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Factors affecting the behavior of inflation in the country under the asymmetric preferences of the central bank towards inflation

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Abstract

The broad impact of inflation on economic indicators and welfare has led monetary authorities, particularly central banks, to maintain inflation at a desirable or target level, thereby preventing the costs associated with rising inflation in society. Sometimes, the central bank fails to achieve its goals due to monetary policy asymmetry or time inconsistency. Thus, this study aimed to evaluate factors affecting the country's inflation behaviour by emphasising the central bank's asymmetric preferences regarding inflation in 1981-2023 in the Islamic Republic of Iran using the ARDL method. The results showed that financial development and production gaps hurt inflation. In addition, trade liberalization, exchange rate, and inflation uncertainty, under the conditions of the central bank's asymmetric preferences towards inflation, positively affect inflation, indicating a trade-off between production and inflation. Inflationary (inflation higher than the target inflation) monetary policy mistakes are less common when the central bank is confident about the state of the economy. Central banks are confident about the economy and less worried about inflationary monetary policy errors (inflation above the target). Therefore, the central bank is suggested to use monetary policy tools regularly and principled and avoid the principle of surprise in the economic field.

Keywords: inflation, asymmetric preferences, central bank, ARDL method
2020 MSC: 91G15

1 Introduction

There are far-reaching consequences for society when inflation disrupts macroeconomic indicators, slows economic growth, increases unemployment, and widens income inequality. In addition, persistently excessive inflation can lead to severe political instability in a country and damage the credibility of macroeconomic officials, especially central banks. In addition, the uncertainty caused by high inflation rates worsens people's expectations of future inflation. Dornbusch et al. [16] noted that inflation implies that "your money cannot buy as much today as it could yesterday." Such periods of inflation often lead to public discontent, especially when wages fail to keep pace with rising prices [43]. Monetary authorities work hard to maintain inflation at a target level to avoid the social costs of inflation, which is particularly true of central banks. For example, the Phillips curve describes the inverse link between inflation and

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unemployment, which many macroeconomists contend exists, at least in the near run. So, to accomplish their goals, policymakers try to take advantage of this link by enacting monetary policy and other macroeconomic stabilization measures. Still, politicians and policymakers frequently differ on how these policies should be carried out and what their results should be [3, 14, 20]. This discord can sometimes lead to time inconsistency and asymmetric preferences within the central bank. According to Friedman, monetary policy may lay a solid foundation for an otherwise fundamentally stable economy. Decisions should be based on assessments and discretion of the present circumstances, according to Kydland and Prescott [27], who argued that policies should be optimal at the time. Consumption, investment, and the availability of workers are all economic decisions people make in response to government policy and monetary policy. However, after the public makes these economic decisions, the initially optimal policy may no longer be suitable, prompting policymakers to adopt a different approach. This shift in government stance undermines the expectations of businesses, consumers, and the labor force regarding the future state of the economy. At this point, time inconsistency—referring to the changing preferences of economic decision-makers—becomes apparent, indicating a misalignment between what is preferred at one point in time and policymakers' preferences over time. The problem of time inconsistency suggests that governments seek long-term policies and appropriate economic growth, sometimes achieved through unexpected inflation. As a result, government commitments to price stability are often met with skepticism and are less credible. In contrast, central banks prioritize price stability, even in the short term.

In light of this background, this research aims to determine what variables affect inflation and how monetary policy asymmetry affected the Islamic Republic of Iran from 1981 to 2022.

2 Factors affecting inflation

Inflation's extensive impact and susceptibility have made it a key macroeconomic indicator for evaluating economic performance. Inflation, defined as the persistent increase in the general price level and the continuous decline in the purchasing power of money, is fundamentally an undesirable economic phenomenon. It brings about numerous costs, including disruptions in the price system, reductions in savings, diminished incentives for investment through innovation, productivity improvement, and cost reduction, capital flight from real sectors to speculative activities, income redistribution in favor of asset holders at the expense of wage earners, inflationary expectations, a preference for holding tangible assets over intangible ones, and a tendency to invest through short-term contracts rather than long-term ones. The persistence of inflation reinforces inflationary expectations, exacerbating inflation inertia [38, 45].

There is no consensus among economic schools of thought regarding the causes and factors influencing inflation. Keynesians attribute inflation to changes in interest rates [9, 11]. Structuralists believe that inflation is driven by agricultural bottlenecks and foreign exchange shortages [35]. Meanwhile, proponents of cost-push inflation argue that rising production costs, such as wages, interest rates, imported raw materials, electricity supply, and transportation, cause it. Pull-based demand According to Sabran et al. [39], Anagaw [6], and Dauda and Abdulkareem [15], inflation happens when the demand for products and services surpasses the supply, resulting in rising prices.

Whatever the stance on the subject, from an economic point of view, two main groups of variables contribute to inflation: those on the supply side and those on the demand side. Economic variables that raise manufacturing costs and inflation are known as supply-side factors. Production expansion, capital creation, oil pricing, imports, tax levels, salaries, and currency rates are all important elements affecting the supply side. Conversely, inflation is caused by demand-side forces, which increase domestic demand for goods and services. According to [17], some essential demand-side determinants are expanding the money supply, private consumption, and government consumption expenditures. Some of the most essential variables impacting inflation will be discussed later on.

2.1 Money supply

Economists and their respective schools of thought disagree on how the money supply affects inflation. The long-term neutrality and super-neutrality of money are two basic ideas commonly debated in this setting. The neutrality hypothesis asserts that permanent changes in the money supply level do not affect actual variables in the long run, merely causing inflation. The super-neutrality hypothesis suggests that permanent changes in the growth rate of the money supply also do not influence actual variables in the long run. Accepting or rejecting either of these hypotheses has significant implications for the role of monetary policy.

