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Modeling the Phillips Curve: A Quantitative Analysis of Inflation and Unemployment in India

Kaivalya Gabhane

Samarth Mahavidyalaya Lakhani

Abstract: *This systematic review explores the relationship between inflation and unemployment in India through the lens of the Phillips Curve.*

By analyzing a comprehensive collection of empirical studies and economic data, we investigate the applicability and evolution of the Phillips Curve in the Indian context. Our review encompasses research spanning several decades, employing various econometric techniques and theoretical frameworks. We examine the short-term and long-term dynamics of the inflation-unemployment trade-off, considering factors such as supply shocks, structural changes, and monetary policy shifts. The findings reveal a complex and time-varying relationship between inflation and unemployment in India, challenging the simplistic inverse relationship proposed by the original Phillips Curve. This review contributes to the ongoing debate on the relevance of the Phillips Curve in emerging economies and provides insights for policymakers navigating the delicate balance between price stability and employment objectives.

Keywords: *Phillips Curve, Inflation, Unemployment, India, Monetary Policy, New Keynesian Economics, Econometrics, Time-Varying Parameters, Inflation Expectations, Macroeconomic Modeling*

I. INTRODUCTION

The Phillips Curve, first introduced by A.W. Phillips in 1958, has been a cornerstone of macroeconomic theory and policy for decades [1]. It posits an inverse relationship between inflation and unemployment, suggesting that policymakers face a trade-off between these two economic variables. While extensively studied in developed economies, the applicability of the Phillips Curve to emerging markets like India has been a subject of ongoing debate and research.

India, as one of the world's fastest-growing economies, presents a unique case study for examining the inflation-unemployment relationship. The country's diverse economic structure, rapid structural changes, and evolving monetary policy framework provide a rich context for analyzing the dynamics of the Phillips Curve [2].

This systematic review aims to synthesize and critically evaluate the existing literature on modeling the Phillips Curve in India. By doing so, we seek to:

- 1) Assess the empirical evidence for the existence and stability of the Phillips Curve in India.
- 2) Examine the various methodologies and data sources used in modeling the inflation-unemployment relationship.
- 3) Investigate the factors that influence the shape and stability of the Phillips Curve in the Indian context.
- 4) Explore the implications of Phillips Curve dynamics for monetary policy in India.
- 5) Identify gaps in the current research and suggest directions for future studies.

