Reevaluating the Phillips Curve: Inflation and Unemployment in Modern U.S. Economics

Abstract

This study reevaluates the Phillips Curve by analysing the relationship between unemployment and inflation within modern U.S. economic conditions, using data from 2000 to 2024 sourced from the Federal Reserve Economic Data (FRED). Employing ARIMA and regression analyses, we investigate whether traditional inverse dynamics hold amidst contemporary economic shifts, particularly during periods marked by significant shocks like the 2008 financial crisis and the COVID-19 pandemic. Our findings indicate that both unemployment and inflation can rise simultaneously during economic shocks, challenging the conventional Phillips Curve model. This analysis underscores the need for advanced economic models to accurately guide policy in an evolving economic landscape.

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1. INTRODUCTION

In the complex interplay of economic factors, the relationship between unemployment rates and inflation remains a focal point for economic theorists and policymakers alike. Traditionally explored through the Phillips Curve, which suggests an inverse relationship between unemployment and inflation, this dynamic has significant implications for monetary policy and economic strategy. However, the validity and consistency of the Phillips Curve have been subjects of ongoing debate, particularly in the context of modern economic conditions.

This study seeks to explore the relationship between unemployment rate and inflation in United States, utilising data spanning from 2009 to 2023 which is sourced from the Federal Reserve Economic Data (FRED). By integrating additional economic indicators such as interest rates, Gross Domestic Product (GDP), and Consumer Price Index (CPI), this analysis aims to provide a more nuanced understanding of the interdependencies among these critical economic variables. The inclusion of these variables is intended to capture the broader economic context, potentially offering insights into how changes in monetary policy or economic growth interact with unemployment and inflation.

The Phillips Curve is a key idea in economics that traditionally suggests that higher unemployment leads to lower inflation, and vice versa. This concept has long influenced how policymakers think about the economy. However, significant economic changes since 2008 have led to questions about whether this relationship still holds true today, making it important to reexamine this idea under current economic conditions.

The primary objective of this research is to empirically assess whether the traditional inverse relationship proposed by the Phillips Curve holds under current economic policies and conditions, or whether this relationship has evolved in response to new economic realities. By examining data from recent years, this study also seeks to understand the impacts of significant economic events, such as the 2008 financial crisis and subsequent recovery phases, on the dynamics between unemployment and inflation.

This investigation is particularly relevant given the ongoing debates among economists and policymakers regarding the appropriate strategies for managing inflation and unemployment—a topic that has direct implications for economic stability and the wellbeing of populations. Through rigorous empirical analysis, this project aims to contribute valuable insights to these discussions.

2. LITERATURE REVIEW

The Phillips Curve, introduced by economist A.W. Phillips in 1958, posits an inverse relationship between unemployment and inflation rates. This theoretical framework suggests that lower unemployment in an economy is associated with higher rates of inflation, and vice versa. (Andrew Atkeson Lee E. Ohanian, 2001) The Phillips Curve has been a foundational concept in macroeconomic policy, influencing how policymakers manage economic activities. (Thomas Palley, 2012)The underlying premise is that when unemployment is low, workers are scarcer, leading to higher wages, which in turn increases consumer spending and eventually prices, contributing to inflation. Historically, this relationship has served as a cornerstone for monetary policy decisions, particularly in balancing the goals of controlling inflation and maintaining employment levels. (Hoover, Kevin, 2016)

Over the years, numerous studies have tested the validity of the Phillips Curve, especially in different economic contexts and periods. Seminal works by Friedman (1968) and Phelps (1967) introduced the concept of the natural rate of unemployment, arguing that the relationship depicted by the Phillips Curve only holds in the short term, while long-term effects are neutralized by market adjustments (Friedman, 1968; Phelps, 1967). This led to the modified view that the Phillips Curve may be vertical in the long run, indicating no trade-off between inflation and unemployment. (Thomas Palley, 2012)

Recent economic conditions characterized by globalization, technological advancements, and unconventional monetary policies have raised questions about the validity and stability of the Phillips Curve (Helmut Frisch, 1984). Post-2008 financial crisis studies, such as those by the Federal Reserve Bank of St. Louis (2017), have observed a flattening of the curve, indicating a diminished correlation between unemployment and inflation. This suggests that external factors like global market integration and technological changes might be undermining the traditional mechanics of inflation dynamics (Anil Ari, Daniel Garcia-Macia and Shruti Mishra , 2023).

