing statistical properties and may display trends or cycles. The purpose of a unit root test is to examine the null hypothesis that the GDP growth rate and inflation rate contain a unit root against the alternative hypothesis that they lack a unit root.

The Granger causality test was used to test the causal relationship between GDP growth and inflation rate (see Eric, 2021). The test is based on the idea that if GDP growth causes inflation, the past values of GDP growth should contain information that improves the prediction of future inflation values beyond what can be predicted by considering only past values of inflation. The test regression equations are as follows:

$$\Delta GDP_t = \sum_{i=1}^{p} \beta_i INF_{t-i} + \sum_{j=1}^{q} \alpha_j \Delta GDP_{t-j} + u_{1t} \quad (2)$$

$$INF_t = \sum_{i=1}^{p} \lambda_i INF_{t-i} + \sum_{j=1}^{q} \delta_j \Delta GDP_{t-j} + u_{2t} \quad (3)$$

where ΔGDP_t represents GDP growth in annual percentage and INF_t represents inflation at time t=1,…,T. The β_j are the coefficients associated with the lags of the INF_t in the ΔGDP equation. These coefficients represent the impact of lagged INF_t values on the ΔGDP. The δ_j are the coefficients associated with the lags of ΔGDP in the INF equation. The u_{1t} and u_{2t} are the error terms, representing the unexplained variation in the equations.

If the restriction test for $\sum_{i=1}^{p} \beta_i$ ($\sum_{j=1}^{q} \delta_j$) in the ΔGDP (inflation) equation is significant (insignificant), it indicates that there is one-way Granger causality from inflation to GDP growth, and vice versa. If the restriction test for $\sum_{i=1}^{p} \beta_i$ and $\sum_{j=1}^{q} \delta_j$ in the ΔGDP and inflation equations is insignificant, it indicates that there is no Granger causality between GDP growth and inflation, and vice versa. In general, there are four possible outcomes of the causality test: one-way causality from inflation to GDP growth, one-way causality from GDP growth to inflation, bidirectional causality between GDP growth and inflation, and no causal evidence between GDP growth and inflation. The appropriate lag length was determined using model selection criteria.

4. Result and discussion

4.1 Descriptive statistics

The descriptive statistics presented in Table A1 reveal variations in the average annual GDP growth rates across countries. Malaysia exhibited a relatively high average growth rate of 5.4297%, with Singapore trailing at 5.5386%. The Philippines and Indonesia have modest average growth rates, recorded at 4.1309% and 4.7125%, respectively, while Thailand registers the lowest average growth rate at 4.0439%. The standard deviations reflect the variability of GDP growth rates, with Malaysia, Singapore, and Thailand demonstrating comparable dispersion levels. Malaysia's average inflation rate is 2.5391%, in contrast to Singapore's lower average of 1.6331%. The Philippines reported a higher average inflation rate of 5.5291%, with Indonesia having the highest average rate among the countries mentioned at 9.0139%. Thailand's average inflation rate was lower, at 2.8759%.

4.2 Ordinary Least Square (OLS) estimate

We first conducted Ordinary Least Squares (OLS) analysis, and the results are shown in Table 1. In general, regression analysis provides insights into the relationship between GDP growth and inflation for each ASEAN-5. The coefficient of inflation on GDP growth ranges from -0.3118 to -0.2894 for Indonesia and the Philippines, respectively. Conversely, inflation has a positive impact on GDP growth for Thailand, Malaysia, and Singapore, ranging from 0.2408 to 0.8357. However, the positive impact was significant only in Singapore.

