Impact of COVID-19 and Russia-Ukraine War on the Inflation Rate of South and Southeast Asia

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Abstract

The financial value of money and the overall stability of an economy are significantly impacted by inflation. To investigate the effect of the COVID-19 pandemic and the Russia-Ukraine war on constant inflation rates in South and Southeast Asian countries between January 2019 and December 2022, this research utilizes monthly inflation rate data from the International Monetary Fund. Autoregressive integrated moving average modeling and prediction of inflation rates and the Bai-Perron method to estimate the structural breakdown of monthly inflation rate series are employed. Graphical methods and theoretical tests are used to diagnose the models, and the Chow test is utilized to assess structural breakdown in the monthly inflation rate series. The findings indicate that the Russia-Ukraine war since February 2022 has a more significant impact on the selected countries than the COVID-19 pandemic during January 2020 to December 2021.

Keywords: Inflation rate, ARIMA, COVID-19, Russia-Ukraine war, Forecasting.

I. Introduction

Inflation refers the overall level of prices for goods and services rises, resulting in a decrease in a currency's purchasing power. There are various factors that can cause inflation, including an increase in the quantity of money in circulation, a rise in the demand for goods and services, or a decrease in their availability. Government actions, such as adjustments in interest rates or fiscal policies, can also impact inflation. Inflation has both positive and negative effects on the economy. A moderate degree of inflation is generally considered beneficial because it stimulates investment and consumption, creates job opportunities, and reduces the real value of debt. However, high levels of inflation can eventually lead to an economic slowdown or even a recession by reducing consumer purchasing power, increasing economic uncertainty and instability[1].

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has had a significant impact on the economies of South and Southeast Asia[2,3]. Governments implemented measures such as lockdowns and social distancing to curb the virus's spread, resulting in a global health crisis. The economic impact of these policies was severe, particularly for industries such as tourism, manufacturing, and retail. The pandemic has slowed economic growth, resulted in job losses and reduced incomes across the region. There have also been supply chain disruptions and reduced trade, leading to a decline in exports. Many small and medium-sized businesses have struggled to survive due to the pandemic's economic effects. It was estimated that the pandemic's economic impact in the region to be $170 billion, with growth projections for 2020 revised downwards from 5.2% to 2.2%[1]. The pandemic has affected both the demand and supply sides of the economy, resulting in reduced trade, tourism, and investment. Inflation rates increased significantly during the pandemic[4]. Their study analyzed monthly data from September 1997 to August 2022 and found that inflation rates rose in February and May 2020 due to COVID-19 and again in March 2022 following the Russian invasion. However, the inflation rate began to decline gradually after March 2022. Consumer Price Index (CPI) also increased significantly due to the COVID-19 pandemic and later in February 2022 due to the Russia-Ukraine crisis. The study shows that all types of inflation were affected by the COVID-19 pandemic and the Russia-Ukraine crisis. Given the impact of these events on the economies of South and Southeast Asia, studying the topic is worthwhile.

In 2014, Russia annexed Crimea from Ukraine, triggering ongoing conflict in eastern Ukraine and leading to the displacement of thousands of people and severe damage to infrastructure. The most recent and largest wave of conflict began in February 2022 when Russia launched a full-scale invasion of Ukraine. This war has had far-reaching effects on the global economy, including in South and Southeast Asia[5]. As Ukraine is a crucial transit nation for Russian gas shipments to Europe, energy prices have been significantly impacted, leading to price hikes that have disrupted gas supplies and affected economies that rely on energy imports, such as those in South and Southeast Asia. The inflation rate has surged in many developing countries due to higher fuel and food prices caused by the war[6-8]. The disruption of the global supply chain has also led to increased import prices for countries involved in the conflict. According to several studies, the war has caused an increase in global inflation rates, affecting major

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economic countries such as the USA, Canada, UK, and the EU, who have imposed significant financial sanctions on Russia in response. The full extent of the economic impact of the Russia-Ukraine war is difficult to measure, but it is clear that it has created significant economic challenges for many countries in the region.

The aim of this study is twofold: first, to investigate whether the monthly inflation rate is influenced by either war or pandemic, and second, to predict the inflation rate and identify any structural changes in the observed time series data. The study is divided into several sections, including data sources and methodology, analysis and interpretation of research findings, and a conclusion.