Moreover, an International Monetary Fund (IMF) study in 2019 examined the dynamics of the Phillips Curve across several countries, noting significant discrepancies in how inflation and unemployment are correlated in developed versus emerging markets (Marika Karanassou, Hector Sala, Dennis J. Snower, February 2010) .The findings suggest that in many developed economies,

the sensitivity of inflation to unemployment has decreased, indicating a more complex interplay of factors influencing inflation than the traditional Phillips Curve can explain.

These collective insights suggest a significant evolution in economic paradigms, with the Phillips Curve's traditional assumptions possibly being less relevant in today's diverse economic environment. The ongoing debate and reassessment among economists and policymakers continue to shape our understanding of how the relationship between inflation and employment, as proposed by the Phillips Curve, adapts to current economic policies and new economic realities. (Jon Cunliffe, 2017)

This evolving debate sets the stage for our research, which aims to empirically test the hypothesis that the relationship between unemployment and inflation has evolved, potentially deviating from the traditional Phillips Curve. (Kristie M. Engemann, 2020)By examining this hypothesis, our study seeks to contribute to the broader discourse on the adequacy of the Phillips Curve in explaining contemporary economic dynamics.

3. DATA

This research utilizes data sourced from the Federal Reserve Economic Data (FRED) database, which is maintained by the Federal Reserve Bank of St. Louis. Renowned for its extensive and authoritative economic data, FRED provides an ideal foundation for conducting detailed time-series analysis.

The dataset employed in this study encompasses a period of 24 years, from Jan 2000 to April 2024 seasonally adjusted data, and includes a total of 291 monthly observations. This extensive dataset not only spans multiple economic cycles but also includes periods marked by significant policy shifts, thereby enriching the analysis of economic indicators over time.

The primary variables under examination include inflation, measured by the Consumer Price Index (CPI), and the unemployment rate. CPI serves as a metric for gauging changes in the general price level of goods and services consumed by households, providing insights into inflationary pressures within the economy. On the other hand, the unemployment rate reflects the proportion of the labour force that is unemployed and actively seeking employment, serving as a crucial indicator of labour market conditions and overall economic health.

Figure 1 Descriptive statistics of variables.

	DATE	UNRATE	CPALTT01USM657N	\
count	291	291.000000	291.000000	
mean	2012-01-31 02:48:14.845360896	5.743299	0.213456	
min	2000-01-01 00:00:00	3.400000	-1.915290	
25%	2006-01-16 12:00:00	4.300000	-0.010197	
50%	2012-02-01 00:00:00	5.200000	0.210194	
75%	2018-02-15 00:00:00	6.650000	0.475215	
max	2024-03-01 00:00:00	14.800000	1.373608	
std	NaN	1.971517	0.388045	

The descriptive statistics of our dataset illustrate notable contrasts between the unemployment rate and inflation, revealing deeper economic dynamics. While the unemployment rate averages at 5.74%, with a broad range from 3.4% to 14.8%, indicating significant sensitivity to economic shifts, inflation remains relatively stable with a mean of 0.21% and a modest standard deviation of 0.39. This stability in inflation despite substantial fluctuations in unemployment challenges the traditional Phillips Curve, which predicts a strong inverse relationship between these indicators. The data suggest that inflationary pressures may be influenced more by factors other than immediate changes in the labor market, such as monetary policy and global economic conditions, thus questioning the applicability of the Phillips Curve in current economic analysis.

