Modern Economy, 2025, 16(3), 469-498
https://www.scirp.org/journal/me
ISSN Online: 2152-7261
ISSN Print: 2152-7245

Beyond Monetarism: A Comprehensive Approach to Understanding Inflation

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How to cite this paper: Sanyal, P., & Ehlen, M. A. (2025). Beyond Monetarism: A Comprehensive Approach to Understanding Inflation. *Modern Economy, 16,* 469-498.
https://doi.org/10.4236/me.2025.163023

Received: December 26, 2024
Accepted: March 28, 2025
Published: March 31, 2025

Abstract

We construct new measures of structural change at the economy level and at the industry levels and then demonstrate with Bayesian regression models that inflation rate is mainly determined by these structural changes. There is no room for monetary policy affecting inflation rates. The main finding of the study is that structural changes and dummy variables of financial crisis and the dummy variable for COVID-19 have significant effects on the inflation rate, contrary to the monetarist views that money supply growth is the main determinant of inflation rates and nominal GDP growth. Our findings have significant implications for policymakers, suggesting that traditional monetary policy tools may be less effective than structural reforms in managing inflation.

Keywords

Bayesian Models, Monetary Policy, Inflation Rate

1. Introduction

Despite the long-standing monetarist view that inflation is primarily a monetary phenomenon, this study proposes a different perspective. We argue that structural changes, rather than monetary policy, are the main determinants of inflation rates. Our analysis suggests that money supply has negligible or no significant effects on inflation rates and nominal GDP growth.

To support this argument, we develop new measures of structural changes at both the macroeconomic and industry levels. These measures, which have not been previously considered in the literature, provide a more comprehensive understanding of the factors driving inflation. Using Bayesian regression models with Lasso priors, we demonstrate that these structural changes significantly influence inflation rates. This approach moves beyond traditional monetary policy explanations and offers a novel framework for understanding inflationary pressures. By focusing on structural determinants, we challenge the conventional wisdom about the relationship between money supply, interest rates, and inflation.

The paper is structured as follows: In the next section, we briefly describe the current debate on monetary policy by the Central bank, including its interest rate policies on nominal GDP growth and the inflation rates. Section 3 presents a novel way of defining structural changes in the economy as well as measuring structural changes at the industry level. Section 4 presents the main results of the study using Bayesian approaches and shows that structural changes are the main determinants of the inflation rates in an economy using data from January 1994 to December 2023. The main finding is that structural changes and dummy variables of financial crisis and the dummy variable for COVID-19 have significant effects on the inflation rate, contrary to the monetarist views that money supply growth is the main determinant of inflation rates and nominal GDP growth. Section 5 concludes with a few policy implications.

2. Overview of Literature

In 1970, Friedman (1970) first asserted that inflation is fundamentally a monetary phenomenon, meaning it occurs only when the money supply grows more rapidly than output. This perspective, later known as the "monetarist doctrine," included several key propositions.

1) There is a consistent though not precise relation between the rate of growth of the quantity of money and the rate of growth of nominal income. The underlying principle is that if the quantity of money grows rapidly, so will nominal income, and conversely.[1]

2) On average, a change in the rate of monetary growth produces a change in the rate of growth of nominal income about six to nine months later. This is an average that does not hold in every individual case. Sometimes the delay is longer, sometimes shorter.[2]

3) On average, the effect on prices comes about six to nine months later after the effect on income and output, so the total delay between a change in monetary growth and a change in the rate of inflation averages something between 12 - 18

[1]This proposition stems from the equation of exchange: $MV = PT$, where M is money supply, V is velocity of money, P is average price level, and T is the level of transactions. While an increase in M mathematically necessitates an increase in P or T (or both), this identity does not inherently imply causation. It does not automatically follow that changes in money supply cause changes in price levels or nominal income growth. The equation merely describes a relationship without establishing the direction of influence among its components.

[2]Milton Friedman illustrated the challenge of long and variable lags in monetary policy through the analogy of a shower with unreliable temperature controls. When someone turns on the shower, they may find the water initially freezing cold if it hasn't been used recently, indicating a delay in reaching a comfortable temperature. In response, they might increase the hot water flow, but after another delay, they could find themselves scalded. To remedy this, they turn down the hot water, only to end up shivering from the cold, and this cycle continues. This analogy reflects how central bankers can struggle to manage economic activity or inflation through active monetary policy due to these unpredictable lags, making effective control nearly impossible.

months.[3]

4) In the short run, which may be as much as five or ten years, monetary changes affect primarily output. Over the decades, on the other hand, the rate of monetary growth affects primarily prices. Thus, inflation is always and everywhere a monetary phenomenon.[4]

2.1. A Critique of the Monetarist Mechanical Version of the Quantity Theory of Money

Monetarists rely on the equation of exchange, $MV = PT$, where M is the money supply, V is the velocity of circulation, P is the general price level, and T represents the total transactions in the economy. They argue that if V remains stable and the economy operates near full employment, an increase in M will proportionally raise P, implying money is neutral in the long run and inflation is purely a monetary phenomenon. However, this view assumes a uniform and proportional impact of inflation across all economic sectors, ignoring the role of time, the structure of productive stages, and the complexities of capital theory. Critics argue that this oversimplification fails to account for the dynamic and heterogeneous effects of monetary changes on the economy.[5]

2.2. Austrian Theory on Business Cycles

In 1912, von Mises (1912) argued that money is not neutral, as new money enters the economy unevenly, benefiting early recipients with increased purchasing power and causing sequential price changes across sectors, a process obscured by aggregate measures like the CPI. Anderson (1949) further criticized the quantity theory of money for ignoring the microeconomic processes and individual decisions driving price changes, emphasizing the complexity of economic interactions. These critiques highlight the limitations of monetarist theory, which oversimplifies economic cycles by attributing crises primarily to monetary contraction. In reality, downturns stem from a more intricate process involving credit expansion, inflation, and structural distortions in production, leading to unsustainable booms and eventual crises. Rothbard (1962) reinforced this critique by challenging the mathematical and economic validity of the equation of exchange ($MV = PT$), arguing that it fails to capture the dynamic and heterogeneous nature of monetary impacts on the economy. Together, these perspectives underscore the need for a more nuanced understanding of economic fluctuations beyond sim-

[3]We use data on GDP deflator for the period 1994 to 2023. We find no evidence of lagged money supply growth affecting the inflation rate. In fact, the coefficient of this variable is not significant in all our regression models, thus invalidating Friedman's proposition.

[4]This is a bogus claim in the sense that short run consists of five to ten years. Does one lag the value of money supply by five or ten years to find any impacts of money supply on output growth? On the other hand, how does one measure the rate of money supply growth for decades or longer? Does one take the average of the money supply growth over 20 years, over 15 years? Friedman is silent on this issue.

[5]This subsection draws from de Soto's work on monetary theory, particularly his analysis of the Austrian School's perspective on the non-neutrality of money.

plistic monetary explanations.

Rothbard critiques the equation of exchange ($MV = PT$) as more of an ideogram than a precise economic tool, highlighting two key flaws: heterogeneity of components and mathematical inconsistency. He argues that aggregating dissimilar elements like the general price level (P), which is a weighted average of diverse prices, and the quantity of goods (Q), which vary in quality and nature, is conceptually and mathematically unsound, akin to adding apples and oranges. This undermines the equation's validity and reliability, leading to significant economic implications: it limits its usefulness for monetary policy, oversimplifies complex economic relationships, and misrepresents economic reality by obscuring the true nature of interactions. Rothbard concludes that while the equation may serve as a conceptual framework, it lacks the rigor needed for precise economic modeling or policymaking, emphasizing the need for critical examination of foundational economic theories.

Hayek (1967), building on the Austrian theory of the business cycle, emphasized three key ideas: 1) Spontaneous order, where complex economic structures emerge without central planning; 2) The role of prices as signals guiding resource allocation; 3) The non-neutral effects of monetary changes. He critiqued monetarist theory for oversimplifying the relationship between money supply and prices, focusing only on the general price level while neglecting the impact on relative prices. Hayek argued that monetary changes distort relative prices, leading to resource misallocation and unemployment. His theories remain relevant today, particularly in analyzing the effects of artificially low interest rates, such as those set by the Federal Reserve from 2008 to 2014, which can create unsustainable investment booms followed by downturns. Hayek's insights continue to inform discussions on economic stability, employment, and the unintended consequences of monetary policy.[6]

Monetarists advocate for policies aimed at preventing economic recessions by maintaining steady growth in the money supply, exemplified by Friedman's K-percent rule, which proposes expanding the money supply at a fixed annual rate (e.g., 3%). However, this approach is criticized for addressing only the symptoms of crises, such as monetary contraction, rather than their root causes, potentially prolonging recessions by impeding the liquidation of misguided investments and risking stagflation. Critics argue that the K-percent rule is vulnerable to political pressures, economic fluctuations, and financial innovations, which can disrupt liquidity demands and render the rule destabilizing. Moreover, the monetarist claim that inflation is purely a monetary phenomenon is challenged by empirical evidence and alternative perspectives, such as Nitzan's (1992) structural approach, which emphasizes the role of economic interactions and structural changes in driving inflation. This highlights the limitations of monetarist policies and the need for a more nuanced understanding of economic dynamics.

[6]Please see Hayek, new studies in philosophy, politics, economics and the history of ideas, pp. 215.

