



## Examine the impact of inflation on economic growth

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### Abstract

*In research and economic management, a comprehensive understanding of the correlation between GDP growth and inflation is of paramount importance. This paper uses the Bayesian model averaging to examine whether the impact of inflation on long-run economic growth is robust to alternative model parameters. The empirical results show that the relationship between inflation and economic growth is non-linear and the optimal inflation rate is 4.07 percent. Inflation below the threshold of 4.07 percent exhibits a positive but statistically insignificant impact on economic growth; inflation above the threshold of 4.07 percent has a negative yet negligible impact on economic growth. The authors' findings differ from previous findings in eliminating the effects of inflation when instrumental variables are used.*

**Keywords:** economic growth, inflation, inflation threshold, Bayesian model averaging (BMA).

**JEL classification:** E01, E31, E52.

## 1. Problem statement

Inflation and economic growth remain the central concerns in macroeconomic theory, and financial management policies also focus on these two critical issues. Achieving high, sustainable economic growth and maintaining low inflation are the two primary objectives of governments and policymakers.

A thorough understanding of the correlation between GDP growth and inflation is essential in research and economic management. The trade-off between maintaining economic growth and controlling inflation is not only a big challenge for policymakers but also directly affects a nation's economic and social well-being. Therefore, understanding this relationship provides valuable insights into how economic factors interact and, from there, make appropriate policy decisions.

Whether inflation affects long-term growth has been one of the most widely studied questions since concerns about economic growth re-emerged. If higher inflation reduces long-term growth, then the problem can be addressed with known policies that may be easier to implement than promoting investment in human capital or developing new technology.

There have been many studies on the relationship between economic growth and inflation. The studies use many different methods, mainly on groups of countries, with a few studies for one country. Demircuc-Kunt and Levine (1995) survey used data from 41 countries from 1986 to 1993 to examine how rising inflation affects the financial system. Inflation is measured by market size, concentration, market volatility, financial institution development, and the international impact of inflation. The rate of increase in inflation is closely related to the development of the banking system and non-bank financial institutions (Dinh and Dinh, 2022).

The empirical literature on the relationship between growth and inflation is divided into two main parts. Some studies have found a negative and significant relationship between inflation and economic growth, while others have confirmed a positive and significant relationship between inflation and economic growth (Iqbal and Nawaz, 2010). These studies highlight the possibility of a non-linear relationship between inflation and economic growth. The empirical study by Iqbal and Nawaz (2010) found that the relationship between inflation and economic growth is non-linear and supports the hypothesis that low and stable inflation promotes economic growth and vice versa.

In Vietnam, several studies have explored the relationship between economic growth and inflation. According to some studies (Nguyen, 2017), inflation can exert a one-way impact on economic growth; that is, when inflation is low, it will promote growth, but when inflation is high, it will inhibit growth. Some other studies suggest that the relationship between inflation and economic growth is non-linear; that is, there is an optimal inflation threshold for economic growth, and if inflation exceeds that threshold, it will harm growth. The optimal inflation threshold for Vietnam is estimated to range from 3.79 percent (Ho, 2019) to 5.56 percent (Nguyen et al., 2015). In addition, the relationship between inflation and economic growth also depends on many other factors such as monetary policy, stimulus policy, world economic situation, raw material prices, oil prices, exchange rates, etc.

Dinh and Dinh (2022) developed an empirical model to test the non-linear relationship between inflation and economic growth in Vietnam and recommended using the autoregression methodology with an empirical research sample in Vietnam from 2021 to 2022 to determine the optimal inflation threshold for Vietnam.

Despite the extensive literature on inflation and growth, studies have not considered inflation when reassessing the robust determinants of growth. This paper uses Bayesian model averaging to test whether the impact of inflation on long-run economic growth is robust to alternative model parameters. Model uncertainty addresses the question of which variables to include in the regression. Bayesian model averaging provides a formal way to measure the importance of variables in an uncertain model. It allows the explanatory variables to vary across all possible combinations and then considers the posterior probabilities of the variables in the actual model.