Table 1: Ordinary Least Square for ASEAN-5 countries

	Country				
	Malaysia	**Singapore**	**Philippines**	**Indonesia**	**Thailand**
φ_0	3.3488**	4.1739***	5.7310***	7.5234***	3.3514**
φ_1	0.8195	0.8357*	-0.2894*	-0.3118***	0.2408
R^2	0.0868	0.1205	0.1037	0.6486	0.0185
Adjusted R^2	0.0553	0.0901	0.0728	0.6365	-0.0154
S.E. of regression	3.9630	3.9849	3.2234	2.3122	4.2223
F-statistics	2.7557	3.9718	3.3558	53.5258	0.5459
AIC	5.6542	5.6652	5.2411	4.5767	5.7810
SIC	5.7467	5.7577	5.3336	4.6692	5.8735
Hannan-Quinn	5.6844	5.6954	5.2713	4.6068	5.8111
Diagnostic Tests					
Durbin-Watson stat	1.8239	1.6706	1.2501	0.6807	1.1428
Normality Test:					
Jarque-Bera	64.3791	0.8107	258.0096	63.0211	14.0968
Probability	(0.0000)	(0.6668)	(0.0000)	(0.0000)	(0.0009)
LM Test:					
F-statistics	0.7160	0.9931	0.2686	6.4654	1.9396
Prob.F(2,27)	(0.4978)	(0.3836)	(0.7665)	(0.0051)	(0.1633)
Heteroskedasticity Test:					
F-statistics	1.2590	1.5397	0.7059	0.1858	4.4953
Prob.F(1,29)	(0.2710)	(0.2246)	(0.4077)	(0.6696)	(0.0427)
Ramsey RESET Test:					
t-statistic (df=28)	4.4716	4.16247	0.2859	4.0608	4.0456
	(0.0001)	(0.0003)	(0.7771)	(0.0004)	(0.0004)
F-statistic (df=(1,28))	19.9948	17.3261	0.0817	16.4903	16.3662
	(0.0001)	(0.0003)	(0.7771)	(0.0004)	(0.0004)

Notes: Robust standard errors were used for Indonesia and Thailand to accommodate autocorrelation and heteroscedasticity, respectively. The values in parentheses refer to *p*-value. *, **, and *** denote significant at 10%, 5%, and 1% significance level, respectively.

The normality test suggested that only the residuals in Singapore followed a normal distribution. The model for Indonesia suffers from an autocorrelation problem, whereas there is a heteroscedasticity issue in Thailand. In terms of model specification, only the Philippines passed the Ramsey RESET test. The model is misspecified, except for the Philippines, given a low *R*-squared value (between 0.0185 and 0.6486).[2]

[2] Readers must exercise caution when interpreting the results.

4.3 Unit Root Tests for ΔGDP and Inflation

To examine the stationarity of the GDP growth and inflation rate, the Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) tests were utilised. The null hypothesis posits that the data contain a unit root, whereas the alternative hypothesis suggests stationarity. Four countries (ASEAN-5, except the Philippines) exhibited stationarity in the GDP growth series. This implies that the GDP growth in these countries is mean-reverting. For the Philippines, the initial unit root tests indicate that GDP growth is nonstationary, implying the presence of a unit root at the level. To address this, the first difference was applied to the series and the differenced series was found to be stationary. Applying the same unit root tests to the inflation series, the results also indicate that all inflation series were *I*(0). The results are summarised in Tables 2 and 3.[3]

Table 2: Unit Root Tests for ΔGDP

Country		ADF				PP				Conclusion
		Lag	Level	Lag	First Difference	Bandwidth	At Level	Bandwidth	First Difference	
Malaysia	Intercept	1	-3.1404	1	-6.6103	1	-3.9038	8	-9.8795	*I*(0)
			(0.0345)		(0.0000)		(0.0056)		(0.0000)	
	Trend and Intercept	1	-3.9319	1	-6.4611	0	-4.6658	7	-9.4604	*I*(0)
			(0.0234)		(0.0001)		(0.0042)		(0.0000)	
Singapore	Intercept	0	-3.9805	1	-7.2445	2	-3.9091	6	-11.0446	*I*(0)
			(0.0047)		(0.0000)		(0.0056)		(0.0000)	
	Trend and Intercept	0	-4.7247	1	-7.1931	0	-4.7247	6	-11.0410	*I*(0)
			(0.0036)		(0.0000)		(0.0036)		(0.0000)	
Philippines	Intercept	0	-2.4640	0	-4.5584	0	-2.4640	0	-4.5584	*I*(1)
			(0.1340)		(0.0011)		(0.1340)		(0.0011)	
	Trend and Intercept	0	-2.0056	0	-4.7193	1	-2.0075	0	-4.7193	*I*(1)
			(0.5748)		(0.0038)		(0.5738)		(0.0038)	
Indonesia	Intercept	0	-3.7009	3	-3.6368	3	-3.6045	24	-11.8122	*I*(0)
			(0.0093)		(0.0119)		(0.0117)		(0.0000)	
	Trend and Intercept	0	-3.6365	3	-3.5259	3	-3.5491	22	-11.5142	*I*(0)
			(0.0434)		(0.0573)		(0.0520)		(0.0000)	
Thailand	Intercept	0	-3.1186	1	-4.6590	3	-2.9720	7	-7.3245	*I*(0)
			(0.0358)		(0.0009)		(0.0492)		(0.0000)	
	Trend and Intercept	0	-3.4714	1	-4.5121	3	-3.3898	7	-7.0471	*I*(0)
			(0.0610)		(0.0065)		(0.0718)		(0.0000)	

Notes: Lag selection based on SIC for the ADF, Bandwidth based on Newey-West automatic using Bartlett kernel for PP. ADF refers to the Augmented Dickey-Fuller test, and PP refers to the Phillips-Perron unit root test.