Accordingly, several studies (e.g., [1, 4, 5, 10, 32, 33, 42, 45]) have found a positive relationship between inflation and money supply, with this relationship being dependent on money demand and money supply dynamics. In contrast, Ellahi [18] highlighted the negative effect of money supply on inflation.

2.2 Exchange rate

There is some disagreement in the economic literature regarding the nature of the link between currency exchange rates and inflation. The particular economic circumstances of the nation in issue determine the extent to which exchange rates affect inflation. For instance, studies by [1, 28, 30, 42, 45] have demonstrated that a long-term and short-term equilibrium relationship exists between inflation and exchange rates, and the real effective exchange rate is a key determinant of inflation. Conversely, [5, 8, 32] found evidence of a negative relationship between inflation and exchange rates.

2.3 Trade liberalization

The impact of trade liberalization on domestic inflation is ambiguous in economic literature, as this relationship may vary across different countries. Rogoff [36] argued that greater openness of an economy contributes to lower inflation. Ashra [7] contended that openness leads to better resource allocation and increased capacity utilization, boosting production efficiency and encouraging foreign direct investment. As a result, economic growth is enhanced, and prices decline. Kurihara [26] also demonstrated a positive relationship between international trade openness and inflation in Asia and OECD countries, with the connection being stronger in Asian countries than in the OECD. Conversely, some studies have pointed to a negative relationship between inflation and trade openness. For example, Kirkpatrick and Nixon [24] suggested that due to import restrictions and barriers, trade openness may not necessarily lead to reduced inflation. Mukhtar [31] showed that, in the long term, there is a negative relationship between inflation and trade liberalization in Pakistan.

Overall, the relationship between trade liberalization and inflation can be explained through two theoretical perspectives: the spillover theory and the cost-push theory. According to the spillover theory—primarily advocated by proponents of trade openness—lower inflation rates can be achieved through greater integration with the global economy because increased competition and efficient resource allocation foster economic growth, reducing inflation and firms' pricing power in domestic markets. Furthermore, stronger market competition means more cautious and less inflationary monetary policies are expected to be implemented.

In contrast, the cost-push theory posits that inflation rates rise with trade liberalization. This theory arises from the monopoly power that monetary authorities may gain in the international market due to increased demand for domestically produced goods from foreign consumers. Additionally, open economies are expected to import goods and services from other countries, which could contribute to domestic inflation.

2.4 Production (economic growth)

The Phillips curve is a popular tool for explaining the connection between inflation and GDP growth; it implies that NGDP is positively correlated with inflation and -unemployment is negatively correlated with NGDP. Inflation expectations were factored into this curve, nevertheless, by Friedman and Phillips. According to their argument, the positive correlation between the two variables is just temporary, and while inflation expectations are present, they might go up or down simultaneously. The positive correlation between GDP growth and inflation is eventually canceled out by inflation expectations adjusting and the Phillips curve shifting vertically. Lucas and other rational expectations theorists expanded on this idea, arguing that the Phillips curve's depiction of a positive relationship between short-term economic growth and inflation is not always accurate. They conjectured that monetary policy predictability is crucial to this relationship. Economic policies do not impact output and employment if monetary measures are stated and implemented predictably, as the Phillips curve stays vertical even in the short run. Therefore, there is no validity to the idea that inflation and production are linked in the short or long run.

2.5 Inflation uncertainty

Economists disagree on the nature of the relationship between inflation uncertainty and inflation. According to the Friedman-Ball Paradigm, an increase in the inflation rate leads to higher inflation uncertainty, reducing gross domestic product (GDP) growth. The Peregrine and Maskase Paradigm (1987), also known as the Rival Paradigms, posits that rising inflation results in a decline in real income and wealth. To mitigate this erosion, countries with high inflation pay closer attention to inflation forecasts. Reducing forecasting errors when measuring uncertainty leads to negative effects of inflation on inflation uncertainty. According to the Cukierman and Metzler Paradigm, there is a positive relationship between inflation uncertainty and inflation. These positive effects arise from the public's lack of awareness of policymakers' preferences. Through monetary policies, policymakers aim to stimulate production growth and curb inflation. However, uncertainty in monetary policies can lead to higher future inflation rates. On the other

hand, Holland argues that an increase in inflation uncertainty leads to a decrease in the average inflation rate. The Holland Paradigm, often referred to by economists as central bank stabilization, claims that an increase in inflation uncertainty will compel policymakers to implement contractionary monetary policies to prevent the negative effects of inflation on social welfare, ultimately leading to a reduction in inflation.

The geopolitical risk index and inflation have a complicated and often confusing relationship. Uncertainty and higher business costs caused by international tensions are two factors that can contribute to inflation. However, increasing inflation may sometimes indicate a robust economy, which in turn may mitigate geopolitical threats. Although these two factors are not directly connected, they can influence each other under certain conditions. [12] using long-term historical data for 43 countries, demonstrated that geopolitical risks are associated with higher inflation, reduced economic activity, increased military spending, higher public debt, and reduced trade with the rest of the world. Larger geopolitical risks are also linked to more uncertain inflation and higher upside risks for inflation. They also showed that global geopolitical risks increase inflation [45].