II. Methodology

Data and variables

To examine the influence of the Russian-Ukraine war and the COVID-19 pandemic on the inflation rate of South and Southeast Asian countries, this research collected monthly inflation rates (expressed as a percentage change from the previous period) from the International Monetary Fund (IMF)[9]. The study utilized secondary data sourced from the IMF, covering monthly inflation rates from January 2019 to December 2022 for South Asian countries including Bangladesh, India, Maldives, and Nepal. Similarly, the analysis included data on monthly inflation rates from January 2019 to December 2022 for Southeast Asian countries, such as Brunei, the Philippines, Singapore, and Vietnam. A few other countries in this region are not included in this study for the lack of data consistency and availability.

ARIMA model, stationarity and forecasting

The ARIMA (Autoregressive Integrated Moving Average) model equation for a time series with parameters (p, d, q) is:

$$Y_t = c + \phi_1 Y_{t-1} + \ldots + \phi_p Y_{t-p} - \theta_1 \varepsilon_{t-1} - \ldots - \theta_q \varepsilon_{t-q} + \varepsilon_t \; ; \; 0 < t < \infty$$

where, Y_t is the value of the time series at time t, c is a constant, $\phi_1 \ldots \phi_p$ are the parameters of the autoregressive (AR) component of the model, which represent the effect of past values of the time series on the current value, $\theta_1 \ldots \theta_q$ are the parameters of the moving average (MA) component of the model, which represent the effect of past error terms on the current value, ε_t is the error term at time t, which is assumed to be normally distributed with mean 0 and constant variance, d is the degree of differencing required to make the series stationary.

To perform forecasting using an ARIMA model[10,11], we need to first estimate the model parameters (p, d, q) using a training dataset. Once we have the estimated parameters, we can use them to make predictions on a testing dataset. The general steps followed in this study for forecasting with an ARIMA model are as follows: first, we split the time series data into a training set of 80% and a testing set of 20%, then determining the order of differencing (d) required to make the series stationary, next step is to plot the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the differenced series to determine the order of the AR and MA components (p and q) and to fit the ARIMA model to the training set using maximum likelihood estimation, we then use the fitted model to make predictions on the testing set and evaluate the accuracy of the predictions using measures such as the root mean squared error (RMSE) or the mean squared error (MSE).

Chow test

The Chow test[12] is used in this study as statistical test to determine whether there is a significant difference between two regression models, one estimated using the entire sample data and the other estimated using two or more subgroups of the data. The null hypothesis is that there is no structural break in the relationship between the independent and dependent variables of the regression model. The alternative hypothesis is that there is a structural break, indicating that the relationship between the variables changes in a systematic way over time or across different groups.

The Chow test statistic is calculated here as:

$$F = ((RSSR - RSSUR) / q) / (RSSUR / (n - 2k - q))$$

where, $RSSR$ is the residual sum of squares from the regression model estimated on the entire sample data, $RSSUR$ is the residual sum of squares from the separate regression models estimated on the subgroups of the data, q is the number of parameters estimated in the separate models, k is the number of independent variables in the regression model, n is the total number of observations in the data set. If the calculated F-statistic is greater than the critical value of the F-distribution at a chosen significance level, the null hypothesis is rejected in favor of the alternative hypothesis, indicating a significant structural break in the relationship between the variables. Under the null hypothesis that there is no structural break, the Chow test statistic follows an F-distribution with degrees of freedom $(k, n - 2k)$. A rejection of the null hypothesis indicates that there is indeed a structural break in the data.

Bai-Perron method

The Bai-Perron[13] method is implemented in this study for the detection of structural breakdown in the time series data. It involves estimating a model with a potentially varying number of structural breaks, and testing whether there is evidence of breaks in the data.

The equation used for the Bai-Perron method can be written as follows:

$$Y_t = \alpha_t + \beta_t X_t + \varepsilon_t \; ; \; 0 < t < \infty$$

where, Y_t is the value of the dependent variable (i.e., the time series) at time t, X_t is the value of the independent variable (if any) at time t, α_t is the intercept term, which may vary over time due to structural breaks, β_t is the slope coefficient, which may also vary over time due to structural breaks, ε_t is the error term, which is assumed to be normally distributed with mean zero and constant variance. The Bai-Perron method involves estimating this equation for a range of possible break points, and then selecting the model that provides the best fit to the data. The method uses a likelihood ratio test to determine whether there is evidence of structural breaks, and if so, where they occur.