2.3. Structuralist School of Thought on Inflation

The structural school of thought defines inflation from a "value-quantity" perspective, expressing it as a ratio between aggregate value and aggregate quantity of commodities. This approach views inflation as arising from the dynamic interplay between the business and industrial sectors, rather than as a weighted average of individual prices. The inflation rate is determined by the difference between the rate of change in aggregated value (representing business conditions) and the rate of change in aggregate quantity (representing industrial conditions). This formulation suggests that inflation occurs when there are underlying shifts in either aggregate value, aggregate quantity, or both. Nitzan (1992) expands on this concept by proposing that the inflation rate can be expressed as a function of various business and industry variables, such as business sales, employment rates, or capacity utilization, each offering distinct insights into economic conditions. This perspective emphasizes the dynamic and evolving nature of inflation, driven by the changing relationship between business and industrial spheres.[7]

Vague (2016) study challenges the conventional monetarist theory that rapid money supply growth causes inflation. Analyzing data from 47 countries representing 91% of global GDP from 1960 onwards, Vague examined six scenarios combining different definitions of rapid money growth and high inflation. He found that high inflation rarely followed periods of rapid money supply growth, and conversely, many instances of high inflation were not preceded by rapid money supply expansion. Vague defined rapid money growth using three criteria: a 20-percentage point increase in the money supply to GDP ratio over five years, 60% nominal M2 growth over five years, or 200% nominal growth over five years. High inflation was defined as either three or five consecutive years with inflation rates of 5% or higher. Based on these findings, Vague concluded that while the U.S. economy might experience some inflation increase, it would likely be due to factors other than monetary policy.[8]

Fix (2021) formulates the idea that the average rate of inflation is simply wrong as it can be misleading. The author criticizes the monetary doctrine in that money supply gives only meaningful insights into inflation only if price change is uniform. If price changes significantly by commodity groups, then the movement of the average price says little about the movement of individual prices. This also implies that money supply growth says little about real world inflation. The author finds that big business is systematically benefiting from inflation, which means that big corporations are raising prices faster than everyone else. In other words, it is the market structure, such as oligopolies that are driving inflation in the real world.[9]

Taylor & Barbosa-Filho (2021) present a comprehensive critique of monetarist

[7]See for example, Nitzan (1992), Inflation as Restructuring, A Theoretical and Empirical Account of the U.S. Experience.

[8]See for example, https://ysi.ineteconomics.org/event/rapid-money-supply-growth-does-not-cause-inflation/.

[9]See for example, Fix (2021) study at: https://evonomics.com/the-truth-about-inflation-why-milton-friedman-was-wrong-again/.

inflation theories, advocating instead for a structural, cost-based approach. Their analysis emphasizes the importance of macroeconomic accounting, considering both GDP and GDI, which monetarism's microeconomic focus overlooks. The authors argue that inflation stems from unresolved conflicts over income distribution and is driven by cost structures, particularly the interplay between labor costs, import costs, and profits. They demonstrate how declining labor share and wage growth lagging behind price inflation plus productivity growth contradict monetarist assumptions about wage-price spirals. The paper highlights the significant role of import costs and the cyclical nature of inflation, aligning with Marx-Goodwin cycle theories. Ultimately, the authors contend that the Federal Reserve cannot directly control inflation through monetary policy alone, challenging core monetarist beliefs and presenting inflation as a complex macroeconomic phenomenon influenced by structural factors and international dynamics.[10]

We provide the contrasting economic approaches of the various schools of thought in Table A1.

In the next section, we examine the method of our study, and the dataset used in the study.

3. Data and Methods

We collected data on the following variables following Nitzan (1992).

1) Rate of change of Nominal GDP
2) Rate of change of real GDP
3) Rate of change of employment
4) Rate of change of business sales
5) Rate of change of private sector employment
6) Rate of change of unemployment (U6)
7) Idle Capacity index

The data was collected for the period January 1994 to December 2023.

3.1. Inflation Rate Calculation

The inflation rate was computed as follows:

$$\text{Infl} = \text{Rate of change of Nominal GDP} - \text{Rate of change of real GDP} \quad (1)$$

Equation (1) holds because the rate of change in nominal GDP includes both the growth in real output and the increase in prices i.e. the inflation rate. Mathematically, we can express this as: Rate of change in nominal GDP = Rate of change in real GDP + Inflation rate.[11] Thus, rearranging the above equation, we get the inflation rate to be the difference between the rate of change of nominal GDP and

[10]See for example, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3812809.

[11]We considered three measures of inflation: 1) Rate of change of nominal GDP minus the rate of change of real GDP; 2) Sum of the rate of change of nominal GDP and the unemployment rate; and 3) Sum of the rate of change of nominal GDP and the idle-capacity index. Measures 2 and 3 are highly correlated, suggesting redundancy. Our primary measure shows moderate to strong negative correlations with measures 2 and 3 (−0.721 and −0.690 respectively), indicating it provides distinct information. Thus, we retain our primary measure due to its distinct information content, assuming theoretical relevance.

the rate of change of real GDP.

3.2. Measuring Structural Change

We also construct various measures of structural changes using the above variables as follows:

$$\text{Str1} = \text{Rate of change of Nominal GDP} - \text{Rate of change of employment} \quad (2)$$

This measure of structural change (instead of inflation rate as postulated by (Nitzan, 1992) can be interpreted as follows: Given that the first variable is a proxy for business conditions and the second variable being a proxy for industrial conditions, the difference between them provides a measure of structural change. The remaining measures of structural change are computed based on the rate of change in business sales and industry variables.

They are defined as follows:

$$\text{Str2} = \text{Rate of change of business sales} - \text{Rate of change of real GDP} \quad (3)$$

Equation (3) can be considered as a measure of structural change in an economy for several reasons:

1) Composition of economic activity: Real GDP encompasses all sectors of the economy, including consumer spending, business investment, government spending, and net exports. Business sales, on the other hand, primarily reflect the commercial sector. When these two metrics diverge, it suggests shifts in the relative importance of different economic components.

2) Productivity changes: If business sales are growing faster than real GDP, it may indicate improvements in productivity or efficiency in the business sector. Conversely, if real GDP is growing faster than business sales, it could suggest productivity gains in other sectors or changes in the non-business components of the economy.

3) Value addition vs. turnover: Real GDP measures the value added in an economy, while business sales represent turnover. A gap between these rates could indicate changes in the value-addition process, such as increased outsourcing or vertical integration.

4) Sectoral Shifts: A divergence between these rates can signal shifts between economic sectors. For example, if service industries are growing faster than goods-producing industries, business sales might not fully capture this change, while real GDP would.

Thus, by analyzing the difference between these two rates of change, economists and policymakers can gain insights into the evolving structure of the economy, identifying areas of growth, decline, or transformation.

$$\text{Str3} = \text{Rate of change of business sales} - \text{Rate of change of private employment} \quad (4)$$

Equation (4) can also be interpreted as a measure of structural change for the following two main reasons:

1) Labor Market Dynamics: The relationship between business sales and employment growth can highlight changes in labor market dynamics. For instance,

a growing gig economy or increased automation can lead to higher business sales without a corresponding increase in traditional employment, indicating structural shifts in how labor is utilized. With the current adoption of artificial intelligence in many sectors including the tech sector, there has been significant growth in business sales without a corresponding increase in employment.[12]

2) Value Addition and Economic Composition: Changes in the composition of the economy, such as a move towards high-value-added sectors like finance, insurance, and real estate, can lead to higher business sales without proportional employment growth. This reflects structural changes in the economy's value addition processes.

By analyzing the difference between these two rates, economists can gain insights into the underlying structural changes in the economy, such as shifts in productivity, sectoral composition, and labor market dynamics.

$$\text{Str4} = \text{Rate of change of business sales} + \text{Rate of change of unemployment} \quad (5)$$

There are several reasons why Equation (5) can be considered as a measure of structural change. They are enumerated below:

1) Divergence between output and employment: This measure captures the relationship between economic output (represented by business sales) and labor market dynamics (represented by unemployment). A significant divergence between these two rates can indicate structural shifts in the economy.

2) Sectoral shifts: Changes in this combined measure can reflect shifts between economic sectors. For example, if traditional industries decline while new sectors emerge, it might lead to simultaneous growth in business sales and unemployment as the labor market adjusts.

3) Labor market mismatches: A rise in both business sales and unemployment could indicate a skills mismatch in the labor market, where job requirements are changing faster than workers can adapt. This is a characteristic of structural unemployment.[13]

The policy implication is that changes in this measure can signal the need for targeted policies to address structural issues, such as retraining programs or education initiatives to align workforce skills with evolving business needs. By combining the rate of change in business sales with the rate of change in unemployment, this measure provides a more comprehensive view of structural economic changes than either metric alone. It captures both the output side (business performance) and the input side (labor market dynamics) of the economy, offering insights into fundamental shifts in how the economy operates and generates value.

$$\text{Str5} = \text{Rate of change of business sales} + \text{Idle capacity index} \quad (6)$$

Equation (6) can be interpreted as a measure of structural change for several reasons. They are explained below:

1) Business cycle indicator: This combination provides insight into both de-

[12]See for example, https://ventionteams.com/solutions/ai/adoption-statistics.

[13]See for example, https://www.investopedia.com/terms/s/structuralunemployment.asp.

mand (sales) and supply (capacity utilization) sides of the economy. When sales growth changes while idle capacity remains high, it may indicate structural shifts rather than just cyclical fluctuations.

2) Adaptation to demand: Changes in sales growth coupled with idle capacity trends show how well businesses are adapting their production capacity to meet changing demand patterns. Structural changes often require significant adjustments in capacity utilization.

