UNIVERSIDADE FEDERAL DE JUIZ DE FORA
FACULDADE DE ECONOMIA
PROGRAMA DE PÓS-GRADUAÇÃO EM ECONOMIA

ALESSANDRO AUGUSTO COSTA XAVIER

Two Essays on Regional Heterogeneity in the Wage–Unemployment Relationship in Brazil

Juiz de Fora
2026

ALESSANDRO AUGUSTO COSTA XAVIER

Two Essays on Regional Heterogeneity in the Wage–Unemployment Relationship in Brazil

Tese apresentada ao Programa de Pós-Graduação em Economia da Universidade Federal de Juiz de Fora como requisito parcial à obtenção do título de Doutor em economia.

Orientador: Dr. Eduardo Simões de Almeida

Coorientador: Dr. Wilson Luiz Rotatori Corrêa

Juiz de Fora

2026

Ficha catalográfica elaborada através do Modelo Latex do CDC da UFJF
com os dados fornecidos pelo(a) autor(a)

Sobrenome, Nome do autor.
Two Essays on Regional Heterogeneity in the Wage–Unemployment Relationship in Brazil / ALESSANDRO AUGUSTO COSTA XAVIER. – 2026.
60 f. : il.

Orientador: Eduardo Simões de Almeida
Coorientador: Wilson Luiz Rotatori Corrêa
tese (Doutorado) – Universidade Federal de Juiz de Fora, Faculdade DE ECONOMIA. PROGRAMA DE PÓS-GRADUAÇÃO EM ECONOMIA, 2026.

1. Phillips Curve. 2. Regional Heterogeneity. 3. Wage Inflation. I. Simões de Almeida, Eduardo, orient. II. Título.

Alessandro Augusto Costa Xavier

Two Essays on Regional Heterogeneity in the Wage-Unemployment Relationship in Brazil

Tese apresentada ao Programa de Pós-graduação em Economia da Universidade Federal de Juiz de Fora como requisito parcial à obtenção do título de Doutor em Economia. Área de concentração: Economia

Aprovada em 17 de junho de 2026.

BANCA EXAMINADORA

Dr. Eduardo Simões de Almeida - Orientador

Universidade Federal de Juiz de Fora

Dr. Wilson Luiz Rotatori Corrêa - Coorientador

Universidade Federal de Juiz de Fora

Dr. Sidney Martins Caetano

Universidade Federal de Juiz de Fora

Dr. José Simão Filho

Universidade Federal de Juiz de Fora

Dr. Jefferson Souza Fraga

Universidade Federal de Sergipe

Dr. Michel Cândido de Souza

Universidade Federal dos Vales do Jequitinhonha e Mucuri

Juiz de Fora, 08/06/2026.

Documento assinado eletronicamente por **Eduardo Simoes de Almeida**, **Professor(a)**, em 18/06/2026, às 09:52, conforme horário oficial de Brasília, com fundamento no § 3º do art. 4º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Wilson Luiz Rotatori Correa**, **Professor(a)**, em 18/06/2026, às 11:48, conforme horário oficial de Brasília, com fundamento no § 3º do art. 4º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Michel Candido de Souza**, **Usuário Externo**, em 18/06/2026, às 12:10, conforme horário oficial de Brasília, com fundamento no § 3º do art. 4º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Sidney Martins Caetano**, **Professor(a)**, em 18/06/2026, às 14:22, conforme horário oficial de Brasília, com fundamento no § 3º do art. 4º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Jose Simao Filho**, **Professor(a)**, em 19/06/2026, às 10:48, conforme horário oficial de Brasília, com fundamento no § 3º do art. 4º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **JEFFERSON SOUZA FRAGA**, **Usuário Externo**, em 28/07/2026, às 13:10, conforme horário oficial de Brasília, com fundamento no § 3º do art. 4º do Decreto nº 10.543, de 13 de novembro de 2020.

A autenticidade deste documento pode ser conferida no Portal do SEI-Ufjf (www2.ufjf.br/SEI) através do ícone Conferência de Documentos, informando o código verificador **3017729** e o código CRC **269BF3D4**.

AGRADECIMENTOS

Agradeço, em primeiro lugar, à minha família, especialmente à minha mãe, Adencie Costa, ao meu irmão, Vinicius Victor, pelo carinho, companheirismo e apoio constantes, e ao meu pai, Alessandro Xavier, por seu apoio e presença paternal.

Expresso minha mais profunda gratidão ao meu orientador, Prof. Eduardo Simões, cuja orientação, confiança, dedicação e generosidade intelectual foram fundamentais para o desenvolvimento desta tese e para minha formação acadêmica e profissional. Seus ensinamentos, as inúmeras discussões e o constante incentivo marcaram profundamente minha trajetória como economista, deixando um legado pelo qual serei sempre grato.

Agradeço também ao meu coorientador, Wilson Luiz pelas valiosas contribuições, pelas sugestões criteriosas e pelo apoio ao longo do desenvolvimento deste trabalho, que enriqueceram significativamente esta pesquisa.

Registro ainda meu agradecimento ao Programa de Pós-Graduação em Economia da Universidade Federal de Juiz de Fora (PPGE-UFJF) pela sólida formação acadêmica que me proporcionou. Em especial, agradeço aos professores Sidney Martins e José Simão, cuja dedicação ao ensino e a generosidade na transmissão do conhecimento exerceram papel fundamental na minha formação como pesquisador.

Por fim, registro meu sincero agradecimento à Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) pelo apoio financeiro concedido durante este período de dedicação integral aos estudos. Esse suporte foi fundamental para o desenvolvimento desta pesquisa e para a conclusão desta tese.

RESUMO

Nesta tese, investiga-se a relação entre crescimento salarial e taxa de desemprego por uma ótica regional para a economia brasileira a partir de uma abordagem empírica que incorpora explicitamente a heterogeneidade regional e mudanças na condução da política macroeconômica. A literatura recente tem enfatizado os ganhos de se considerar a variação regional na identificação da Curva de Phillips, motivando a estratégia adotada neste trabalho. No primeiro ensaio, analisa-se, por meio de modelos Bayesianos de Vetores Autorregressivos (BVAR), a relação entre o hiato da taxa de desemprego e a inflação salarial para o Brasil e suas unidades federativas, evidenciando que essa relação não é homogênea, mas sim marcada por significativa heterogeneidade regional, tanto no mercado de trabalho agregado quanto em suas segmentações formal e informal. No segundo ensaio, utilizando técnicas de dados em painel e painel espacial, examina-se como mudanças na condução da política macroeconômica, especialmente a transição de uma postura dovish para uma postura hawkish a partir de 2016, afetam a relação entre taxa de desemprego e inflação salarial, mostrando que a Curva de Phillips salarial no Brasil torna-se mais evidente nesse período, além de destacar o papel das expectativas de inflação salarial e dos efeitos espaciais entre regiões. Em conjunto, os resultados da tese evidenciam que a Curva de Phillips no Brasil é sensível à heterogeneidade regional, e ao regime de política macroeconômica, oferecendo assim novas evidências para a compreensão da dinâmica inflacionária no país.

Palavras-chave: Curva de Phillips; Heterogeneidade Regional; Inflação Salarial.

ABSTRACT

This thesis investigates the relationship between wage growth and the unemployment rate from a regional perspective for the Brazilian economy through an empirical approach that explicitly incorporates regional heterogeneity and changes in the conduct of macroeconomic policy. Recent literature has emphasized the gains from considering regional variation in the identification of the Phillips Curve, motivating the strategy adopted in this study. In the first essay, the relationship between the unemployment rate gap and wage inflation is analyzed for Brazil and its states using Bayesian Vector Autoregressive (BVAR) models, showing that this relationship is not homogeneous, but rather characterized by significant regional heterogeneity in both the aggregate labor market and its formal and informal segments. In the second essay, using panel data and spatial panel techniques, the study examines how changes in the conduct of macroeconomic policy, especially the transition from a dovish to a hawkish stance beginning in 2016, affect the relationship between unemployment and wage inflation. The findings indicate that the wage Phillips Curve in Brazil becomes more evident during this period, while also highlighting the role of wage inflation expectations and spatial effects across regions. Taken together, the results of this thesis show that the Phillips Curve in Brazil is sensitive to regional heterogeneity and to the macroeconomic policy regime, thereby providing new evidence for understanding inflation dynamics in the country.

Keywords: Phillips Curve; Regional Heterogeneity; Wage Inflation.

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

IBGE	Instituto Brasileiro de Geografia e Estatísitca
BVAR	Bayesian Vector Autoregression

CONTENTS

Introduction

The Phillips Curve has played a central role in macroeconomics by describing the relationship between inflation and the level of economic activity, typically measured by unemployment. In the Brazilian case, most empirical studies have relied on aggregate national data to assess this trade-off.

In light of this, this thesis proposes a comprehensive analysis of the Phillips Curve in the Brazilian economy by combining empirical approaches that explicitly account for regional heterogeneity and changes in the macroeconomic policy regime. The first essay investigates the existence of regional heterogeneity in the relationship between wage growth and unemployment. To this end, Bayesian Vector Autoregressive (BVAR) models are estimated for Brazil and its 27 federative units using recent data from the Continuous National Household Sample Survey (PNADC). The results show that shocks to the unemployment gap affect wage inflation differently across states, as well as across the formal and informal segments of the labor market. The second essay examines the role of changes in macroeconomic policy in shaping the dynamics of the Phillips Curve. Using panel data and spatial panel techniques, the results indicate that the relationship between unemployment and wage inflation becomes statistically significant only after the policy regime shift beginning in 2016, suggesting that the wage Phillips Curve "awakens" during this period. In addition, spatial spillover effects are identified, indicating that wage dynamics depend not only on local conditions but also on developments in neighboring regions.

Taken together, the two essays contribute to the literature by showing that the Phillips Curve in Brazil is neither static nor homogeneous, but instead depends on regional factors and the policy regime. By integrating disaggregated empirical evidence, this thesis offers a new perspective on inflation dynamics in Brazil, with important implications for the formulation of more effective macroeconomic policies that are sensitive to regional differences.

The thesis is organized as follows: in addition to this introduction, Chapter 1 presents the first essay, entitled "Regional Heterogeneity in the Unemployment–Wage Inflation Trade-Off in Brazil." Chapter 2 presents the second essay, entitled "The Awakening of the Sleeping Beauty: Identifying the Phillips Curve under Shifts, Shocks, and Spillovers." Finally, the Conclusions section summarizes the main findings and discusses their implications.

1 Regional heterogeneity in the unemployment-wage inflation tradeoff in Brazil

Resumo

Frequentemente, assume-se uma estrutura de Curva de Phillips em nível nacional, segundo a qual os choques da taxa de desemprego afetam a inflação salarial de forma homogênea em todo o Brasil, implicando uma dinâmica semelhante entre as unidades federativas ao longo do tempo. Este trabalho tem como objetivo avaliar empiricamente essa hipótese, investigando a presença de heterogeneidade regional na Curva de Phillips Salarial (CPS) brasileira. Diante das limitações de dados, a estratégia empírica baseia-se em modelos Bayesianos de Vetores Autorregressivos (BVAR), a partir dos quais são estimadas 28 CPS, sendo uma para o Brasil e uma para cada unidade federativa. Os resultados mostram como a inflação salarial responde a choques no hiato do desemprego tanto no nível nacional quanto no regional. Especificamente, um choque de um desvio padrão no hiato do desemprego reduz o crescimento salarial em diversas unidades federativas, sendo 16 ao considerar todos os mercados de trabalho, 13 no mercado formal e 6 no mercado informal. No nível nacional, a inflação salarial nominal apresenta uma redução média de aproximadamente 0,50 ponto percentual no mercado formal, ao passo que, no mercado informal, a resposta média é estatisticamente nula. Em contraste, no nível regional, observam-se reduções médias de cerca de 0,44 ponto percentual no mercado formal e de 0,38 ponto percentual no mercado informal, evidenciando a presença de heterogeneidade regional na dinâmica da Curva de Phillips Salarial entre as regiões brasileiras.

Palavras-chave: Heterogeneidade Regional; Inflação Salarial; Hiato do Desemprego; VAR Bayesiano.