3 Time inconsistency of monetary policy and inflation within the Phillips curve framework

Regarding the issue of time inconsistency and the fact that stable equilibrium is accompanied by inflationary bias, the concept of Lucas' monetary surprise concerning the Phillips curve and the trade-off between unemployment and inflation can be employed. Here, it is assumed that monetary authorities can fully control the inflation rate. Markets are continuously cleared, and economic agents have rational expectations. The strong version of rational expectations, or its mathematical interpretation, is defined as the subjective expectations of economic agents about any economic variable equal to the conditional mathematical expectation of that variable, given the information available when the expectations are formed. In other words:

$$\pi_t^e = E\pi_t. \tag{3.1}$$

In addition, the unemployment rate is a downward function of unexpected inflation (the difference between actual and expected inflation). In other words, unexpected positive inflation can reduce unemployment.

$$U_t = U_n - \lambda(\pi_t - \pi_t^e) \qquad \lambda > 0 \tag{3.2}$$

in which, U_t represents the unemployment rate in period t, U_n is the natural rate of unemployment, π_t is the actual inflation rate in period t, π_t^e is the expected inflation rate in period t, and λ is a positive coefficient.

Equation (3.2), or the Phillips curve, represents the constraint policymakers face, indicating that higher unemployment must be accepted to achieve lower inflation or higher inflation must be tolerated. As a result of this concept, economic policymakers believe that various combinations of inflation and unemployment can be managed by employing conventional economic policies such as fiscal and monetary policies. In this context, the social welfare function, which is maximized through the choice of economic policy, can be expressed as follows:

$$S = S(\pi_t, U_t) \qquad \frac{\partial S}{\partial \pi} < 0, \quad \frac{\partial S}{\partial U} < 0. \tag{3.3}$$

In this social welfare function, the unemployment and inflation rates are considered "bad" (goods for which less is preferred to more). An increase in either of these variables decreases social utility and welfare (as illustrated in Figure 1).

Referring to Figure 1, the intersection of the social welfare function with the constraint (the Phillips curve) represents different scenarios of consistent, inconsistent, and optimal equilibria. In this context, a consistent policy seeks to maximize the social welfare function subject to the constraint of the Phillips curve. S_1, S_2, S_3, and S_4 represent the indifference curves for the social welfare function. Since inflation and unemployment are "bads," the ranking of utility on the indifference curves is such that $S_1 > S_2 > S_3 > S_4$.

Points along the long-term Phillips curve represent potential equilibrium points because, at each of these points, unemployment is at its natural rate, and therefore, inflation is accurately predicted by economic agents, meaning $\pi_t = \pi_t^e$. In macroeconomic inconsistent equilibria, the Phillips curve will not be vertical, and the condition for achieving optimal equilibrium requires zero inflation expectations and the equality of societal unemployment with natural unemployment. An optimal macroeconomic equilibrium is attained if zero or negligible inflation expectations exist. To reach this optimal equilibrium, both the constraint and objective curves must shift downward, which can be achieved by reducing inflation expectations. It is important to note that any inflationary bias or increase in

expected inflation among private firms leads to a more significant deviation from the optimal equilibrium and makes it more challenging to achieve, pushing the economy closer to an inconsistent equilibrium. Additionally, when expected inflation equals actual inflation, the Phillips curve becomes vertical, representing consistent equilibria. In Figure 1, the social welfare function S_2 is tangent to the Phillips curve at point O. Therefore, point O represents the optimal social situation.

