Estimating the Inflation Threshold in Vietnam: A Threshold Autoregressive Approach with Output Gap Dynamics

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Abstract

The relationship between inflation and economic growth is an ongoing concern of researchers and policymakers. Most previous studies on Vietnam's inflation threshold have focused narrowly on the inflation and economic growth relationship. However, if potential output is the ultimate goal of macroeconomic policies, it is necessary to identify the inflation threshold at which the effect of inflation on the gap between the real output and potential output reverses direction from positive to negative, which means the real output is closer to the potential output. Following this perspective, this paper investigates the relationship between the inflation threshold and the output gap in Vietnam by applying the discrete threshold autoregressive model with quarterly data from 2001q1 to 2018q4. The model results identify two threshold values with three regimes of inflation: 0.91% and 1.54% per quarter (i.e., 3.6% to 6.16% per year). If the inflation is within this threshold, the real GDP tends to approach the potential level. If the quarterly inflation is below 0.91% or exceeds 1.54%, it leads to an increase in the distance between the real output and its optimal level. These findings provide important policy implications for inflation control and macroeconomic management in Vietnam and represent the first application of a TAR model incorporating output gap and financial variables in this context.

Keywords: Inflation threshold, output gap, discrete threshold autoregressive model.

1. Introduction

Exploring the relationship between inflation and output is of concern to both researchers and policymakers. A good output performance along with low and stable inflation is the main objective of macroeconomic policy. Most current research confirms that a non-linear relationship exists between these two important variables. The literature implies that inflation is necessary to foster the economy, but accelerating inflation is not favored owing to undesirable distribution and social welfare effects (Eggoh & Khan, 2014), especially in medium and longrun growth (Khan & Senhadji, 2001). This means that inflation will have a beneficial effect on economic growth only if it is within an appropriate level, which is called

the inflation threshold, or the optimal level of inflation. The inflation threshold is a point at which the effect of inflation on economic growth switches from positive to negative (Sarel, 1996).

Vietnam was recognized for successfully escaping poverty and becoming the world's 34th largest economy in terms of GDP, as measured by purchasing power parity (PPP), according to the International Monetary Fund's 2024 ranking. Like citizens in many developing countries, Vietnamese citizens have faced unstable movements of inflation on the way to escaping poverty. For many years, a higher inflation rate has been considered the price for higher economic growth in Vietnam. However, two-digit inflation, which has caused uncertainty, has alarmed Vietnam's policymakers as they seek an optimal inflation level for the economy.

The relationship between Vietnam's inflation and output has increasingly attracted the attention of researchers as well as policymakers. A growing body of empirical literature has attempted to quantify the inflation threshold for Vietnam using a variety of data, methods, and dependent variables (Tran, 2018; Tung & Thanh, 2015; Nguyen, 2022, 2023; Tu et al., 2025; Bui & Nguyen, 2023; and Vo et al., 2019). The majority of these studies confirm the existence of a nonlinear relationship between inflation and macroeconomic outcomes; however, important limitations remain, particularly with regard to the treatment of cyclical conditions and financial variables. While the existing studies contribute valuable insights into the inflation–growth and inflation–finance relationships in Vietnam, they suffer from several shared limitations. They generally use output growth rather than output gap, thus neglecting the cyclical position of the economy. Most adopt linear or semi-parametric models, which are limited in capturing threshold behavior under different macro-financial regimes. They often overlook financial condition variables, such as credit expansion, interest rates, or capital market activity, which are known to affect how inflation translates into macroeconomic outcomes. No study to date has applied a threshold autoregressive (TAR) model to simultaneously capture the interaction between inflation, output gap, and financial conditions. Therefore, while several inflation thresholds have been estimated for Vietnam, none have systematically modeled these thresholds using output gap as the dependent variable, nor have they accounted for the financial and institutional context within which inflation operates. This gap is particularly relevant given Vietnam's evolving monetary policy framework, financial deepening, and commitment to macroeconomic stability.

Against this backdrop, the purpose of this study is to answer the question of whether there exists any optimal threshold effect of inflation in relation to the output gap distance

needed to support sustainable economic growth in Vietnam. To answer this question, this study applies the discrete threshold autoregressive model (TAR) developed by Hansen (1999). This study contributes to the literature by employing the output gap instead of output growth to investigate the inflation threshold in a developing economy such as Vietnam. Besides, we include financial condition indicators in the model to explore the optimal inflation rate for Vietnam.

Current analysis employs seasonally adjusted quarterly data covering the period from 2001q1 to 2018q4, in which Vietnam's economy experienced an unprecedented phase of structural changes and deepening globalization of its economy. In particular, this period was characterized by Vietnam's shift from a centrally managed economy to one that is influenced by the open market, and significant trade liberalization, foreign direct investment inflows, and rapid economic growth. Through this period, Vietnam was dealing with the legacy of the late 1990s Asian financial crisis, high inflation in the late 2000s, and the protracted round of macroeconomic stabilization policies that followed. Vietnam, as a very open and import-dependent economy, thus became heavily exposed to these external shocks. The sharp increase in inflation was further amplified around the 2007–2008 global financial crisis, which affected international commodity prices and financial markets. This period is also vital because it covers Vietnam's entry to the World Trade Organization (WTO) in 2007, which significantly affected Vietnam's trade flows, investment environment, and economic structure as a whole. Data up to 2018 is included, which reflects the pre-Covid-19 economic environment and provides a pre-Covid-19 benchmark for comparison with subsequent economic developments. As a result, examining the inflation threshold and output gap in this particular period allows a full-scale overview of how these two macroeconomic variables moved on each other during the time of economic convergence and adjustment. In that period there were relatively tough years of a global financial shock, and that is one of the reasons why the period is interesting when considering a threshold autoregressive model.

The sections that follow provide a comprehensive literature review on inflation thresholds and their macroeconomic determinants, describe the research methodology, report and discuss the results of the analyses, and conclude by identifying the policy implications of this research.

2. Literature review

2.1 Theoretical foundation

This study draws upon two primary macroeconomic theories to frame its analysis of nonlinear inflation dynamics: the Phillips Curve and the Welfare Loss Function. These

frameworks jointly explain how inflation transmits through the output gap and financial channels, thereby shaping macroeconomic stability.