Abstract

It is often assumed that the Phillips Curve exhibits a national-level structure, whereby unemployment rate shocks affect wage inflation homogeneously across Brazil, implying similar dynamics among the federative units over time. This study aims to empirically assess this hypothesis by investigating the presence of regional heterogeneity in the Brazilian Wage Phillips Curve (WPC). Given data limitations, the empirical strategy relies on Bayesian Vector Autoregressive (BVAR) models, from which 28 WPCs are estimated: one for Brazil as a whole and one for each federative unit. The results show how wage inflation responds to unemployment gap shocks at both the national and regional levels. Specifically, a one-standard-deviation shock to the unemployment gap reduces wage growth in several federative units, namely 16 when considering all labor markets, 13 in the formal labor market, and 6 in the informal labor market. At the national level, nominal wage inflation exhibits an average decline of approximately 0.50 percentage points in the formal labor market, whereas, in the informal labor market, the average response is statistically insignificant. In contrast, at the regional level, the average reductions are approximately 0.44 percentage points in the formal labor market and 0.38 percentage points in the informal labor market, highlighting the presence of regional heterogeneity in the dynamics of the Wage Phillips Curve across Brazilian regions.

Keywords: Regional Heterogeneity; Wage Inflation; Unemployment Gap; Bayesian VAR.

1.1 Introduction

Most empirical estimates of the Phillips Curve in the Brazilian literature have relied on aggregate, national-level data, focusing exclusively on macroeconomic variables for the country as a whole to assess the unemployment–inflation tradeoff (Aragón e Medeiros, 2017; De Mendonça e de Siqueira Galveas, 2013; Ferreira e Palma, 2015; Machado e Portugal, 2014; Mansilla et al., 2020; Mendes et al., 2023; Oliveira e Feijó, 2015; Ponzoni e Zilli, 2015; Sachsida et al., 2017; Tombini e Alves, 2006) and, to a lesser extent, to wage inflation (De Campos et al., 2010; Nobrega et al., 2020).However, this approach to assessing the unemployment–inflation tradeoff may fail to adequately capture labor market asymmetries and the substantial regional heterogeneities observed across the country. Estimates using aggregated data may not accurately capture the effect of local business cycles on the link between unemployment and wage growth, especially if regional unemployment rates vary independently. Aggregate monetary policy may then fail to stabilize individual state labor markets, prompting migration and widening regional disparities. Additionally, this approach ignores the greater volatility in key variables like unemployment and wage inflation seen at more regional levels.

The regional variation in the relationship between price inflation and unemployment in Brazil has been partially explored by Sachsida (2009) and dos Santos Fernandes e Portugal (2023). In turn, Xavier e de Moura (2023) investigated a wage Phillips Curve across Brazil's 27 federative units employing a panel vector autoregression (PVAR-GMM) approach. However, these studies did not estimate this tradeoff by state, potentially overlooking regional differences in labour markets. Each federal unit has unique wage and unemployment patterns, so analysing the wage-unemployment relationship requires attention to local specifics. A nuanced, context-aware approach improves the accuracy of region-specific economic policies. In Brazil, regional analysis depends on wage inflation data instead of price indices, as only a few metropolitan areas have price data. Wage data from the Continuous National Household Sample Survey (PNADC) is available for all states since 2012.

Accordingly, this study seeks to empirically examine the regional heterogeneity of the unemployment-wage inflation tradeoff in Brazil and its federative units by estimating 28 Bayesian Vector Autoregressive (BVAR) models. Thus, the sample comprises data from the PNADC, the Central Bank of Brazil (BCB), and the Brazilian Institute of Geography and Statistics (IBGE), covering the period from the second quarter of 2012 to the fourth quarter of 2025, totaling 53 quarterly observations.

The Bayesian approach is well-suited for estimating VAR models because its use of prior distributions helps manage many parameters. Introducing the Minnesota prior further streamlines estimation by limiting posterior probabilities to relevant hyperparameters. This feature is particularly advantageous in the present study, which is based on a limited sample size. This empirical strategy captures regional differences more accurately and clarifies the link between wage growth and unemployment nationwide. As Levy (2019) notes, considering both local unemployment rates and wage inflation is key to properly identifying the Phillips Curve.

This study contributes to related literature in three main aspects. First, to the best of our knowledge, it is the first to detect regional heterogeneity in the relationship between the unemployment rate and wage growth, both for the aggregate labor market and for each Brazilian federative unit representing a novel contribution even in comparison with evidence from emerging and developed countries. Second, the analysis of regional heterogeneity in this relationship is conducted separately for the formal and informal labor market segments, allowing for an understanding of structural differences between these two sectors. Third, few studies have examined wage inflation as a response variable to shocks in the unemployment gap. Therefore, this study seeks to investigate this relationship in the Brazilian economy, employing new proxy measures for wage inflation—such as average nominal earnings derived from the PNADC—and constructing an unemployment gap using the Singular Spectrum Analysis (SSA) approach as a filtering method.

The main results indicate that shocks to the unemployment gap generate significant responses in wage growth. The analysis found that a one-standard-deviation shock to the unemployment gap in Q2 significantly reduces wage growth in 16 federative units for all labor markets, 13 for the formal market, and 6 for the informal market. It was observed that, when accounting for the heterogeneity across federative units, Brazil as a whole exhibited average responses of -0.50 and zero in the formal and informal labor markets, respectively. In contrast, the federative units showed averages of -0.44 and -0.38 for the same markets. The results showed that both formal and informal labor markets influenced outcomes, revealing heterogeneity across federal units and market types. Standard deviations were 0.39 for both markets combined, 0.38 for the formal market, and 1.52 for the informal market.

The remainder of this paper is structured as follows. Section 1.2 presents the empirical strategy and the data used for model estimation. Section 1.3 discusses the main results. The final section summarizes the conclusions and highlights the key contributions of the study.

1.2 Empirical strategy

This section presents the BVAR model, including the prior and posterior specifications used in the empirical analysis of the unemployment-wage inflation tradeoff for Brazil and for each federative unit, in the first subsection. Next, the dataset employed in the study is described. Finally, a descriptive analysis of the variables used is conducted.

1.2.1 Bayesian Vector Autoregressive (BVAR)

Traditional VAR models may encounter challenges related to high dimensionality, arising from the large number of parameters to be estimated relative to the limited length of available time series (Sims, 1980). As an alternative, the BVAR model can be employed. In general, the Bayesian approach treats sample values as non-stochastic and conducts inference by assigning probability densities to model parameters through suitable prior distributions. Inference is then performed based on the likelihood of the observed data, yielding posterior distributions for the parameters. The BVAR framework thus enables the incorporation of relevant prior information and produces more precise and robust estimates through sampling from the posterior distribution.

In the Bayesian approach, reliable posterior estimates are possible even with small samples, thanks to the Minnesota prior, which addresses VAR high dimensionality using only two hyperparameters. This method also enables updating prior probabilities for all parameters using available data (Miranda-Agrippino e Ricco, 2018). Therefore, the BVAR model is well-suited for handling high dimensionality and limited time series data in this study.

1.2.1.1 Prior Specification

This study adopts the Minnesota prior, originally proposed by Robert Litterman and colleagues at the University of Minnesota (Litterman, 1980). The choice of this prior is motivated by the empirical regularity that most macroeconomic time series behave similarly to a multivariate random walk with drift. The Minnesota prior is parameterized as follows: (i) the hyperparameter , which controls the overall tightness of the prior and varies between 0.0001 and 5; (ii) the parameter , which governs the rate at which the prior variance decays as the lag order increases, taking values between 1 and 3; and (iii) the prior variance of the model, set at 10,000,000, which defines the initial dispersion of the coefficients. Furthermore, the flexible implementation of the model allows users to define customized priors for fictitious observations.

The BVAR model also provides specific options for the Markov Chain Monte Carlo (MCMC) method and the Metropolis-Hastings (MH) algorithm, which is used to explore the posterior hyperparameter space. It is possible to adjust the number of iterations to be discarded or stored, as well as to apply sample thinning to reduce memory requirements and serial autocorrelation. Proper exploration of the posterior distribution is facilitated by options that allow either manual tuning of the individual proposals for the MH algorithm or automatic adjustment until a target acceptance rate is achieved. These customization features enable flexible analyses using a variety of established and specialized methods (Kuschnig and Vashold, 2021). In the present study, automatic adjustment of the target acceptance rate was employed with the following limits: (i) lower bound set at 0.25; and

(ii) upper bound set at 0.45.

1.2.1.2 Posterior Specification

In the present study, the MCMC parameters were set as follows: (i) 30,000 iterations were performed; and (ii) the first 10,000 iterations were discarded. This configuration was chosen considering the sample size used for estimating the BVAR, which comprises 53 observations, from the second quarter of 2012 to the second quarter of 2025. Additionally, to ensure model stability and assess the robustness of the results, the Geweke test was applied to verify the convergence of the MCMC chains.

1.2.1.3 Impulse response function

To assess the effect of heterogeneity across states, impulse response functions (IRFs) were employed to capture the response of wage growth to shocks in the unemployment gap. The IRFs were simulated over a twelve-quarter horizon using the Cholesky decomposition of the variance–covariance matrix. For structural identification, the variables were ordered from the most exogenous to the most endogenous as follows: unemployment gap, backward inflation expectations, forward-looking inflation expectations, and wage growth. This ordering implies that wage growth responds to shocks contemporaneously in all other variables.

1.3 Data

The sample used in this study is composed of data from the PNADC, the Central Bank of Brazil (BCB), and the Brazilian Institute of Geography and Statistics (IBGE). All variables are quarterly, covering the period from the second quarter of 2012 to the second quarter of 2025, both for Brazil as a whole and for its 27 federative units. The variables used for the BVAR analysis are:

a) Unemployment rate: unemployment and underutilization rates of the labor force, in the reference week, for persons aged 14 or over (Table 4099 – SIDRA[1]);
b) Wage Growth Rate: Average monthly nominal earnings, usually received in the reference month, from the main job and all jobs (Table 6472 – SIDRA);
c) Formal Wage Growth Rate: Average monthly real earnings, usually received in the reference month, from the main job and all jobs, for employees in the private sector, excluding domestic workers with a formal work contract (Table 5440 – SIDRA);
d) Informal Wage Growth Rate: Average monthly real earnings, usually received in the reference month, from the main job and all jobs, for employees in the

[1] The series (a)–(d) are available at https://sidra.ibge.gov.br/pesquisa/pnadct/tabelas, while the series (e)–(f) are available at https://www.ipeadata.gov.br/Default.aspx.

private sector, excluding domestic workers without a formal work contract (Table 5440 – SIDRA);

e) backward Inflation Expectation: The general Broad Consumer Price Index (IPCA) will be used as a proxy, adopting a lag to construct this variable (IPEADATA);

f) Forward-Looking Inflation Expectation: Average inflation expectation – IPCA – accumulated rate for the next 12 months (IPEADATA);

The choice of the sample period is justified by the introduction of the unemployment rate measurement in the PNADC, which became a new proxy for the unemployment rate, particularly after the discontinuation of the Monthly Employment Survey (PME from the acronym in Portuguese) in 2016.

To construct the unemployment gap for Brazil and its federative units from the unemployment rate, the SSA approach was adopted as a filtering method. This technique is particularly effective in isolating the cyclical component of the unemployment rate, clearly separating it from the underlying trend, as well as from seasonal effects and noise present in the data. Furthermore, SSA has been recommended for the analysis of short, noisy time series Mineva e Popivanov (1996), which is the case in this study, with 53 quarters of data.

To calculate wage growth rates for both the states and Brazil, the nominal average earnings were used. According to IBGE's (2014) methodology, this variable is obtained by dividing total earnings by the number of employed individuals in each quarter. This procedure provides an estimate of the quarterly wage rate per employed person in each federative unit.