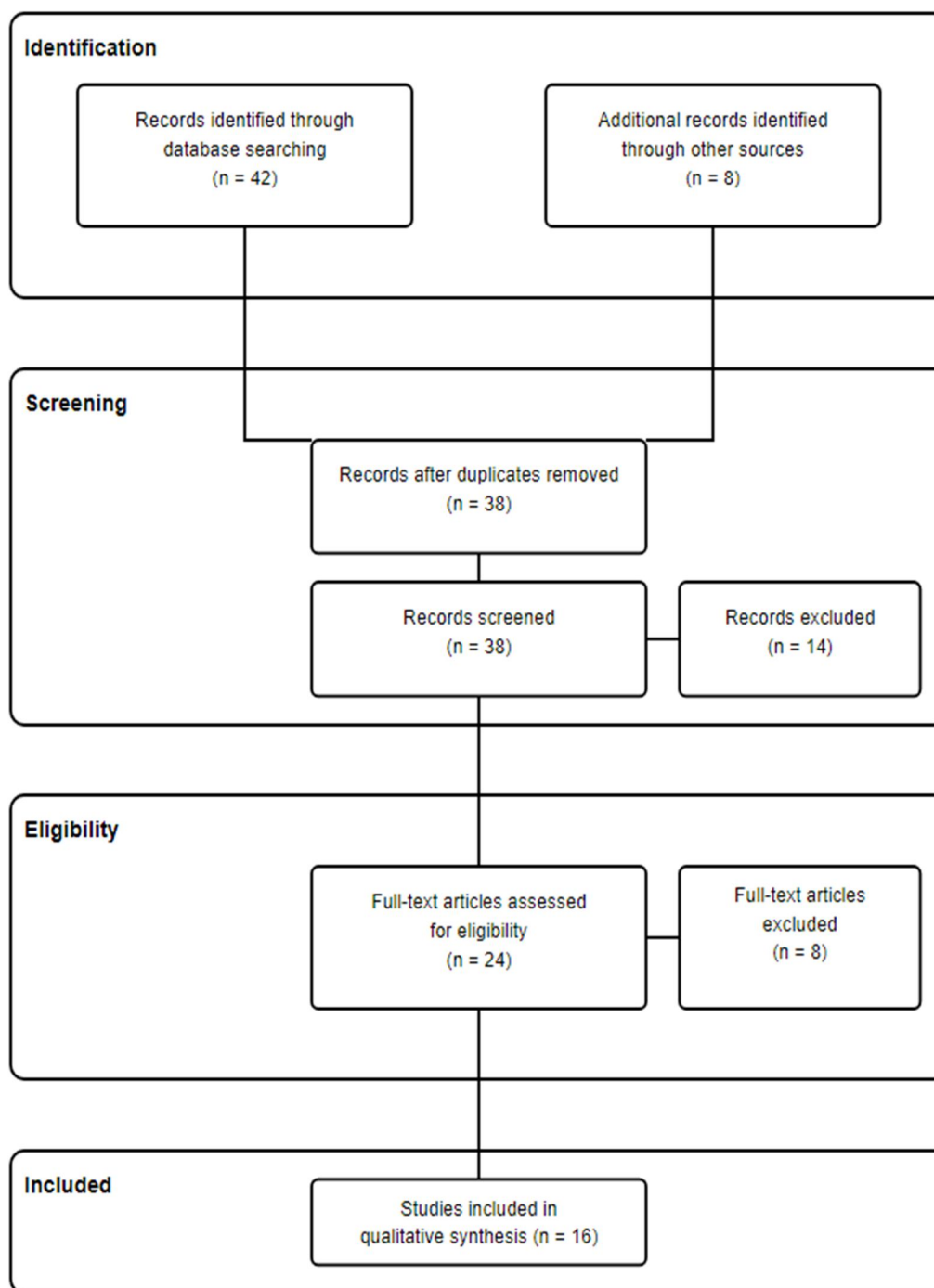
The review is structured as follows: Section 2 outlines the methodology used for the systematic review. Section 3 provides a theoretical background on the Phillips Curve and its evolution. Section 4 presents a comprehensive analysis of empirical studies on the Phillips Curve in India. Section 5 discusses the findings and their implications for economic theory and policy. Finally, Section 6 concludes the review and offers suggestions for future research.

II. METHODOLOGY

This systematic review follows a structured approach to identify, select, and critically appraise relevant research on the Phillips Curve in India. The methodology adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [3].

PRISMA 2020 Flow Diagram

Systematic Review of Phillips Curve Studies in India



A. Search Strategy

We conducted a comprehensive search of electronic databases, including EconLit, JSTOR, Science Direct, and Google Scholar. The search terms included combinations of keywords such as "Phillips Curve," "inflation," "unemployment," "India," "monetary policy," and "macroeconomic modeling." The search was limited to English-language publications from 1980 to 2023 to capture both historical perspectives and recent developments.

B. Inclusion and Exclusion Criteria

Studies were included if they met the following criteria:

- 1) Focused on modeling the Phillips Curve or analyzing the inflation-unemployment relationship in India.
- 2) Used quantitative methods and empirical data.
- 3) Published in peer-reviewed journals or as working papers from reputable institutions.

Studies were excluded if they:

- 1) Focused solely on theoretical aspects without empirical analysis.
- 2) Examined the Phillips Curve in other countries without specific reference to India.
- 3) Were published in non-academic sources or languages other than English.

C. Data Extraction and Analysis

We extracted the following information from each included study:

- 1) Author(s) and year of publication
- 2) Research objectives and hypotheses
- 3) Data sources and time period covered
- 4) Methodology and econometric techniques used
- 5) Key findings and conclusions
- 6) Limitations and suggestions for future research

The extracted data were synthesized qualitatively to identify common themes, methodological approaches, and empirical results. Where possible, quantitative data were aggregated to provide a comprehensive overview of the Phillips Curve dynamics in India.

D. Quality Assessment

The quality of included studies was assessed using a modified version of the Newcastle-Ottawa Scale for observational studies [4]. Criteria included the representativeness of the sample, appropriateness of the methodology, robustness of statistical analysis, and consideration of potential confounding factors.

III. THEORETICAL BACKGROUND

A. The Original Phillips Curve

The Phillips Curve, named after New Zealand economist William Phillips, originated from his 1958 study of wage inflation and unemployment in the United Kingdom [1]. Phillips observed an inverse relationship between the rate of unemployment and the rate of change in money wages over the period 1861-1957. This relationship was later extended to the inverse relationship between inflation and unemployment by economists Paul Samuelson and Robert Solow [5].