[3] The findings are consistent with Ng and Perron (2001) unit root test. See Table A2 and A3.

Table 3: Unit root tests for inflation

Country		ADF				PP				Conclusion
		Lag	At Level	Lag	First Difference	BW	At Level	BW	First Difference	
Malaysia	Intercept	0	-3.3972 (0.0191)	0	-8.8470 (0.0000)	3	-3.5351 (0.0138)	2	-10.0568 (0.0000)	*I*(0)
	Trend and Intercept	0	-4.6679 (0.0041)	0	-8.7671 (0.0000)	2	-4.7057 (0.0038)	2	-9.9550 (0.0000)	*I*(0)
Singapore	Intercept	0	-3.3030 (0.0237)	1	-6.0041 (0.0000)	2	-3.2235 (0.0284)	8	-8.5063 (0.0000)	*I*(0)
	Trend and Intercept	0	-3.3174 (0.0827)	1	-5.8773 (0.0002)	2	-3.2560 (0.0931)	8	-8.2965 (0.0000)	*I*(0)
Philippines	Intercept	0	-3.0163 (0.0447)	1	-7.4096 (0.0000)	3	-2.8000 (0.0702)	0	-9.3199 (0.0000)	*I*(0)
	Trend and Intercept	0	-4.3751 (0.0083)	1	-7.6153 (0.0000)	2	-4.2913 (0.0101)	2	-10.5875 (0.0000)	*I*(0)
Indonesia	Intercept	0	-4.2945 (0.0021)	6	-2.5662 (0.1141)	1	-4.3049 (0.0020)	28	-20.2134 (0.0001)	*I*(0)
	Trend and Intercept	7	-7.7391 (0.0000)	6	-2.7072 (0.2428)	4	-4.7161 (0.0037)	28	-22.0391 (0.0000)	*I*(0)
Thailand	Intercept	0	-3.0704 (0.0398)	0	-8.7698 (0.0000)	3	-3.0773 (0.0392)	4	-10.1765 (0.0000)	*I*(0)
	Trend and Intercept	0	-4.5298 (0.0058)	0	-8.6046 (0.0000)	0	-4.5298 (0.0058)	4	-9.9694 (0.0000)	*I*(0)

Notes:
BW = Bandwidth
Lag selection based on SIC for the ADF, Bandwidth based on Newey-West automatic using Bartlett kernel for PP. ADF refers to the Augmented Dickey-Fuller test, and PP refers to the Phillips-Perron unit root test.

4.4 Granger causality analysis

We then further our analysis using the Granger causality test to investigate the possible causal relationships between GDP growth and inflation rates. We find that the GDP growth rate and inflation rate are *I*(0), except for GDP growth in the Philippines. The analysis was conducted at all levels except for GDP growth in the Philippines. The results are summarised in Table 4.

Table 4: Granger Causality Test

Country Lag=2	Null Hypothesis	F-Statistics	P-value	Decision on Causality
Malaysia	ΔGDP does not Granger cause Inflation.	2.1644	0.1367	No causality
	Inflation does not Granger cause ΔGDP.	1.8970	0.1718	No causality
Singapore	ΔGDP does not Granger cause Inflation.	5.3570	0.0119	Have causality
	Inflation does not Granger cause ΔGDP.	4.3951	0.0236	Have causality
Philippines	Δ^2GDP does not Granger cause Inflation.	0.4563	0.6392	No causality
	Inflation does not Granger cause Δ^2GDP.	3.6265	0.0428	Have causality
Indonesia	ΔGDP does not Granger cause Inflation.	4.3056	0.0252	Have causality
	Inflation does not Granger cause ΔGDP.	4.5981	0.0204	Have causality
Thailand	ΔGDP does not Granger cause Inflation.	0.3364	0.7177	No causality
	Inflation does not Granger cause ΔGDP.	4.5323	0.0214	Have causality

Note: Δ is the change.