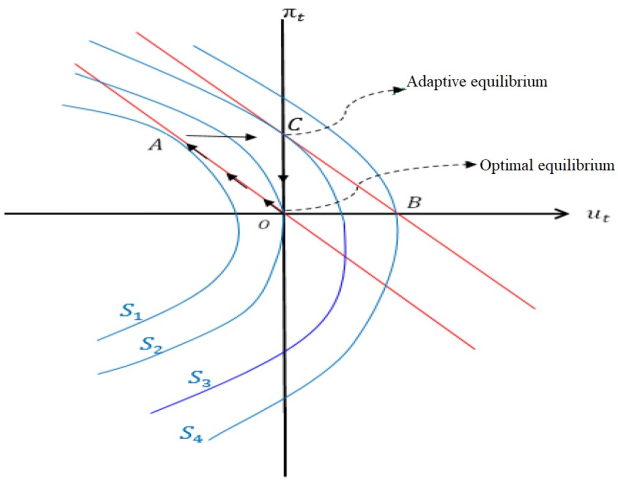

Figure 1: Adaptive and optimal equilibrium diagram

Suppose the economy is suboptimal, such as point C, where the social welfare function S_3 is tangent to the short-term Phillips curve. This point can represent a long-term equilibrium and is also considered consistent. The monetary authorities, aiming to achieve the optimal equilibrium at point O, might declare a zero inflation target, which can be realized by reducing the money supply. If private agents believe the government's announced policy and base their decisions on it, they will adjust their inflation expectations, causing the short-term Phillips curve to shift downward and pass through point O. In this scenario, in response to reduced aggregate demand, production and employment levels do not decline, meaning that production and employment remain stable. Thus, inflation is reduced without any loss in output, resulting in a sacrifice ratio of zero. The question arises: what guarantee is there that government officials will adhere to their stated policy and not deviate from it? If, after the public's inflation expectations decrease due to the government's announced policy, the authorities fail to follow through on their commitment and do not reduce the money supply growth, they could generate unexpected, positive inflation. This surprise inflation could temporarily increase output and employment, moving the economy to point A, which is preferable to point O. However, this situation is unlikely to be sustainable because unemployment is below the natural rate at point A $\pi_t > \pi_t^e$. During the initial policy implementation, policymakers may realize that changing the policy could achieve better results. Without a binding rule that commits them to their initial policy, they might use their discretionary power to increase the money supply growth rate, aiming to create a positive, unexpected inflation and enhance social welfare. Since private agents act rationally, they will recognize this deception by the authorities and raise their expectations. Consequently, the economy will return to point C, which will be consistent over time. At this point, unemployment is at its natural rate, but inflation is somewhat positive, indicating that consistent equilibrium requires positive inflation above the target level. Therefore, without binding rules and previous commitments, monetary authorities have sufficient incentive to deceive agents to increase social welfare. However, the ability to change policies (discretionary power) is a double-edged sword for the government. Economic policymaking is not limited to a single period; policymakers must consider a longer-term horizon. Over the long term, the future consequences of current policies will impact the reputation and credibility of the policymakers, creating a difficult choice for policymakers when implementing their strategies. Suppose government officials succeed in lowering unemployment and inflation by deviating from their announced policy in one period. In that case, they risk losing credibility with economic agents, and their future policy announcements may no longer be trusted. As a result, they face a dilemma: either they change their policies to achieve short-term gains by deceiving economic agents, or they may conclude that the long-term benefits of maintaining credibility through adherence to initial policies outweigh the short-term advantages of changing those policies.

4 Experimental studies

Inflation has been the subject of much empirical research, with studies spanning various approaches and periods. Money supply, interest rates, exchange rates, inflation expectations, imported inflation, and GDP are the main factors that these studies use to try to understand the intricate dynamics of inflation. In their study titled "Determinants of Inflation in Somalia: An ARDL Approach," [44] examined the factors that contributed to inflation in Somalia, including the money supply, GDP, and exchange rates, from 1970 to 2010 using the ARDL approach. According to the study, inflation and money supply are positively correlated over the long run. In particular, the inflation rate jumps by a significant 39.35% when the money supply increases by just 1%. A strong negative correlation exists between GDP and inflation over the long run; for example, a 1% rise in GDP is correlated with a 261.17% drop in inflation. In his work titled "External and Internal Determinants of Inflation: Application to Libya, 1980-2019," [40] looked into the factors that affected inflation in the Libyan economy from 1980 to 2019. According to the data, there was a positive correlation between inflation and the export value index. When mitigating the effects of oil exports on inflation, the export industry was a complete failure. Furthermore, the study discovered a positive correlation between inflation and the budget deficit, a negative and insignificant correlation with the velocity of money, and a positive correlation with the import value index. These domestic factors that impact inflation were examined alongside the velocity of money and the import volume index. According to the results, a rise in the budget deficit causes the public debt to rise, which in turn causes a rise in the balance of payments deficit, a decrease in foreign exchange reserves, higher prices, and a depreciation of the domestic currency. Additionally, the data show that the velocity of money does not adjust to inflation, and Libya's economy is still not producing enough capital and consumer products. Therefore, the government relies largely on foreign sources for these things and financing imports. In their study titled "Determinants of Inflation Rate: Evidence from Panel Data," Ujkani and Gara [43] used panel data methodology to examine the impact of macroeconomic factors on inflation rates in 40 countries from 2012 to 2023. These countries included 6 in Latin America, 2 in the Western Balkans, 19 in Europe, 10 in Asia, 2 in Africa, and Australia. According to the study, increasing the money supply leads to higher inflation rates. Therefore, the money supply has a positive effect on inflation rates. Trade volume and economic growth positively affect these countries' inflation rates. Inflation is more heavily influenced by economic growth than by trade volume. In their study titled "Measuring Inflation Expectations and Their Impact on Inflation Dynamics in Colombia," [37] they sought to determine if inflation expectations had any bearing on inflation dynamics in Colombia from 2010 to 2019. At first, they used financial market data, economic surveys, and macroeconomic models to predict inflation expectations based on the New Keynesian Phillips curve technique. Their next step was to analyze how these predicted inflation rates affected the actual inflation rate. The study discovered that the effect of inflation expectations as determined by each approach on inflation varied significantly. Expectations based on the market, as opposed to those based on surveys or models, significantly affected the inflation dynamics. For their work "Trade Openness and Inflation Rate in China: Empirical Evidence from Time Series Data," Tahir et al. [41] used the ARDL approach to analyze the relationship between trade openness and China's inflation rate from 1987 to 2019. According to the study, trade openness negatively and statistically significantly affected inflation, proving that trade openness can be employed to counteract rising inflation. The same applies to the other variables influencing inflation: government expenditure, GDP growth, currency rates, and the money supply. Increases in the money supply and government expenditure temporarily lower inflation. [38], in a study titled "The Impact of Monetary Shocks on Inflation in Selected West Asian Countries," examined the effects of positive and negative monetary shocks on inflation rates in West Asian countries, including Iran, Armenia, Jordan, Azerbaijan, Pakistan, Oman, Saudi Arabia, Kyrgyzstan, Kazakhstan, Qatar, Kuwait, and Georgia, using panel data from 2000-2020. The results indicated that the impact of monetary shocks on the general price level in West Asian countries varies in significance and magnitude. In Iran, Pakistan, Kyrgyzstan, Kuwait, and Georgia, monetary shocks had a symmetric effect on the general price level. In contrast, the effect of monetary shocks was asymmetric in Jordan, Azerbaijan, and Qatar. In Saudi Arabia, Oman, and Kazakhstan, only negative shocks influenced the general price level, resulting in an asymmetric effect of monetary shocks on prices in these countries. Moreover, the study found that in all the countries studied, the impact of negative shocks on prices was greater than positive shocks.