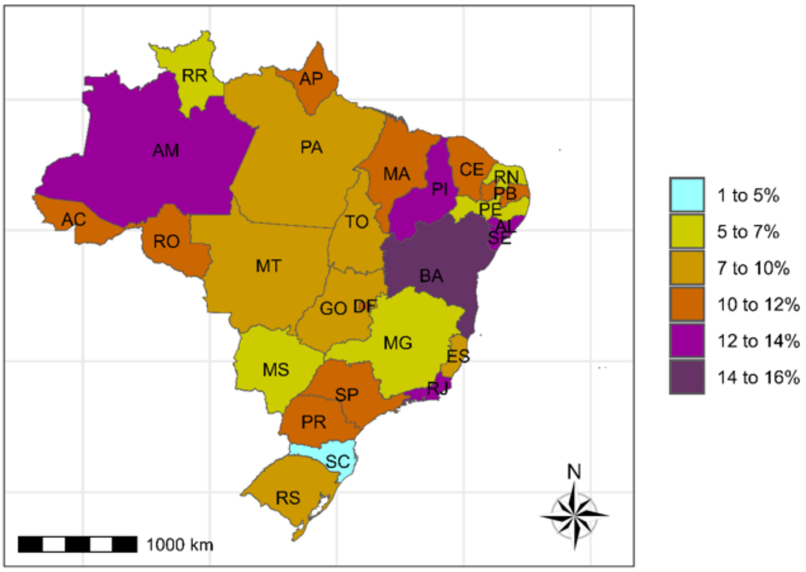
1.3.1 Descriptive Analysis

In 2013, Brazil's average unemployment rate was 7.25%, decreasing to 6.8% in 2014. However, between 2015 and 2017, due to political instability and one of the most severe economic crises in the country's history, the unemployment rate rose sharply, reaching 8.5% in 2015 and 11.3% in 2016. Despite improvements in international economic conditions from 2017 onward and increased confidence among economic agents in government policies, the labor market showed no significant progress in its indicators. During this period, the unemployment rate remained relatively stable, averaging 11.3% between 2017 and 2019.

The rise in unemployment rates experienced by the Brazilian economy in recent years contrasts with the results observed in some states. During the period from 2012 to 2025, Brazil's average unemployment rate was 9.9%. However, states such as Amazonas (AM) and Bahia (BA) recorded average unemployment rates of 13.9% and 14.6%, respectively. On the other hand, eleven states reported average unemployment rates below the national average. Notably, the state of Santa Catarina (SC) registered an average rate of only 5%.

Figure 1 illustrates the distribution of average unemployment rates by state during the 2012–2025 period.

Figure 1 - Average Unemployment Rate in Brazilian States from April 2012 to June 2025



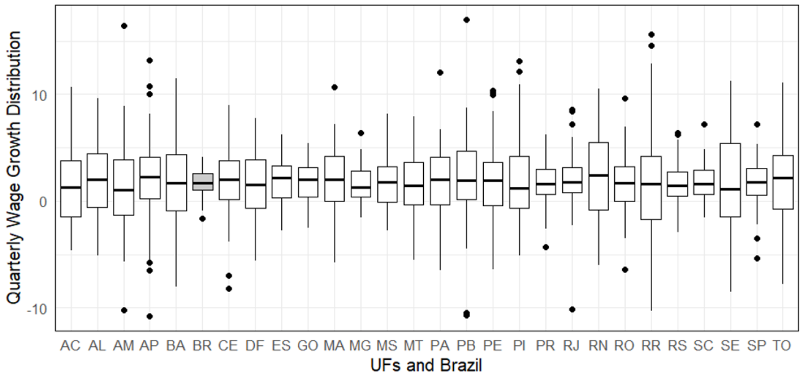
Source: Author's own elaboration.
Note: Figure 1 presents a choropleth map of the average unemployment rate across Brazil's federative units (UFs from the acronym in Portuguese) over the period from 2012 to 2025. The percentage variations are color-coded on a scale ranging from light cyan, olive, mustard, burnt orange, purple, to dark violet. The UFs are identified by their respective abbreviations. For a detailed correspondence between abbreviations and full state names, see Table 2 in Appendix A. The map scale indicates that 1 centimeter corresponds to 1,000 kilometers. The compass rose, located in the lower-right corner, provides cardinal directions and assists with spatial orientation.

Figure 2 reveals substantial disparities in wage growth rates, reflecting the underlying structural differences across Brazil's federative units. States in the Southeast and South regions exhibit box plots with lower dispersion and variability, indicating a more concentrated and homogeneous wage distribution a pattern consistent with the aggregate behavior observed for Brazil as a whole. Conversely, states in the North, Northeast, and Center-West regions display more elongated box plots, suggesting greater heterogeneity and volatility in wage dynamics.

During the analysis, outliers were detected at both ends of the wage distribution in states such as Amazonas, Amapá, Paraíba, Pernambuco, and Rio de Janeiro. These outliers may reflect particularities of local labor markets or specific socioeconomic factors influencing wages in these regions. The detection of such disparities underscores the importance of further investigation to understand their underlying causes and their impact on the overall landscape of wage distribution in the country.

According to Levy (2019), measuring nominal wage growth is subject to a potential source of bias. In addition to sectoral or quality changes, if the proportion of part-time jobs relative to total employment is countercyclical, this may distort labor supply measurements.

Figure 2 - Box Plot of Wage Growth Rate from April 2012 to June 2025



Source: Author's own elaboration.
Note: Figure 2 presents a box plot illustrating the distribution of wage growth rates. The box plot is a graphical representation that provides information on the central tendency, dispersion, and presence of extreme values of a variable. The central rectangle, known as the "box," represents the interquartile range, which spans from the 25th to the 75th percentile of the data. The line inside the box indicates the median, corresponding to the value that divides the distribution in half. The "whiskers" extending above and below the box represent the range of values, excluding outliers. Individual points located beyond the whiskers are considered outliers and are depicted as isolated black dots. This visual representation allows for a quick comparison of distributions across federative units (UFs) and for Brazil as a whole, making it possible to identify differences and potential extreme values. The white boxes correspond to individual UFs, while the gray box represents Brazil (BR). For a detailed correspondence between UF abbreviations and their full names, refer to Table 2 in Appendix A.

During recessions, there is a risk of underestimating the quarterly full-time equivalent wage, while in periods of economic expansion, wages may be overestimated. Such distortion can affect the estimated coefficient of the unemployment-wage inflation tradeoff, leading to an apparent lower rate of nominal wage growth during periods of high unemployment due to measurement errors.

In contrast to other countries, where wage measurement can be influenced by variations in the share of formal employment, Brazil adopts an approach that incorporates informal jobs through the PNADC, helping to mitigate this potential bias. By including informal employment in the estimation of nominal wage growth, the measure becomes more comprehensive and less prone to distortions arising from fluctuations in the share of formal employment over time.

However, the presence of informal jobs may still introduce some uncertainty into wage estimates, as these occupations tend to offer lower pay and less stable working conditions compared to formal employment. Thus, although the inclusion of informal jobs in the PNADC represents a positive step toward mitigating potential distortions and rigidities, the limitations and volatile nature of these occupations must be considered when interpreting nominal wage estimates in Brazil.

1.4 Results

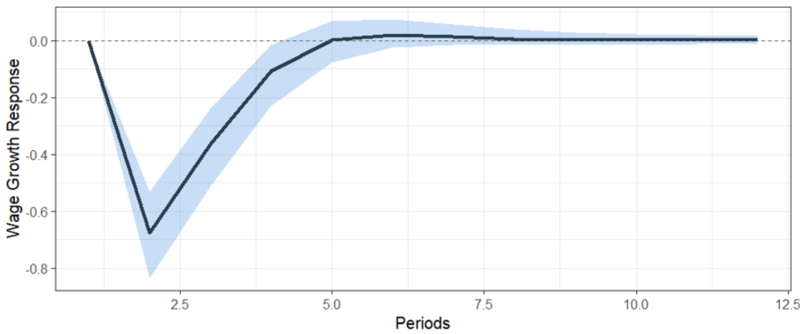
1.4.1 Analysis of the Combined Informal and Formal Labor Markets

To assess regional heterogeneity in the relationship between nominal wage growth and unemployment gaps in the combined formal and informal labor market, IRFs were analyzed across the 28 estimated BVAR models. To ensure model stability and evaluate the robustness of the results, the Geweke test was applied to verify the convergence of the MCMC chains. The test results, presented in Table 3 of the appendix, provide no statistical evidence to reject the null hypothesis of equality between means, indicating that the MCMC chains converge to the desired stationary distribution. This outcome reinforces the reliability of the models and the consistency of the estimates obtained.

In the BVAR model, the median of the posterior probability distribution provides a robust estimate of the expected effect of a shock in one variable on the others. The light blue area, corresponding to a 68% credibility interval, represents the uncertainty associated with the estimated effects. This representation allows for a probabilistic interpretation of the IRFs.

Figure 3 presents the IRF obtained from an estimation using aggregated data for the Brazilian economy. An unexpected one standard deviation shock in the unemployment gap leads to a reduction in the wage growth rate relative to equilibrium, of approximately –0.67 percentage points in the second quarter. Furthermore, a sequence of negative effects can be observed over the subsequent quarters, converging to the steady state from the fifth quarter onward.

Figure 3 - BVAR Impulse Response Function for Brazil

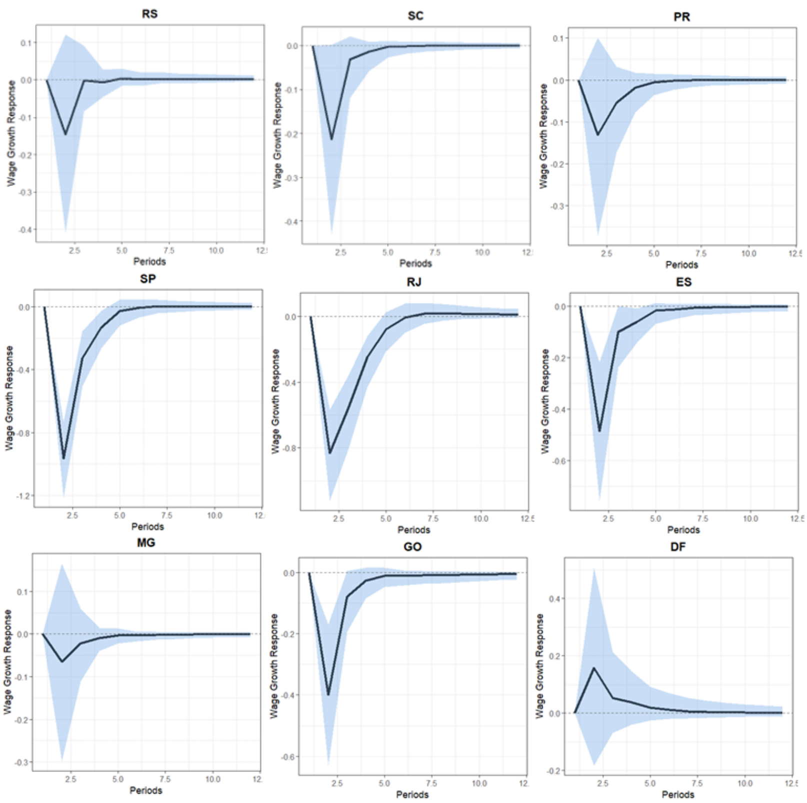


Source: Author's own elaboration.
Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

Figure 4 presents the IRFs results for the states in the Southeast and South regions, as well as for the Distrito Federal (DF) and Goiás (GO) in the Central-West region. In the South region, composed of Paraná (PR), Santa Catarina (SC), and Rio Grande do Sul

(RS), the IRFs included zero, which may indicate that combining the formal and informal labor markets does not fully capture a relationship between the unemployment gap and wage growth, as these states have more developed economies where the informal market is less significant. In contrast, all Southeast states showed significant responses of wage growth to unemployment gap shocks, except for Minas Gerais (MG). Notably, São Paulo (SP) experienced a reduction in wage growth of -0.97 percentage points in the second quarter. Additionally, in the Central-West region, Goiás displayed a significant IRF, while the Distrito Federal (DF) included zero.