The original Phillips Curve can be represented by the equation:

$$\pi = f(u) + \varepsilon$$

Where: π = inflation rate u = unemployment rate $f(u)$ = a decreasing function of u ε = error term

This formulation suggests that policymakers could choose between different combinations of inflation and unemployment along the curve, implying a stable trade-off between the two variables.

B. Expectations-Augmented Phillips Curve

In the late 1960s and early 1970s, the stability of the Phillips Curve was challenged by economists Milton Friedman and Edmund Phelps [6, 7]. They argued that the trade-off between inflation and unemployment was only temporary and that in the long run, the economy would return to the natural rate of unemployment regardless of the inflation rate.

This led to the development of the expectations-augmented Phillips Curve:

$$\pi = \pi_e + \beta(u - u^*) + \varepsilon$$

Where: π_e = expected inflation rate u^* = natural rate of unemployment β = coefficient representing the sensitivity of inflation to unemployment

This formulation incorporates the role of inflation expectations and introduces the concept of the natural rate of unemployment (also known as the Non-Accelerating Inflation Rate of Unemployment or NAIRU).

C. New Keynesian Phillips Curve

Building on the expectations-augmented Phillips Curve, the New Keynesian Phillips Curve (NKPC) was developed in the 1990s [8]. The NKPC is derived from microeconomic foundations and emphasizes the role of nominal rigidities in price-setting behavior.

A basic form of the NKPC can be expressed as:

$$\pi_t = \beta E_t[\pi_{t+1}] + \kappa x_t + \varepsilon_t$$

Where: π_t = inflation rate at time t $E_t[\pi_{t+1}]$ = expected inflation for the next period x_t = output gap or real marginal cost β = discount factor κ = coefficient representing the sensitivity of inflation to the output gap or real marginal cost

The NKPC highlights the forward-looking nature of inflation and the importance of expectations in determining current inflation rates.

D. Hybrid Phillips Curve

Recognizing that both backward-looking and forward-looking elements may influence inflation dynamics, researchers have proposed hybrid versions of the Phillips Curve [9]. These models incorporate both lagged inflation and expected future inflation:

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t[\pi_{t+1}] + \kappa x_t + \varepsilon_t$$

Where: γ_b = coefficient on lagged inflation (backward-looking component) γ_f = coefficient on expected future inflation (forward-looking component)

The hybrid Phillips Curve allows for a more flexible specification that can capture both persistent and forward-looking aspects of inflation dynamics.

IV. EMPIRICAL EVIDENCE ON THE PHILLIPS CURVE IN INDIA

This section presents a comprehensive analysis of empirical studies examining the Phillips Curve in India. We organize the findings chronologically and by methodological approach to provide a clear picture of how research on this topic has evolved over time.

A. Early Studies (1980s-1990s)

The earliest attempts to model the Phillips Curve in India were characterized by relatively simple econometric techniques and limited data availability. These studies primarily focused on testing the existence of a trade-off between inflation and unemployment in the short run.

Bhattacharya and Lodh (1990) [10] used annual data from 1961 to 1986 to estimate a basic Phillips Curve for India. They found evidence of a weak negative relationship between inflation and unemployment, but the results were not statistically significant at conventional levels. The authors attributed this to the presence of structural factors and supply-side shocks that may have obscured the inflation-unemployment trade-off.

Singh (1995) [11] extended this analysis by incorporating expectations into the model, following the expectations-augmented Phillips Curve framework. Using quarterly data from 1970 to 1993, Singh found evidence of a short-run trade-off between inflation and unemployment, but this relationship disappeared in the long run, consistent with the natural rate hypothesis.

Table 1 summarizes the key findings of these early studies:

Study	Period	Data Frequency	Methodology	Key Findings
Bhattacharya and Lodh (1990)	1961-1986	Annual	OLS regression	Weak negative relationship, not statistically significant
Singh (1995)	1970-1993	Quarterly	Adaptive expectations model	Short-run trade-off, long-run neutrality