The Phillips Curve, originating from the seminal work of Phillips (1958) and later extended by Friedman (1968) and Phelps (1967), posits that inflation dynamics are significantly influenced by the state of the real economy. In its modern form, the Phillips Curve captures the core transmission mechanism through the output gap, representing the deviation of actual output from its potential. When the economy overheats (positive output gap), upward pressure on prices emerges due to increased demand and tighter labor markets. Conversely, negative output gaps ease inflationary pressure. This relationship forms the basis of many central banks' inflation-targeting frameworks, whereby policy tools such as interest rates influence aggregate demand and, in turn, the inflation trajectory via the output gap. The model was further expanded to incorporate supply shocks and expectations, acknowledging that external price pressures (e.g., commodity shocks) and agents' anticipations of future inflation also shape short-term inflation dynamics. These additions have allowed the Phillips Curve to remain a relevant tool for analyzing inflation in various macroeconomic contexts.

Complementing this is the Welfare Loss Function, particularly in the context of New Keynesian models. Proposed by Woodford (2003), the loss function measures deviations from inflation and the optimal-targeted output. At first, it only considered inflation and the output gap as arguments, a policy trade-off. Recent extensions of the model, however, have introduced financial variables into the loss function, hence encompassing another channel through which inflation and monetary policy affect macroeconomic stability. The effects can be positive or negative, depending on the specific aspect of financial conditions, such as credit growth, exchange rate volatility, or asset prices. For instance, credit booms may contribute to overheating and asset bubbles, which amplify the effects of inflation on output variability. The augmented loss function features measures of financial stability as well as of exchange rate misalignments together with inflation and output gaps, emphasizing the multi-dimensional nature of optimal monetary policy. These developments indicate that the impact of inflation on real economic performance is propagated not only through the traditional output gap channel but also through the changing state of the financial system.

2.2 Empirical evidence

Building upon the theoretical foundations outlined above, a growing body of empirical research has sought to estimate the inflation threshold and explore its macroeconomic implications. One of the earliest and most influential strands of research on the inflation–growth nexus seeks to identify the optimal level of inflation by exploring the

possibility of a non-linear relationship. Foundational studies in this literature have provided compelling empirical evidence that inflation may promote growth only up to a certain threshold, beyond which its effects become detrimental. Fischer (1993) identified a potential non-linear relationship between inflation and economic growth, noting the simultaneous occurrence of growth and low inflation, thereby contributing novel insights to the field. Consistent with Fischer (1993), Ghosh & Phillips (1998), employing a decision tree methodology, identified inflation as a key determinant of economic growth; however, they also cautioned against its potential negative impacts on growth. Another representative research study on cross-country data is Sarel (1996), who found evidence of a structural break at the inflation rate; that is, inflation could have a negative effect on economic growth when it surpassed the optimal level.

Despite recognition of the non-linear relationship between movements of inflation and output, discussion of the inflation threshold determinants has evolved. A number of empirical studies have investigated the relationship between inflation and the output gap rather than output growth (Lown & Rich, 1997; Higo & Nakada, 1999; Dwyer et al., 2010; Tiwari et al., 2014). Their findings imply that the output gap is a significant variable for inflation determination because the macroeconomic policy's target approaches the optimal output rather than reaching output growth. For example, Lown & Rich (1997) studied the U.S. case over the period 1965–1996, and Dwyer et al. (2010) analyzed U.K. inflation over the period 1980–2010. Higo & Nakada (1999) undertook a cross-country study for industrialized countries (Japan, the U.S., Germany, the U.K., and Canada). Tiwari et al. (2014) used the wavelet framework, combined with classical time series analysis and frequency domain analysis, to test the Phillips curve theory about the relationship between inflation and output gap in France. Their results indicated that the fluctuations in both inflation and output gap were correlated, whereas the output gap led inflation in the short and medium term. In line with this evolving focus, Hwang & Zhu (2024) investigate how oil price shocks affect inflation in a state-dependent manner, using panel data from 30 countries over two decades. Their results reveal that inflationary impacts from oil price shocks are significantly stronger during economic booms than in recessions. Notably, they find that although inflation-targeting regimes do not outperform non-inflation-targeting regimes in reducing the magnitude or volatility of inflation, they do help shorten the duration of inflation deviations from the target range. These findings highlight the importance of macroeconomic regime context and suggest that the effectiveness of monetary policy depends not only on the instrument itself but also on

the prevailing phase of the business cycle. The result reinforces the need to consider the output gap and dynamic policy responses when analyzing inflation thresholds.

Along with the growing literature on the determinants of the inflation threshold, there have been increasing concerns about the role of financial conditions on the optimal level of inflation, especially after the 2007–2009 global financial crisis. Khan & Rana (2012) demonstrated that different inflation thresholds for the same country depended on the country's macroeconomic conditions, such as the level of financial development, the rate of investment/GDP, the level of trade openness, and the size of public debt. Woodford (2013) stressed the role of the financial condition and condition of output gaps in the inflation–growth relationship; that is, if the central bank's policy only focuses on an inflation target, it can put pressure on output, leading to instability of the real economic sector. Therefore, to ensure stability in the real economic sector, monetary policy should be planned and implemented flexibly in relation to the context of financial conditions (e.g., interest rates, credit growth, and risk of financial bubble) as well as fundamental indicators, including the output gap.

Despite growing studies examining the relationship between inflation and output growth, estimating the inflation threshold in the relationship with the distance of the output gap and financial condition has been opened and attracted researchers and policymakers. Rousseau & Wachtel (2002) highlight a critical interaction between inflation and financial development. Their study reveals that the positive contribution of financial depth to economic growth diminishes and can even reverse when inflation exceeds a certain threshold, estimated between 13% and 25%. This finding suggests that high inflation not only affects real variables like output or employment but also disrupts the efficiency of financial intermediation. It suggests that the inflation threshold might affect growth through its effect on the ability of the financial system to allocate resources efficiently. Baglan and Yoldas (2014) and Eggoh and Khan (2014) noted that the threshold level is country-specific in nature. At the same time, another study by Ogrokhina & Rodriguez (2019) also furnishes strong evidence on the extent to which the dynamic structuring of inflation targeting regimes and capital account openness influence macroeconomic performance in developing countries. Their findings suggest that by adopting inflation targeting and high financial openness, countries sharply decrease the foreign currency share of public debt. Notably, the gains are apparent only beyond a threshold of financial openness, and we see them most clearly three years after policy intervention. These results underscore the need to assess the performance of inflation targeting through the lens of a wider policy framework, including institutional credibility,

financial integration, and macroeconomic stability. This also provides additional evidence on the inclusion of financial condition variables in models of inflation thresholds.