Hung [22], in a study titled "The Output-Inflation Trade-Off in the Presence of Foreign Capital: Evidence for Vietnam," analyzed this issue over the period from February 2008 to September 2018 using a Time-Varying-Coefficient VAR model in Vietnam. The study considered a baseline model including three variables: inflation rate, economic growth rate, and credit growth, and examined the response of inflation and output to a positive 1% credit supply shock. The findings revealed that credit growth policies, accelerating output growth, also lead to higher inflation rates, indicating a trade-off between inflation and economic growth. Subsequently, foreign capital flows were included in the model, concluding that the primary determinant of inflation in Vietnam is credit supply growth. In contrast, foreign capital flows largely influence output growth. The output-inflation trade-off was reduced with the inflow of foreign investment. The model was further extended to include the exchange rate, and the results showed that a

positive 1% credit supply shock led to a 0.033% increase in monthly inflation in the second month, an effect that dissipated by the sixth month, with no significant impact on output. These findings are broadly consistent with the model's estimates in the presence of foreign capital flows. In other words, even with the exchange rate considered, the output-inflation trade-off in the presence of foreign capital flows is reduced compared to the baseline model. Chesang and Naraidoo [13], in a study titled "Parameter Uncertainty and Inflation Dynamics in a Model with Asymmetric Central Bank Preferences," examined the effect of uncertainty in the output-inflation trade-off on inflation, using a monetary model with asymmetric central bank preferences towards output based on the Lucas signal-extraction framework (1973) in South Africa. The study's results showed that incorporating uncertainty leads to changes in indirect control and, consequently, in direct control by authorities. In other words, through a less aggressive increase in interest rates, output decreases less when inflation exceeds its target level, which aligns with the Brainerd conservatism principle. They also demonstrated that asymmetric output stabilization significantly explains inflation spikes, and it appears that monetary authorities are more averse to recessionary business cycles than booms. [2], in a study titled "The Monetary Policymaker's Reaction Function in the Iranian Economy: A Smooth Transition Regression (STR) Approach" examined the reaction function of Iran's Central Bank, focusing on changes in the nominal interest rate as the primary monetary policy tool in response to changes in state variables, such as oil price fluctuations, exchange rate fluctuations, inflation gap, and output gap, using the Smooth Transition Regression (STR) model over the period 2002-2019. The results showed that Iran's monetary policymaker's reaction function is nonlinear. Secondly, it was observed that with the inclusion of exchange rate fluctuations and oil price changes in the model, the scenario shifts from inflation targeting towards output targeting as the output gap coefficient increases relative to the inflation coefficient. Thirdly, oil price changes affect the monetary policymaker's reaction function through the exchange rate gap channel.

[29] a study titled "The Asymmetric Impact of Monetary Policies on Unemployment in Iran" examined the dynamic asymmetric effects of money supply growth on the unemployment rate using the NARDL model during the quarterly period from 2005:2 to 2022:1. The study's findings indicated that, based on the Wald test, asymmetry exists in the short term, but no such relationship is present in the long term. Consequently, the analysis of effects is focused solely on the short term. According to the results, a 1% positive change in money supply growth can lead to a 0.21% increase in the unemployment rate. In comparison, a 1% decrease in money supply growth from three periods earlier can result in a 0.25% decrease in the unemployment rate. Therefore, although the effects of positive and negative changes in money supply on the unemployment rate are inelastic in the short term, these effects are not statistically equivalent, and the asymmetry in the impact of monetary policy changes in money supply is evident. Thus, monetary policymakers should pay particular attention to this asymmetry in its effects on the unemployment rate. It is worth noting that the coefficients of the long-term monetary policy variables, in line with the Wald test, are not statistically significant and, therefore, cannot be interpreted. [21] a study titled "Examining the Asymmetric Impact of Monetary Shocks on Bank Credits during Business Cycles (Testing the New Keynesian Perspective; A Case Study of Iran)" explored the asymmetry in the impact of monetary policy during business cycles on bank credits over the period 1998-2018 using the Smooth Transition Regression model. The results showed that when economic growth in Iran exceeds 3.62%, a regime shift occurs with a moderate adjustment speed of 8.58%, and economic growth as a threshold variable has a positive and significant impact on bank credits. Additionally, the results indicated that monetary policy has different effects on bank credits depending on the levels of economic growth (recession or boom). This impact is positive and significant in both regimes, but it decreases in the second regime compared to the first, suggesting that monetary policy during a recession is more effective on bank credits than during a boom; in a recession, the lower lending capacity of banks due to financial crises and the resulting limited public access to loans increases the impact of monetary policy compared to a boom period. The asymmetry of monetary policy, stemming from varying economic conditions according to the New Keynesian perspective, is confirmed for Iran's economy. Accordingly, monetary policymakers must consider business cycles when implementing policies. [23] in a study titled "Does the Time Inconsistency Problem Exist in Iran's Economy?" analyzed the time inconsistency between the rising unemployment rate and inflation in Iran's economy based on the Barro-Gordon model from 1971-2010. The study's findings indicated that the Barro-Gordon model can explain the long-term behavior of unemployment and inflation. Moreover, the results of model constraints showed that the time inconsistency problem is valid for the short-term relationship between unemployment and inflation. [19] in a study titled "Asymmetric Preferences of Monetary Authorities and Inflation-Unemployment Behavior in Iran: A Game Theory Approach," examined inflation and unemployment behavior in Iran from the second quarter of 2005 to the third quarter of 2011. The study's results revealed that the Central Bank of Iran exhibits asymmetric behavior toward deviations of the unemployment rate from the target unemployment rate. Therefore, monetary authorities place greater importance on positive deviations of unemployment from the target rate than negative deviations. The findings suggest that inflation behavior in Iran can be explained using the general framework of game theory. Given that the conditional variance of unemployment plays a significant role in explaining inflation behavior, it is recommended

that policymakers address the factors causing fluctuations in the labor market through appropriate policies to prevent changes in inflation.