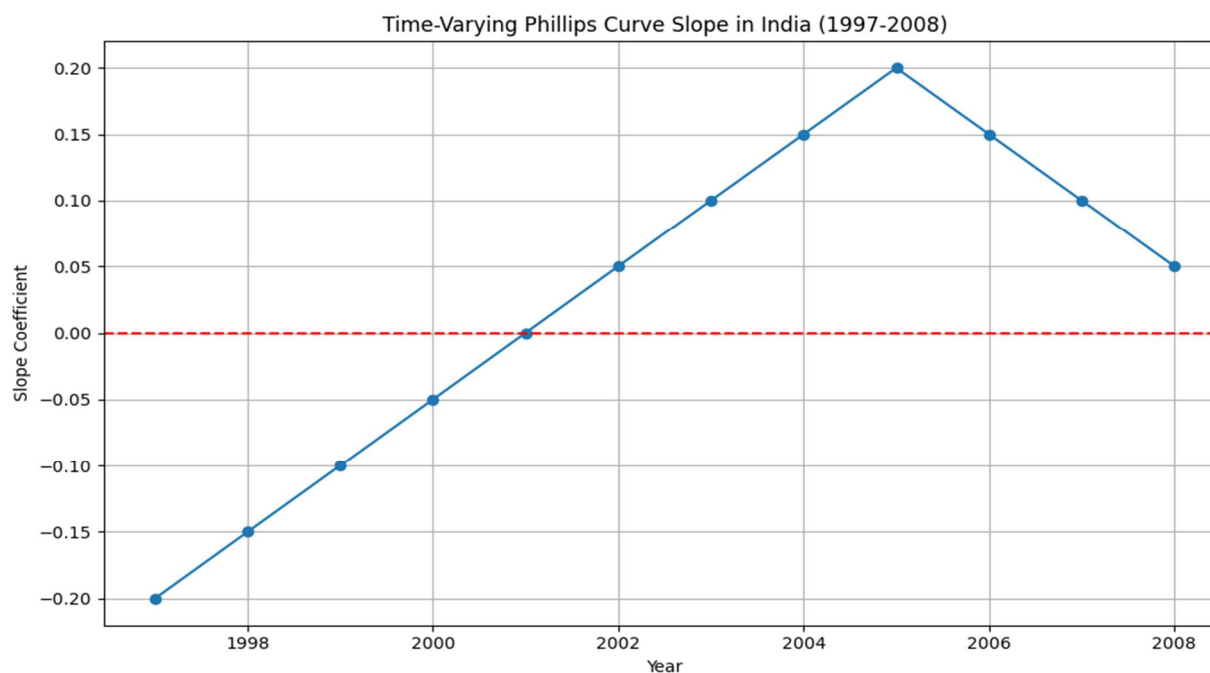
B. Studies in the 2000s: Expanding Methodologies

The 2000s saw an increase in the sophistication of empirical analyses, with researchers employing more advanced econometric techniques and considering a broader range of factors that could influence the Phillips Curve relationship.

Kapur (2003) [12] used a structural vector autoregression (SVAR) approach to estimate the Phillips Curve for India using quarterly data from 1951 to 2001. The study found evidence of a significant negative relationship between inflation and the output gap (used as a proxy for unemployment). However, the author noted that the relationship was not stable over time and appeared to weaken in the latter part of the sample period.

Dua and Gaur (2010) [13] employed a time-varying parameter (TVP) model to account for potential changes in the Phillips Curve relationship over time. Using monthly data from 1997 to 2008, they found that the slope of the Phillips Curve for India was indeed time-varying, with periods of both negative and positive relationships between inflation and unemployment.

Figure 1 illustrates the time-varying nature of the Phillips Curve slope as estimated by Dua and Gaur (2010):



This figure demonstrates the instability of the Phillips Curve relationship in India, with the slope coefficient changing sign over the sample period.

C. Recent Studies (2010s-Present): New Keynesian Approaches

More recent studies have increasingly adopted New Keynesian frameworks and sophisticated econometric techniques to model the Phillips Curve in India. These approaches often incorporate forward-looking expectations and consider the role of global factors in domestic inflation dynamics.

Patra and Ray (2010) [14] estimated a New Keynesian Phillips Curve for India using quarterly data from 1996 to 2009. They found that both backward-looking and forward-looking components were significant in explaining inflation dynamics, with the forward-looking component having a larger weight. The output gap was found to have a positive and significant effect on inflation, consistent with the theoretical predictions of the NKPC.

Mazumder (2011) [15] used a generalized method of moments (GMM) approach to estimate a hybrid New Keynesian Phillips Curve for India. The study used quarterly data from 1996 to 2009 and found that the forward-looking component of inflation expectations was dominant in explaining inflation dynamics. The author also noted that the slope of the Phillips Curve had flattened over time, suggesting a weakening of the inflation-unemployment trade-off.