3) Investment signals: Persistent idle capacity despite sales growth may indicate reluctance to invest in new capacity, possibly due to structural uncertainties or shifts in the economy.

The addition of these two metrics is significant because of the following:

1) Comprehensive view: It combines demand-side (sales) and supply-side (capacity) information, providing a more holistic picture of economic activity.

2) Balancing short-term and long-term factors: Sales growth tends to reflect short-term economic conditions, while idle capacity can indicate longer-term structural issues. Combining them balances these perspectives.

3) Efficiency assessment: The sum of these metrics helps assess overall economic efficiency, as it captures both the pace of economic activity and the utilization of available resources.

By combining the rate of change in business sales with an idle capacity index, analysts and policymakers can gain deeper insights into structural changes occurring in the economy, beyond what either metric alone might reveal.

Thus, our measures of structural change in an economy are the first of its kind to model inflation rate as a function of structural changes by incorporating both economic and industry conditions.

3.3. Descriptive Statistics with Measures of Inflation Rate & Components of Structural Changes

This sub-section examines key descriptive statistics related to inflation rates and the components that contribute to structural changes at the business and at the industry levels. We will analyze various measures of inflation and their underlying factors to provide a comprehensive overview of price dynamics.

In **Figure 1**, the x-axis represents time in quarters, spanning from 1994 to 2023. The y-axis shows the inflation rate, which appears to range from about −10% to 15%. Each point on the line represents the average inflation rate for a quarter.

Some observations from the graph are as follows: 1) There is significant volatility in the inflation rate over the years; 2) Inflation rate fluctuates between negative (deflation) and positive values; 3) The most recent data points seem to show a sharp increase in inflation; 4) The average inflation rate over the period is -1.47%, indicating a general trend of deflation over the years.

Next, we provide some explanations of the trends of inflationary and deflationary periods.

Significant Inflationary Periods:

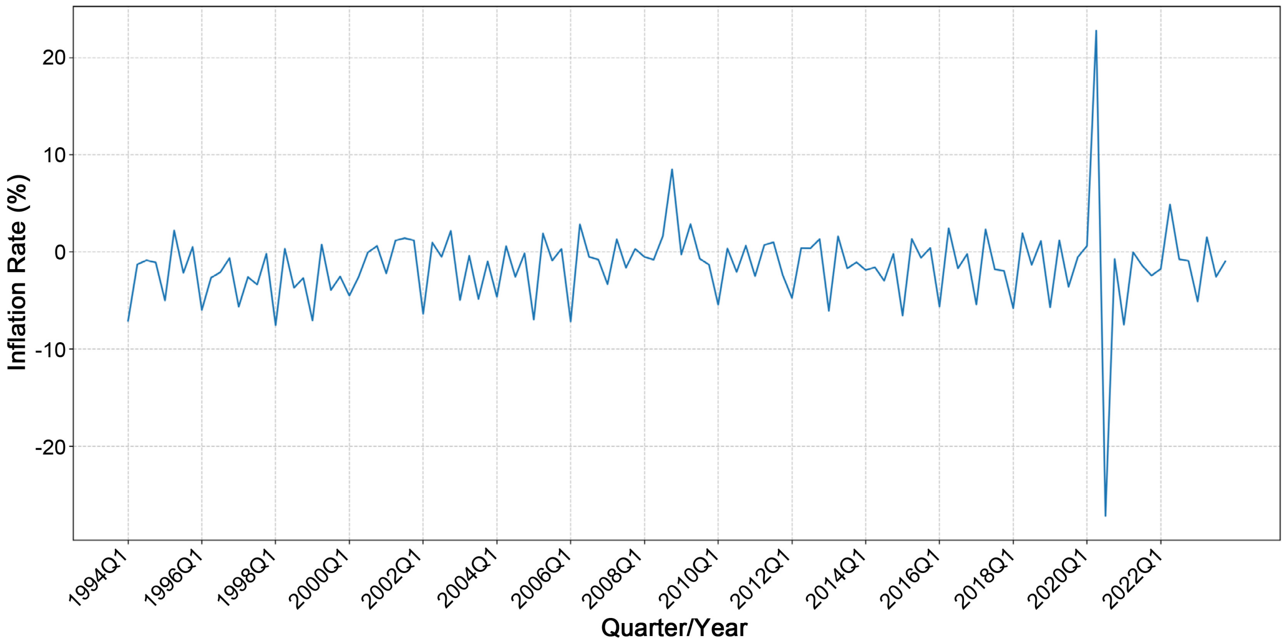

Figure 1. Quarterly inflation rate over time. Source: Authors' computations based on Bureau of Economic Analysis (BEA) data.

1) June 2020 (22.76%):

- This period of high inflation could be attributed to economic disruptions caused by the COVID-19 pandemic. The pandemic led to supply chain disruptions, increased demand for certain goods, and fiscal stimulus measures, all contributing to inflationary pressures.

2) December 2008 (8.5%):

- The global financial crisis of 2008 led to significant economic turmoil. Governments and central banks around the world implemented various monetary and fiscal policies to stabilize economies, which could have led to inflationary pressures during this period.

Significant Deflationary Periods:

1) March 2021 (−7.49%):

- This period might reflect the ongoing adjustments in the economy as it continued to recover from the pandemic's initial impact of the pandemic with large fluctuations in both demand and supply.

2) September 2020 (−27.19%):

- This sharp deflation could be a result of the economic impact of the COVID-19 pandemic, where demand for goods and services plummeted due to lockdowns and economic uncertainty.

3) March 2006 (−7.16%):

- This deflationary period could be linked to the prelude to the financial crisis, where certain sectors experienced downturns.

4) March 1998 (−7.55%):

- The Asian financial crisis, which began in 1997, had widespread effects on global markets, leading to deflationary pressures in many economies.

5) March 1994 (−7.1%):

- This period might be associated with economic adjustments following the early 1990s recession, where economies were stabilizing and adjusting to new monetary policies.

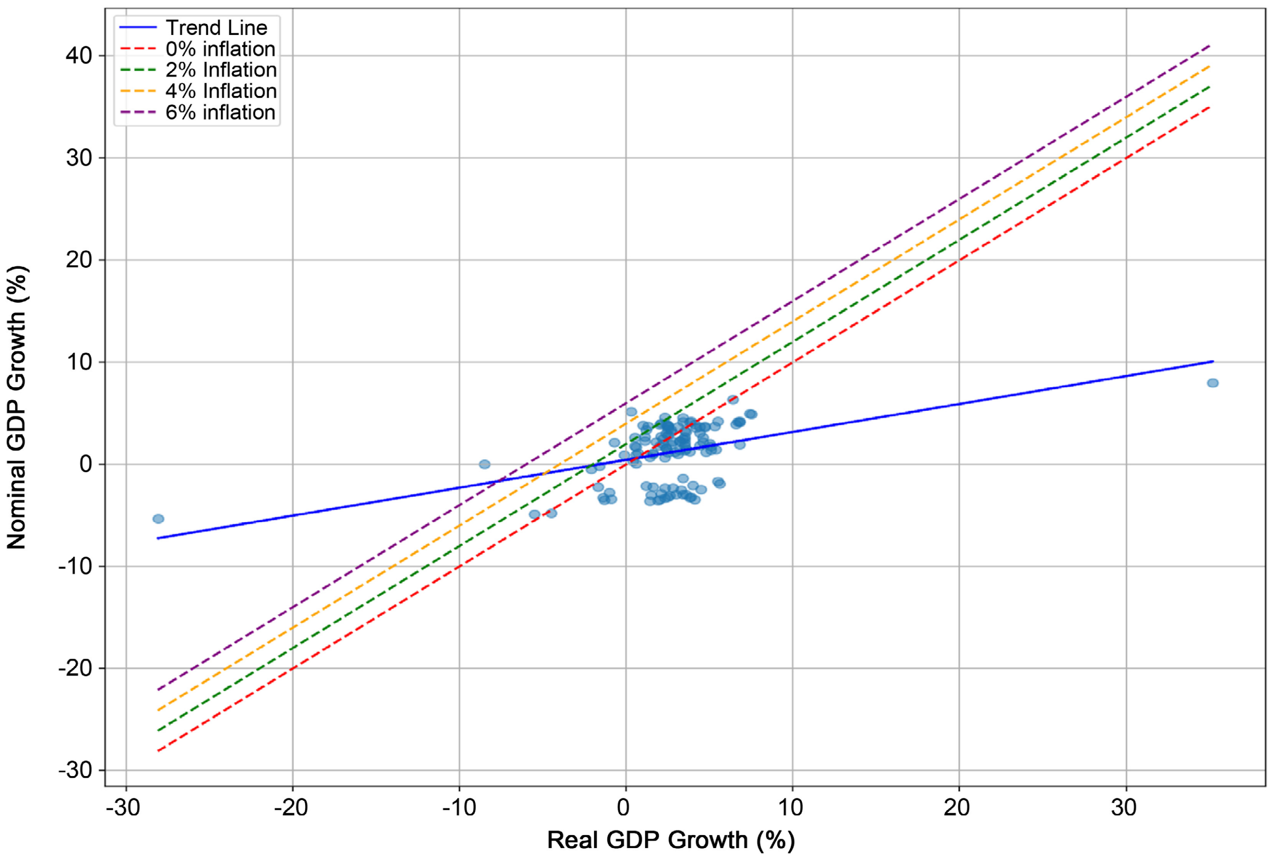

Figure 2. Isogrowth presentation between rate of change of nominal GDP and rate of change of real GDP. Source: Authors' computations based on Bureau of Economic Analysis (BEA) data.