Figure 4 - BVAR Impulse Response Functions for RS, SC, PR, SP, RJ, ES, MG, GO, and DF



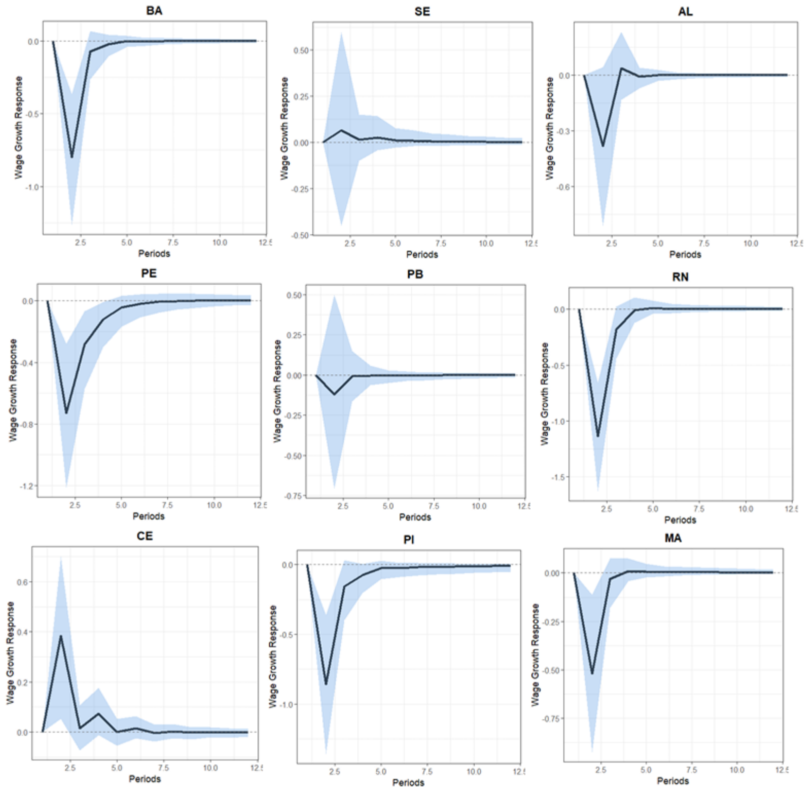
Source: Author's own elaboration.

Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

According to the results presented in Figure 5, which refer to the states in the Northeast region, three states exhibit IRFs that include zero, while the remaining states show significant responses in wage growth to a shock in the unemployment gap. Notably, Rio Grande do Norte (RN) experienced a wage growth response of -1.14 percentage points.

According to the results presented in Figure 6, which refer to the remaining states of the Central-West region and all states in the Northern region, only Amazonas (AM), Amapá (AP), and Pará (PA) show IRFs that include zero. The other states exhibited

Figure 5 - BVAR Impulse Response Functions for BA, SE, AL, PE, PB, RN, CE, PI, and MA

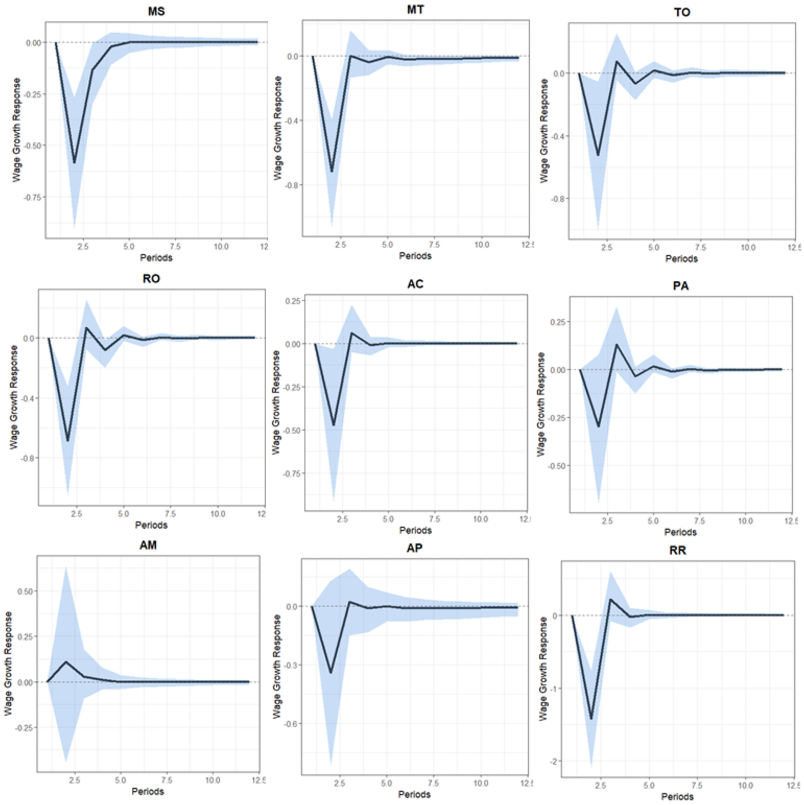


Source: Author's own elaboration.
Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

significant wage growth responses to a shock in the unemployment gap, with Roraima (RR) standing out for experiencing a substantial reduction of -1.42 percentage points in the second quarter. In the case of PA and AM, which did not show significant responses, these states had high unemployment rates during the period considered. This suggests that in these economies, wages may not respond to a shock in the unemployment gap, possibly reflecting labor market inertia.

These results highlight the heterogeneity of labor market behavior across different regions of Brazil, reflecting the economic, political, and social specificities of each state. Understanding these regional dynamics is important for formulating more effective and targeted public policies aimed at promoting stability and sustainable economic growth nationwide.

Figure 6 - BVAR Impulse-Response Functions for MS, MT, TO, RO, AC, PA, AM, AP, and RR



Source: Author's own elaboration.
Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

1.5 A Disaggregated Analysis of the Formal and Informal Labor Markets

In order to compare the results obtained in the previous section, BVAR models were estimated to represent the unemployment-wage inflation tradeoff across the Federative Units. In this context, two alternative measures of this variation were used: the formal wage growth rate, represented by the average monthly earnings of private-sector workers with formal contracts, and the informal wage growth rate, represented by the average monthly earnings of private-sector workers without formal contracts. These analyses aim to isolate the impacts of the unemployment rate on wage variation, allowing for a distinct assessment of effects on formal and informal wages, in contrast to aggregated wage measures.

Appendix B presents the IRFs for these two versions of wage growth. Figures 1B, 2B, and 3B correspond to the formal labor market, while Figures 4B, 5B, and 6B refer to the informal labor market. The stability of the models and the robustness of the results were assessed using the Geweke test, which evaluates the convergence of the

MCMC chains. The results of this test, shown in Table 4 for formal wage growth and Table 5 for informal wage growth in Appendix B, did not provide statistical evidence to reject the null hypothesis of equality between the means, indicating that the MCMC chains converge to the intended stationary distribution.

Figures 1B and 4B, which report the responses for the disaggregated markets, show effects of -0.50 percentage points for the formal labor market and zero percentage points for the informal one. This indicates that the effects become less pronounced or even null when the labor markets are disaggregated. In contrast, the response of wage growth in the second quarter was -0.67 percentage points when using aggregated data for both the formal and informal labor markets, considering the aggregated data representing the Brazilian economy as a whole.

Moreover, Figures 1B, 2B, and 3B in Appendix B show that São Paulo (SP), Piauí (PI), and Pará (PA) exhibit the most pronounced responses of wage growth in the formal labor market to a shock in the unemployment gap, with values of -0.71, -1.24, and -0.48 percentage points, respectively. This highlights a greater sensitivity of formal employment contracts.

In the informal sector, as shown in Figures 4B, 5B, and 6B in Appendix B, the states of Rio Grande do Sul (RS) and Tocantins (TO) exhibit positive responses of 0.91 and 1.73 percentage points in wage growth, respectively. In contrast, states such as Amazonas (AM), Paraíba (PB), and Rondônia (RO) show pronounced declines of -1.66, -1.74, and -2.25 percentage points, respectively, following a one-standard-deviation shock to the unemployment gap, suggesting a higher sensitivity of wages in the informal labor market.

1.6 Summary of Results

Table 1 presents the IRF results for Brazil and its 27 federative units, considering three labor market segments: combined formal and informal, formal only, and informal only. It can be observed that Brazil exhibits significant wage growth responses to a shock in the unemployment gap in the second quarter for both the combined formal and informal labor markets and the formal labor market alone. Four federative units: Piauí (PI), Rio de Janeiro (RJ), Rio Grande do Norte (RN), and São Paulo (SP) also show sizeable responses. In Rio de Janeiro (RJ) and São Paulo (SP), the wage growth response to an unemployment gap shock persists for five quarters when considering both the formal and informal markets together or the formal market alone.

In the Central-West region, all federative units, such as Goiás (GO), Mato Grosso (MT), and Mato Grosso do Sul (MS), except the Distrito Federal (DF), showed significant wage growth responses to an unemployment gap shock when considering both the combined formal and informal labor market and the formal labor market separately. However, none of these federative units exhibited significant responses in the informal labor market alone. In the Northern and Northeastern regions, only Pará (PA) and Roraima (RR), and Rio Grande do Norte (RN) and Piauí (PI), respectively, displayed significant wage growth responses to an unemployment gap shock in the formal sector. This suggests that the formal labor market in these regions responds less strongly than the informal market. It is worth noting, however, that Pará exhibited a positive wage growth response to an unemployment gap shock, which contradicts the expected signal of the tradeoff.

In Table 1, when considering only the responses that do not include zero and excluding aggregated results for Brazil, thus focusing solely on the federative units, it is observed that the average wage growth response to a one standard deviation shock in the unemployment gap in the second quarter ahead was -0.67, -0.44, and -0.38 percentage points for the combined formal and informal market, the formal market, and the informal market, respectively. More importantly for our purposes, the variability of the responses was substantial, with standard deviations of 0.39, 0.38, and 1.49 for the combined formal and informal market, the formal market, and the informal market, respectively, highlighting the significant heterogeneity in the relationship between the unemployment gap and wage growth across Brazil's federative units.

The maximum recorded values were 0.38 in Ceará (CE) for the combined formal and informal sectors, -0.27 in Mato Grosso (MT) and Santa Catarina (SC) for the formal sector only, and 1.73 in Tocantins (TO) for the informal sector. In contrast, the minimum values were -1.42 in Roraima (RR) for the combined formal and informal sectors, -1.24 in Piauí (PI) for the formal sector, and -1.74 in Paraíba (PB) for the informal sector alone. Positive responses may reflect regional or sectoral specificities, such as wage rigidity, sectoral composition effects, or temporary supply shocks that raise wages despite higher unemployment. In turn, the IRF for Brazil as a whole is -0.67 for the combined formal and informal labor markets, -0.50 for the formal market, and zero for the informal market.

When analyzing the convergence of the wage growth responses to a one standard deviation shock in the unemployment gap, the averages were 3, 3.15, and 3.3 quarters, with standard deviations of 0.90, 0.77, and 1.50 for the combined formal and informal market, the formal market, and the informal market, respectively. The relatively higher variability in the informal market reflects differences in how quickly wages adjust across states. Notably, São Paulo (SP) required five quarters to converge in both the combined and formal only markets, while in the informal market their responses stabilized faster, within three quarters, suggesting a quicker adjustment in the informal sector. PR, in contrast, only converged in the eighth quarter for the informal market, indicating a slower wage adjustment in that federal units.

Table 1-Summary of IRF Results

Federative Unit (UF)	Informal and Formal		Formal		Informal	
	Response: 2/Q	Convergence After	Response: 2/Q	Convergence After	Response: 2/Q	Convergence After
Brazil	-0.67	5	-0.50	3	Contains zero	
AC	-0.47	3	Contains zero		Contains zero	
AL	Contains zero		Contains zero		Contains zero	
AM	Contains zero		Contains zero		-1.66	3
AP	Contains zero		Contains zero		Contains zero	
BA	-0.80	3	Contains zero		Contains zero	
CE	0.38	3	Contains zero		-1.04	6
DF	Contains zero		Contains zero		Contains zero	
ES	-0.49	3	-0.60	3	Contains zero	
GO	-0.40	3	-0.40	3	Contains zero	
MA	-0.52	3	Contains zero		Contains zero	
MG	Contains zero		-0.33	3	0.71	3
MS	-0.58	3	-0.37	3	Contains zero	
MT	-0.72	3	-0.27	3	Contains zero	
PA	Contains zero		-0.48	3	Contains zero	
PB	Contains zero		Contains zero		-1.74	3
PE	-0.73	3	Contains zero		Contains zero	
PI	-0.86	3	-1.24	3	1.72	3
PR	Contains zero		Contains zero		Contains zero	
RJ	-0.83	5	-0.54	5	Contains zero	
RN	-1.14	3	-0.60	3	-1.13	3
RO	-0.68	3	Contains zero		-2.25	3
RR	-1.42	3	-0.65	3	Contains zero	
RS	Contains zero		Contains zero		0.91	3
SC	Contains zero		-0.27	3	Contains zero	
SE	Contains zero		Contains zero		Contains zero	
SP	-0.97	5	-0.71	5	-1.05	3
TO	-0.52	3	Contains zero		1.73	3
Mean	-0.67	3.00	-0.44	3.15	-0.38	3.3
Median	-0.70	3.00	-0.40	3.00	-1.04	3.00
Sd	0.39	0.90	0.38	0.77	1.49	1.50
Min.	-1.42	3	-1.23	3	-2.25	3
Max.	0.38	5	0.48	5	1.73	6

Source: Author's own elaboration.