III. Analysis and Results

In this section, we perform a stationarity test on the series, and if it is found to be non-stationary, we take the first and second-order differences and test them for stationarity. Next, we select the best model for forecasting based on the Root Mean Squared Error (RMSE) and Mean Percentage Error (MPE) criteria. We then assess the accuracy of the selected model graphically and test the normality of the residuals using the Ljung-Box normality test. After that, we forecast the monthly inflation rate for the next 12 months using the selected model. For each country, we conduct a Chow test to determine if there is a structural break in the series, and calculate the breakpoints and their 95% confidence intervals using the Bai-Perron method. Finally, we plot the structural breakpoints of the series on the Fitted vs Real values graph of the inflation rate and analyze the reason for these breakpoints. The graphical analysis will demonstrate the impact of the COVID-19 pandemic and the Russia-Ukraine war on the inflation rate of South Asian and Southeast Asian countries.
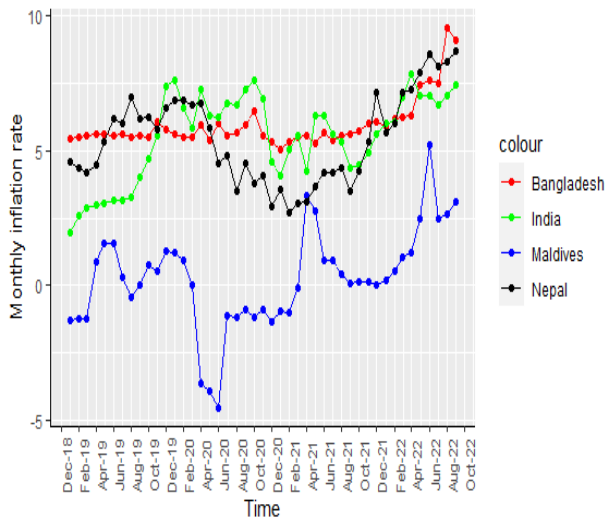

Fig. 1. a) Monthly inflation rate of South Asian countries
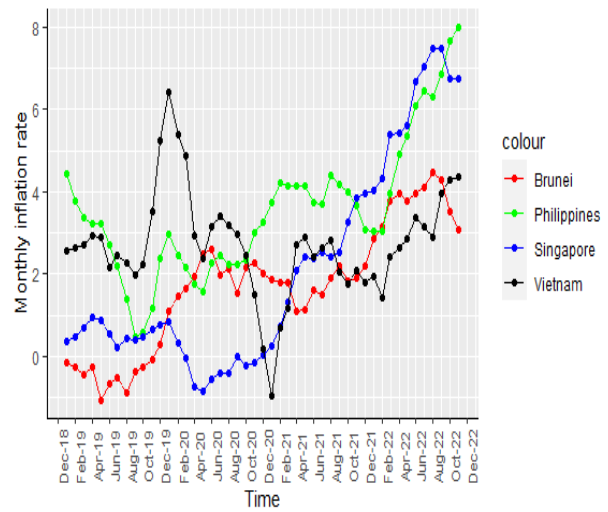

Fig. 1. b) Monthly inflation rate of Southeast Asian countries

The combined graph in Figure 1a displays the monthly inflation rates plot for the South Asian countries analyzed in this study. It is evident from the figure that all the countries experienced a substantial rise in inflation rates following the onset of the Russia-Ukraine war in February 2022. Maldives

encountered a significant inflation rate spike after the beginning of 2021, while India and Nepal witnessed high inflation rates after September 2021. However, Bangladesh's inflation rate remained mostly unaffected until February 2022. Since Sri Lanka's inflation rate is substantially higher than the other

South Asian countries, it is not included in Figure 1a to enable better observation of the series for the other countries.

Figure 1b shows the monthly inflation rate series plot for the Southeast Asian countries considered in our study. The figure indicates a significant increase in inflation rates for the depicted countries, especially after the onset of the Russia-Ukraine war in February 2022. The Philippines encountered a significant inflation rate surge after June 2022, while Vietnam experienced a rapid increase in inflation at the beginning of 2021. Brunei experienced high inflation rates after July 2019, and Singapore's inflation rate started increasing from April 2020 and continued to

rise until August 2022. Therefore, from Figures 1a and 1b, we can conclude that the Russia-Ukraine war has impacted the inflation rate of these countries. Furthermore, the COVID-19 pandemic may have contributed to the remaining significant changes in the inflation rate of these countries.

Initially, it is necessary to convert the monthly inflation series into a stationary one since it currently is non-stationary. To achieve this, we will obtain the series' difference and then assess if it becomes stationary by utilizing the Augmented Dickey-Fuller test.