Figure 2 shows the relationship between Real GDP Growth and Nominal GDP Growth, with several key features:

1) Scatter plot: Each point represents a quarter's data for Real and Nominal GDP growth.

2) Trend line (blue): This line shows the general relationship between Real and Nominal GDP growth.

3) Reference lines: These dashed lines represent different inflation rates (0%, 2%, 4%, and 6%). Points above these lines indicate periods with higher inflation than the reference line.

Interpretation of the Results:

1) The positive correlation (0.4568) indicates that Real and Nominal GDP growth tends to move in the same direction, but the relationship is not very strong.

2) The trend line's slope (0.2735) suggests that, on average, for every 1% increase in Real GDP growth, Nominal GDP growth increases by about 0.2735%.

3) The R-squared value (0.2087) indicates that only about 20.87% of the variation in Nominal GDP growth can be explained by Real GDP growth, suggesting other factors play a significant role.

4) Most data points fall between the 0% and 6% inflation reference lines, indicating that inflation typically ranges between these values for the given period.

5) Points above the red dashed line (0% inflation) represent periods where Nominal GDP growth exceeded Real GDP growth, indicating positive inflation.

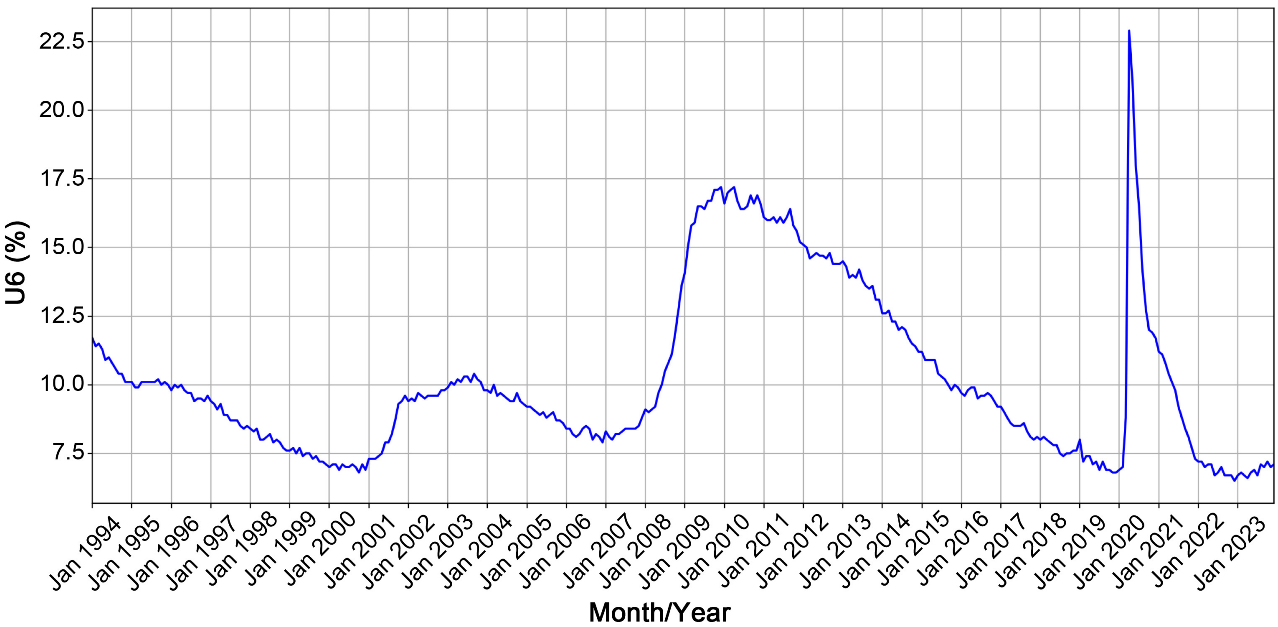

Figure 3. Unemployment rate (U6) as a broad measure of labor underutilization (in %). Source: Authors' computations based on Bureau of Labor Statistics (BLS) data.

Figure 3 shows the U6 unemployment rate from 1994 to December 2023. The U6 unemployment rate is a broad measure of labor underutilization. It includes not only the officially unemployed but also discouraged workers, those marginally attached to the labor force.

Several observations are noteworthy:

- The average U6 unemployment rate over this period is about 10.17%.
- The lowest rate was 6.5%, and the highest was 22.9%.
- There were several peaks in the U6 rate, which likely correspond to economic recessions or downturns ~ the most prominent peaks are visible around 2009-2010 (likely the Great Recession) and in 2020 (COVID-19 pandemic) periods.
- The recent trends show that after the dramatic spike in 2020, there has been a sharp decline in the U6 rate, suggesting a rapid recovery in the labor market.
- The standard deviation of 3.02 suggests considerable variations in the U6 rate over time.

Significant Events: Date: 2020-04-01, Rate 22.9%:

- The highest U6 rate of 22.9% occurred in April 2020, which coincides with the economic impact of the COVID-19 pandemic.

- The lowest U6 rate of 6.5% was recorded in December 2022, indicating a strong recovery in the labor market post-pandemic.

Importantly, the plot and statistics suggest that the U.S. labor market has gone through significant changes over the past three decades. Economic crises, such as the Great Recession and the COVID-19 pandemic, have caused sharp increases in the U6 rate, indicating widespread job losses and unemployment during these periods.

The current low U6 rate could indicate a strong economy but might also present challenges for employers in finding workers. It is important to note that while a low U6 rate is generally a positive indicator for the economy, extremely low rates can sometimes precede economic downturns or indicate potential wage pressures.

Figure 4. Total Capacity Utilization (TCU) percentage over time. Source: Authors' calculations based on data from the Federal Reserve Bank of St. Louis, FRED Economic Data, Capacity Utilization: Total Index [TCU].

Figure 4 shows the Total Capacity Utilization (TCU) during the period 1994 to 2023. The overall trend shows that the TCU has fluctuated over time, showing several cycles of increases and decreases. The general trend appears to be slightly downward.

Several observations of the above plot are noteworthy:

- Highest TCU: 84.77 on December 1994.
- Lowest TCU: 64.69 on April 2020.
- We can observe noticeable decline of TCU around 2001-02 after a period of economic recession.
- There was a significant drop in the index from 2008 to 2009 corresponding to the Great Recession.
- The most dramatic decline in the series occurred during early 2020 corresponding to the COVID-19 pandemic.

Mean and Volatility of TCU:

The mean TCU over the entire period is about 78.51% with a standard deviation of about 3.69%. In addition, the median (50% percentile) is slightly higher than the mean at 78.7%, suggesting a slight negative skew in the distribution. The interquartile range (25% - 75%) is relatively narrow at about 4.64 percent points, suggesting that most of the time, TCU stays within a fairly consistent range. The TCU appears to have become more volatile during the past two decades, with larger swings.

3.4. Cross-Correlations between Inflation Rate and Structural Changes

Table 1 shows the cross-correlations between the dependent and the independent variables in the model to assess the relationships between these variables.

Table 1. Cross-correlation analysis.

Variables	Infl	Str1	Str2	Str3
Infl		0.412	−0.547	−0.546
Str1	0.412		−0.721	−0.690
Str2	−0.547	−0.721		0.999
Str3	−0.546	−0.690	0.999	

Source: Authors' own computations.

The positive correlation between price changes, nominal GDP growth, real GDP growth, and employment growth suggests a complex relationship. As there was deflationary trend in the data, it is plausible that the correlation between nominal GDP and employment might be affected by downward wage rigidity, as employers may struggle to cut nominal wages even as prices fall. The presence of wage rigidities likely amplified the Fed's concerns about deflation and influenced its policy decisions, leading to more aggressive and preemptive actions to maintain price stability and support employment.

In order to evaluate the negative correlation between inflation and the second measure of Structural change (Str2), we can provide a better explanation by considering the following economic conditions and trends:

1) *Globalization and Trade Dynamics*:

This period saw significant globalization, which increased competition and efficiency in many sectors. This could have led to business sales growth aligning more closely with real GDP growth, as businesses adapted to global market conditions.

2) *Technological Advancements*:

This period also saw rapid technological advancements, which improved productivity growth, allowing businesses to maintain or increase sales without a proportional increase in real GDP. This could explain the narrowing gap between business sales growth and real GDP growth.[14]

[14]See for example, https://www.econstor.eu/bitstream/10419/56150/1/39295690X.pdf.

3) *Inflation Targeting*:

Central banks in United States and other developed countries, adopted inflation targeting which helped in stabilizing inflation expectations. This may have contributed to a more predictable relationship between business sales and real GDP growth.

The above factors may have contributed to a more synchronized movement between business sales and real GDP during these deflationary periods, leading to the observed negative correlation.

For the negative correlation between inflation (infl) and the third measure of structural change (Str3) can best be explained by a combination of increased labor market flexibility, technological advancements and globalization. Technological improvements allowed companies to maintain or increase sales with fewer employees, while globalization pressured businesses to optimize their operations. Additionally, central banks' focus on inflation control helped stabilize inflation expectations, further influencing employment and business strategies.

From our analysis, structural variables 2, 4 and 5 are perfectly correlated. Thus, we can remove two of them from our analysis, and we can still conduct our Bayesian regression analysis without any loss of generality. Thus, we only consider structural changes 1, 2, and 3 in our Bayesian regression modeling with LASSO priors. We describe our method in the next section.

3.5. Bayesian Models and LASSO Priors

Bayesian models view estimation as a problem of integrating prior information with information gained from data i.e. from the probability distributions. This model differs from the frequentist approach, which treats regression as an optimization problem that results in a point estimate. We use the method of Karabatsos (2015) to estimate the marginal posterior estimates of the determinants of inflation using a Bayesian LASSO regression model.