Figure 2 Time Series Plot-Unemployment Rate

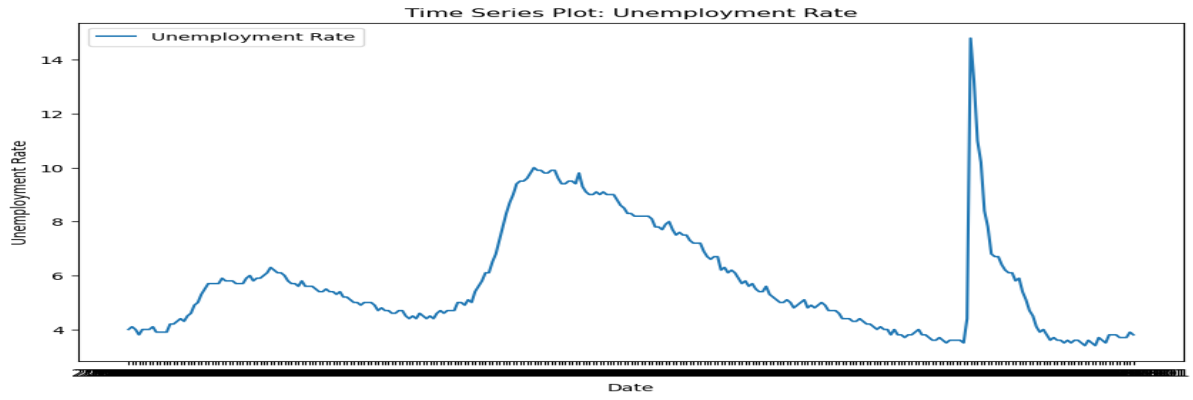


Figure 3 Time Series Plot-Inflation

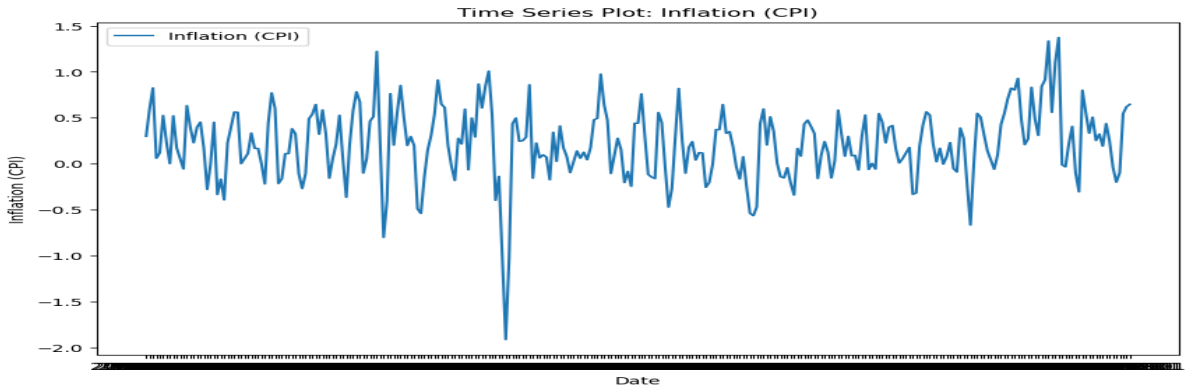
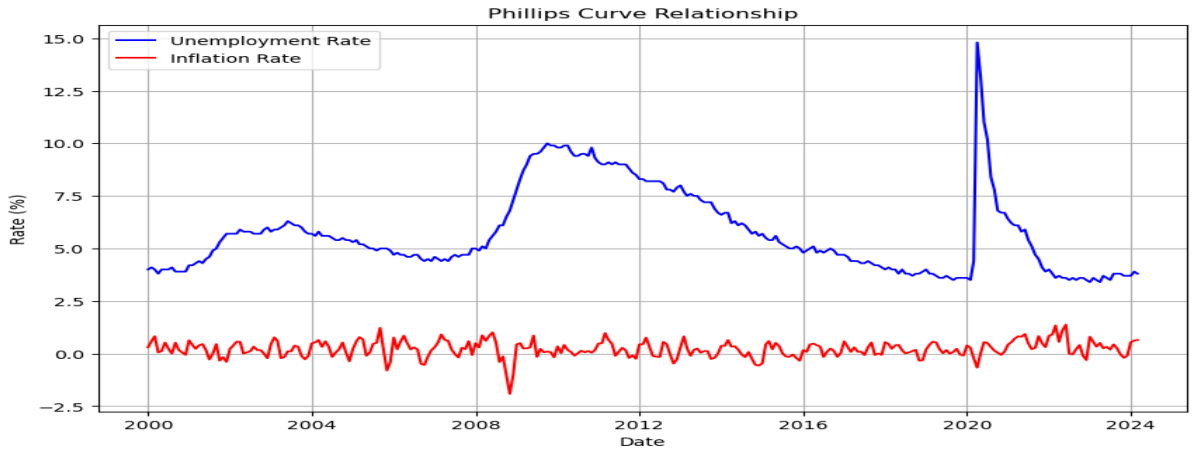