Note: In the table, the term "Response: 2/Q" refers to the response of the wage growth rate, expressed in percentage points, following a one-standard-deviation shock to the unemployment gap in the second quarter. The columns correspond sequentially to the combined formal and informal market, the formal market only, and the informal market only. "Convergence after" indicates the quarter in which the IRF converges to the steady state. The term "Contains zero" denotes a null effect on the wage growth rate in response to a shock in the unemployment gap. The mean, median, and standard deviation (sd) are calculated excluding the response for Brazil, as well as the Federal Units whose IRFs contain zero. The abbreviations Min. and Max. stand for minimum and maximum, respectively. For a detailed correspondence between the abbreviations and the federative units (UFs), please refer to Table 2 in Appendix A.

1.7 Concluding Remarks

This study testing regional heterogeneity in the relationship between wage inflation and unemployment in Brazil through a BVAR approach, estimating 28 models, one for the country as a whole and one for each of the 27 federative units. The results reveal a short-term relationship between wage inflation and the unemployment gap in the Brazilian economy, as evidenced by the IRFs analyses for several states and for Brazil overall. Moreover, significant differences were observed in the responses across various measures of wage growth among the federative units when accounting for changes in the unemployment gap.

These findings highlight the complexity of the underlying economic relationships and underscore the importance of a comprehensive analysis to better understand wage and employment dynamics in Brazil's diverse labor market structures. The results proved to be sensitive when comparing the combined formal and informal markets with the formal and informal sectors analyzed separately. This sensitivity reflects the distinct nature of each segment, as the formal sector includes only registered workers, while the informal sector encompasses those without formal labor contracts. Unlike other industrialized economies, Brazil exhibits a high degree of heterogeneity in its labor market, which may influence how monetary policy is transmitted across regions and employment types.

In sum, the main conclusion is that regional aspects play a significant role in how a shock to the unemployment gap affects wage growth in Brazil. The question that arises, therefore, is how to incorporate this regional heterogeneity into the formulation of monetary policy within a monetary union governed by a single monetary authority, such as the Central Bank.

Appendix A

Table 2-Initials and Names of Federative Units and Macro-Regions

Macro-Region or State		**Macro-Region or State**	
Macro-Region or State	**Initials**	**Macro-Region or State**	**Initials**
North	N	**Southeast**	SE
Rondônia	RO	Minas Gerais	MG
Acre	AC	Espírito Santo	ES
Amazonas	AM	Rio de Janeiro	RJ
Roraima	RR	São Paulo	SP
Pará	PA		
Amapá	AP		
Tocantins	TO	**South**	S
Northeast	NE	Paraná	PR
Maranhão	MA	Santa Catarina	SC
Piauí	PI	Rio Grande do Sul	RS
Ceará	CE		
Rio Grande do Norte	RN		
Paraíba	PB	**Center-West**	CW
Sergipe	SE	Mato Grosso do Sul	MS
Bahia	BA	Mato Grosso	MT
Alagoas	AL	Goiás	GO
Pernambuco	PE	Distrito Federal	DF

Source: Author's own elaboration.

Appendix B

Table 3-Convergence Test of the Markov Chains formal and informal Wage Growth Rate

Brazil and UF	z-score	UF	z-score	UF	z-score
RS	0,8482	BA	0,2661	MS	0,7406
SC	0,6236	SE	0,1852	MT	0,7541
PR	0,2867	AL	0,8766	TO	0,6918
SP	0,2487	PE	0,7455	RO	0,4626
RJ	0,8473	PB	0,6284	AC	0,8278
ES	0,935	RN	0,8947	PA	0,8906
MG	0,099	CE	0,1449	AM	0,8724
GO	0,2737	PI	0,6437	AP	0,7603
DF	0,1642	MA	0,3156	RR	0,8768
		Brazil	0,3685		

Source:Author's own elaboration.

Note: The table presents Z-score values, where a value higher than the pre-determined significance level of 5% (0.05) indicates that there is insufficient evidence to reject the null hypothesis that the two parts of the MCMC come from the same distribution. Therefore, the chain can be considered to have reached convergence, and the results are reliable. In all cases analyzed for the UFs and Brazil, the Z-scores were higher than 0.05. For a detailed correspondence between the initials and the UFs, please refer to Table 2 in Appendix A.

Table 4-Convergence Test of the Markov Chains formal Wage Growth Rate

Brazil and UF	z-score	UF	z-score	UF	z-score
RS	0,9789	BA	0,8779	MS	0,1485
SC	0,3516	SE	0,6378	MT	0,8462
PR	0,2117	AL	0,9561	TO	0,6252
SP	0,3131	PE	0,4098	RO	0,9268
RJ	0,7454	PB	0,4709	AC	0,2223
ES	0,1456	RN	0,9504	PA	0,2732
MG	0,353	CE	0,1589	AM	0,4552
GO	0,5975	PI	0,6599	AP	0,4256
DF	0,7944	MA	0,9449	RR	0,6468
		Brazil	0,921		

Source:Author's own elaboration.

Note: The table presents Z-score values, where a value higher than the pre-determined significance level of 5% (0.05) indicates that there is insufficient evidence to reject the null hypothesis that the two parts of the MCMC come from the same distribution. Therefore, the chain can be considered to have reached convergence, and the results are reliable. In all cases analyzed for the UFs and Brazil, the Z-scores were higher than 0.05. For a detailed correspondence between the initials and the UFs, please refer to Table 2 in Appendix A.

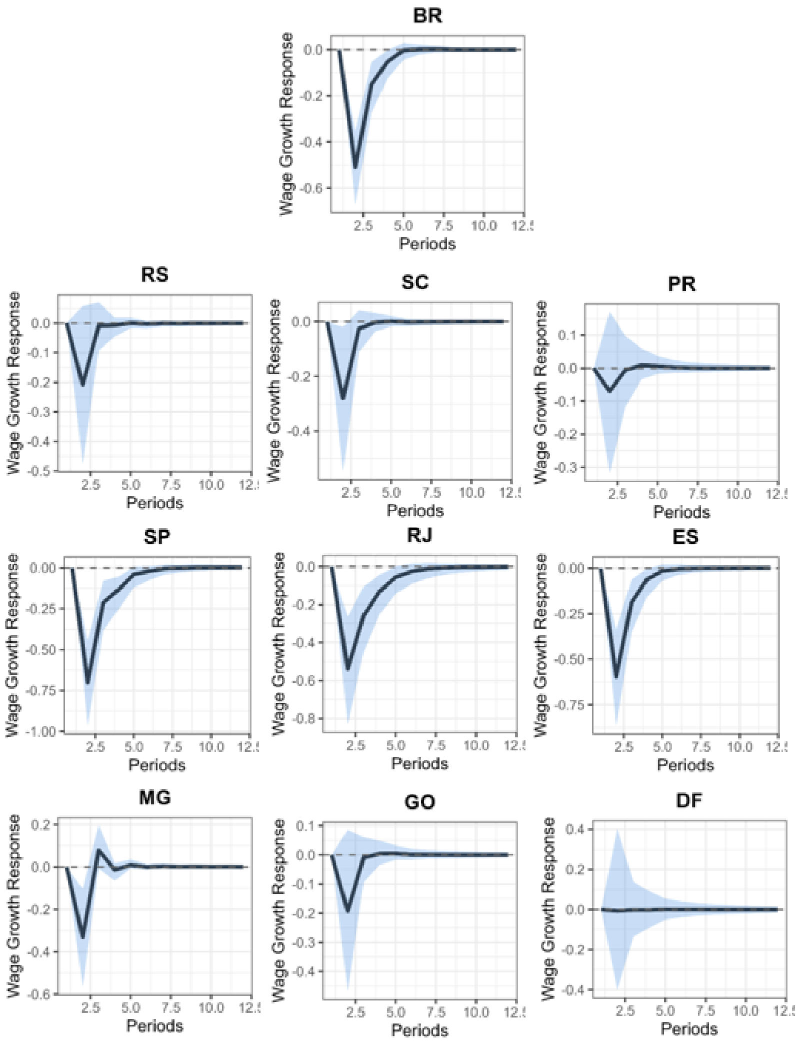
Table 5-Convergence Test of the Markov Chains informal Wage Growth Rate

Brazil and UF	z-score	UF	z-score	UF	z-score
RS	0,089	BA	0,3436	MS	0,2665
SC	0,8537	SE	0,2746	MT	0,6573
PR	0,1955	AL	0,6208	TO	0,5441
SP	0,7941	PE	0,3815	RO	0,5826
RJ	0,3546	PB	0,6367	AC	0,2964
ES	0,8328	RN	0,4261	PA	0,4555
MG	0,1765	CE	0,124	AM	0,7582
GO	0,3795	PI	0,443	AP	0,8505
DF	0,5294	MA	0,857	RR	0,4696
		Brazil	0,344		

Source:Author's own elaboration.

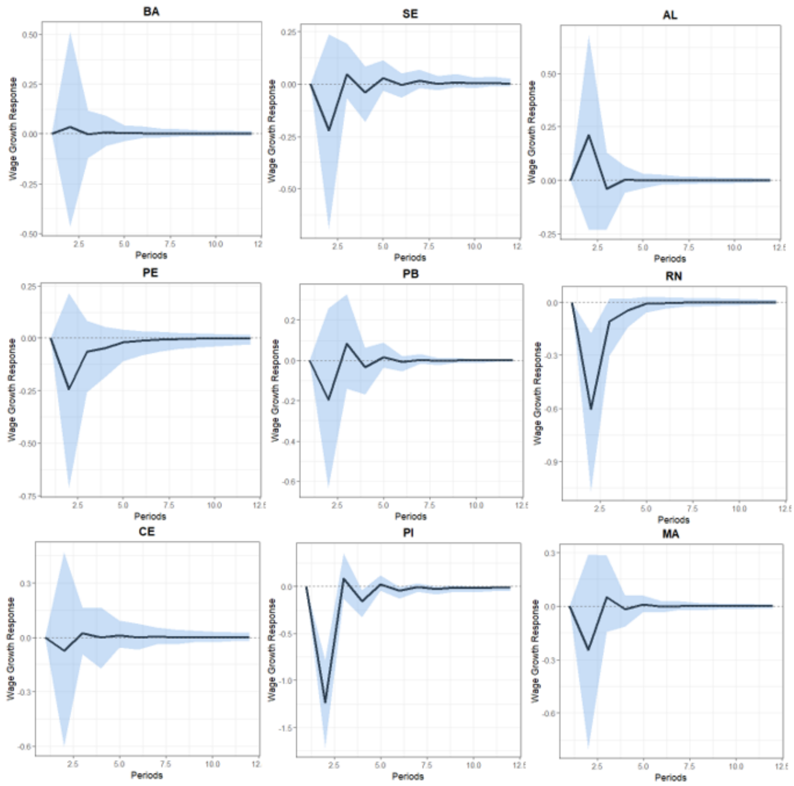
Note: The table presents Z-score values, where a value higher than the pre-determined significance level of 5% (0.05) indicates that there is insufficient evidence to reject the null hypothesis that the two parts of the MCMC come from the same distribution. Therefore, the chain can be considered to have reached convergence, and the results are reliable. In all cases analyzed for the UFs and Brazil, the Z-scores were higher than 0.05. For a detailed correspondence between the initials and the UFs, please refer to Table 2 in Appendix A.