With the development of the literature, more and more researchers applied sophisticated threshold modeling techniques in various empirical domains, such as panel studies with global coverage and country-specific studies on developing countries. Bick (2010) was the first to set up a general panel threshold model that verified the statistical and economic importance of the optimal level of inflation, that is, the level beyond which inflation starts to become harmful. Kremer et al. (2013) employed a large panel data sample of 124 countries and discovered that a group of developing countries has an optimal inflation threshold of 17%, and for a group of developed countries, it was much lower at 2%. Thanh (2015) used the Panel Smooth Transition Regression (PSTR) model to calculate the inflation threshold for ASEAN-5 countries (Indonesia, Malaysia, the Philippines, Thailand, and Vietnam) covering the period between 1980 and 2011. The study reported a threshold of 7.8% for this group of countries. Threshold effects of inflation on banking performance have been investigated by Khue & Lai (2020) within the context of the ASEAN-6 by taking a panel data approach. They find that inflation deeper than 5% has a negative impact on banks' profitability, which seems to imply a non-linear relationship. There have also been studies on investigating the threshold(s) of inflation over individual developing countries. For example, Singh and Kalirajan (2003) found a threshold level of inflation around 6% for India, above which inflation inhibits growth. Similarly, Nazir et al. (2017) estimated the non-linear threshold as 5.5%–9% for Pakistan, based on non-linear methodologies, which implies that the presence of a moderate level of inflation will maintain economic growth; however, a higher level will undermine economic growth. For Nigeria, Falegan & Amali (2023) discovered that inflation accelerates economic growth up to a level of 18% before hampering growth. Bhusal & Silpakar (2011) researched the threshold level of inflation for Nepal, and they found it at the level of 6%.

Some studies that focused on Vietnam's threshold inflation have been conducted as follows: Tran (2018), Tung & Thanh (2015), Nguyen (2022, 2023), Tu et al. (2025), Bui & Nguyen (2023), and Vo et al. (2019). Tran (2018) utilized Sarel's (1996) threshold regression model to investigate the optimal level of inflation for Vietnam from 1990 to 2015. The model indicated that 3%–4% inflation was beneficial for economic growth, but the positive impact withered as inflation approached 5.5%–7.5%. Likewise, based on OLS, 2SLS, and GMM estimation over the period 1986-2013, Tung & Thanh (2015) found an inflation threshold of around 7%. While these studies were among the first to estimate

Vietnam-specific thresholds, they primarily relied on output growth as the dependent variable and did not account for cyclical dynamics such as the output gap or monetary policy stances. In an effort to extend the inflation threshold literature, Nguyen (2023) examined the nonlinear effect of inflation on the relationship between banking development and economic growth. Using a threshold regression model, the study revealed that inflation above 9.19% reduced the positive influence of banking development on growth. This finding suggests that inflation can undermine financial intermediation, particularly in developing economies. Likewise, Nguyen (2022) found that financial development could only promote economic growth when inflation remained below a 9.2% threshold. Although these studies move beyond a simple inflation–growth nexus, they do not directly model the inflation threshold in relation to output gap dynamics or explicitly examine financial condition variables such as credit growth or capital flows. Besides, Bui & Nguyen (2023) explored the nonlinear effect of inflation on the stock market of Vietnam by considering the capitalization of listed companies. The study found a threshold of inflation of 1.9% using a quadratic regression model, and for inflation levels greater than the threshold, market capitalization decreased sharply. This result stands out as illustrating how inflation influences financial stability, not only in real economic variables. Further, Tu et al. (2025) investigated the factors influencing banking stability in Vietnam based on machine learning methods such as Ridge regression and ElasticNet. Although one of the predictors was inflation, the study did not try to estimate threshold effects or to test the impact of inflation with business cycles. Similarly, Vo et al. (2019) studied the impact of financial inclusion on macroeconomic stability, and they indirectly considered inflation as a mediating variable, but without modeling threshold effects. In general, despite these studies having made significant empirical contributions to the inflation–growth and inflation–finance linkage in Vietnam, they have left a number of gaps open, notably around the structure and dynamic of the output gap and the role of financial conditions on sculpting inflation threshold effects.

3. Research methodology

3.1. Discrete threshold autoregressive model

The discrete threshold autoregressive model is introduced in Hansen (1999) to analyze the effect of inflation on the output gap, where the model estimates the correct inflation threshold that drives the economy closer to its "potential output" but not too far below it, to reduce the gap between the actual output and the potential level. The TAR model is used in this study as there may be discrete regime shifts in the macroeconomic relationship. Unlike PSTR, which is based on the assumption of smooth transitions, TAR is more suitable

to find the abrupt non-linear effects, especially when the policy response or structural changes result in sharp behavioral changes. This renders TAR very appropriate to analyze the effect of inflation on the output gap in a transition economy such as Vietnam, where financial and institutional circumstances may cause clearly defined thresholds of the output gap.

This model has a form as follows:

$y_t = x_t \beta + z_t \delta_1 (q_t \leq \gamma_1) + z_t \delta_1 (q_t > \gamma_1) + u_t$

yt: dependent variable at time t

xt: explanatory variable outside the threshold mechanism at time t

zt: explanatory variable in the threshold mechanism at time t

β, δ: correlation coefficient

qt: threshold variable

γ_1: threshold value

To determine the inflation threshold by applying the discrete threshold autoregressive model, we chose the output gap as the dependent variable and the inflation rate as the threshold. Other variables, representing financial condition, trade openness, and supply shocks, were also applied to the model (Woodford, 2013; Khan & Rana, 2012; Thanh, 2015). These variables included measures of money supply, the world oil price, the exchange rate, the VN-Index, and trade openness.

Dependent variable: Square of the output gap (OUTPUTGAP_SQUARE).

The smaller the value of this variable is, the closer the economy is to reaching its "potential output."

The objective of this research is to determine a range of inflation wherein outside the range, higher inflation will widen the output gap despite the initial stage of the output gap being positive or negative. The reason that the output gap is in the squared form (OUTPUTGAP_SQUARE) is to eliminate the negative value of this variable. *Explanatory variables:* initial output gap OUTPUTGAP (−1), inflation (CPI), money supply (MS), the world oil price (POIL), exchange rate (Nominal Effective Exchange Rate - NEER), VN-Index (VNINDEX), and the degree of trade openness (TRADEOPEN). In this specification, CPI is the threshold-determining variable; VNINDEX, POIL, NEER, and MS are in the threshold regime(s)[1] and the initial output gap OUTPUTGAP (−1) and TRADEOPEN are outside the threshold regime(s).