5 Method

In this applied-causal research, inflation behavior is modeled based on the New-Keynesian Phillips Curve (NKPC), considering the Central Bank's asymmetric preferences toward inflation (Model extraction is presented in Appendix A.). The approach follows studies by [13, 25, 37], and is considered as follows:

$$\pi_t = \rho_0 + \rho_1 y_t + \rho_2 \delta^2_{\pi t} + \rho_3 fd_t + \rho_4 to_t + \rho_5 ex_t + u_t \tag{5.1}$$

in which, π represents the current period's inflation, y_t denotes the output gap, $\delta^2_{\pi t}$ represents inflation uncertainty, fd_t refers to financial development, to_t indicates trade openness, ex_t denotes the exchange rate, and U is the error term. Additionally, the symbol $t = 1...T$ represents the period from 1981 to 2022. Given the model, time series data are used. Therefore, the model is estimated using the ARDL method. The measurement of variables is presented in Table 1.

Table 1: Variables and symbols used in the model [34]

	Variable		**Indicator**	**Resource**
Dependent Variable	Inflation	π	Consumer Price Index (CPI)	Central Bank
Independent Variables	Financial development	FD	The ratio of credit allocated to the private sector to GDP	World Bank
	Commercial freedom	INF	The ratio of total exports and imports to GDP	World Bank
	Exchange rate	EX	Fixed Exchange Rate	Central Bank
	Production gap	y_t	Calculation of output gap using the Hodrick-Prescott method	Computational
	Inflation uncertainty	$\delta^2_{\pi t}$	The standard deviation of return	Computational

6 Empirical results

6.1 Calculation of the output gap

The output gap was calculated using the Hodrick-Prescott (1997) method. In this method, the time series under examination is assumed to have a deterministic time trend, and the output gap is then calculated as the deviation from the long-term steady trend. Accordingly, the time series must be decomposed into two components. The first component corresponds to the long-term trend of the time series, which is detrended and stationary, while the second component represents deviations from the steady long-term trend. This study's initial value of the λ coefficient was set to 100, based on previous research and the default setting for annual data in the software used. The results are presented in Figure 2.

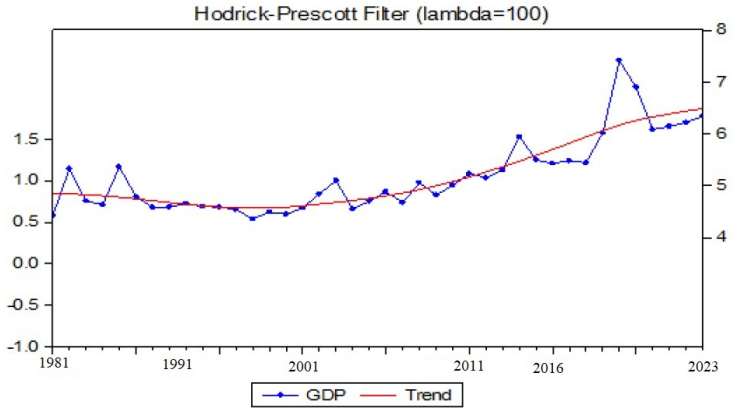

Figure 2: Results of Output Gap Estimation Based on the Hodrick-Prescott Filter ($\lambda = 100$) (1981-2023)

6.2 Calculation of inflation uncertainty

Time series data from 1981 to 2023 were used to model inflation uncertainty in this study. Since inflation is stationary, it is necessary to identify the appropriate equation to describe inflation behavior, determining the number of autoregressive and moving average terms needed to estimate the mean equation based on the variable's level. For this purpose, Figure 3 is presented.

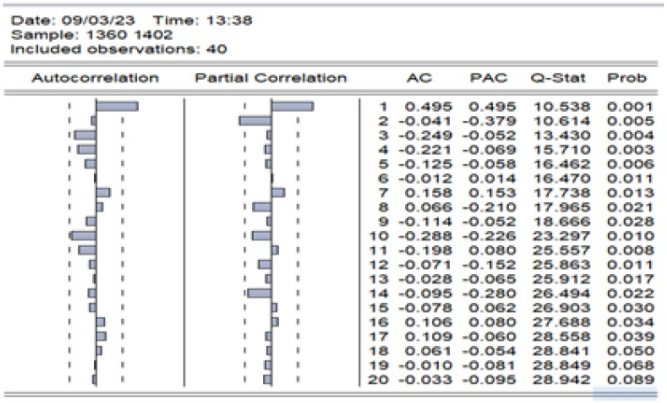

Figure 3: Correlogram of Inflation at the Level

Based on the correlogram, the ARIMA(1,0,2) process has been selected as the best model to explain inflation's behavior. The next step involves confirming the presence of heteroskedasticity in the residuals. The Lagrange Multiplier (ARCH-LM) test was used to investigate the presence of heteroskedasticity (ARCH effects) in the selected model, and the results are presented in Table 2.