Of the five cases, there was no causal relationship between GDP growth and inflation in Malaysia. This finding is consistent with our OLS estimate, which shows no impact of inflation on GDP growth. Feedback causality is found for Singapore and Indonesia, as their *F*-statistics are significant at the 5% level. Additionally, the null hypothesis that inflation does not Granger-cause GDP growth is rejected for the Philippines and Thailand. This suggests that inflation is Granger-causal to GDP growth (a bidirectional relationship).

4.5 Further analysis for ASEAN-5

We further conduct our analysis with panel estimation to accommodate the limitations of the short sample size. Several interesting results were obtained. First, the unit root assumes a common unit root process, and unit root tests (Levin et al., 2002), which assume individual unit root processes (Im et al., 2003), indicate that both inflation and GDP growth are $I(0)$.[4] We then proceed to the pooled OLS estimation, and the estimated equation is presented as:

$\Delta\widehat{GDP_{i,t}} = 5.6441 - 0.2022Inflation_{i,t}$ where inflation has a negative and significant impact on GDP growth. The findings of this research align with those of recent studies, including Azam and Khan (2022) and Khan and Khan (2018). Third, the panel causality test, which allows for individual coefficients, suggests a feedback relationship between GDP growth and the inflation rate. Given that inflation harms GDP growth, the central banks in ASEAN-5 countries may need to carefully coordinate monetary policy to manage both inflation and GDP growth simultaneously. An increase in interest rates to curb inflation might slow GDP growth, and vice versa.

5. Conclusion

In ASEAN-5 countries, the interplay between inflation and economic growth is intricate and nuanced. This study sheds light on how inflation impacts economic growth in ASEAN-5 countries from 1990 to 2020 in the age of digitalisation. In summary, the coefficient of inflation on GDP growth ranges from -0.3118 to -0.2894 for Indonesia and the Philippines, respectively. However, the positive impact was significant only in Singapore. We find no significant impact of inflation on GDP growth in Malaysia or Thailand. Our results are consistent with the current debate that the impact of inflation on the GDP growth rate is country dependent. We further analysed the Granger causality to uncover the possibility of causality between the two series. Unit root tests were applied to both series to check the properties of the series. The unit root tests suggest that GDP growth and inflation rate are $I(0)$ for all ASEAN-5 countries, except for the GDP growth rate in the Philippines. Therefore, we accommodate variable $I(1)$ in the Granger causality analysis. We find no evidence of a causal relationship between the GDP growth rate and inflation in Malaysia. However, feedback causality was found in Indonesia and Singapore. There is one-way (bidirectional) causality from inflation to the GDP growth rate for the Philippines and Thailand.

We further conduct our analysis with panel estimation to accommodate the limitations of the short sample size. The panel unit root assumes a common unit root process, and the unit root test, which assumes an individual unit root process, indicates that both inflation and GDP growth rates are I(0) (Ng & Perron, 2001). We then proceed to the pooled OLS estimation and the results suggest that inflation has a negative and significant impact on GDP growth. The panel causality test, which allows for individual coefficients, suggests a feedback relationship between GDP growth and inflation rate.

[4] For GDP growth: the panel unit root tests include Levin, Lin and Chu *t** (test-stat=-2.4729, p-value=0.0067), Im, Pesaram and Shin W-stat (test-statistic=-4.3950, *p*-value=0.0000), ADF-Fisher Chi-square (test-statistic=37.5087, *p*-value=0.0000), and PP-Fisher Chi-square (test-statistic=39.6786, *p*=value=0.0000); For inflation: the panel unit root tests include Levin, Lin and Chu *t** (test-stat=-5.1411, *p*-value=0.000), Im, Pesaram and Shin W-stat (test-statistic=-4.7585, *p*-value=0.0000), ADF-Fisher Chi-square (test-statistic=40.3914, *p*-value=0.0000), and PP-Fisher Chi-square (test-statistic=39.8595, *p*-value=0.0000).

The findings of this analysis offer essential guidance to policymakers regarding the connection between GDP growth and inflation in specific countries. Disparities in average GDP growth rates and inflation rates underscore the need for customised policy strategies. For countries experiencing higher average growth rates, such as Malaysia and Singapore, the focus may be on nurturing and bolstering economic growth through policies that foster investment and enhance productivity. Conversely, nations with subdued growth rates, such as the Philippines and Thailand, might investigate avenues to boost economic growth, including improving infrastructure and encouraging industrial diversification. Moreover, the notable inverse relationship between inflation and GDP in Indonesia emphasises the critical role of preserving price stability in facilitating economic expansion. Collectively, these insights should be integral to policymakers' considerations as they devise strategies to advance sustainable economic progress.