A Bayesian regression model takes the following form:

$$y_i \mid \beta_0, x_i, \beta, \sigma \sim N\left(\beta_0 + \sum_{j=1}^{p} x_{ij}\beta_j, \sigma\right) \tag{7}$$

In Equation (7), we need to specify a prior on the intercept (β_0), slopes (β), and error variance (σ). As we are standardizing all the predictors and the outcome variable, we can ignore the intercept term. Thus, the choice of prior distribution on β is what determines how much information we learn from the data.

The question then becomes what can be done to restrict learning in a Bayesian Model?

One simple approach to address the above question is to use a prior distribution on the β weights in terms of the expectation of the model so that these weights tend towards zero. For example, we may specify.

$$\beta \sim N\left(0, \sigma_\beta\right) \tag{8}$$

Equation (8) shows that we are jointly estimating the "penalization term" σ_β and β, as opposed to performing cross-validation. As we are jointly estimating

σ_β along with the individual β weights, the Bayesian ridge regression is a simple hierarchical model, where σ_β is interpreted as a group-level scaling parameter that is estimated from pooled information across individual β weights.

It is important to note here that the behavior of both the models is equivalent. Intuitively, as $\sigma_\beta \to \infty$, the prior on σ_β becomes uniform. With a uniform prior density, there is no penalty at all, we are left with the least squares regression. It is important to note that the mode of the resulting posterior distribution over β will be equivalent to the maximum likelihood estimate when the prior on β is uniform.

For the Bayesian LASSO regression, the only difference is in the form of the prior distribution. Specifically, setting a double exponential prior on the β weights is mathematically equivalent in expectation to the frequentist LASSO penalty.[15] In other words,

$$\beta \sim \text{double-exponential}\left(0, \tau_\beta\right) \tag{9}$$

In Equation (9), τ_β ($0 < \tau_\beta < \infty$) is a scale parameter that controls how peaked the prior distribution is around the center. As $\tau_\beta \to 0$, then the model assigns infinite weight on the β weights i.e. there is no learning from the data. Conversely, as $\tau_\beta \to \infty$, the prior reduces to a uniform prior, thus leading to no regularization at all.

The Laplace distribution (double exponential) places much more probability mass directly on zero, which produces the variable selection effect specific to LASSO regression.

The next section looks at the main regression results.

4. Main Results

We present the main results of our study that relates inflation rate to various measures of structural changes in the economy using the Bayesian model with LASSO Priors.

To interpret the posterior estimates of the Bayesian Lasso in the context of how the inflation rate is affected, we need to consider the coefficients associated with each predictor in the model. The Bayesian Lasso provides a probabilistic framework for understanding these coefficients, incorporating both the data and prior information (Table 2).

Table 2. Posterior estimates of the Bayesian model with LASSO priors of the inflation rate with first structural change measure.

Variables	Median Estimate	1st Quartile Estimate	3rd Quartile Estimate	CUSUM
C	−1.747	−1.957	−1.533	0.504
dumcovid	1.024	0.418	1.653	0.498

[15]For additional details, please see https://stats.stackexchange.com/questions/182098/why-is-lasso-penalty-equivalent-to-the-double-exponential-laplace-prior.

Continued

Strone	2.297	2.106	2.487	0.5
dumfin	0.876	0.298	1.473	0.497
Lambda	1.279	0.988	1.603	0.492
sigma^2	26.224	24.884	27.655	0.501
R^2	0.176			

Source: Authors' own computations.

4.1. Specific Interpretation of Posterior Estimates

1) Coefficient for "C": The median estimate for "C" is −1.747, with interquartile estimates ranging from −1.957 to −1.533. This suggests that "C" has a negative effect on the inflation rate, with a relatively narrow range indicating moderate certainty about this negative influence.

2) Coefficient for "dumcovid": The median estimate is 1.024, with interquartile estimates from 0.418 to 1.653. This indicates a positive effect of the COVID-19 dummy variable on the inflation rate, suggesting that the pandemic period is associated with an increase in inflation. The wider interquartile range reflects more uncertainty about the exact size of this effect.

3) Coefficient for "Strone"[16]: With a median estimate of 2.297 and interquartile estimates from 2.106 to 2.487, "Strone" appears to have a strong positive effect on inflation. The narrow range of interquartile estimates indicates high confidence in this positive impact.

4) Coefficient for "dumfin": The median estimate is 0.876, with interquartile estimates from 0.298 to 1.473, suggesting a positive effect on inflation. The variability in the interquartile estimates indicates some uncertainty about the precise magnitude of this effect. This is a dummy variable of financial crisis and the uncertainty of the precise magnitude of this effect resembles the uncertainty of the inflation rate during this time period.

5) Lambda and Sigma Squared: The regularization parameter (Lambda) and the error variance (sigma squared) provide additional context. A Lambda of 1.279 indicates the degree of regularization applied, which affects how much the coefficients are shrunk towards zero. Sigma squared of 26.224 suggests the level of variance in the model's errors.

4.2. Overall Impact on Inflation

Figure 5 shows the posterior median estimates of the coefficients of SBFin, SBCovid, and Strone on the inflation rate. The Bayesian Lasso estimates suggest that certain variables, such as "dumcovid" and "Strone", have a significant positive impact on the inflation rate, while "C" has a negative effect. The Bayesian framework allows for the consideration of uncertainty in these estimates, as reflected in the interquartile ranges. These insights can help in understanding the factors driv-

[16]This variable measures the first indicator of structural change at the economy level.

ing inflation and in making informed economic policy decisions.

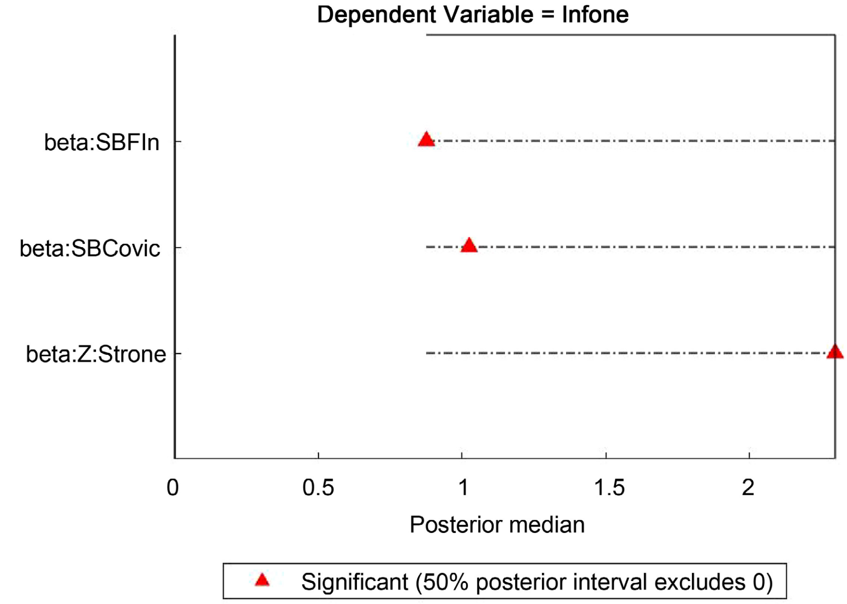

Figure 5. Marginal Posterior distributions from Bayesian LASSO regression on inflation rate. Source: Authors' own computations.

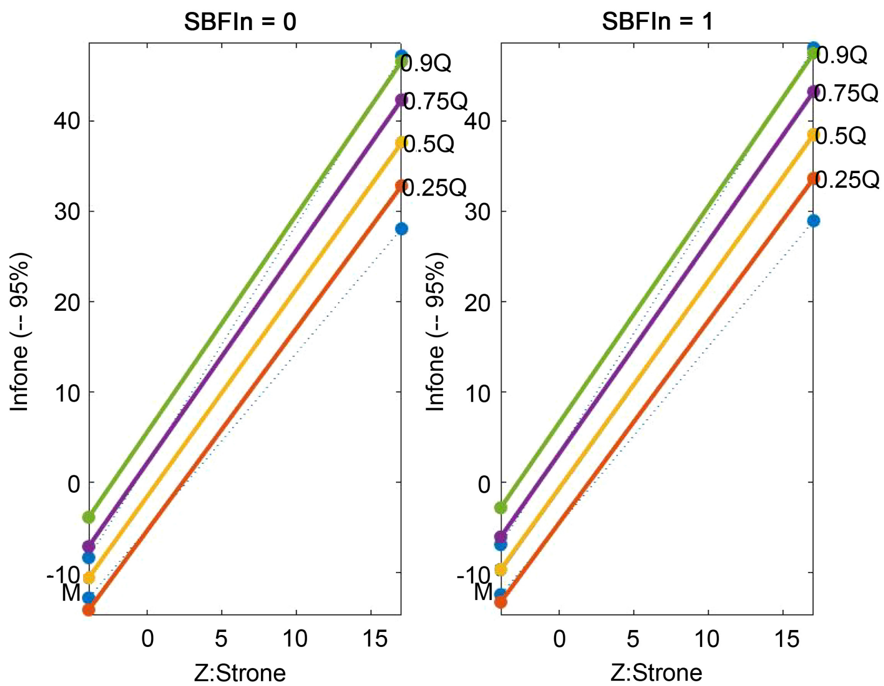

Figure 6. Impact of structural change on inflation rate, conditional on financial crisis. Source: Authors' own computations.