Table 2: Results of the ARCH-LM Test

Statistics	Statistic value	Value
F	0.023	0.9772
LM	0.053	0.9739

According to Table 2, the value of probabilities for both statistics is greater than 5%. Thus, the null hypothesis of the non-existence of variance heterogeneity is accepted, and the opposite hypothesis is rejected. Therefore, variance heterogeneity among disturbance components is not proven, and it is impossible to model inflation fluctuations using the ARCH or GARCH models. Thus, the return standard deviation of the considered variable during the five years was used to calculate inflation uncertainty in this research (Figure 4).

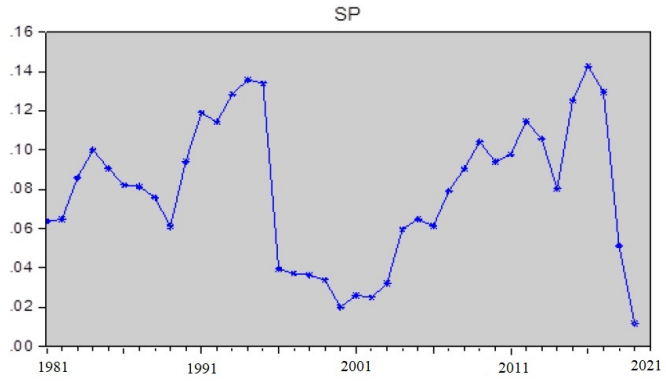

Figure 4: The standard deviation of the return of inflation during 1981-2023

6.3 Reliability of variables

The reliability of the model variables was evaluated using the generalized Dickey-Fuller test. The test results mentioned in Table 3 shows that the model's variables are stable.

Table 3: The result of the generalized Dickey-Fuller test to check the reliability of the variables

Variable	**Number of lag**	**Test equation**	**The critical statistic at the 5% level**	**Generalized Dickey-Fuller computational statistics**	**Result**
production gap	1	With intercept	-2.94	-4.13	I(0)
Inflation	1	With intercept	-2.94	-5.56	I(0)
Financial development	1	With intercept and trend	-3.554	-3.17	I(0)
Commercial freedom	1	With intercept	-3.94	-3.56	I(0)
Exchange rate	1	With intercept	-2.94	-5.56	I(0)
Inflation uncertainty	9	With intercept	-2.94	-2.97	I(0)

6.4 Model estimation

The results of the study's model estimation are presented in Table 4. As indicated by the results, the coefficient of determination is 83%, which suggests an excellent explanatory power of the model. Given its p-value, the F-statistic indicates that the regression is statistically significant overall. The interpretation of the coefficients in Table 4 is as follows:

- The intercept is approximately 19%, which is statistically significant at the 1% level, indicating the average inflation rate during the period under review.
- The estimated coefficient for the output gap under asymmetric central bank preference conditions is significant and negative. Thus, the output gap still influences optimal inflation behavior, indicating a trade-off between output and inflation.
- The coefficient for inflation uncertainty is positive, statistically significant at the 1% level, and consistent with theoretical expectations. This positive sign implies that the Central Bank of the Islamic Republic of Iran is more opposed to low than high inflation. In other words, the central bank exhibits an inflationary bias, indicating that when it is confident about the economic situation, it is less concerned about monetary policy errors leading to inflation that exceeds the target rate.
- The trade liberalization and exchange rate coefficients positively impact inflation because increased trade openness is more related to imports than exports, stimulating demand and rising inflation. The coefficient for financial development has a negative impact on inflation.

Table 4: Estimation Results of the Study Model

Coefficient	**Results**
$\widehat{\rho_0}$	0.198 (9.86)
$\widehat{\rho_1}$	-0.083 (-2.25)
$\widehat{\rho_2}$	0.38 (3.53)
$\widehat{\rho_3}$	-0.25 (-2.33)
$\widehat{\rho_4}$	0.19 (2.18)
$\widehat{\rho_5}$	0.11 (2.06)
Coefficient of determination	0.83
F-value	8.75 (0.0009)

7 Conclusion and recommendations

Inflation has been one of the most significant economic challenges for various countries over the past decades. This phenomenon has numerous adverse effects, including economic instability, poverty, reduced general welfare, increased inequality, and income distribution issues. Therefore, central banks strive to control inflation by implementing monetary policies. However, in some cases, they fail to achieve this goal and encounter a type of time inconsistency. Central time inconsistency implies that the central bank is allowed, but not required, to treat positive deviations of inflation and output from their target values differently than negative deviations. Given this context, this study examined the factors influencing inflation, emphasizing the asymmetric preferences of monetary policy towards inflation during 1981-2023 in the Islamic Republic of Iran. The study's findings indicate that the output gap and inflation uncertainty

negatively and positively impact inflation under asymmetric central bank preference conditions. In other words, there exists a trade-off between output and inflation. Additionally, when the central bank is confident about the state of the economy, it is less concerned about monetary policy errors leading to inflation exceeding the target rate. The coefficients for trade liberalization and exchange rate positively impact inflation, while the coefficient for financial development has a negative impact. Based on the results, it is recommended that the central bank employs monetary policy tools in a rule-based and principled manner, avoiding the element of surprise in the economic sphere.

Appendix A Extraction of the studied model [34]

To derive model [34], the short-term aggregate supply curve is defined as follows.

$$Y_t = Y_t^N + \theta(\pi_t - \pi_t^e) + U_t \qquad U_t \sim (0, \sigma^2) \tag{1.1}$$

in which, Y_t represents actual output, which is a function of Y_t^N, the potential or natural output at the time t, the inflation level π_t at time t, the expected inflation level π_t^e at time t based on information available at t-1, with the parameter θ indicating the sensitivity of output to unexpected changes in price levels and U_t representing a supply shock necessary to create a short-term trade-off between inflation stability and output. It is assumed that U_t follows a normal distribution $N(0, \sigma^2)$. Equation (1.1) states that output exceeds its natural level when the price exceeds expected.