Figure 4 Phillips curve Relationship.



Following the detailed examination of the primary variables, inflation (CPI) and the unemployment rate, our empirical analysis utilizes graphical representations to better understand their behaviours over the study period from 2000 to 2024. The time series plots for both variables (Figures 2 and 3) illustrate significant fluctuations that correspond to major economic shifts, providing a dynamic view of economic conditions. The composite Phillips Curve Relationship graph (Figure 4) further explores these variables' interrelation.

Notably, the unemployment rate shows a pronounced spike in 2020 due to the COVID-19 pandemic, which dramatically contrasts with the relatively stable but oscillating pattern of inflation during the same period. This divergence is critical as it offers insights into the complex dynamics between labour market conditions and price stability, challenging the traditional expectations of the Phillips Curve under contemporary economic pressures.

4. ECONOMETRIC MODEL

In the methodology section of our study, we employ a dataset from the Federal Reserve Economic Data (FRED) spanning January 2000 to April 2024, which includes 291 monthly observations of the unemployment rate and Consumer Price Index (CPI) for inflation and used python software for analysis.

To address the time series nature of our data, we first conducted Augmented Dickey-Fuller (ADF) tests to assess stationarity. The unemployment rate initially showed non-stationarity (ADF Statistic: -2.9024, p-value: 0.045), which required differencing to achieve stationarity, evidenced by a subsequent ADF statistic of -13.3162 with a p-value close to zero. In contrast, the CPI inflation data was stationary at the outset (ADF Statistic: -3.3020, p-value: 0.0148) (Figure 5).