[1] The threshold mechanism is the mechanism in which explanatory variables can directly affect the inflation–output gap transmission mechanism.

In addition, the model uses dummy variables. DUM3 and DUM4 are used to adjust for the seasonality of the quarterly data. DUM5 represents the world's economic crisis during 2007–2009 with strong and abnormal fluctuations of inflation.

Thus, the regression model has the form:

$$OUTPUTGAP\_SQUARE = OUTPUTGAP(-1)\,\beta 1 + TRADEOPEN\,\beta 2 + DUM3\,\beta 3 + DUM4\,\beta 4 + DUM5\,\beta 5 + [CPI\,\delta_1 + MS\,\delta_2 + VNINDEX\,\delta_3 + POIL\,\delta_4 + NEER\,\delta_5\,(CPI \le \gamma_1)] + [CPI\,\delta_1 + MS\,\delta_2 + VNINDEX\,\delta_3 + POIL\,\delta_4 + NEER\,\delta_5\,(CPI > \gamma_1)] + u_t$$

The model is based on the hypothesis that an inflation threshold exists at which the impact of inflation on the output gap changes from a negative direction to a positive direction. That is, when the inflation rate is low, a rise in inflation causes the output gap to decrease. In other words, the "real output" is closer to the "potential output" (negative relation). However, when inflation reaches a certain level, an increase in inflation causes a larger output gap (positive relation).

Thus, the objective of this model is to determine the threshold of inflation, which shifts the impacts of the output gap from negative to positive.

3.2. Data description

Quarterly data from the first quarter of 2001 through the final quarter of 2018 are used to test the discrete threshold autoregressive model. Details of how to calculate the variables included in the model are shown in Table 1.

Table 1: Variables used in the discrete threshold autoregressive model

No	Variable	Symbol	Measurement	Data source	Period
1	Output gap	OUTPUTGAP_SQUARE	Square of the difference between Gross Domestic Product at 2010 prices (bil. VND) and the "potential output" (calculated by H-P filter) -%	GSO[2]	2001q1-2018q4
2	Inflation	CPI	Consumer price index (compared to last period) - %	IFS[3]	2001q1-2018q4
3	Money supply	MS	Money supply (compared to the same period last year) -%	IFS	2001q1-2018q4
4	The world oil price	POIL	Brent Crude oil price - Europe (2001q1=100)	FRED[4]	2001q1-2018q4
5	Degree of trade openness	TRADEOPEN	Total exports and imports/GDP -%	IFS, GSO	2001q1-2018q4

[2] General Statistics Office of Vietnam (GSO)
[3] International Financial Statistics, IMF
[4] Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org

No	Variable	Symbol	Measurement	Data source	Period
6	Exchange rate	NEER	Nominal effective exchange rate (2001q1 = 100), calculated by the method of Hang et al. (2010)[5]	IFS, DOTS[6]	2001q1-2018q4
7	VN-Index	VNINDEX	VN-Index (calculated on a quarterly basis) (2001q1=100)	STOC KBIZ[7]	2001q1-2018q4

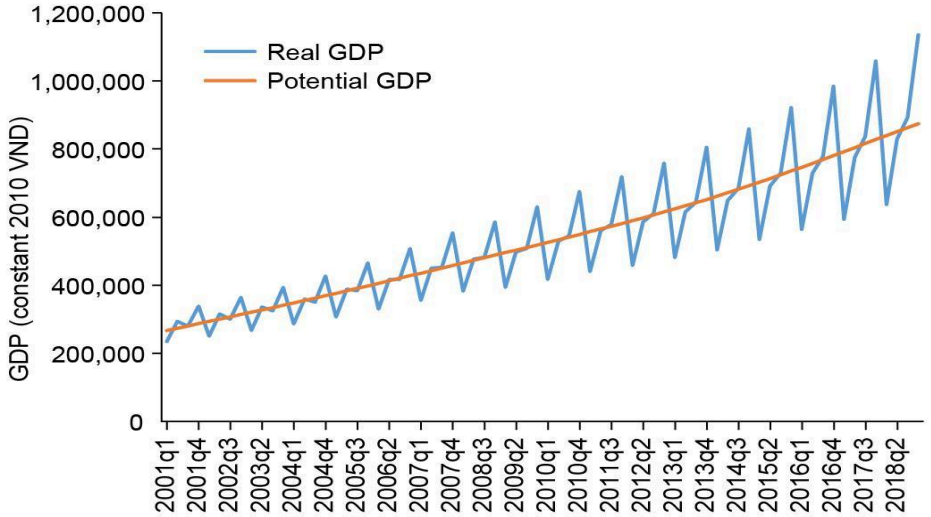
Source(s): *Authors' own creation/work*

Calculation of the "potential output" and the output gap:

Determining the "potential output" level is critical to calculating the output gap. Among the methods that have been used by researchers and policymakers, the H-P (Hodrick-Prescott) filter method is not complicated and thus frequently used. The H-P filter is a non-linear method that decomposes the GDP series into two components: trend and cyclical. After the cyclical component is removed from the GDP, the remaining part is the trend component, representing the potential output. The H-P filter method assumes that cyclical components fluctuate around trend components with decreasing effect over time. Therefore, the average deviation of "actual output" and "potential output" is assumed to be approximately zero during the entire study period. The purpose of this method is to smooth the time trend by allowing the regression coefficients to change over time, to find a time trend that minimizes the sum of the output gap at all times and the speed of change in the "potential output" at the last observation (Economic Committee of the National Assembly and UNDP in Vietnam, 2013).

Figure 1 describes the relation between the actual output and the potential output of Vietnam (calculated by the H-P filter method) in the period of 2001q1–2018q4. In the early years of the research period, the "actual output was relatively close to that of the potential output. However, during the research period, the "actual output" curve increasingly fluctuates and is farther away from the trend of the "potential output" curve, which reflects the increasing level of the output gap.