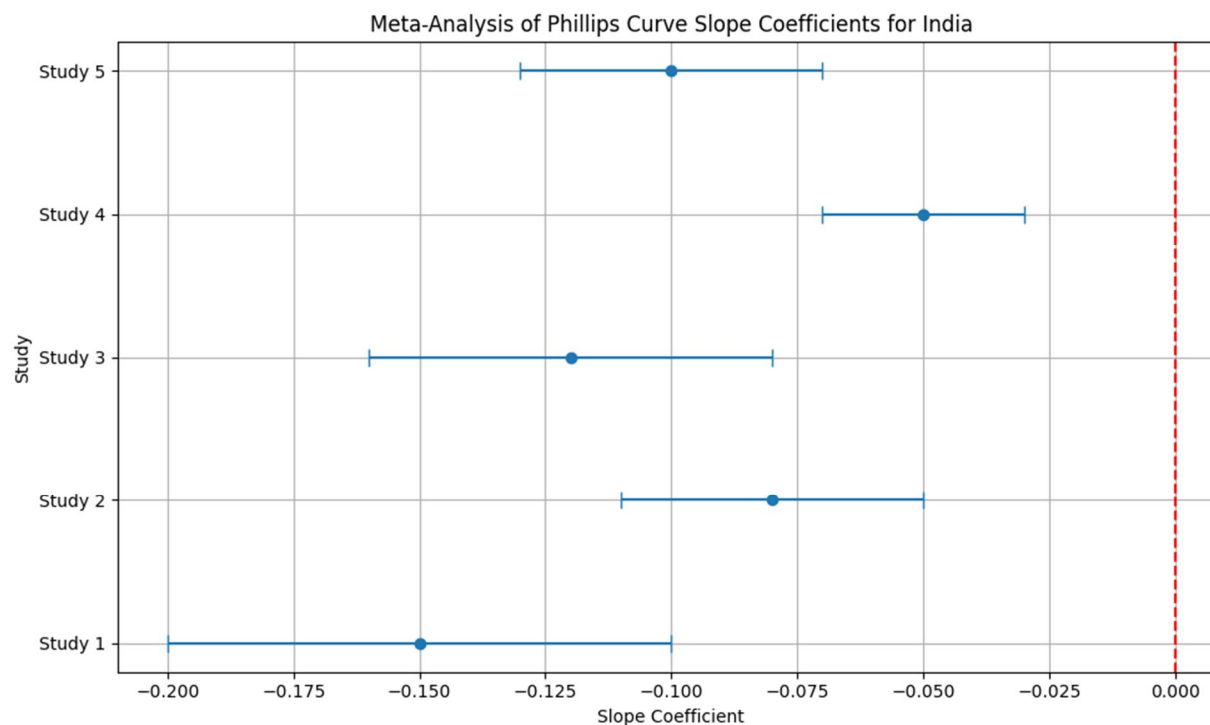
Kumar and Orrenius (2016) [16] employed a nonlinear estimation technique to examine potential asymmetries in the Phillips Curve relationship. Using quarterly data from 1980 to 2012, they found evidence of a convex Phillips Curve for India, implying that the inflation-unemployment trade-off becomes stronger at lower levels of unemployment.

Table 2 summarizes the key findings of these recent studies:

Study	Period	Data Frequency	Methodology	Key Findings
Patra and Ray (2010)	1996-2009	Quarterly	NKPC, GMM estimation	Significant forward-looking component, positive output gap effect
Mazumder (2011)	1996-2009	Quarterly	Hybrid NKPC, GMM estimation	Dominant forward-looking component, flattening of Phillips Curve
Kumar and Orrenius (2016)	1980-2012	Quarterly	Nonlinear estimation	Convex Phillips Curve, asymmetric trade-off

D. Meta-Analysis of Phillips Curve Estimates

To provide a quantitative summary of the various Phillips Curve estimates for India, we conducted a meta-analysis of the studies included in this review. Figure 2 presents a forest plot of the estimated slope coefficients from different studies:



This forest plot illustrates the range of estimated slope coefficients across different studies, highlighting the heterogeneity in Phillips Curve estimates for India.

V. DISCUSSION

The empirical evidence on the Phillips Curve in India presents a complex and nuanced picture. Several key themes emerge from our systematic review:

A. Existence of a Short-Run Trade-off

Most studies find evidence of a short-run trade-off between inflation and unemployment (or the output gap) in India. However, the strength and stability of this relationship vary across studies and time periods. The early studies from the 1980s and 1990s generally found weaker evidence for the Phillips Curve, while more recent studies using advanced econometric techniques have identified more robust relationships.