Figures 6-9 corroborate the main results of the study with the marginal posterior estimates and the conditional distribution of the independent variables on the inflation rate.

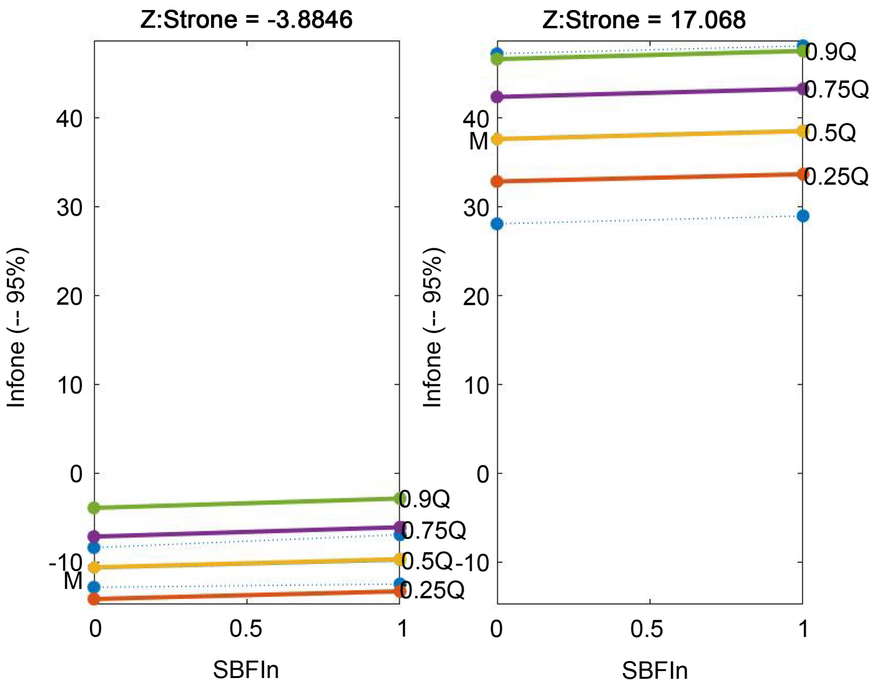

Figure 7. Effect of financial crisis on inflation rate, conditional on structural change. Source: Authors' own computations.

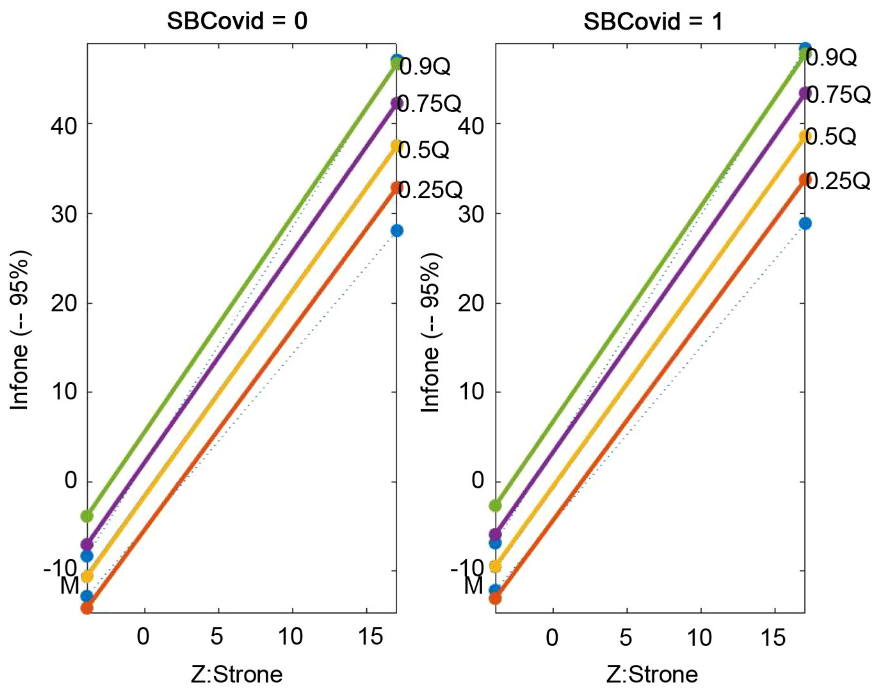

Figure 8. Impact of structural change on inflation rate, conditional on COVID-19. Source: Authors' own computations.

To interpret the posterior estimates of the Bayesian Lasso in the context of how the inflation rate is affected, we need to consider the coefficients associated with each predictor in the model. Table 3 provides these estimates using the second

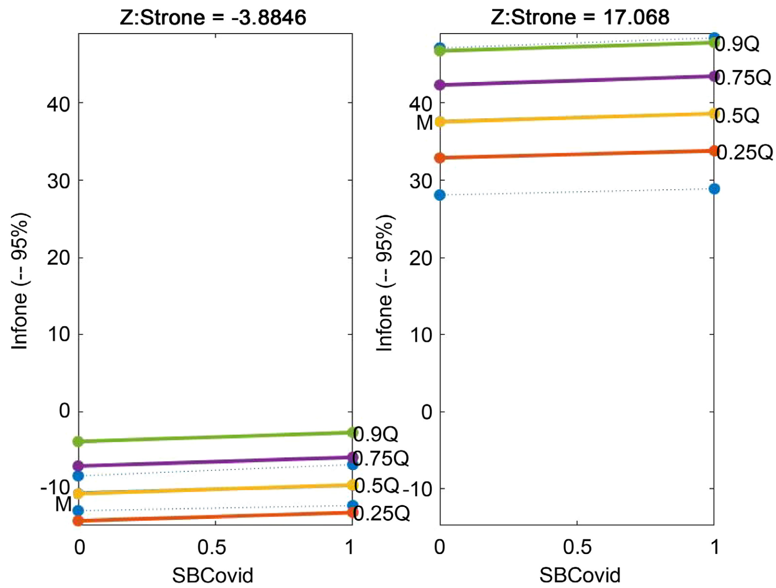

Figure 9. Effect of COVID-19 on inflation rate, conditional on structural change. Source: Authors' own computations.

Table 3. Bayesian LASSO regression results for inflation rate using second structural change measure.

Variables	Median Estimate	1st Quartile Estimate	3rd Quartile Estimate	CUSUM
C	−1.766	−1.959	−1.571	0.499
dumcovid	1.132	0.572	1.704	0.501
Strtwo	−3.064	−3.238	−2.888	0.501
dumfin	0.958	0.421	1.506	0.503
Lambda	1.223	0.940	1.538	0.492
sigma^2	22.083	20.951	23.289	0.499
R^2	0.307			

Source: Authors' own computations.

measure of structural change, which incorporates both the business level and the industry level.

4.3. Specific Interpretation of Posterior Estimates

1) **Coefficient for "C"**: The median estimate for "C" is −1.766, with interquartile estimates ranging from −1.959 to −1.571. This suggests that "C" has a negative effect on the inflation rate, with a relatively narrow range indicating moderate certainty about this negative influence.

2) **Coefficient for "dumcovid"**: The median estimate is 1.132, with interquartile estimates from 0.572 to 1.704. This indicates a positive effect of the COVID-19 dummy variable on the inflation rate, suggesting that the pandemic period is associated with an increase in inflation. The wider interquartile range reflects

more uncertainty about the exact size of this effect.

3) Coefficient for "Strtwo"[17]: With a median estimate of −3.064 and interquartile estimates from −3.238 to −2.88, "Strtwo" appears to have a strong negative effect on inflation. The narrow range of interquartile estimates indicates high confidence in this negative impact.

4) Coefficient for "dumfin": The median estimate is 0.958, with interquartile estimates from 0.421 to 1.506, suggesting a positive effect on inflation. The variability in the Interquartile estimates indicate some uncertainty about the precise magnitude of this effect. This is a dummy variable of financial crisis and the uncertainty of the precise magnitude of this effect resembles the uncertainty of the inflation rate during this time period.

5) Lambda and Sigma Squared: The regularization parameter (Lambda) and the error variance (sigma squared) provide additional context. A Lambda of 1.223 indicates the degree of regularization applied, which affects how much the coefficients are shrunk towards zero. Sigma Square of 22.083 suggests the level of variance in the model's errors.

4.4. Overall Impact on Inflation

The Bayesian Lasso estimates suggest that certain variables, such as "dumcovid" and "Strtwo", have a significant positive and negative impact on the inflation rate respectively, while "C" has a negative effect. The negative relationship between the rate of change of business sales and real GDP with inflation rates can be attributed to decreased demand, stagnant economic growth, altered consumer behavior, cautious business pricing strategies, and hesitance in investment. These factors collectively contribute to a lower inflation environment, highlighting the interconnectedness of economic indicators and their impact on inflation dynamics.

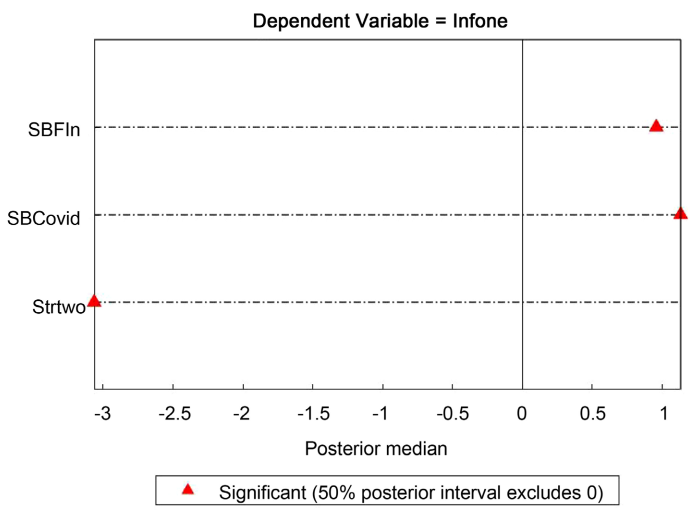

Figure 10. Marginal posterior distributions from Bayesian LASSO regression on inflation rate using second structural change measure. Source: Authors' own computations.