## **2. Research method**

The ongoing trend of high inflation worldwide has raised interest in inflation fluctuations with different concerns and methods. Keynes's research suggests that, in the short run, there will be a trade-off between inflation and growth. Accordingly, achieving high growth necessitates tolerating a certain level of inflation. During this period, growth rate and inflation move in the same direction. In the long run, increases in inflation aimed at fostering growth may fail to yield additional gains and could even lead to a decline in GDP (Nguyen, 2017). However, the existence and nature of the relationship between inflation and economic growth, such as the channels through which it affects real economic activities, are topics of considerable interest and debate due to inconclusive results.

The relationship between inflation and economic growth can be derived using the standard growth equation:

$$Growth = X\beta + \varepsilon \quad (1)$$

Where *Growth* is the GDP growth rate, *X* is the set of explanatory variables,  $\beta$  is the slope coefficient associated with the explanatory variables, and  $\varepsilon$  is the error term. This basic equation is extended to capture the relationship between inflation and economic growth using the following equation:

$$Growth = \alpha_0 + \alpha_1 Inf + X\beta + \varepsilon \quad (2)$$

Where *Inf* is inflation by consumer price index (CPI), *X* is the matrix of other explanatory variables,  $\beta$  is the slope coefficient matrix and  $\varepsilon$  is the error term.

The neoclassical growth model uses investment and population growth in the growth analysis. Increased investment, coupled with a decrease in the population growth rate, promotes economic growth. International trade theory suggests that the inclusion of economic openness in the growth regression has a positive relationship with growth. Money supply is an essential indicator of financial development. Development in the financial sector has a positive relationship with economic growth. The growth model uses the following explanatory variables: investment, population growth, money supply M2, and economic openness.

This study incorporates several additional variables into the model, such as total population, labor force participation rate, employment-to-working-age population ratio, unemployment rate, human capital, and lagged inflation, as control variables. The aim is to use as many variables as possible to ensure that important variables explaining growth can be identified when running the regression to calculate the average of the Bayesian model.

The model is estimated based on the data set of GDP growth rate, gross fixed capital formation (GFCF) (also known as an investment), population, population growth rate, labor force, employment, unemployment and inflation at consumer prices, openness (calculated as the percentage of total exports and imports (Exp+Imp) in GDP) extracted from WDI (WB); money supply M2 extracted from MacroVar; human capital index per capita in Vietnam based on years of schooling and return to education in PWT 10.01 (University of Groningen). The data has been available since 1986 and updated to 2022.

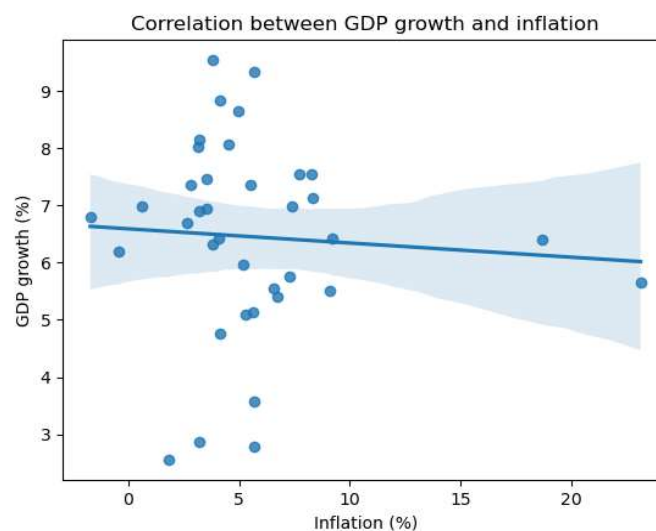
The study applies the Bayesian model averaging (BMA) method, which applies Bayesian inference to problems of model selection, estimation, and prediction that combine to create simple model selection criteria and predict less risk.

In short, the BMA method relies on the posterior probability of each model. The posterior probability depends on the prior probability and the actual data (likelihood). First, we have to set the posterior probability of the models using a probability distribution (usually uniform, assuming that the models have the same probability). Next, BMA analyses each model and calculates the Bayesian Information Criterion (BIC). Finally, the posterior probability is calculated. The model with the highest posterior probability will be selected as the “optimal” model (Steel, 2011).

### 3. Results and discussion

The typical approach is to run a linear regression with GDP per capita growth as the dependent variable and several factors, including inflation, as independent variables. Figure 1 shows the relationship between GDP growth and inflation from 1986 to 2022.