Figure 1.B - BVAR Impulse Response Functions with formal market for BR, RS, SC, PR, SP, RJ, ES, MG, GO and DF



Source: Author's own elaboration.
Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

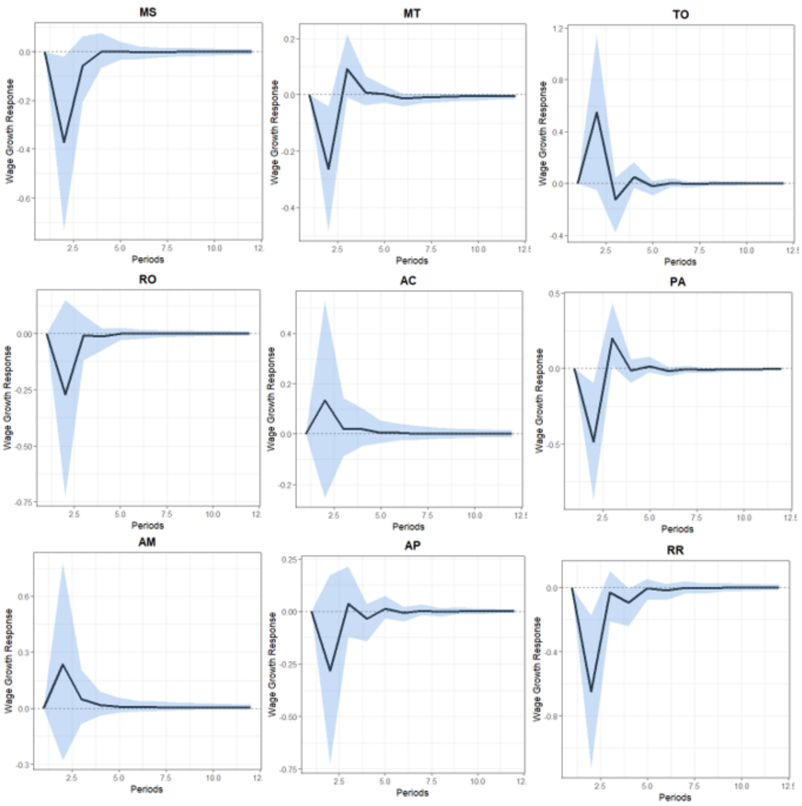
Figure 2.B - BVAR Impulse Response Functions with formal market for BA, SE, AL, PE, PB, RN, CE, PI, and MA



Source: Author's own elaboration.

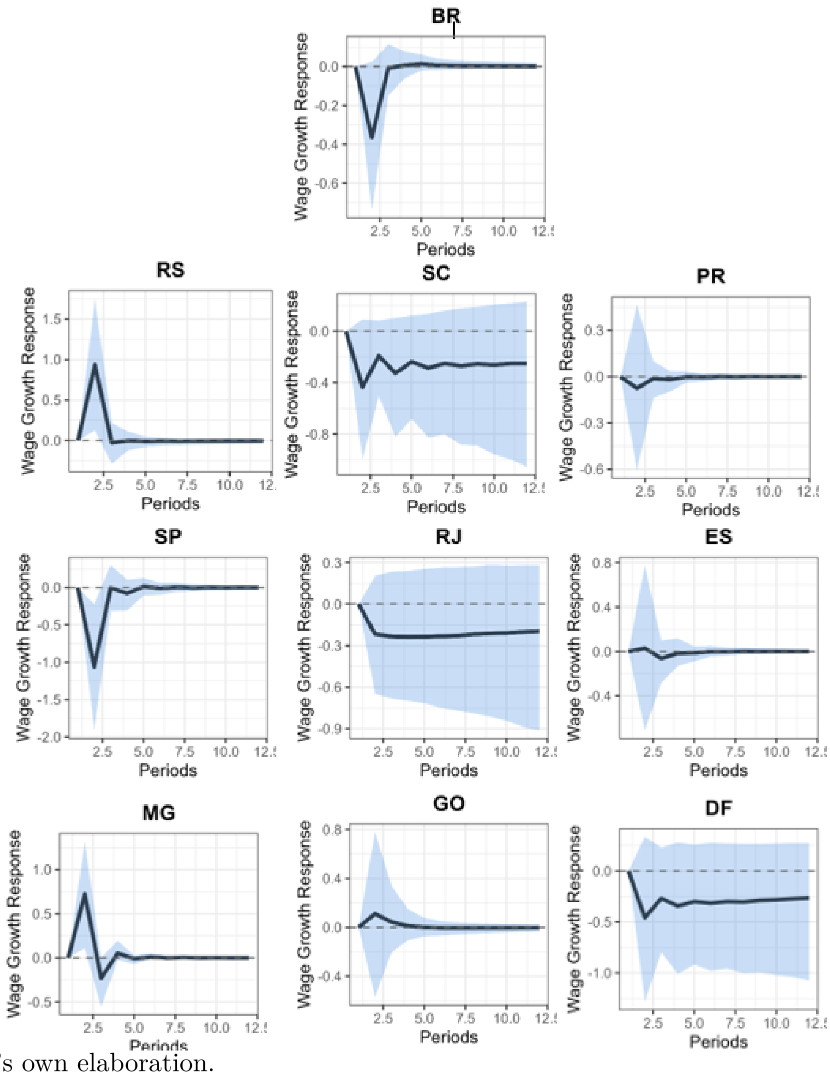
Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

Figure 3.B - BVAR Impulse-Response with formal market Functions for MS, MT, TO, RO, AC, PA, AM, AP, and RR



Source: Author's own elaboration.
Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

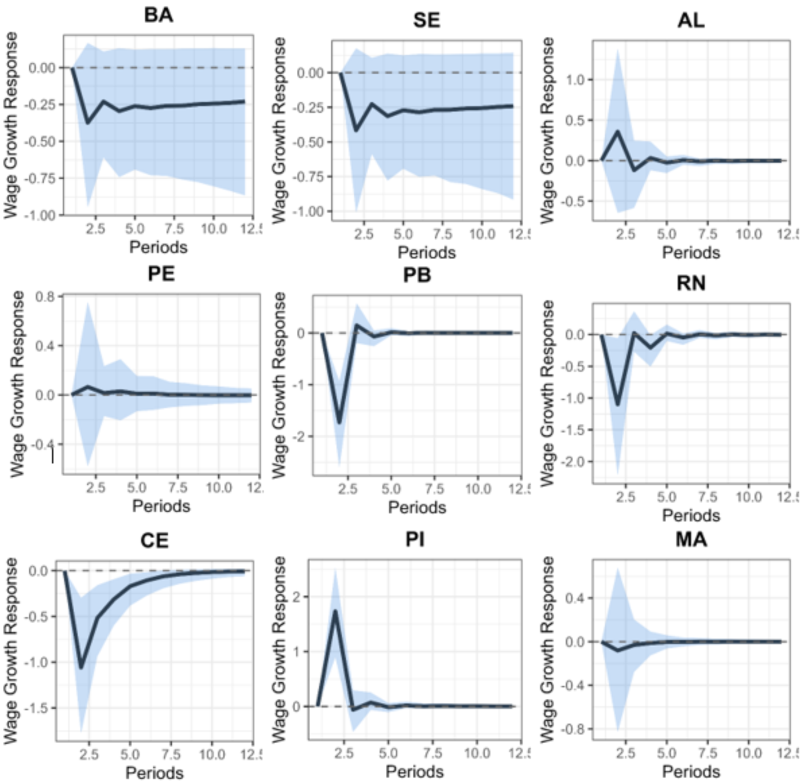
Figure 4.B - BVAR Impulse Response with informal market Functions for BR , RS, SC, PR, SP, RJ, ES, MG, GO and DF



Source: Author's own elaboration.

Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

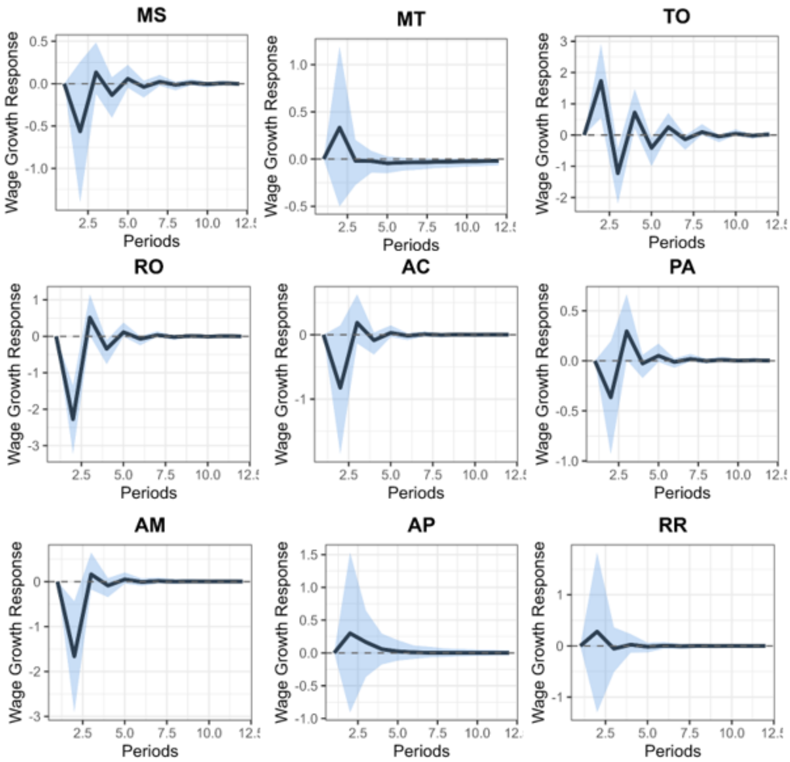
Figure 5.B - BVAR Impulse Response Functions with informal market for BA, SE, AL, PE, PB, RN, CE, PI, and MA



Source: Author's own elaboration.

Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

Figure 6.B - BVAR Impulse-Response Functions with informal market for MS, MT, TO, RO, AC, PA, AM, AP, and RR



Source: Author's own elaboration.

Note: In the figure, the black solid line represents the median of the posterior probability distribution, while the shaded light blue area corresponds to the 68% credibility interval. The x axis represents the periods, while the y axis shows the response of wage growth to a one standard deviation shock in the unemployment gap. For a detailed correspondence between the abbreviations and the Brazilian states (UFs), please refer to Table 2 in Appendix A.

2 The Awakening of the Sleeping Beauty: Identifying the Phillips Curve under Shifts, Shocks, and Spillovers

Resumo

A literatura recente sobre economias desenvolvidas tem explorado a hipótese de uma Curva de Phillips inativa, frequentemente atribuída a expectativas de inflação bem ancoradas ou a fatores estruturais, como a expansão do comércio eletrônico e o aprofundamento da globalização. Em contraste, no contexto brasileiro, a inatividade da Curva de Phillips parece ter derivado de uma postura de política macroeconômica deliberadamente acomodativa. Posteriormente, em meio ao impeachment de um presidente, mudanças recorrentes de política e uma série de choques econômicos e institucionais, o Brasil experimentou um verdadeiro experimento natural macroeconômico. A transição na política macroeconômica acomodática entre 2012 e 2015 para uma postura mais restritiva entre 2016 e 2023, juntamente com a adoção de um novo regime fiscal, representa um ponto de inflexão significativo na condução da política econômica. Nesse contexto, o objetivo deste estudo é identificar a Curva de Phillips salarial regional para o Brasil. Os principais resultados indicam que a Curva de Phillips salarial regional no Brasil apenas "desperta" após a mudança na política macroeconômica, sugerindo que essa relação se torna relevante apenas a partir de 2016, apresentando um coeficiente de inclinação negativo.

Palavras-chave: Curva de Phillips Salarial Regional; Mudanças de Política Econômica; Choques Econômicos; Transbordamentos Espaciais.

Abstract

Recent literature on developed economies has explored hypotheses regarding an inactive Phillips curve, often attributed to well-anchored inflation expectations or structural factors such as the expansion of e-commerce and deepening globalization. In contrast, within the Brazilian context, the inactivity of the Phillips curve appears to have stemmed from a carefully accommodative macroeconomic policy stance. Subsequently, amidst a presidential impeachment, recurring political changes, and a series of economic and institutional shocks, Brazil underwent a genuine natural macroeconomic experiment. The transition from an accommodative macroeconomic policy stance between 2012 and 2015 to a more restrictive one between 2016 and 2023—coupled with the adoption of a new fiscal regime—represents a significant turning point in the conduct of economic policy. Against this backdrop, this study aims to identify the regional wage Phillips curve for Brazil. The main results indicate that the regional wage Phillips curve in Brazil only "awakens"following the shift in macroeconomic policy; the relationship becomes relevant only from 2016 onwards, exhibiting a negative coefficient.

Keywords: Regional Wage Phillips Curve; Policy Shifts; Economic Shocks; Spatial Spillovers.