[17]This variable is the second indicator of structural change and is measured as the difference between the rate of change of business sales and the rate of change of real GDP growth.

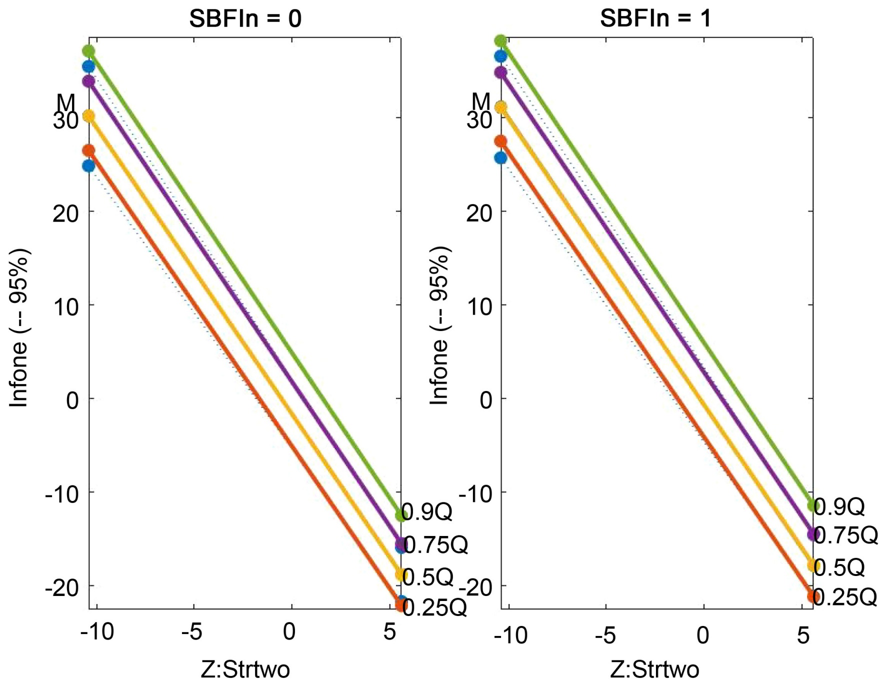

Figure 11. Impact of structural change (measure two) on Inflation rate, conditional on financial crisis. Source: Authors' own computations.

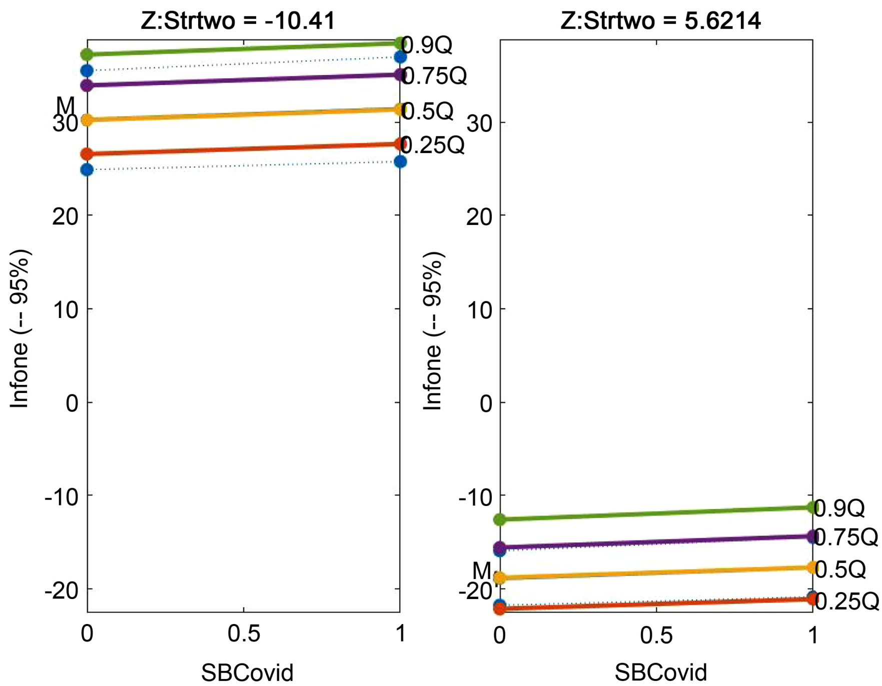

Figure 12. Effect of COVID-19 on inflation rate, conditional on structural change (measure two). Source: Authors' own computations.

Figures 10-12 corroborate the main findings of Table 2 with the posterior estimates and the conditional probability distributions of the independent variables on their effect on the inflation rate.

5. Conclusion and Policy Implication

Our study makes two significant contributions to existing literature. First, the study demonstrates with actual data on inflation rate, nominal GDP growth and various measures of money supply that the relationship between money supply growth and nominal income growth is not consistent when tested with actual data. This may suggest that factors beyond monetary growth significantly influence nominal income. With regard to the inflation rate, our study shows that this timing is inconsistent, with the actual delay varying significantly, undermining the notion of a predictable sequence from monetary changes to inflation.

Second, we construct different measures of structural changes at the economy level as well as at the business level. Our first measure of structural change has a significant positive impact on the inflation rate, while we also find that the inflation rate increased during the pandemic period. The Bayesian framework allows for the consideration of uncertainty in these estimates, as reflected in the interquartile ranges. These insights can help in understanding the factors driving inflation and in making informed economic policy decisions.

Finally, our second measure of structural change, defined as the difference between the rate of change in business sales and the rate of change in real GDP growth, significantly and negatively impacts the inflation rate. This inverse relationship can be explained by factors such as reduced demand, stagnant economic growth, shifts in consumer behavior, cautious pricing strategies by businesses, and hesitancy in investment. Together, these factors contribute to a lower inflation environment, underscoring the interconnectedness of economic indicators and their influence on inflation dynamics.

In light of these findings, policymakers should consider prioritizing structural reforms over traditional monetary interventions, such as inflation targeting and interest rate targeting to manage inflation effectively. By focusing on the underlying structural changes within the economy, such as shifts in industry dynamics and consumer behavior, policymakers can better anticipate and respond to inflationary pressures. This approach not only aligns with the evidence presented in our study but also offers a more sustainable path for economic stability. Furthermore, understanding the nuanced relationship between structural changes and inflation can aid in designing targeted policies that address specific economic challenges, thereby enhancing the overall efficacy of policy measures.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix 1: Contrasting Approaches to Economics

Table A1. A simplified version of economic approaches—macroeconomist, Austrian school and the structural school of thought.

Aspects	Macroeconomists (Monetarists and Keynesians)	The Austrian School	Structural School
Role of time	The influence of time is ignored	Time plays an essential tole	Time plays a significant role by highlighting the long-term and gradual nature of inflationary processes driven by structural factors
Role of capital	Capital is viewed as a homogenous fund which reproduces on its own	"Capital" is viewed as a heterogenous set of goods which receive constant wear and must be replaced	Capital is a critical factor in production shaping the long-term productive capacity of an economy and addressing structural bottlenecks
Role of Money	Money affects the general level of prices. Changes in relative prices are not considered.	Money affects the economic process by modifying the structure of relative prices	Money is a secondary factor that reacts to inflationary pressures arising from deeper structural issues within an economy.
Macroeconomic aggregates	Macroeconomic aggregates prevent the analysis of underlying microeconomic factors	Macroeconomic phenomena are explained in terms of variations in relative prices	Macroeconomic aggregates as complex outcomes of deep-seated structural features of an economy, rather than simply the result of monetary or short-term demand factors
Role of Savings	Saving is not important	Savings play an important role in causing a longitudinal change in the productive structure and also determines the sort of technology to be used	Savings is viewed in the context of broader structural features of the economy, including income distribution, sectoral differences, and the overall process of economic development.

Continued

Causes of Economic Crises	Crises have exogenous shocks (technological, errors in monetary policy etc.)	Economic crises are endogenous which explains their recurrent nature (corrupt institutions: fractional reserve and artificial credit expansion)	Economic crises are deeply rooted in structural imbalances and deficiencies within an economy
Determination of Production costs	Production costs are objective and pre-determined	Production costs are subjective and not pre-determined	Production costs are determined by long-term structural factors: Sectoral imbalances and bottlenecks, institutional arrangements, & historical patterns of development
Determination of Market prices	Historical costs of production tend to determine market prices	Market prices tend to determine production costs, not vice versa	Market imperfections and structural constraints impact price formation
Determination of Interest rate	Short-term interest rate is believed to have a predominant monetary origin	Interest rate is a market price determined by the subjective valuations of time preferences. The interest rate is used to determine the present value by discounting the expected future flow of returns	Interest rates are determined by a combination of structural factors and institutional arrangements rather than purely by market forces of supply and demand

Source: Compiled by the Author from de Soto (2020), analyzing key findings on dimensions of economic approaches.

Appendix 2: VECM Analysis of Phillips Curve with Structural Breaks

The Phillips Curve remains a fundamental macroeconomic concept, but its practical application has evolved significantly since 1994. Modern analysis suggests it is best viewed as one of many tools for understanding inflation dynamics rather than a stable, mechanical relationship. The current literature emphasizes the need for more sophisticated, multi-factor approaches to inflation modeling that account for structural changes, global influences, and non-linear relationships.