Table 1. South and Southeast Asian countries time series models and post-estimations

Country	Dicky-Fuller test	Model	RMSE	MPE	Ljung-Box test	Chow test
Bangladesh	Second order stationary (p<0.001)	ARIMA(2,2,0)	0.952	5.43	Independence of fitted model and residual (p=0.54)	Structural breakdown exist (p<0.05)
India	Second order stationary (p<0.01)	ARIMA(0,2,2)	0.795	6.36	Independence of fitted model and residual (p=0.65)	Structural breakdown exist (p<0.01)
Maldives	First order stationary (p<0.05)	ARIMA(2,1,2)	2.211	35.81	Independence of fitted model and residual (p=0.89)	Structural breakdown exist (p<0.001)
Nepal	Second order stationary (p<0.001)	ARIMA(2,2,2)	2.093	28.11	Independence of fitted model and residual (p=0.49)	Structural breakdown exist (p<0.001)
Brunei	Second order stationary (p<0.001)	ARIMA(1,2,0)	0.748	7.13	Independence of fitted model and residual (p=0.18)	Structural breakdown exist (p<0.05)
Philippines	First order stationary (p<0.01)	ARIMA(3,1,3)	2.832	35.19	Independence of fitted model and residual (p=0.26)	Structural breakdown exist (p<0.001)
Singapore	Second order stationary (p<0.01)	ARIMA(2,2,0)	0.786	6.46	Independence of fitted model and residual (p=0.13)	Structural breakdown exist (p<0.01)
Vietnam	First order stationary (p<0.05)	ARIMA(2,1,1)	1.093	17.20	Independence of fitted model and residual (p=0.61)	Structural breakdown exist (p<0.001)

To determine the most appropriate ARIMA model for forecasting the monthly inflation rate for the next twelve months, the series has been divided into two sections: t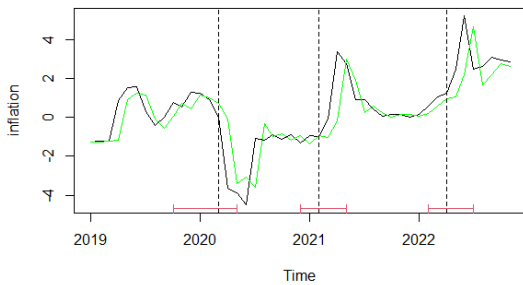he training set and the test set. The training set encompasses the first 80% of the data, whereas the test set consists of the remaining 20%.
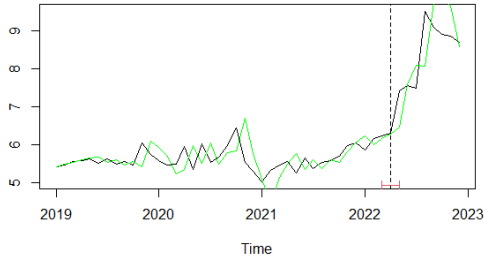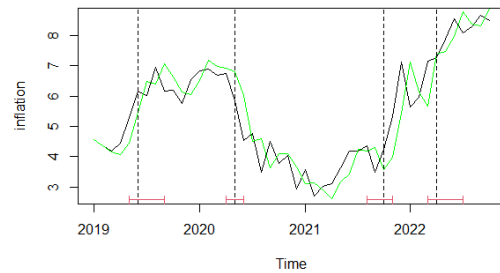
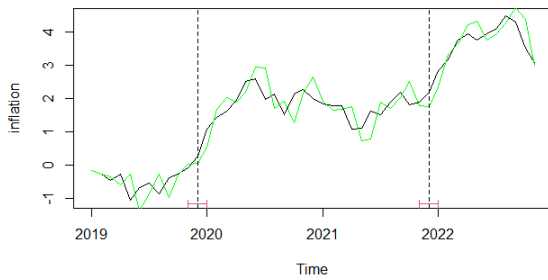**Fig. 2.** a) Structural breakpoints of the inflation of Bangladesh
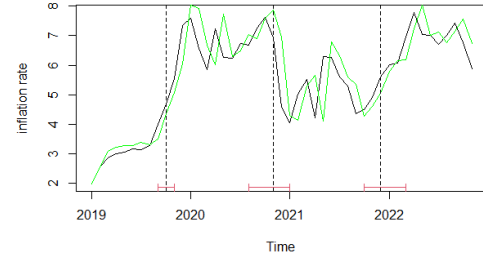
Fig. 2. b) Structural breakpoints of the inflation of India
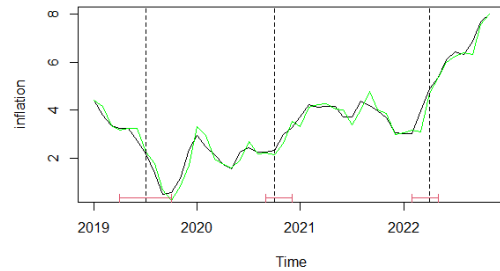
Fig. 2. c) Structural breakpoints of the inflation of Maldives
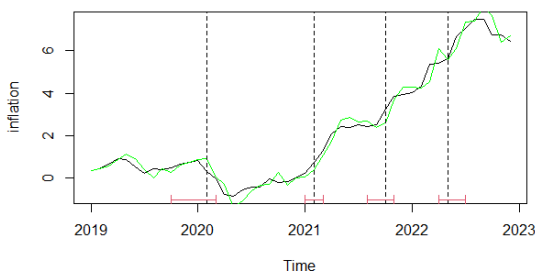
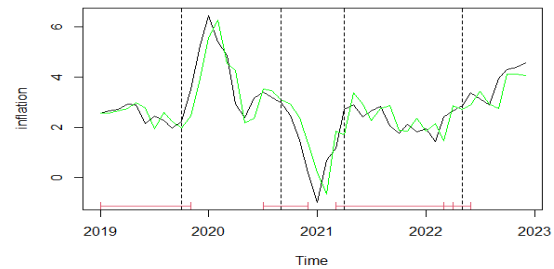**Fig. 2.** d) Structural breakpoints of the inflation of Nepal