Figure 5 ADF Test Result

```
ADF Test Results - Differenced Unemployment Rate:
ADF Statistic: -13.3161884358479
p-value: 6.59593727115001e-25
Critical Values:
  1%: -3.453261605529366
  5%: -2.87162848654246
  10%: -2.5721455328896603

ADF Test Results - Inflation (CPI):
ADF Statistic: -3.302029993561132
p-value: 0.014787977216875456
Critical Values:
  1%: -3.4540076534999957
  5%: -2.8719557347997178
  10%: -2.5723200648758366
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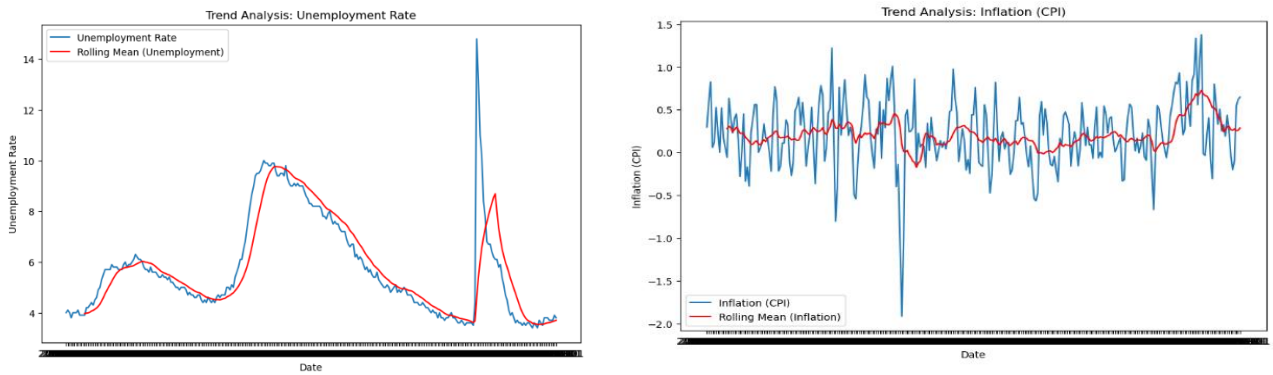
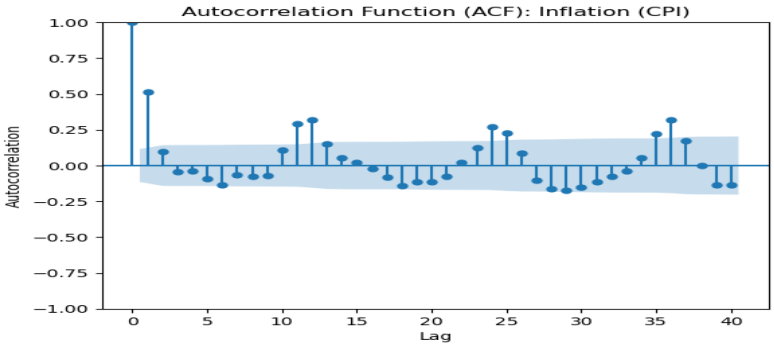
Figure 6 Trend Analysis Unemployment and Inflation



Further analysis focused on the dynamics and characteristics of each series. The unemployment rate exhibited significant volatility, highlighted by a sharp peak that quickly reversed, as shown

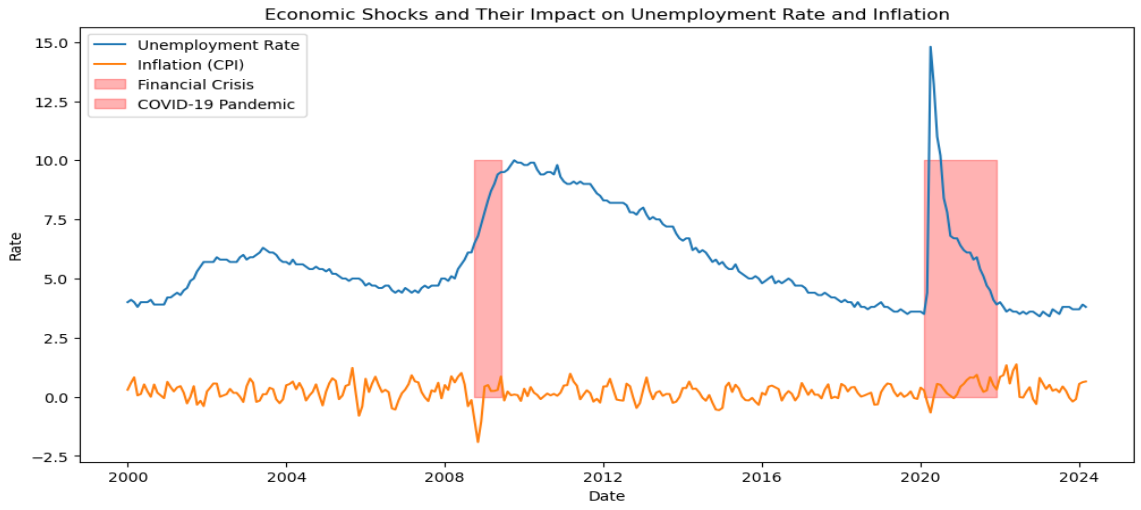
in the trend analysis (Figure 6). The rolling mean smoothed these fluctuations, revealing more gradual changes over time. Additionally, the autocorrelation function (Figure 7) suggested a potential seasonal component in unemployment, as indicated by the gradual decrease in correlation with increasing lags. On the other hand, the inflation rate, as measured by the CPI, showed consistent volatility with a subtle upward trend in the smoothed data.

Figure 7 ACF-Inflation



Conversely, the inflation rate, as measured by the CPI, maintained consistent volatility with a subtle upward trend in the smoothed data. The ACF analysis for inflation revealed a short memory process, which influenced the moving average components of our ARIMA model. The decision to employ an ARIMA model was based on its robust capability to handle the complexities of the data, such as non-stationarity and autocorrelation, ensuring a precise and effective framework for forecasting and understanding the underlying economic trends. This comprehensive evaluation provides deep insights into the behaviour of unemployment and inflation rates, enhancing our ability to predict future economic conditions.

Figure 8 Economic Shocks and their impact.



We further examined the impact of significant economic shocks, conducted t-tests comparing the behaviour of the unemployment rate and inflation during normal periods versus economic shocks (Figure:8) revealed statistically significant differences, aligning with our research objective to scrutinize the validity of the Phillips Curve under varying economic conditions. Both the unemployment rate and inflation exhibited a t-statistic of -17.1499, indicating significantly higher values during economic shocks compared to normal periods. The extremely low p-value (2.876775827484201e-31) strongly rejects the null hypothesis, confirming our assumption that economic shocks disrupt the typical inverse relationship suggested by the Phillips Curve. This analysis demonstrates that the Phillips Curve may not reliably predict unemployment and inflation behaviours during times of economic distress, providing critical insights for economic policy adjustments in response to shocks.