Here are some of the main critiques of the Phillips curve causal relationship:

1) *Key Empirical Challenges*:

- Globalization effects have weakened the domestic inflation-unemployment relationship
- Anchored inflation expectations since the 1990s have reduced the curve's predictive power
- The "missing disinflation" puzzle during the 2008-2009 recession
- The "missing inflation" puzzle during the post-2009 recovery period

2) *Modern Modifications*:

- Incorporation of expectations and forward-looking components
- Recognition of non-linear relationships and threshold effects
- Integration of global factors and supply chain dynamics

3) *Recent Developments* (2020-2024):

- Supply chain disruptions challenged traditional demand-pull inflation assumptions
- The curve's behavior during the rapid recovery challenged conventional wisdom
- Recent inflation surge despite low unemployment rates questions the traditional framework

4) *Policy Implications*:

- Reduced reliability as a forecasting tool for central banks
- Recognition of asymmetric responses to positive and negative shocks
- Importance of considering supply-side factors alongside demand pressure

For the sake of completeness of this study, we examine the relationship between inflation and U6 unemployment rate using a Vector Error Correction Model (VECM) approach, with particular attention to structural breaks during the Financial Crisis and COVID-19 periods. The study reveals significant variations in the inflation-unemployment relationship across different economic regimes.

<u>Methodology</u>

- Vector Error Correction Model (VECM) Implementation
- Johansen Cointegration Testing
- Structural Break Analysis
- Lag Structure Optimization

Data and Period Definitions

Normal Period: Pre-2008 and between Financial Crisis and COVID-19 Financial Crisis: 2008-2009 COVID-19 Period: 2020-2021.

Cointegration Analysis Results

The Johansen cointegration test revealed:

- Trace Statistic: 184.93
- Critical Values (95%): 15.49
- Evidence of cointegrating relationship between variables

Structural Break Analysis

Normal Period

- Optimal Lag: 10 months
- R-squared: 0.07
- Relationship Strength: Weak

Financial Crisis

- Optimal Lag: 3 months
- R-squared: 0.69
- Relationship Strength: Strong

COVID-19

- Optimal Lag: 1 month
- R-squared: 0.04
- Relationship Strength: Very Weak

Key Findings

- Significant variation in lag structures across different economic periods
- Strongest relationship observed during Financial Crisis period
- COVID-19 period showed disruption of traditional economic relationships
- Normal periods exhibit longer adjustment periods between inflation and unemployment

Conclusions

The VECM analysis reveals that the Phillips Curve relationship varies significantly across different economic regimes. The Financial Crisis period showed

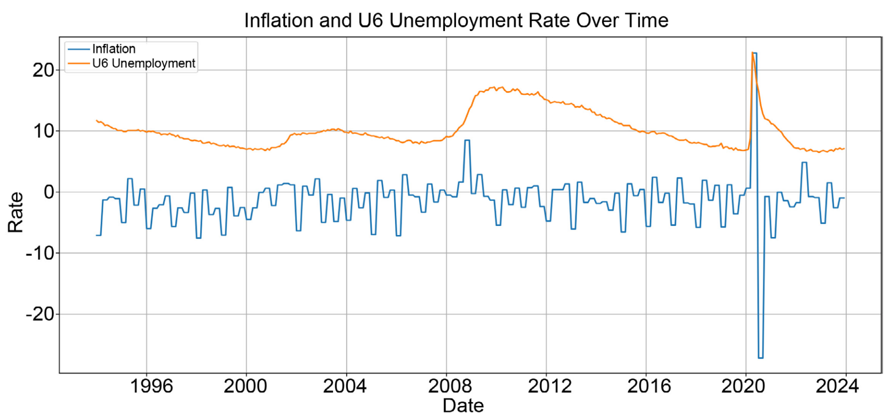

Figure A1. Trend of GDP deflator and unemployment rate for the period 1994 to 2023. Source: Authors' own computations.

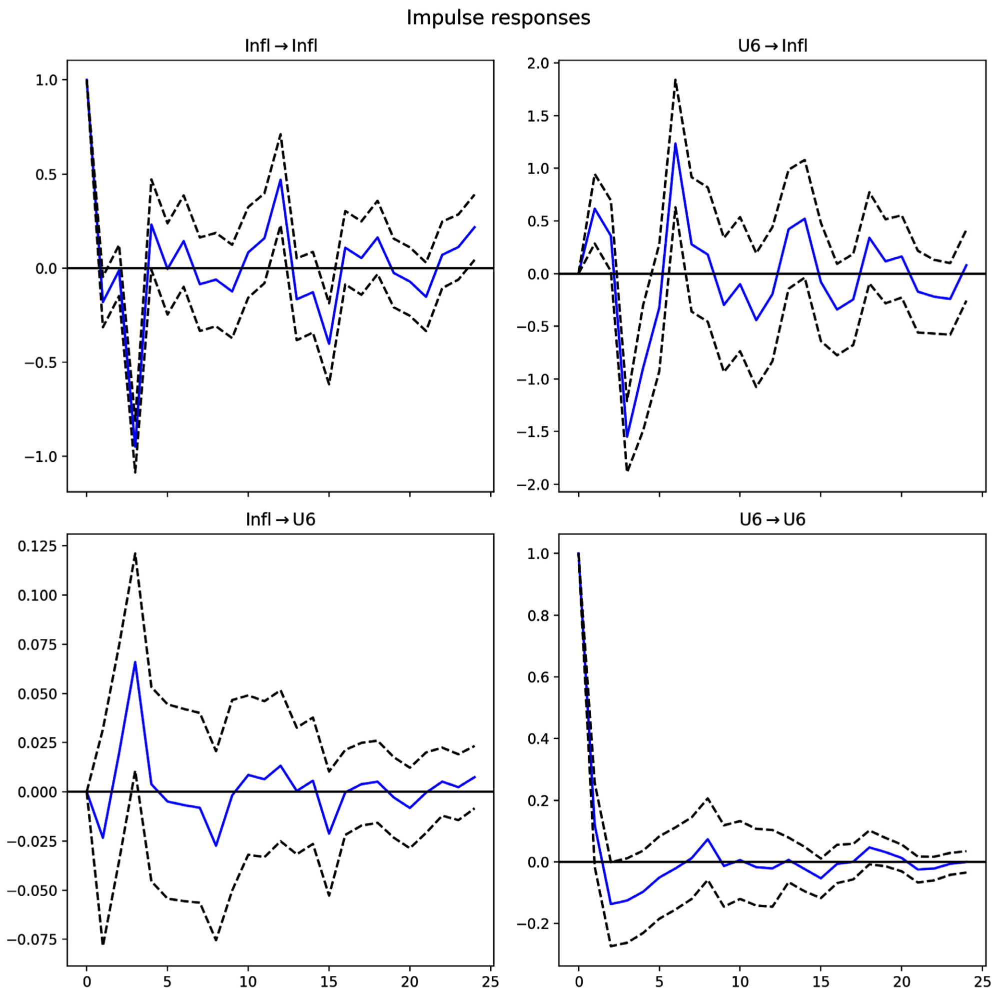

Figure A2. Dynamic response of inflation and unemployment to shocks. Source: Authors' own computations.

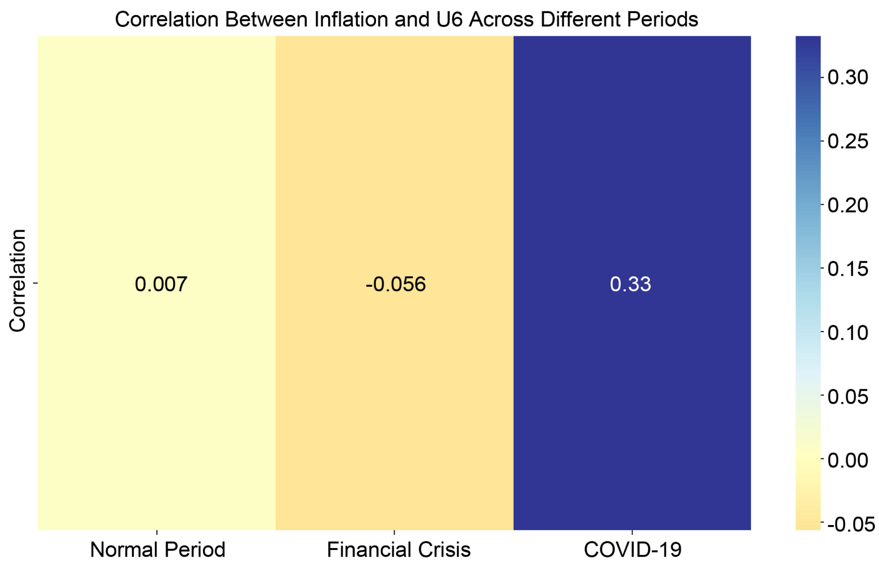

Figure A3. Correlation heatmaps across different time periods.

the strongest and most rapid relationship, while the COVID-19 period demonstrated unique characteristics that deviated from traditional economic relationships. These findings[18] suggest that policy makers should consider the current economic regime when making decisions based on the Phillips curve relationship.

The heatmap displays the correlation between inflation and U6 unemployment rate across different periods.

[18]We have performed additional analyses on the dynamics of the inflation rate and the unemployment rate and these results can be obtained from the authors' upon reasonable request (**Figures A1-A3**).