Fig. 2. e) Structural breakpoints of the inflation of Brunei

Fig. 2. f) Structural breakpoints of the inflation of Philippines

Fig. 2. g) Structural breakpoints of the inflation of Singapore

Fig. 2. h) Structural breakpoints of the inflation of Vietnam

Figures 2a to 2h show the structural breakpoints of eight countries inflation rates with 95% confidence intervals, where the black-bold line shows the observed inflation rates and dotted line depicted the predicted inflation rates. Stationary check was done by the Dicky-Fuller test, plotted in table 1. Figure 2a shows that there is only one structural breakpoint in the monthly inflation rate of Bangladesh, which occurred between March 2022 to May 2022. This breakpoint coincides with the start of the Russia-Ukraine war in February 2022. After the breakpoint, the monthly inflation rate of Bangladesh increased significantly until September 2022, after which it began to slowly decrease. This suggests that the Russia-Ukraine war had a major impact on the inflation rate of Bangladesh, leading to a significant increase in prices for goods and services. Figure 2b illustrates that there are three structural breakpoints in the monthly inflation rate of India. The first breakpoint occurred in October 2019, and was caused by a high food inflation rate due to delayed and disrupted crop harvests resulting from drought and erratic rain. The second breakpoint was observed in November 2020, during which the inflation rate rapidly decreased, indicating India's economy was recovering from the pandemic. The third breakpoint was observed between October 2021 and March 2022, and was influenced by the COVID-19 pandemic and the Russia-Ukraine war, resulting in a gradual increase in the inflation rate after the breakpoint. Initially, we must make the series stationary as it is currently nonstationary. To accomplish the stationary check, this study computes the difference of the series and then conduct an Augmented Dicky-Fuller test to determine whether the series has become stationary.

Figure 2c infers that the inflation rate of Maldives is expected to increase in the upcoming months. This trend is likely due to the effect of Russia invading Ukraine in February 2022. We can conclude that there are three structural breakdowns in the series of Maldives inflation rate. The first breakdown occurred in March 2020, and after this breakpoint, the inflation rate of Maldives decreased rapidly due to domestic policy measures implemented by the government to ease the burden of the lockdown. The second breakpoint was in February 2021, which was caused by the COVID-19 pandemic. The third breakpoint occurred in February 2022 due to the Russia-Ukraine war, and after these breakpoints, the inflation rate of Maldives increased significantly. According to figure 2d, it can be inferred that the inflation rate in Nepal is expected to rise in the coming months, with a projected inflation rate of around 10% in October 2023, which is considered to be very high. The series contains a total of four structural breakdown points. The first one occurred in June 2019, after which inflation increased. The second occurred in May 2020, after which

Nepal's inflation began to decrease as they were recovering from high inflation. The third occurred in October 2021, during the second wave of COVID-19, as inflation was rising. The fourth occurred in April 2022 due to the Russia-Ukraine war, and after the breakpoint, inflation increased significantly.