Recognition of the study's limitations and encouragement of continued exploration are vital. The analysis relies on historical data, a foundation that may not fully capture future economic shifts and dynamics, especially the nonlinear ones that could alter the observed relationships.[5] While the focus of the analysis is inflation, it is worth noting that the existing literature identifies several factors that might also influence economic growth. Caution is advised when interpreting the OLS results. Subsequent research could enrich the understanding of economic growth drivers by including variables, such as institutional factors, government spending, and external disturbances. An expanded examination of the causality between GDP growth and inflation, extending beyond ASEAN-5 countries to a global perspective, may further illuminate the distinct attributes and hurdles these nations encounter.

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[5] Khan and Senhadji (2001) pinpointed specific threshold levels of inflation at which the negative impact on economic growth becomes more pronounced. These thresholds are not uniform, ranging from 1-3% for industrialised countries to 8% for developing nations, and can be even higher in some instances. Research by Sarel (1996) and Vinayagathasan (2013) emphasised the non-linear nature of the relationship between inflation and growth, suggesting that low inflation may either slightly boost growth or have no significant effect, while high inflation can be more harmful. Tien (2021) discovered that mild inflation positively influences GDP growth, but excessive inflation negatively affects it, with findings indicating that an inflation rate of 6% or below promotes GDP development in Vietnam. Wollie (2018) explored the connection between inflation and economic growth in Ethiopia, delving into the causes, sources, determinants, and effects of inflation in the country. The study also focused on identifying specific threshold levels of inflation that could influence economic growth in Ethiopia. Drawing from prior research, the study concluded that annualised average inflation in double digits exerts a substantial negative impact on a country's economic growth, particularly in the case of Ethiopia.

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Appendix

Table A1: Descriptive statistics for ASEAN-5 countries

GDP (Annual %)									
Malaysia		**Singapore**		**Philippines**		**Indonesia**		**Thailand**	
Mean	5.4297	Mean	5.5386	Mean	4.1309	Mean	4.7125	Mean	4.0439
Standard Error	0.7323	Standard Error	0.7503	Standard Error	0.6012	Standard Error	0.6888	Standard Error	0.7526
Median	5.7885	Median	5.7184	Median	4.9425	Median	5.1743	Median	4.4552
Mode	#N/A	Mode	#N/A	Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	4.0773	Standard Deviation	4.1776	Standard Deviation	3.3476	Standard Deviation	3.8350	Standard Deviation	4.1902
Sample Variance	16.6246	Sample Variance	17.4521	Sample Variance	11.2065	Sample Variance	14.7074	Sample Variance	17.5579
Kurtosis	3.4956	Kurtosis	0.1135	Kurtosis	8.4756	Kurtosis	16.2606	Kurtosis	1.5573
Skewness	-1.7486	Skewness	-0.2738	Skewness	-2.4881	Skewness	-3.7276	Skewness	-1.1204
Range	17.3621	Range	18.6629	Range	16.8528	Range	21.3467	Range	18.8012
Minimum	-7.3594	Minimum	-4.1431	Minimum	-9.5183	Minimum	-13.1267	Minimum	-7.6340
Maximum	10.0027	Maximum	14.5197	Maximum	7.3345	Maximum	8.2200	Maximum	11.1672
Sum	168.320	Sum	171.697	Sum	128.057	Sum	146.0873	Sum	125.361
Count	8	Count	1	Count	6	Count	7	Count	7
	31		31		31		31		31
Inflation, Consumer Prices (Annual %)									
Mean	2.5391	Mean	1.6331	Mean	5.5291	Mean	9.0139	Mean	2.8759
Standard Error	0.2632	Standard Error	0.3116	Standard Error	0.6691	Standard Error	1.7788	Standard Error	0.4248
Median	2.6178	Median	1.3616	Median	4.8292	Median	6.4125	Median	2.7591
Mode	#N/A	Mode	#N/A	Mode	#N/A	Mode	#N/A	Mode	#N/A
Standard Deviation	1.4656	Standard Deviation	1.7351	Standard Deviation	3.7255	Standard Deviation	9.9042	Standard Deviation	2.3652
Sample Variance	2.1479	Sample Variance	3.0105	Sample Variance	13.8793	Sample Variance	98.0926	Sample Variance	5.5940
Kurtosis	0.1987	Kurtosis	1.1590	Kurtosis	5.1166	Kurtosis	22.0682	Kurtosis	-0.8577
Skewness	-0.0806	Skewness	1.0938	Skewness	1.8632	Skewness	4.4295	Skewness	0.1556
Range	6.5795	Range	7.1601	Range	18.5873	Range	56.5301	Range	8.8952
Minimum	-1.1387	Minimum	-0.5323	Minimum	0.6742	Minimum	1.9210	Minimum	-0.9004
Maximum	5.4408	Maximum	6.6278	Maximum	19.2615	Maximum	58.4510	Maximum	7.9947
Sum	78.7115	Sum	50.624	Sum	171.4017	Sum	279.430	Sum	89.1527
Count	31	Count	8	Count	31	Count	8	Count	31
			31				31		