A.1 The central bank's objective function

The inflation-targeting approach is defined within the framework of optimal monetary policy. Optimal monetary policy is derived by minimizing the social loss function subject to the constraints of the monetary transmission mechanism. The social loss function is expressed in terms of the variables the central bank defines as its targets and aims to adjust monetary policy accordingly to achieve those goals. A widely used specification for central bank preferences is the quadratic loss function. However, recent literature suggests the use of asymmetric preferences (LINEX). Under this approach, the central bank is allowed, but not required, to treat positive deviations of inflation and output from their target values differently than negative deviations because a policymaker facing the stabilization of inflation and output tends to focus on output stability during periods of low inflation but prioritizes combating inflation when inflation is high. The LINEX loss function can be expressed as follows:

$$L = \frac{exp(\alpha(\pi_t - \pi_t^*)) - \alpha(\pi_t - \pi_t^*) - 1}{a^2} - \frac{exp(\emptyset(y_t - y_t^*)) - \alpha(y_t - y_t^*) - 1}{\emptyset^2} \qquad \alpha \neq 0 \quad \theta \neq 0 \tag{1.2}$$

in which, $(\pi_t), (y_t), (\pi_t^*)$, and (y_t^*) represent the actual inflation rate, actual output level, target inflation rate, and target output level, respectively. α and θ indicate the degree of asymmetry in the central bank's objective function, with θ representing the relative weight assigned to output deviations. Asymmetry in the loss function implies that the policymaker reacts more strongly to deviations from the target in one direction than deviations in the opposite direction.

If $(\alpha > 0)$, it suggests that the central bank is more concerned about inflation being above the target than below it. In other words, an increase in inflation above the target is weighted more heavily than an equivalent decrease in inflation. Specifically, from equation (1.2), when inflation exceeds the target $(\pi_t > 0)$, the exponential term in the loss function dominates the linear term, and the loss associated with a positive deviation increases exponentially. Thus, high inflation is more undesirable for the central bank than low inflation, and increased inflation volatility is likely to result in lower average inflation. The reverse holds when inflation is below the target $(\pi_t < 0)$. If the degree of asymmetric preferences regarding output $\emptyset > 0$, the central bank is more dissatisfied with high output levels than low ones.

In other words, the central bank is more averse to negative output deviations than positive ones. The sequence of events determining the optimal policy choice is framed within a strategic game between the central bank and private agents. First, private agents form their expectations about the inflation rate at time t, which is the basis for wage negotiations and is embedded in nominal contracts. Second, considering these expectations, the central bank sets the inflation target before shocks occur. To determine the optimal inflation rate, the central bank minimizes the asymmetric loss function subject to Equation (1.1) constraints and then implements monetary policy. Finally, random real shocks to both demand and supply occur. The key point here is that when setting monetary policy, the central bank is uncertain about the magnitude of shocks affecting employment and output. It lacks complete information about the shocks impacting the economy. After the shocks occur, the central bank gathers this new information and attempts to adjust its policy in the subsequent stages of events.

A.2 Optimal inflation behavior under asymmetric preferences towards inflation

When the central bank's preferences are asymmetric concerning deviations from the inflation target but symmetric concerning output fluctuations from the potential output, the policymaker's optimization problem is formulated as follows:

$$\max_{y_t,\pi_t} L = E_{t-1}\left[\sum_{t=0}^{\infty}\left\{-\beta^t\left[\left(\frac{e^{\alpha\pi_t}-\alpha\pi_t-1}{a^2}\right)+\frac{\lambda}{2}(y_t)^2\right]-\beta^t\mu_{2t}\left[y_t-\theta(\pi_t-\pi_t^e)-U_t\right]\right\}\right]. \tag{1.3}$$

The first-order conditions of the following non-linear targeting rule result:

$$-E_{t-1}\left(\frac{e^{\alpha\pi_t}-1}{a}\right)-\lambda E_{t-1}\theta_t y_t = 0 \tag{1.4}$$

in Equation (1.4), as a particular case when $(\alpha \to 0)$, a linear form results. The inflation targeting rule implies that the policymaker adjusts output through the interest rate whenever inflation deviates from the target. The asymmetric response of the output gap (via the interest rate) to positive and negative deviations of inflation from the target is a function of the parameters $\alpha, \lambda, and\theta_t$ (which vary over time) and the exponential term. Equation (1.4) can be linearized by converting the exponential terms using a first-order Taylor series expansion around $(\alpha = 0)$.

$$-E_{t-1}\pi_t\frac{\alpha}{2}E_{t-1}(\pi_t)^2-\lambda E_{t-1}\theta_t y_t = 0. \tag{1.5}$$

Assuming that π_t is conditionally normal, the expression can be approximated for expected inflation and output levels. In this case, the deviation of inflation from the target will be a function of the output gap and the conditional variance of inflation.

$$\pi_t = -(\lambda\theta_t)y_t - \frac{\alpha}{2}\sigma_{\pi t}^2 \tag{1.6}$$

in Equation (1.6), inflation is a function of the output gap (y_t) and the conditional variance of inflation $(\sigma_{\pi t}^2)$. Equation (1.6) shows that if high inflation is more undesirable than low inflation for the central bank $(\alpha > 0)$, the central bank is inclined to accept an inflation rate that is, on average, lower than the target level. In this case, an increase in inflation volatility will cause the policymaker to reduce the average inflation rate.

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