Figure 2e displays the structural breakpoints of Brunei. The analysis reveals that there are two structural breakpoints in the series. The first breakpoint occurred in December 2019, which was initiated by high food and rent prices. This was further intensified by the COVID-19 pandemic, which led to restrictions on tourism in the country. After the breakpoint, the inflation rate showed a sharp increase. The second breakpoint occurred in December 2021, initially triggered by the COVID-19 pandemic and further amplified by the Russia-Ukraine war in February 2022. After this breakpoint, the inflation rate started to increase gradually. Based on Figure 2f of Philippines, we can observe that there are three structural breakdown points in the series of Philippines inflation rate. The first one occurred in July 2019, which was caused by some policy measures taken by the government to stabilize the prices of food and energy costs, after the breakpoint inflation decreased. The second one occurred in October 2020, which was due to the COVID-19 pandemic. The third one occurred in April 2022, which was caused by the Russia-Ukraine war. After each of these breakpoints, the inflation rate started to increase quickly. Figure 2g reveals the presence of four structural breakdown points in the series of monthly inflation rate data of Singapore. The first breakpoint occurred around February 2020, during which time inflation was gradually decreasing. The second breakpoint occurred in February 2021, followed by a third in October 2021. During this period, the overall inflation rate increased significantly due to higher private transport and accommodation inflation, with the primary reason being the COVID-19 pandemic. The fourth breakpoint was observed from April 2022 to July 2022, and during this time, inflation increased sharply due to the Russia-Ukraine war. The inflation rate increased significantly after the second and third breakpoints due to the COVID-19 pandemic, which was further exacerbated by the Russia-Ukraine war after the fourth breakpoint. Figure 2h shows the structural breakdowns of Vietnam timeseries data. The plot does indicate a drastic increase in the monthly inflation rate after January 2020, during the COVID-19 pandemic. This increase is also delineated after the month of February, 2022, due to the Russia-Ukraine war, however the peak is not as much as the pandemic period.

IV. Conclusion

Both pandemics and wars can have significant direct and indirect impacts on the economies of countries. A pandemic can affect not only the country in which it originates, but also other countries that are not directly affected. Similarly, a war can affect the economies of the countries involved, as well as those that are not directly involved. In our study, the Russia-Ukraine war had a noteworthy impact on the inflation rates of all South Asian countries, as well as four Southeast Asian countries, this finding matched with the previous review[1]. Bangladesh's inflation rate was not significantly affected by the COVID-19 pandemic, but it rose sharply after the war. India's inflation rate also increased due to the pandemic, and then further increased after the war. Maldives, which heavily relies on tourism, was severely impacted by the pandemic, and its inflation rates increased rapidly after the war. Nepal's economy, which was heavily reliant on tourism, was greatly impacted by the pandemic-induced lockdowns, resulting in an increase in inflation. The country was also significantly affected by the Russia-Ukraine war. Brunei, despite having a robust economy, experienced an increase in inflation due to the pandemic. The Philippines' inflation rate was affected by both the COVID-19 pandemic and the Russia-Ukraine war. Singapore, being a developed country, experienced an increase in inflation from the beginning of the pandemic, and the Russia-Ukraine war further compounded inflationary pressures. Vietnam, being a developing country, did experience significant impacts from either the pandemic or the war, yet Vietnam's inflation rate was lower than the COVID-19 period.

Our analysis indicates that the eight countries studied were significantly impacted by the Russia-Ukraine war[5]. Furthermore, all eight countries had already experienced an increase in inflation rates due to the COVID-19 pandemic. The situation worsened for these countries after Russia invaded Ukraine in February 2022, as their economies were already struggling due to the pandemic, this study findings have similarities with the previous studies as well[7,8]. The added impact of the war exacerbated economic conditions in these countries. To mitigate the impact of pandemics and wars, governments can implement various measures. These include increasing spending on public works programs and infrastructure projects to stimulate the economy and create jobs. Fiscal and monetary policies such as tax cuts, subsidies, interest rate reductions, and quantitative easing can also be implemented. Countries can diversify their economies to reduce reliance on a single industry or sector, which can help mitigate the impact of pandemics or wars that disproportionately affect specific industries.

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