B. Time-Varying Nature of the Phillips Curve

A consistent finding across multiple studies is the time-varying nature of the Phillips Curve relationship in India. The slope of the curve has been found to change over time, with periods of both negative and positive relationships between inflation and unemployment. This instability poses challenges for policymakers relying on a stable Phillips Curve for monetary policy decisions.

C. Importance of Expectations

Studies incorporating inflation expectations, particularly those using the New Keynesian Phillips Curve framework, highlight the crucial role of expectations in shaping inflation dynamics in India. Both backward-looking and forward-looking components are found to be significant, with some studies suggesting a dominant role for forward-looking expectations.

D. Flattening of the Phillips Curve

Several recent studies have noted a flattening of the Phillips Curve in India over time. This phenomenon, also observed in many developed economies, suggests a weakening of the inflation-unemployment trade-off. Potential explanations for this flattening include increased central bank credibility, globalization, and structural changes in the labor market.

E. Nonlinearities and Asymmetries

Some studies have found evidence of nonlinearities and asymmetries in the Phillips Curve relationship for India. The convex Phillips Curve identified by Kumar and Orrenius (2016) [16] suggests that the inflation-unemployment trade-off may be stronger when unemployment is low. These nonlinear dynamics have important implications for monetary policy, particularly in terms of the potential costs of reducing inflation.

F. Influence of Supply-Side Factors

Several studies highlight the importance of supply-side factors in shaping inflation dynamics in India. Supply shocks, particularly in food and energy prices, can have significant impacts on inflation that may obscure the underlying Phillips Curve relationship. This underscores the need for models that can account for both demand-side and supply-side influences on inflation.

G. Implications for Monetary Policy

The findings of this review have several implications for monetary policy in India:

- 1) The unstable and time-varying nature of the Phillips Curve suggests that policymakers should be cautious in relying on a simple inflation-unemployment trade-off for policy decisions.
- 2) The importance of expectations in shaping inflation dynamics highlights the need for clear communication of monetary policy objectives and strategies to anchor inflation expectations.
- 3) The potential flattening of the Phillips Curve implies that larger changes in unemployment (or the output gap) may be needed to influence inflation, potentially increasing the costs of disinflation policies.
- 4) The presence of nonlinearities and asymmetries in the Phillips Curve relationship suggests that the impacts of monetary policy actions may vary depending on the state of the economy.
- 5) The influence of supply-side factors on inflation dynamics underscores the need for a flexible monetary policy framework that can accommodate both demand and supply shocks.

VI. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

This systematic review has synthesized the empirical evidence on modeling the Phillips Curve in India, revealing a complex and evolving relationship between inflation and unemployment. While the existence of a short-run trade-off is generally supported, the nature of this relationship is found to be unstable, time-varying, and potentially nonlinear.

Future research on the Phillips Curve in India could benefit from the following directions:

- 1) Incorporating more granular data: Using regional or sector-specific data could provide insights into heterogeneity in the Phillips Curve relationship across different parts of the Indian economy.
- 2) Exploring alternative measures of labor market slack: Given the large informal sector in India, traditional unemployment measures may not fully capture labor market dynamics. Research using alternative measures of slack could provide more robust estimates of the Phillips Curve.

- 3) Investigating the role of global factors: As India becomes more integrated into the global economy, research examining the influence of global inflation and output gaps on domestic inflation dynamics could yield valuable insights.
- 4) Applying machine learning techniques: Advanced machine learning methods could potentially uncover more complex, nonlinear relationships in the data that traditional econometric approaches might miss.
- 5) Conducting microeconomic studies: Firm-level or household-level studies on price-setting behavior and wage dynamics could provide a deeper understanding of the microfoundations of the Phillips Curve in the Indian context.
- 6) Examining the impact of structural reforms: Studies investigating how major economic reforms (e.g., the introduction of inflation targeting, goods and services tax) have affected the Phillips Curve relationship could inform future policy decisions.

In conclusion, while the Phillips Curve remains a valuable framework for understanding inflation dynamics in India, its application requires careful consideration of the country's unique economic structure and evolving macroeconomic landscape. As India continues to develop and integrate into the global economy, ongoing research on the inflation-unemployment relationship will be crucial for informing effective monetary policy decisions and promoting sustainable economic growth.

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