2.1 Introduction

Recent literature has pointed to a weakening of the traditional relationship between price inflation, wages, and the level of economic activity, usually represented by unemployment and output rates, in both the United States and the European Union. This phenomenon has sparked debate over a possible inactive or asleep Phillips Curve (PC). A recurrent explanation attributes this “dormancy” to the increased credibility and effectiveness of central banks in controlling inflation, which has contributed to the anchoring of inflation expectations. In this context, empirical evidence for the United States, such as that presented by Blanchard (2016),Murphy (2018) e Powell (2018), indicates that although the PC remains analytically relevant, its slope has become significantly flatter since the 1980s, largely reflecting the stabilization of inflation expectations. Another line of research emphasizes structural factors, such as the expansion of online commerce Cavallo (2018) and the deepening of globalization Forbes (2019) e Gao et al. (2024), as additional determinants of the reduced sensitivity of inflation to economic fluctuations. These elements may have contributed to lower cost pass-through to final prices, thereby altering the traditional dynamics of the Phillips Curve observed in previous decades.

Considering this unusual macroeconomic quasi-experiment, this study aims to identify the existence of a trade-off between unemployment and wage inflation in Brazil over the turbulent period from 2012 to 2023. It leverages shifts in macroeconomic policy and broader external and internal shocks, using spatial variation and spillover effects across the 27 Brazilian federative units[1] to estimate a regional wage Phillips Curve.

However, the wage Phillips Curve faces important identification challenges, particularly due to the endogeneity between wage inflation and the unemployment rate. Several authors (Levy, 2019; Abreu e Silva Lopes, 2021; Dovì et al., 2021; Kapetanios et al., 2021; Gabriel, 2023) highlight the possibility of simultaneity between these variables. This simultaneity can arise when cost-push shocks such as fluctuations in the prices of imported inputs or external geopolitical events (e.g., wars or supply constraints in commodity markets) simultaneously impact economic activity and nominal wage inflation. In such cases, the unemployment rate may become correlated with the regression error term, thereby violating the exogeneity assumption required for causal inference. The present study addresses the endogeneity problem by leveraging exogenous shifts in economic policy as an identification strategy, taking advantage of the natural macroeconomic experiment recently experienced in Brazil. It is assumed that these policy shifts are not directly driven by factors related to wage inflation or unemployment, allowing it to be treated as an exogenous event. Consequently, this structural change in the policy regime is expected to

[1] Brazil is composed of 26 states and one federal district, totaling 27 federative units. A Table A.4.1 in the appendix. Throughout this text, the terms “states” and “federative units” are used interchangeably.

induce a shift in the slope of the wage Phillips Curve, providing empirical evidence of a potentially time-varying relationship.

Additionally, the use of spatially disaggregated data allows for advances in the identification and estimation of the Phillips Curve by more effectively addressing issues related to structural heterogeneity and the nature of shocks affecting different local economies. As argued by Fitzgerald et al. (2024) and McLeay e Tenreyro (2020), regional-level data are particularly useful for distinguishing between demand and supply shocks, especially in contexts where monetary policy is centralized and does not necessarily adequately accommodate regional demand shocks. Hazell et al. (2022) observe that, in panel models with time fixed effects, long-term inflation expectations generally homogeneous across regions due to the unified conduct of monetary policy are absorbed by these effects, which allows for a better isolation of the response of real variables, such as wages and unemployment, to specific common shocks. Moreover, regional disaggregation increases the number of available observations, which helps mitigate endogeneity problems frequently associated with limited samples. This approach has been adopted in various economies. In the United States, Beraja et al. (2019) analyze the Phillips curve based on wage data, while Kumar e Orrenius (2016) explore the wage-price version of the Phillips curve. McLeay e Tenreyro (2020) and Hazell et al. (2022) also examine price dynamics at the regional level. For the European Union, LeSage e Pace (2009) investigates the empirical validity of the wage Phillips curve version based on subnational data. In emerging economies such as China, El-Shagi e Tochkov (2024) use regional data to study the transmission mechanisms of inflation, reinforcing the relevance of disaggregated analysis for understanding inflationary dynamics.

The present study estimates panel data models that incorporate both temporal and state fixed effects. Time fixed effects aim to capture common variations associated with wage growth over time, while state fixed effects allow for control of unobserved, time-invariant characteristics specific to each federative unit, such as cultural, institutional, and policy differences. Although the use of regional data with time fixed effects helps isolate aggregate wage trends, this strategy may not fully capture the spatial formation of such wage dynamics. For this reason, the analysis also incorporates the possibility of spatial spillovers in the wage growth rate, with the objective of assessing whether wage changes in a given state are influenced by wage increases or decreases in neighboring states. The hypothesis of spatially interdependent wage adjustment is supported by empirical evidence highlighting the importance of spatial spillovers in the dynamics of the Phillips Curve (Yesilyurt e Elhorst, 2014; Aginta, 2024; Lasarte-Navamuel et al., 2025).

Studies on the Phillips Curve in Brazil have mostly explored the link between inflation and aggregate economic activity, using time series with unemployment or output as measures of activity (Tombini e Alves, 2006; De Mendonça e de Siqueira Galveas, 2013; Machado e Portugal, 2014; Ferreira e Palma, 2015; Ponzoni e Zilli, 2015; Aragón e Medeiros, 2017; Triches e Feijó, 2017; Mansilla et al., 2020; Mendes et al., 2023). In parallel, a less explored strand of the literature has examined the price Phillips Curve using disaggregated data, as in the studies by Sachsida (2009) and dos Santos Fernandes e Portugal (2023). In contrast, the literature on the wage Phillips Curve in Brazil is relatively scarce. One important contribution is the study by Nobrega et al. (2020), which analyzes the relationship between wage inflation and the unemployment rate using aggregate data. In turn, Xavier e de Moura (2023) estimated a version of the wage Phillips Curve for Brazil's 27 states using a panel vector autoregression framework.

Therefore, this study contributes to the literature in three main ways. First, by leveraging the macroeconomic quasi-experiment experienced by the Brazilian economy, it identifies the nonlinearity resulting from shifts in macroeconomic policy, helping to "awaken" the Phillips Curve in Brazil by addressing the endogeneity between wage inflation and unemployment. Second, through the use of regional-level data variation, the study captures both observed and unobserved heterogeneities across states, enabling a more detailed assessment of the asymmetric effects of shocks and policy changes, while also accounting for interactions and spillovers across regions. Finally, by capturing expectation formation through the inclusion of annual fixed effects, and by incorporating a spatial lag of the wage growth rate to account for regional interdependencies, the study provides a more precise characterization of the dynamic relationship between unemployment and wage inflation over time and across Brazilian states.

The main results indicate that the regional wage Phillips Curve in Brazil only "awakens" after the shift in macroeconomic policy, suggesting that such a relationship becomes statistically significant from 2016 onward with a negative slope coefficient. However, the robustness of this finding emerges only when both time fixed effects and state-specific fixed effects are explicitly incorporated, and more importantly, when spatial interdependences and spillovers across regions are taken into account.

In addition to this introduction, the study is organized into four further sections. Section 2.2 discusses the institutional context surrounding the shifts in macroeconomic policy and the major economic external and internal shocks experienced by the Brazilian economy. Section 2.3 details the empirical strategy and the data employed in the analysis. Section 2.4 presents and discusses the main results. Finally, Section 2.5 provides concluding remarks.

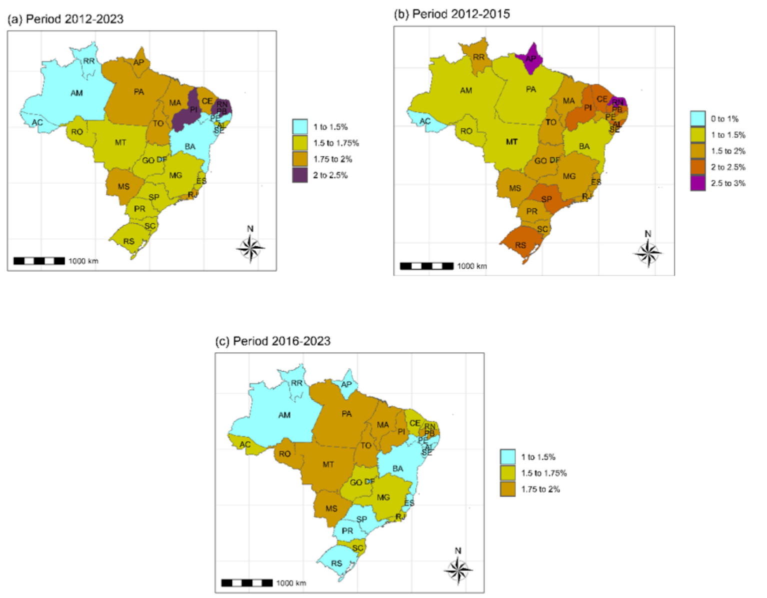
2.2 Policy Shifts and Economic Shocks in Brazil

This return to inflation discipline and fiscal control, however, came at a significant cost to the Brazilian economy. Between 2016 and 2022, the unemployment rate remained at double-digit levels, highlighting a clear trade-off between price stability and economic growth. This scenario reflects a monetary policy focused on inflation control, albeit at the expense of the labor market and economic activity.

Regarding the variations in wage growth across states following changes in macroeconomic policy, Figure 7(b) shows that the period between 2012 and 2015 was characterized by a wide dispersion in wage growth, with states such as Acre state (AC) experiencing an increase of only 0.86%, whereas Rio Grande do Norte state (RN) recorded growth of 2.71%. This dispersion contrasts with the greater uniformity observed in wage growth during the policy period, as illustrated in Figure 7(c), between 2016 and 2023, where the difference between the state with the lowest wage growth (Federal District, DF) and that with the highest growth (Paraíba, PB) was less than one percentage point. Figure 7(a), covering the entire period, suggests that aggregate analysis may obscure wage changes associated with shifts in macroeconomic policy stance.

Furthermore, the lower dispersion of wage growth observed during the 2016-2023 period appears to be more closely related to the underlying inflation dynamics than to a symmetric response to external shocks, such as the COVID-19 pandemic or Ukraine conflict. In this context, inflation control and the adoption of a more restrictive macroeconomic policy may have contributed to reducing the variability of wage growth, thereby promoting greater interregional stability.

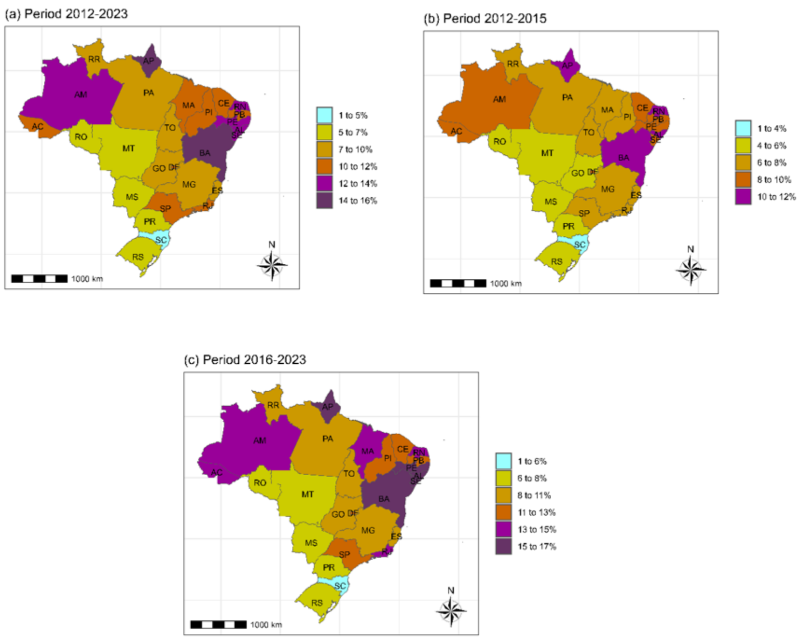
Figure 7 - Average Wage Growth Rate in Brazilian States



Source: Author's own elaboration.
Note: Figure 7 presents a choropleth map of the wage growth rate across Brazil's federative units (UF) over three distinct periods. Figure 7(a) covers the entire period from 2012 to 2023. Figure 7(b) refers to the flexible (dovish) policy period from 2012 to 2015, while Figure 7(c) encompasses the period from 2016 to 2023, characterized by a stricter (hawkish) policy. Percentage variations are color-coded on a scale ranging from light cyan, olive, mustard, burnt orange, purple, to dark violet. The federative units are referred to by their respective abbreviations. For a detailed correspondence between abbreviations and federative units, please refer to Table 11 in the Appendix of this study. The map scale indicates that 1 centimeter on the map corresponds to 1,000 kilometers. The compass rose, located in the lower right corner of the map, shows cardinal directions and aids spatial orientation.