[5] Nguyen T.T.H. et al. (2010)
[6] Direction of Trade Statistics, IMF
[7] https://www.stockbiz.vn/IndicesStats.aspx

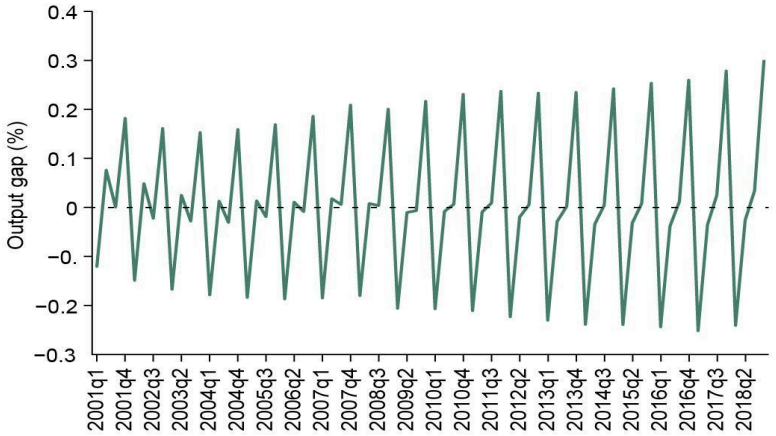


Source(s): *Authors' own creation/work*

Figure 1: Actual and potential GDP of Vietnam, 2001–2018

After calculating the "potential output", the output gap is determined by taking the difference between the "actual output" and the "potential output."

Output gap = (Actual GDP−Potential GDP) / Potential GDP * 100%



Source(s): *Authors' own creation/work*

Figure 2: Output gap of Vietnam in the period 2001–2018

Figure 2 reveals that the output gap fluctuated around +/−0.1%, reaching its highest value of approximately 0.3% in the 4th quarter of 2018.

3.3. Analytical process

Step 1: Test statistical hypotheses (checking stationarity of the data series, the phenomenon of redundancy/lack of variables, heteroskedasticity, and autocorrelation in the model).

Step 2: Check the nonlinear relationship between inflation and the output gap.

The following equation is used to verify whether there is a nonlinear relationship between the output gap and inflation:

$$OUTPUTGAP\_SQUARE = \alpha_0 + \alpha_1 CPI + \alpha_2 CPI^2 + Matrix\ X$$

Where OUTPUTGAP_SQUARE is the squared form of the output gap variable, and CPI reflects the inflation rate.

If α_2 equals zero, there is a linear relationship between the output gap and inflation. The relationship between these two variables is inverse when α_1 is negative. Conversely, if α_1 is positive, OUTPUTGAP_SQUARE rises when CPI increases. However, α_2 is expected to be non-zero. In case the sign of α_1 and α_2 is opposite and the relationship between these two coefficients is statistically significant, it can be concluded that there is a level of inflation at which the impact of inflation on the output gap reverses from negative/unaffected to positive.

Step 3: Run the discrete threshold autoregressive model.

4. Research results and discussion

4.1. Testing statistical hypotheses

Stationarity is one of the first fundamental statistical property tests when analyzing time series data to avoid spurious regression. An Augmented Dickey-Fuller (ADF) test was used to determine the stationarity of the data series, with the 10-lag limit to make sure that the errors in these equations were white noise. The Schwarz Info Criterion (SIC) was used to select the lag for the ADF test equation. The results of the test (Appendix A1) show that all variables (except CPI) are stationary at the 1% level of significance when taking the first difference. Thus, the CPI variable was used in the level form, whereas other variables, including MS, POIL, TRADEOPEN, VNINDEX, and NEER, were used in the form of the first-order difference. Although the OUTPUTGAP_SQUARE variable was not stationary at level, it was still used in this form. This is explained by investigating the results of the co-integration relationship testing between OUTPUTGAP_SQUARE and CPI. Specifically, this was done as follows. During regression, non-stationary time series of data led to fake regression. Although using the first difference form of variables can ensure stationarity, valuable information about the long-term direct relationship between the macro variables may be lost. Therefore, if the Johansen test or regression model of residuals shows a co-integration relationship, and the error correction model shows a long-term relationship, directly regressing the variables will not encounter fake regression problems. Indeed, the Johansen co-integration test results show that there is a co-integration relationship between inflation and the output gap (see Appendix A2). Regressing the output gap on inflation, followed by regressing the change in the residual on the lagged residual by one quarter. The result is statistically significant at the 1% level which demonstrates a co-integration relationship between inflation and the output gap (see Appendix A3). The error correction model, with a

1% statistically significant ECM coefficient, also shows an adjustment toward the long-term equilibrium between OUTPUTGAP_SQUARE and CPI (see Appendix A4).

- *Checking the phenomenon of redundancy/lack of variables in the model:*

The results of the Ramsey (Appendix A5) and redundancy tests (Appendix A6) show that there is neither a missing variable nor a redundant variable in the model.

- *Checking and correcting the phenomenon of heteroskedasticity and autocorrelation in the model*

The test results reveal that there is heteroskedasticity and an autocorrelation phenomenon in the model. To address these issues, the HAC (Newey - West) method is applied. After using the HAC method, the results of checking the heteroskedasticity and autocorrelation can be seen in Table 2.

Table 2: Diagnostic Tests for Serial Correlation and Heteroskedasticity

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.053467	Prob. F(1,58)	0.8180
Obs*R-squared	0.064470	Prob. Chi-Square(1)	0.7996

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.056168	Prob. F(10,59)	0.4099
Obs*R-squared	10.62823	Prob. Chi-Square(10)	0.3872
Scaled explained SS	8.211770	Prob. Chi-Square(10)	0.6082

Source(s): *Authors' own creation/work*

4.2. Checking the nonlinear relationship between inflation and the output gap

This step assumes that the dependence of the output gap on inflation is the quadratic function (parabola). If the coefficient of inflation and the coefficient of squared inflation are opposite and statistically significant, it can be concluded that a nonlinear relationship exists. The regression results confirm that there is a nonlinear relationship between inflation and output gap, represented as follows:

$$OUTPUTGAP\_SQUARE = 0.0329664264127 - 0.00951676437095 * CPI(-2) + 0.0010622109449 * CPI(-2)^2$$

4.3. Results of the discrete threshold autoregressive model

The discrete threshold autoregressive model reveals that there are two threshold values of inflation (quarterly): 0.91% and 1.54% (see Table 3). According to these results, inflation

has two thresholds—a lower bound of 0.91%/quarter and an upper bound of 1.54%/quarter. At the same time, the threshold effect is not immediate but occurs within a three-quarter delay. Inflation that is either too low (below 0.91%/quarter) or too high (above 1.54%/quarter) leads to an increase in the output gap.