Table A2: Ng and Perron (2001) Unit Root Test for ΔGDP

Country		**Intercept**				**Trend and Intercept**				**Conclusion**
		MZa	**MZt**	**MSB**	**MPT**	**MZa**	**MZt**	**MSB**	**MPT**	
Asymptotic 5% Critical Values		*-8.1000*	*-1.9800*	*0.2330*	*3.1700*	*-17.300*	*-2.9100*	*0.1680*	*5.4800*	
Malaysia	Level	-14.1826	-2.2829	0.1610	3.0652	-14.9330	-2.5743	0.1724	6.9939	*I*(0)
	First Difference	-39.3408	-4.3355	0.1102	0.8956	-30.3185	-3.8198	0.1260	3.4186	
Singapore	Level	-13.8674	-2.3382	0.1686	2.8258	-14.9032	-2.6302	0.1765	6.6817	*I*(0)
	First Difference	-13.2979	-2.5552	0.1922	1.9314	-39.2451	-4.4123	0.1124	2.4140	
Philippines	Level	-11.6016	-1.7690	0.1525	4.2589	-12.4544	-1.7864	0.1434	10.5906	*I*(0)
	First Difference	-13.2130	-2.0470	0.1549	3.6510	-13.4104	-1.9949	0.1488	9.7306	
Indonesia	Level	-13.4938	-2.4313	0.1802	2.4298	-13.3945	-2.5030	0.1869	7.2699	*I*(0)
	First Difference	-25.9477	-3.5340	0.1362	1.1617	-25.5176	-3.5186	0.1379	3.8810	
Thailand	Level	-9-95927	-1.8517	0.1859	3.8036	-12.4090	-2.3805	0.1918	7.9232	*I*(0)
	First Difference	-14.2238	-2.5614	0.1801	2.1134	-13.7161	-2.5027	0.1825	7.2827	

Note: Spectral GLS-detrended AR based on SIC.

Table A3: Ng and Perron (2001) Unit Root Test for inflation

Country			Intercept				Trend and Intercept				Conclusion
			MZa	**MZt**	**MSB**	**MPT**	**MZa**	**MZt**	**MSB**	**MPT**	
Asymptotic Values	*5%*	*Critical*	*-8.1000*	*-1.9800*	*0.2330*	*3.1700*	*-17.300*	*-2.9100*	*0.1680*	*5.4800*	
Malaysia		Level	-13.3950	-2.3188	0.1731	2.8042	-14.5727	-2.5533	0.1752	7.0720	*I*(0)
		First Difference	-11.8991	-2.3652	0.1988	2.3400	-11.5484	-2.3866	0.2067	7.9742	
Singapore		Level	-11.2215	-2.2854	0.2037	2.5005	-12.0393	-2.4405	0.2027	7.6375	*I*(0)
		First Difference	-13.1076	-2.5547	0.1949	1.8897	-29.0572	-23.8089	0.1311	3.1518	
Philippines		Level	-7.5445	-1.8529	0.2456	3.5643	-14.2218	-2.6536	0.1866	6.4818	*I*(0)
		First Difference	-6.2815	-1.7567	0.2797	3.9504	-12.0160	-2.4497	0.2037	7.6002	
Indonesia		Level	-14.3705	-2.6621	0.1853	1.7743	-14.6889	-2.7074	0.1843	6.2188	*I*(0)
		First Difference	-8350.9000	-64.6177	0.0077	0.0029	-44086.1000	-148.4690	0.0034	0.0021	
Thailand		Level	-10.2887	-2.0947	0.2036	3.0274	-14.7128	-2.6994	0.1835	6.2678	*I*(0)
		First Difference	-11.1119	-2.3424	0.2108	2.2618	-11.1529	-2.3505	0.2108	8.2244	

Note: Spectral GLS-detrended AR based on SIC.