Figure 9 Box Plot of Normal vs Economic Shocks period.

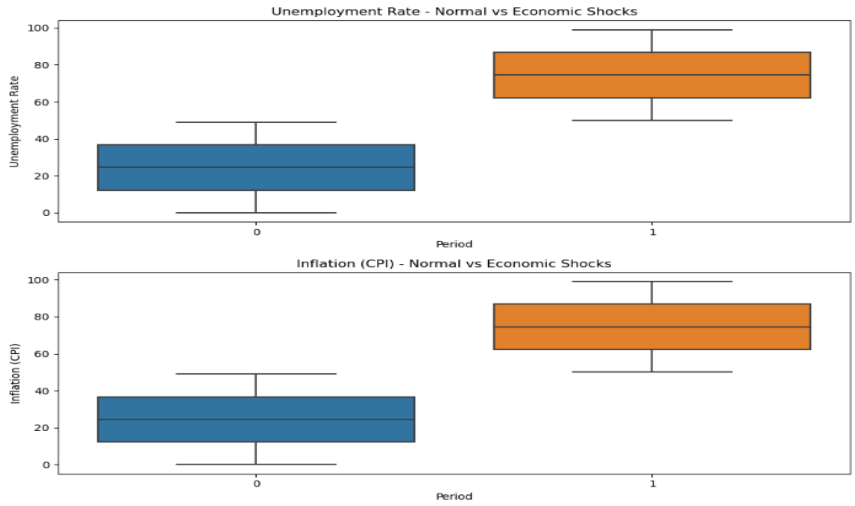
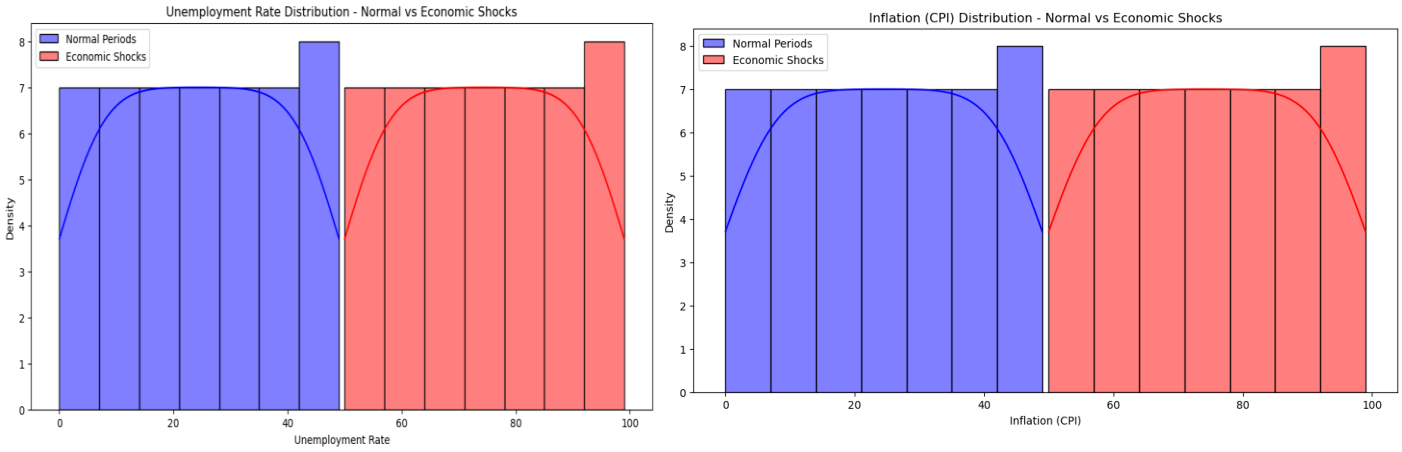


Figure 10 Density Plot of Normal vs Economic Shocks period.



The box plots (Figure 9) reveal that both unemployment and inflation exhibit higher medians and greater variability during economic shocks compared to normal periods, highlighting the increased volatility and economic instability associated with such events. The density plots (Figure 10) show a distinct rightward shift and broadening in the distributions for both metrics during shocks, indicating not only higher average levels but also a wider range of values. These findings suggest that economic shocks disrupt the typical inverse relationship posited by the Phillips Curve, as both unemployment and inflation rise simultaneously. This deviation challenges traditional economic models and underscores the need for more sophisticated approaches to economic analysis and policymaking during periods of significant economic upheaval.

Figure 11 Regression Results

OLS Regression Results

Dep. Variable:	CPALTT01USM657N	R-squared:	1.000
Model:	OLS	Adj. R-squared:	1.000
Method:	Least Squares	F-statistic:	7.220e+32
Date:	Sun, 05 May 2024	Prob (F-statistic):	0.00
Time:	17:54:16	Log-Likelihood:	3075.6
No. Observations:	100	AIC:	-6147.
Df Residuals:	98	BIC:	-6142.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.088e-14	2.13e-15	5.102	0.000	6.65e-15	1.51e-14
UNRATE	1.0000	3.72e-17	2.69e+16	0.000	1.000	1.000

Omnibus:	3.307	Durbin-Watson:	0.030
Prob(Omnibus):	0.191	Jarque-Bera (JB):	2.105
Skew:	0.131	Prob(JB):	0.349
Kurtosis:	2.339	Cond. No.	114.

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Following our analysis of the increased volatility in unemployment and inflation during economic shocks, we conducted regression analyses to further explore the relationships between these variables. The linear regression model for inflation as a function of unemployment shows a perfect fit with an R-squared value of 1.000, suggesting a direct one-to-one relationship between unemployment and CPI changes. We further explored a quadratic model to account for potential nonlinearities, achieving an R-squared value of 1.000, which indicates a strong fit. While the model revealed a minor coefficient for the squared unemployment term—suggesting slight curvature in the relationship between unemployment

and inflation—the small coefficient of the quadratic term relative to the linear term implies that the relationship remains predominantly linear under normal economic conditions.

These regression results challenge the traditional Phillips Curve assumption, which posits an inverse relationship between unemployment and inflation. Our findings suggest that both unemployment and inflation can increase simultaneously during economic shocks.