Table 3: Results of the discrete threshold autoregressive model

Variable	**Coefficient**		
Regime	**CPI(−3) < 0.91**	**0.91 ≤ CPI(−3) ≤ 1.54**	**CPI(−3) ≥ 1.54**
C	0.043538	0.097310	0.037520
CPI	0.005866	−0.020697	0.001231
DVNINDEX	4.41E-05	−8.19E-05	4.46E-07
DPOIL	−0.000232	0.000390	6.77E-05
DNEER	−0.001739	−0.003014	−0.000363
DMS	0.003194	−0.001130	0.001570
Non-threshold variable			
DUM3	0.027384		
DUM4	−0.119251		
DUM5	0.017337		
D(OUTPUTGAP(-1))	−0.163769		
DTRADEOPEN	−0.043506		

Source(s): *Authors' own creation/work*

In the threshold mechanism, the money supply, exchange rate, stock index, and world oil price also have significant impacts. If inflation is within the threshold (3.6%–6.16%/year), an increase in money supply has a positive impact, which helps narrow the output gap. Similarly, the VN-Index also has a positive impact on the output gap within this defined threshold. However, if inflation exceeds 1.54%/quarter (6.16%/year), an increase in the VN-Index leads to an increase in the output gap, though the effect is minimal. In addition, a rise in world oil prices pushes the "real output" further from the "potential output." Regarding the impact of exchange rates, the results show that VND devaluation has a positive impact on the output gap, mainly due to the dominance of the volume effect over the price effect. Moreover, across all threshold mechanisms, trade openness consistently has the opposite effect on the output gap.

5. Conclusions and policy implications

Based on the results of the discrete threshold autoregressive model, the following conclusions can be drawn:

(i) Inflation within the threshold range (0.91%–1.54%/quarter) helps reduce the output gap, bringing the "actual output" closer to the "potential output." Therefore, the inflation rate should be maintained within the range of 3.6%–6.16%/year to positively impact economic

growth by narrowing the gap between the "real output" and the "potential output." Inflation levels outside this range, whether lower or higher, lead to an increase in the output gap.

(ii) The inflation threshold (3.6%–6.16%/year) serves as a guideline for monetary policy, helping to balance inflation targeting while achieving good potential output.

(iii) An increase in the exchange rate can provide trade advantages and stimulate Vietnam's exports, thereby improving the trade balance while promoting economic growth.

(iv) The trade openness consistently has a positive impact on the output target, contributing to narrowing the gap between "actual output" and "potential output."

Based on the study, the following recommendations are proposed to ensure a balance between economic growth and inflation stability:

First, Vietnam should aim for an inflation target of about 3.6%–6.16%/year to maintain both economic growth and price stability. Empirically, inflation targeting should be established as a target range or with an allowable plus amplitude. This method not only helps stabilize inflation expectations but also provides a reference for policymakers (e.g., the government and the central bank) to implement appropriate measures (such as easing policies) when inflation falls below the lower threshold.

Second, to control inflation effectively, the government must maintain a stable inflation rate for a sufficiently long period and avoid implementing easing policies too early. Because the effectiveness of monetary policy is lagged and affected by market expectations, its implementation should be based on a long-term and flexible approach. Many studies show that inflation in Vietnam has high and prolonged inertia. Therefore, to achieve inflation control effectively, the government must ensure inflation remains stable for an extended period, allowing the economy to adjust and gradually reduce inflation expectations. The model results reveal that the threshold effect becomes significant after three quarters. Considering the lag in implementing monetary policy in Vietnam (about 6–8 months), the inflation targeting should be set for a longer period (5–6 quarters). This finding aligns with BIS (2017), which suggests that central banks should set inflation targets over a 6–8 quarter timeframe to allow sufficient time for policies to fully materialize and to minimize the risk of premature policy reversals. The early easing of monetary and fiscal policies not only undermines sustainable economic growth but also prolongs high inflation expectations, leading to persistent macroeconomic instability. In addition, the coordination of macroeconomic policies (especially monetary policy and fiscal policy) should ensure consistency and compatibility, avoiding contradictory executive actions that could cause distractions that alter the direction of the economy.

Third, efforts should continue to improve the transparency mechanism and strengthen the communication strategy for monetary policy. Experience from other countries shows that effective monetary policy implementation is closely related to managing market expectations as well as policy instruments (through transparency and communication strategies) regarding policies and policy instruments. In Vietnam, the public is often highly sensitive to past inflation, which serves as an important basis in formulating present inflation expectations. Vietnam should take better advantage of transparent and proactive communication to inform the public about how to calculate and select inflation targeting. Strengthening this transparency will help build and reinforce public confidence in executive decisions of both the government and the central bank. This, in turn, may improve the efficacy of macroeconomic management, particularly monetary policy, contributing to overall economic stability and growth. Therefore, the State Bank of Vietnam (SBV) should aim to increase transparency and clarity in its governance framework. Specifically, the SBV should continue to provide clear policy direction, articulate operational goals, and build an effective and professional communication mechanism.

Fourth, there must be a strong and fundamental shift from prioritizing short-term policies to restructuring the economy, thereby increasing the "potential output." Given the limited room for aggregate demand expansion, it is important to focus on expanding the "potential output" curve, increasing labor productivity, boosting economic competitiveness, and improving resource allocation and utilization efficiency in the next phase. Institutional reforms aimed at advancing the three major restructuring programs[8] are key to improving and re-establishing economic balance. These reforms will help strengthen both the space and effectiveness of aggregate demand policies. As a result, policy flexibility can be improved, and the relationship between inflation, economic growth, and financial stability can be addressed more comprehensively and thoroughly.

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References

Baglan, D., & Yoldas, E. (2014). Non-linearity in the inflation-growth relationship in developing economies. *Journal of Policy Modeling*, 36, 373–388. DOI: https://doi.org/10.1016/j.econlet.2014.08.015

[8] State-owned enterprises, public investment, and the banking system.

Bhusal, T. P., & Silpakar, S. (2011). Growth and inflation: Estimation of threshold point for Nepal. *Economic Journal of Development Issues*, 13–14(1–2), 131–138. DOI: https://doi.org/10.3126/ejdi.v13i0.7216

Bick, A. (2010). Threshold effects of inflation on economic growth in developing countries. *Economics Letters*, 108(2), 126–129. DOI: https://doi.org/10.1016/j.econlet.2010.04.040

Bui, N. T., & Nguyen, M.-L. T. (2023). The nonlinear effect of inflation on the stock market: A threshold regression approach. *Quality - Access to Success*, 24(193), 10. DOI: https://doi.org/10.47750/QAS/24.193.02

Dwyer, A., Lam, K., & Gurney, A. (2010). *Inflation and the output gap in the U.K*. HM Treasury Economic Working Paper No. 6.

Economic Committee of the National Assembly & UNDP in Vietnam. (2013). *Estimating the potential output for Vietnam*, RS-06.