FIGURE 1: **Correlation between GDP growth and inflation in the period 1986-2022**



Source: World Development Indicators, DataBank.

This study uses Bayesian model averaging to calculate the posterior probability that certain variables are related to economic growth. Performing BMA for the linear regression model (2) using Python (Basener, 2021) yields the following results:

TABLE 1: Results of Bayesian model averaging

Variable name	Probability	Average coefficient
const	0.863332	-1108.939309
Inf	0.207019	-0.009244
logPop	0.911887	152.58056
gPop	0.2904	-1.085918
logLF	0.623984	250.318145
lfpr	0.488371	4.396513
logEmp	0.543678	-354.871268
EmpR	0.663102	-2.578977
logU	0.237895	0.33033
U_rate	0.461	-6.907759
M2	0.800574	-0.066645
Inv	0.760865	0.28937
hc	0.700507	14.631788
ghc	0.315729	0.211539
Open	0.347896	0.00905
Inf_1	0.381415	-0.030411

*Source:* Author's calculation.

The first column of Table 1 shows the names of the BMA variables, the second column lists the posterior probabilities of the variables, and the third column displays the mean values of the regression coefficients of the explanatory variables. The analysis reveals that inflation has only a 20.7 percent probability of being included in the model as a determinant of real growth, indicating weak evidence that inflation is related to long-run growth. However, it is almost as likely as some other factors that might be expected to be significant, such as population (91.2 percent), the share of M2 in GDP (80 percent), the share of investment in GDP (76 percent), and human capital (70 percent) which are found to be strong determinants of GDP growth.

The regression results with all 15 variables are shown in Figure 2, showing that only the logarithm of population, investment share, human capital and money supply share are statistically significant with a 95 percent confidence level. Inflation has a negative point estimate but is not statistically significant. The remaining variables are all statistically insignificant. The empirical results show that the relationship between inflation and economic growth is non-linear. So how does inflation affect growth and, more specifically, what gives rise to the so-called threshold effect in the relationship? What are the channels through which inflation can affect growth in a non-linear context?

FIGURE 2: OLS regression of all variables

OLS Regression Results				coef	std err	t	P> t	[0.025	0.975]	
<b>Dep. Variable:</b>	GDP_growth	<b>R-squared:</b>	0.732	<b>const</b>	-1465.8951	516.662	-2.837	0.010	-2543.633	-388.157
<b>Model:</b>	OLS	<b>Adj. R-squared:</b>	0.531	<b>lnf</b>	-0.0522	0.062	-0.848	0.407	-0.181	0.076
<b>Method:</b>	Least Squares	<b>F-statistic:</b>	3.643	<b>logPop</b>	200.2039	58.799	3.405	0.003	77.551	322.856
<b>Date:</b>	Tue, 23 Jan 2024	<b>Prob (F-statistic):</b>	0.00398	<b>gPop</b>	0.9781	4.345	0.225	0.824	-8.085	10.041
<b>Time:</b>	16:07:28	<b>Log-Likelihood:</b>	-43.785	<b>logLF</b>	4376.9516	4745.649	0.922	0.367	-5522.298	1.43e+04
<b>No. Observations:</b>	36	<b>AIC:</b>	119.6	<b>lfpr</b>	-17.2602	54.019	-0.320	0.753	-129.941	95.421
<b>Df Residuals:</b>	20	<b>BIC:</b>	144.9	<b>logEmp</b>	-4517.6509	4762.592	-0.949	0.354	-1.45e+04	5416.943
<b>Df Model:</b>	15			<b>EmpR</b>	20.2450	55.371	0.366	0.718	-95.257	135.747
<b>Covariance Type:</b>	nonrobust			<b>logU</b>	0.2993	8.573	0.035	0.972	-17.583	18.182
				<b>U_rate</b>	-32.1354	19.081	-1.684	0.108	-71.937	7.666
<b>Omnibus:</b>	0.678	<b>Durbin-Watson:</b>	2.185	<b>M2</b>	-0.1317	0.046	-2.852	0.010	-0.228	-0.035
<b>Prob(Omnibus):</b>	0.712	<b>Jarque-Bera (JB):</b>	0.108	<b>lnv</b>	0.3904	0.172	2.273	0.034	0.032	0.749
<b>Skew:</b>	-0.053	<b>Prob(JB):</b>	0.947	<b>hc</b>	30.6685	13.283	2.309	0.032	2.962	58.375
<b>Kurtosis:</b>	3.246	<b>Cond. No.</b>	7.04e+06	<b>ghc</b>	-0.0723	0.676	-0.107	0.916	-1.483	1.338
				<b>Open</b>	0.0313	0.022	1.437	0.166	-0.014	0.077
				<b>lnf_1</b>	-0.0795	0.056	-1.419	0.171	-0.196	0.037