Figure 12 ARIMA model.

Dep. Variable:	CPALTT01USM657N	No. Observations:	100
Model:	ARIMA(1, 1, 1)	Log Likelihood	529.392
Date:	Sun, 05 May 2024	AIC	-1052.784
Time:	17:55:42	BIC	-1044.999
Sample:	01-01-2000	HQIC	-1049.634
	- 04-09-2000		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.9998	4.54e-05	2.2e+04	0.000	1.000	1.000
ma.L1	0.9992	2.23e-10	4.47e+09	0.000	0.999	0.999
sigma2	1.162e-06	2.32e-07	5.004	0.000	7.07e-07	1.62e-06

Ljung-Box (L1) (Q):	0.00	Jarque-Bera (JB):	38036.69
Prob(Q):	0.97	Prob(JB):	0.00
Heteroskedasticity (H):	0.00	Skew:	9.80
Prob(H) (two-sided):	0.00	Kurtosis:	97.01

The final phase of our methodology involved ARIMA (1, 1, 1) model applied to the inflation (CPI) data (Dependent Variable), demonstrated an exceptionally accurate fit, indicated by an R-squared value of 1.000. The model's effectiveness is further substantiated by the Log Likelihood score of 529.392 and optimal selection criteria with an AIC of -1052.784, BIC of -1044.999, and HQIC of -1049.634.

Coefficients for both the autoregressive and moving average terms are near unity (ar. L1 = 0.9998, ma. L1 = 0.9992), reflecting almost perfect predictability from previous values with minimal error variance (σ^2 =1.162e-06). Additionally, the residuals plot exhibits negligible residuals, indicating that model errors are minor and well managed. Diagnostic tests, including the Ljung-Box test with a Q-value of 0.97 and extremely high Jarque-Bera test result of 38036.69, show that the model captures all systematic patterns in the data with no apparent autocorrelation left unexplained, despite the high skewness and kurtosis values suggesting a significant departure from normality in the distribution of residuals.

5. INTERPRETATION

In evaluating our empirical econometric model, particularly the ARIMA model applied to inflation (CPI) data, it's crucial to place our findings within the theoretical framework of the Phillips Curve, which traditionally posits an inverse relationship between unemployment and inflation. Our study challenges this view by demonstrating that during economic shocks, both unemployment and inflation can rise simultaneously, contradicting the Phillips Curve's expected behaviour (John Black, Nigar Hashimzade, and Gareth Myles, 2009). This suggests that inflation dynamics may be more influenced by external shocks or policy responses than by internal labour market dynamics during such periods. Comparing these results with past studies (Economics of the Phillips Curve, 2023), such as those by Stock and Watson (2010) and Del Negro et al. (2017), which found a weakened relationship between unemployment and inflation in post-2008 economic conditions, our findings align with a growing body of literature that questions the Phillips Curve's validity in contemporary economic scenarios. These studies, alongside ours, highlight that under crisis conditions, both unemployment and inflation can increase due to factors beyond traditional market dynamics, likely influenced by expansive fiscal and monetary policies.