Eggoh, J., & Khan, M. (2014). On the non-linear relationship between inflation and economic growth. *Research in Economics*, 68, 133–143. DOI: https://doi.org/10.1016/j.rie.2014.01.001

Falegan, B. A., & Amali, C. B. (2023). Inflation threshold and economic growth: Empirical evidence from Nigeria. *Journal of Social Science Studies*, 10(1), 1–12. DOI: https://doi.org/10.5296/jsss.v10i1.20683

Fischer, S. (1993). The role of macroeconomic factors in growth. *Journal of Monetary Economics*, 32(3), 485–512. DOI: https://doi.org/10.1016/0304-3932(93)90027-D

Friedman, M. (1968). The Role of Monetary Policy. *The American Economic Review*, 58(1):1–17. ISSN 00028282. URL http://www.jstor.org/stable/1831652.

Ghosh, A., & Phillips, S. (1998). *Warning: Inflation may be harmful to your growth*. IMF Staff Papers, 45(4), 672–710. https://www.imf.org/external/pubs/ft/staffp/1998/12-98/ghosh.htm

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing and inference. *Journal of Econometrics*, 93, 345–368. DOI: https://doi.org/10.1016/S0304-4076(99)00025-1

Higo, M., & Nakada, S. (1999). What determines the relation between the output gap and inflation? An international comparison of inflation expectations and staggered wage adjustment. *Monetary and Economic Studies*, 17(3). Retrieved from https://www.imes.boj.or.jp/research/abstracts/english/me17-3-5.html

Hwang, I., & Zhu, X. (2024). State-dependent oil price shocks on inflation and the efficacy of inflation targeting regime. *Journal of International Money and Finance*, 144. DOI: https://doi.org/10.1016/j.jimonfin.2024.103077

Khan, M. S., & Senhadji, A. S. (2001). *Threshold effects in the relationship between inflation and growth*. IMF Staff Papers, 48(1), 1–21. DOI: https://www.jstor.org/stable/4621658

Khan, M., & Rana, A. T. (2012). *Explaining inflation-growth non-linearity through its impact on human and physical capital accumulation*. Laboratoire d'Economie d'Orléans (LEO), Université d'Orléans. Retrieved from https://www.vsfs.cz/prilohy/konference/3_sc_a_3_khan-rahna.pdf

Khue, N. N. D., & Lai, Y.-W. (2020). Threshold effects of inflation on the banking sector performance in the ASEAN-6 countries. *Journal of Economic Forecasting*, 23(1), 117–133. Retrieved from https://ipe.ro/new/rjef/rjef1_20/rjef1_2020p117-133.pdf

Kremer, S., Bick, A., & Nautz, A. (2013). Inflation and growth: New evidence from a dynamic panel threshold analysis. *Empirical Economics*, 44, 861–878. DOI: https://doi.org/10.1007/s00181-012-0553-9

Lown, C. S., & Rich, R. W. (1997). *Is there an inflation puzzle?* Federal Reserve Bank of New York, Research Paper No. 9723. Retrieved from https://www.newyorkfed.org/medialibrary/media/research/epr/97v03n4/9712lown.html

National Financial Supervisory Commission. (2015). *Macroeconomic report for the first 6 months of 2015*. Hanoi, Vietnam.

Nazir, M. I., Nawaz, M. A., & Gilal, A. R. (2017). Threshold inflation and economic growth in Pakistan. *MPRA* Paper No. 79649. https://mpra.ub.uni-muenchen.de/79649/

Nguyen, A. T. H. (2023). The nexus between banking development and economic growth in the presence of trade openness and inflation: Case of Vietnam. *Montenegrin Journal of Economics,* 19(3), 137. https://doi.org/10.14254/1800-5845/2023.19-3.11

Nguyen, H. A. T. (2022). The nexus between financial development (FD) and economic growth (EG) in the presence of inflation: Case of Vietnam. *International Journal of Economics and Finance Studies*, 14(4), 45. https://doi.org/10.34109/ijefs.20220103

Nguyen, T. T. H., Minh, D. T., Thanh, T. T., Giang, L. H., & Ha, P. V. (2010). *Choosing exchange rate policy in the context of economic recovery.* In Vietnam Economic Annual Report 2010: Choices for sustainable growth (Ch. 4). Tri Thuc Publishing House.

Ogrokhina, O., & Rodriguez, C. M. (2019). The effect of inflation targeting and financial openness on currency composition of sovereign international debt. *Journal of International Money and Finance*, 97, 1. DOI: https://doi.org/10.1016/j.jimonfin.2019.05.004

Phelps, E. S. (1967) Phillips Curves, Expectations of Inflation and Optimal Unemployment over Time. *Economica*, 34(135):254–281. ISSN 0013-0427. doi: 10.2307/2552025. Retrieved from https://www.jstor.org/stable/2552025.

Phillips, A.W. (1958). The Relationship between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957. *Economica*, 25, 283-299. DOI: https://doi.org/10.1111/j.1468-0335.1958.tb00003.x

Rousseau, P. L., & Wachtel, P. (2002). Inflation thresholds and the finance-growth nexus. *Journal of International Money and Finance*, 21(6), 777–793. DOI: https://doi.org/10.1016/S0261-5606(02)00022-0

Sarel, M. (1996). Nonlinear effects of inflation on economic growth. *IMF Staff Papers*, 43, 199–215. DOI: https://doi.org/10.5089/9781451957099.024

Singh, K., & Kalirajan, K. (2003). The inflation-growth nexus in India: An empirical analysis. *Journal of Policy Modeling*, 25 (4), 377-396. DOI: https://doi.org/10.1016/S0161-8938(03)00011-5

Thanh, S. D. (2015). Threshold effects of inflation on growth in the ASEAN-5 countries: A Panel Smooth Transition Regression approach. *Journal of Economics, Finance and Administrative Science, 20*(39), 41–48. DOI: https://doi.org/10.1016/j.jefas.2015.01.003

Tiwari, A. K., Cornel, O., & Claudiu, T. A. (2014). Revisiting the inflation–output gap relationship for France using a wavelet transform approach. *Economic Modelling*, 37, 464–475. DOI: https://doi.org/10.1016/j.econmod.2013.11.039

Tran, T. H. (2018). The inflation-economic growth relationship: Estimating the inflation threshold in Vietnam. *Studies in Computational Intelligence*, 760, 1014. DOI: https://doi.org/10.1007/978-3-319-73150-6_73