Source: Author's calculation.

Recent literature (Dinh and Dinh, 2022) emphasizes that investment can be considered an important channel through which the impact of inflation is transmitted nonlinearly to economic growth. The nonlinear relationship between investment, inflation and economic growth can be explained by using the development of financial markets. The above empirical BMA results also confirm this: the variables of population, investment, human capital, and money supply M2 have a tight impact on GDP growth. Theoretical and empirical debate predicts that threshold effects are related to inflation rates above some "critical value" or below some "critical value". The optimal inflation threshold is the rate of inflation at which economic growth is most efficient. If inflation is too high or too low, it will hurt economic growth.

Here, we see that the lag of the inflation variable has a larger impact than inflation itself (probability is 38.1 percent vs. 20.7 percent). Therefore, instead of considering inflation, we consider its lag in the model. The threshold model is designed as follows:

$$\begin{aligned} Growth(t) = & \alpha_0 + \alpha_1 Inf(t-1)Dum(Inf \leq Inf^*) + \alpha_2 Inf(t-1)Dum(Inf > Inf^*) \\ & + \alpha_3 \log Pop(t) + \alpha_4 M2(t) + \alpha_5 Inv(t) + \alpha_6 hc(t) + \varepsilon \end{aligned} \quad (3)$$

Where,  $Growth(t)$  is GDP growth at time  $t$ ,  $Inf(t-1)$  is the inflation rate at time  $t-1$ , and  $Inf^*$  is the inflation threshold for different values to find the optimal model (the coefficient of determination  $R^2$  is the largest),  $Dum()$  is a dummy variable,  $\log Pop$  is the logarithm of population is a control variable, representing the labour force,  $M2$  is the proportion of money supply  $M2$  in GDP,  $Inv$  is investment measured by the gross fixed capital formation (GFCF) as a percentage of GDP,  $hc$  is human capital,  $\varepsilon$  is the residual error.

Using a random optimisation algorithm such as simulated annealing (Pham, 2019), to find the value of  $Inf^*$  so that the objective function, the coefficient of determination  $R^2$ , reaches the maximum value. The result of the optimal inflation threshold is determined to be 4.07 percent. Inflation rate below the threshold of 4.07 percent has a positive impact on economic growth but is insignificant, inflation above the threshold of 4.07 percent has a negative effect and is also not significant.

#### 4. Conclusion and policy recommendations

These findings provide some important policy implications. The analysis suggests that inflation rate should be kept below four percent; hence, the State Bank of Vietnam should focus on policies that keep inflation below the inflation threshold as it may help achieve strong economic growth. Inflation rate above the threshold will have adverse consequences for the growth rate. Monetary policy should be designed to stabilize prices and contain inflation. Low inflation is also helpful in reducing financial market volatility since it promotes domestic investment. In the long run, uncontrolled inflation can lead to economic recession, significantly decreasing GDP. Therefore, there is a need for better coordination between monetary and fiscal policies to achieve both objectives, i.e., high and sustainable economic growth alongside low inflation.

These findings confirm several insights that have been found, or at least surmised, over the past decade. For inflation to produce robust results, the data must have a higher frequency than the average to be used in the growth regressions. Furthermore, the results confirm that high inflation observations mainly promote the results. The findings of this study differ markedly from previous findings in that the effects of inflation are removed when instrumental variables are used. Future research should, therefore, take on the critical issue of the endogeneity of inflation. In particular, looking directly at how inflation affects investment, savings, productivity, and similar things is essential.

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### Article history

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Received on February 23, 2024

Revised on March 15, 2024

Accepted on March 16, 2024