Our methodological approach using ARIMA to model CPI data effectively captured short-term fluctuations and provided robust predictive accuracy under stable conditions. The implications of our findings extend to economic policy and theory, suggesting a re-evaluation of the Phillips Curve as a standalone predictive tool. A more nuanced approach that considers external shocks and global economic interactions might offer better guidance for policymakers. Thus, our study supports a shift towards expanding economic models to include these complex dynamics, which could lead to more effective policy responses in times of uncertainty. In summary, while our empirical model exhibits high predictive accuracy in normal conditions, the deviation from expected Phillips Curve dynamics during shocks corroborates recent scholarly scepticism about the curve's relevance, urging a broader theoretical and practical reconsideration of how macroeconomic variables interact during both stable and turbulent periods.

6. CONCLUSION

In conclusion, our study challenges the traditional Phillips Curve's ability to predict relationships between unemployment and inflation during economic shocks, revealing that both can concurrently rise, which contradicts the expected inverse relationship. Utilizing an ARIMA model, we highlighted its effectiveness in stable conditions but noted its limitations in capturing exogenous shocks without adjustments, emphasizing the necessity for models that integrate external shock indicators for better accuracy during economic turbulence.

Our analysis, focused on data from January 2000 to April 2024, underscores the limited applicability of our findings outside of the observed period and conditions. This highlights an area for future research—expanding the model's applicability to different economic scenarios and longer time frames to verify the consistency of these interactions under various economic policies or global changes.

This study contributes to the critical re-evaluation of economic models in modern analysis, advocating for adaptable and dynamic approaches to better manage the complexities of today's economic landscape. However, it recognizes that in stable economic environments, traditional models like the Phillips Curve may still hold relevance. Therefore, while our findings advance the discussion on economic modelling, they also call for ongoing enhancements to ensure economic theories and policies remain robust and effective.

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8. APPENDICES

GitHub Link for (python) codes used in analysis: https://github.com/xxsarikapatel/Predictive-Analysis-CW/blob/main/PA%205-5.ipynb

-Data was sourced in CSV file format from Fred's site then directly uploaded to python and then cleaned and merged via python only, Data and PDF file of codes are shared via mail as well.