Tu, P. T., Hang, N. P. T., & Van, L. T. T. (2025). Factors affecting banking financial stability in Vietnam's emerging economy: A Lasso, Ridge, and ElasticNet regression analysis. *Ianna Journal of Interdisciplinary Studies*, 7(1), 452. DOI: https://doi.org/10.5281/zenodo.14509641

Tung, L. T., & Thanh, P. T. (2015). Threshold in the relationship between inflation and economic growth: Empirical evidence in Vietnam. *Asian Social Science*, 11(10), 105. DOI: https://doi.org/10.5539/ass.v11n10p105

Vo, A. N. H. T. H. E., Van, L. T.-H., Vo, D. U. C. H., & McAleer, M. (2019). Financial inclusion and macroeconomic stability in emerging and frontier markets. *Annals of Financial Economics*, 14(2). DOI: https://doi.org/10.1142/S2010495219500088

Woodford, M. (2003). *Inflation targeting and optimal monetary policy* [Preliminary draft]. Paper prepared for the Annual Economic Policy Conference, Federal Reserve Bank of St. Louis, October 16–17, 2003. Retrieved from https://www.columbia.edu/~mw2230/StLFed.pdf

Woodford, M. (2013). *Monetary policy targets after the crisis.* Paper presented at the IMF Conference "Rethinking Macro Policy II: First Steps and Early Lessons", Washington, DC. Retrieved from https://www.imf.org/external/np/seminars/eng/2013/macro2/pdf/mw2.pdf

Appendix

Appendix A1: Results of ADF test

	Lag based on SIC	t-statistic		Lag based on SIC	t-statistic
OUTPUTGAP_SQUARE	4	0.99			
CPI	1	−5.1***			
MS	5	−1.56	DMS	4	−4.12***
POIL	1	−2.28	DPOIL	1	−6.58***
TRADEOPEN	7	−3.1	DTRADEOPEN	5	−4.02***
VNINDEX	4	−1.9	DVNINDEX	3	−4.8***
NEER	1	−1.87	DNEER	0	−5.06***

Notes: *** denotes for 1% statistical significance.

Source: Estimation from the model

Appendix A2: Results of Johansen Cointegration test

Date: 05/25/19 Time: 21:29
Sample (adjusted): 2001Q4 2018Q4
Included observations: 69 after adjustments
Trend assumption: Linear deterministic trend
Series: OUTPUTGAP_SQUARE CPI
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.208834	20.50974	15.49471	0.0080
At most 1 *	0.061052	4.346699	3.841466	0.0371

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.208834	16.16304	14.26460	0.0248
At most 1 *	0.061052	4.346699	3.841466	0.0371

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

OUTPUTGAP_SQUARE	CPI
56.93567	0.676737
127.0217	−0.172645

Unrestricted Adjustment Coefficients (alpha):

D (OUTPUTGAP_SQUARE)	−0.001198	−0.002137
D (CPI)	−0.680847	0.108074

1 Cointegrating Equation(s): Log likelihood 106.6477

Normalized cointegrating coefficients (standard error in parentheses)

OUTPUTGAP_SQUARE	CPI
1.000000	0.011886
	(0.00296)

Adjustment coefficients (standard error in parentheses)

D(OUTPUTGAP_SQUARE)	−0.068225
	(0.06426)
D(CPI)	−38.76447
	(10.0104)

Source: Estimation from the model

Appendix A3: Results of the residual regression model

Regressing lnoutputgap_abs to lncpi. Setting E = Resid, then regressing D(E) to E(-1):

Dependent Variable: D(E)
Method: Least Squares
Date: 05/25/19 Time: 21:39
Sample (adjusted): 2001Q2 2018Q4
Included observations: 71 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000160	0.003051	0.052489	0.9583
E(-1)	−0.944685	0.126619	−7.460823	0.0000

R-squared	0.446512	Mean dependent var	0.001053
Adjusted R-squared	0.438490	S.D. dependent var	0.034283
S.E. of regression	0.025689	Akaike info criterion	−4.457723

Sum squared resid	0.045536	Schwarz criterion	−4.393985
Log likelihood	160.2492	Hannan-Quinn criter.	−4.432376
F-statistic	55.66388	Durbin-Watson stat	1.815188
Prob (F-statistic)	0.000000		

Source: Estimation from the model

Appendix A4: Results of the error correction model

Dependent Variable: OUTPUTGAP_SQUARE
Method: Least Squares
Date: 05/25/19 Time: 21:46
Sample: 2001Q1 2018Q4
Included observations: 72

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.021657	4.79E-07	45233.27	0.0000
ECM	1.000005	1.40E-05	71476.84	0.0000
CPI	0.000775	1.87E-07	4145.551	0.0000

R-squared	1.000000	Mean dependent var	0.023000
Adjusted R-squared	1.000000	S.D. dependent var	0.025419
S.E. of regression	2.99E-06	Akaike info criterion	−22.56078
Sum squared resid	6.18E-10	Schwarz criterion	−22.46592
Log likelihood	815.1881	Hannan-Quinn criter.	−22.52302
F-statistic	2.56E+09	Durbin-Watson stat	1.967423
Prob (F-statistic)	0.000000		

Source: Estimation from the model

Appendix A5: Results of Ramsey test

Ramsey RESET Test
Equation: EQ03
Specification: OUTPUTGAP_SQUARE C CPI DVNINDEX DPOIL DNEER DMS DUM3 DUM4 DUM5 D(OUTPUTGAP(-1)) DTRADEOPENESS
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.715914	58	0.4769
F-statistic	0.512532	(1, 58)	0.4769
Likelihood ratio	0.615856	1	0.4326

Source: Estimation from the model

Appendix A6: Results of the Redundant test

Redundant Variables Test
Null hypothesis: CPI DVNINDEX DPOIL DNEER DMS DUM3 DUM4 DUM5 D(OUTPUTGAP(-1)) DTRADEOPEN are jointly insignificant
Equation: EQ03HOIQUYLS
Specification: OUTPUTGAP_SQUARE C CPI DVNINDEX DPOIL DNEER DMS DUM3 DUM4 DUM5 D(OUTPUTGAP(-1)) DTRADEOPEN
Redundant Variables: CPI DVNINDEX DPOIL DNEER DMS DUM3 DUM4 DUM5 D(OUTPUTGAP(-1)) DTRADEOPEN

	Value	df	Probability
F-statistic	6.052563	(10, 59)	0.0000
Likelihood ratio	49.41954	10	0.0000

Source: Estimation from the model