Figures 8(a), 8(b), and 8(c) show that states in the Central-South region consistently exhibited lower unemployment rates compared to those in the North and Northeast regions throughout the analyzed periods. This evidence suggests that using the aggregate national unemployment rate may fail to capture the idiosyncratic specificities and heterogeneities of regional labor markets. For instance, Bahia state (BA) recorded an unemployment rate of 11.26% during the 2012-2015 policy period, contrasting with 17% during the 2016-2023 policy period, a variation potentially explained by multiple exogenous factors. These data indicate potential implications for the slope of the Phillips Curve, given the changes in unemployment rates associated with different phases of macroeconomic policy. Furthermore, it is suggested that the greater dispersion, measured by the standard deviation of wages during the 2016-2023 policy period, may reflect specific dynamics of the local labor market.

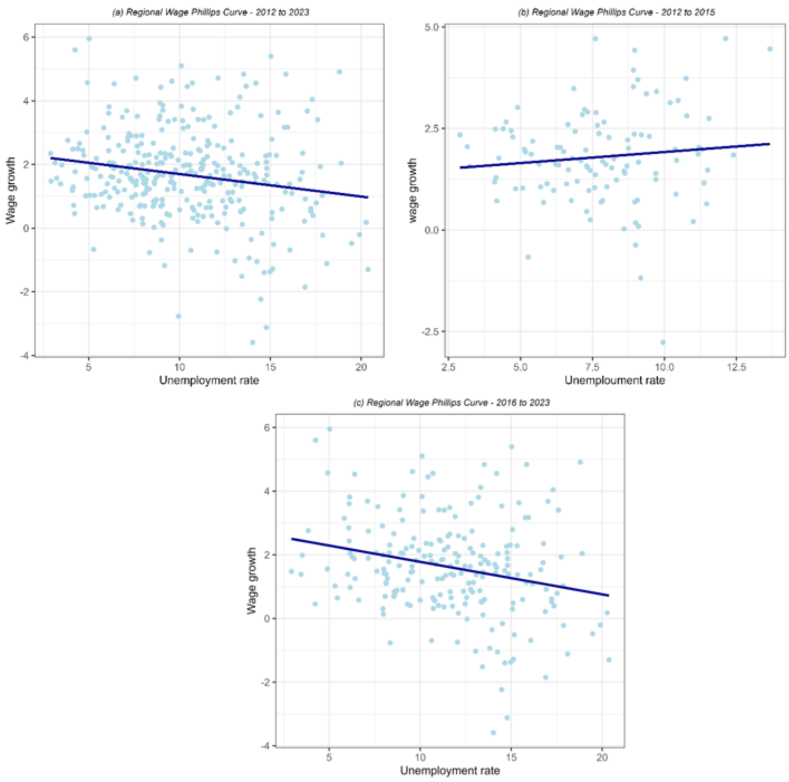
Figure 8 - Unemployment Rate in Brazilian States



Source: Author's own elaboration.
Note: Figure 8 presents a choropleth map of the wage growth rate across Brazil's federative units (UF) over three distinct periods. Figure 8(a) covers the entire period from 2012 to 2023. Figure 8(b) refers to the flexible policy period from 2012 to 2015, while Figure 8(c) encompasses the period from 2016 to 2023, characterized by a stricter policy. Percentage variations are color-coded on a scale ranging from light cyan, olive, mustard, burnt orange, purple, to dark violet. The federative units are referred to by their respective abbreviations. For a detailed correspondence between abbreviations and federative units, please refer to Table 11 in the Appendix of this study. The map scale indicates that 1 centimeter on the map corresponds to 1,000 kilometers. The compass rose, located in the lower right corner of the map, shows cardinal directions and aids spatial orientation.

Figures 9(a), 9(b), and 9(c) display different slopes of the regional wage Phillips Curve estimated using pooled ordinary least squares (OLS). During the 2012–2015 period, the wage Phillips Curve exhibited a positive but statistically insignificant slope, indicating an inactive relationship (see Figure 9(b)). This result may reflect the macroeconomic instability, which impaired the formation of expectations and reduced the responsiveness of economic agents to monetary policy signals. In contrast, between 2016 and 2023—stance—the Central Bank's more assertive approach to meeting inflation targets may have contributed to reduced nominal rigidities, resulting in a steeper wage Phillips Curve. During this interval, the estimated slope was negative and statistically significant (-0.10), indicating a stronger relationship between unemployment and wage growth compared to the earlier period.

Figure 9 - OLS Estimated Regional Wage Phillips Curve



Source: Author's own elaboration.

Note: Figure 9(a) covers the entire period from 2012 to 2023, comprising 324 observations, and displays a regional wage Phillips Curve estimated by OLS with a slope of -0.07, statistically significant at the 1% level. Figure 9(b) corresponds to the flexible policy period from 2012 to 2015, showing a dormant wage Phillips Curve with a positive but statistically insignificant slope, based on 108 observations. Figure 9(c) covers the period from 2016 to 2023, marked by a more restrictive policy stance, and includes 216 observations. In this case, the slope is negative and statistically significant at the 1% level, with a coefficient of -0.10. In the OLS regression , the vertical axis (y) represents the wage growth rate (the dependent variable), while the horizontal axis (x) denotes the unemployment rate. The regression line, shown in dark blue, indicates the estimated slope and the general trend in the data.

2.3 Empirical Strategy

This study aims to identify the regional wage Phillips Curve for Brazil from 2012 to 2023, using regional data from the 27 federative units, while incorporating shifts in macroeconomic policy conduct, economic shocks and spatial spillovers. The goal is to identify potential nonlinearities in the regional wage Phillips Curve that may arise in response to these changes, capturing dynamic variations in the relationship between the wage growth rate π^w_{it} and the unemployment rate u_{it} over the analyzed period, where i represents the specific state and t the time period.

The dummy variable $shift_t$ takes the value 0 for the years 2012 to 2015, corresponding periodo de baixa credibilidade nos indicadores macroeconômicos policy period, and 1 for the years 2016 to 2023, representing período de alta credibilidade nos indicadores macroeconomicos. To assess a possible change in the slope of the regional wage Phillips Curve due to the policy shift, an interaction term between $shift_t$ and the unemployment rate, $shift_t u_{it}$, is included into the regression model to capture whether the effect of unemployment on wage inflation differs across policy regimes.

The formation of expectations in the regional wage Phillips Curve is captured through the temporal dimension. Regarding the temporal dimension, following Hazell et al. (2022) for the United States and Dos Santos Fernandes and dos Santos Fernandes e Portugal (2023) for Brazil, long-term inflation expectations are assumed to be captured by time fixed effects in panel data models. This approach relies on the premise that, while short-term expectations may vary across regions due to local economic conditions, long-term expectations are relatively homogeneous within monetary unions, as they are largely decoupled from the current business cycle. In this study, each Brazilian state is treated as a participant in a common monetary union. The inclusion of time fixed effects thus enables the capture of these long-term expectations, covering the period from 2012 to 2023. Consequently, specific annual dummy variables are incorporated with the aim of explicitly capturing the temporal component of wage inflation expectations and controlling for potential exogenous shocks that may have influenced wage dynamics over the analyzed period.

Furthermore, this study aims to capture the influence of wage growth rates in neighboring regions on the wage growth rate in the region of interest, represented by the spatial lag of the wage growth rate $W\pi^w_{it}$. The spatial weights matrix W was constructed based on the inverse distance criterion, whereby geographically closer regions are assigned relatively higher weights, while more distant regions receive lower weights. This specification incorporates the hypothesis that geographic proximity intensifies interregional interdependence by capturing the attenuating effect of distance on the magnitude of spatial interactions. In the context of wage growth, this approach is particularly relevant, as adjacent regions tend to exhibit stronger linkages whether through labor mobility, market and production connections, or shared macroeconomic conditions. Consequently, wage growth in a given region may exert a more pronounced influence on wage dynamics in neighboring regions. The use of inverse distance as a weighting criterion constitutes an effective representation of spatial interaction, as it reflects the declining spatial effect with increasing distance and indicates that interregional dependence tends to be stronger among geographically closer areas.

In addition to these measures, unobserved heterogeneity in the estimation of the regional wage Phillips Curve is addressed through the inclusion of state-specific fixed effects (μ_i) and time fixed effects represented by annual dummy variables (φ_t). The μ_i control for unobservable characteristics that are constant over time within each state such as cultural, institutional, and policy-related factors unique to each subnational unit. Meanwhile, the φ_t capture not only the evolution of wage growth expectations but also shocks that are common to all states in a given year but vary over time. The specification also includes a constant term α and an error term (ϵ_{it}). As a result, the regional wage Phillips Curve, which incorporates both nonlinearity and spatial spillovers, is formulated as a spatial two-way fixed effect model:

$$\pi_{it}^{w} = \alpha + \rho W \pi_{it}^{w} + \beta u_{it} + \lambda \text{shift}_t u_{it} + \mu_i + \varphi_t + \varepsilon_{it}, \tag{2.1}$$

where in equation (2.1), β and λ are the parameters of interest, capturing the trade-off between the wage growth rate and the unemployment rate. The parameter ρ represents the spatial autoregressive coefficient.

To estimate the regional wage Phillips Curve incorporating nonlinearities, spatial spillovers, and shifts in the conduct of economic policy, disaggregated data by federative unit were employed, with the main source being the Continuous National Household Sample Survey, PNADC, from the acronym in Portuguese. The final dataset comprises all 27 federative units of Brazil, with annual data spanning the period from 2012 to 2023. For each state, annual variables were constructed by averaging the corresponding quarterly data. The aggregation from quarterly to annual frequency is justified by the need to reduce volatility and seasonality inherent in high-frequency series, thereby smoothing transitory fluctuations and short-term noise. Furthermore, the use of annual data enhances comparability across regions and allows for a more robust analysis of medium and long term macroeconomic trends, particularly in a context characterized by external structural shocks and shift in the macroeconomic policy.

The wage growth rate π_{it}^{w} is calculated according to the conventional methodology for determining the percentage change in a variable. Specifically, it corresponds to the ratio between the difference in nominal average earnings between periods t and t-1, and the value observed in t-1. According to the methodology adopted by IBGE (2014), nominal average earnings are computed as the ratio between total labor income and the number of employed individuals, based on quarterly data from the PNADC. The variables used in this study are the following:

a) Unemployment Rate: The rate of unemployment and labor force underutilization observed during the reference week, referring to individuals aged 14 or older;;
b) Wage Growth Rate: Average nominal monthly earnings, usually received in the

reference month, from the main job and all jobs.

For the measurement of the unemployment rate u_{it}, the unemployment rate of individuals aged 14 years or older will be used, considering its variation for each federative unit (UF). This variable serves as a new proxy for the unemployment rate, especially after the discontinuation of the Monthly Employment Survey in 2016.

Table 6 presents descriptive statistics for the main variables, revealing significant variation across different policy regimes. The average unemployment rate during the 2012-2015 period is lower than that observed in both the entire sample and the 2016-2023 period. In contrast, the wage growth rate exhibits a higher average under the 2012-2015 period, although with a lower standard deviation relative to the entire period, suggesting reduced volatility during that phase. Moreover, the patterns of unemployment and wage growth rates reinforce the existence of heterogeneous behaviors associated with the distinct macroeconomic policy regimes.

Table 6 – Descriptive Statistics

2012-2023			
Variable	**Obs**	**Mean**	**SD**
Wage growth rate	324	1.6725	1.4348
Unemployment rate	324	10.3716	3.7464
2012-2015			
Wage growth rate	108	1.8000	1.1762
Unemployment rate	108	7.7820	2.2527
2016-2023			
Wage growth rate	216	1.6771	1.4387
Unemployment rate	216	10.3935	3.7691

Source: Author's own elaboration.
Note: The table reports summary statistics for the variables comprising the regional Phillips Curve specification across three distinct subsamples: the entire period (2012–2023), the period (2012–2015), and the period (2016–2023). "SD"denotes the standard deviation. All values are annual average constructed from quarterly data.

The inclusion of the spatially lagged dependent variable ($W\pi_{it}^{w}$) in model 1 gives rise to what is known as spatial simultaneity, that is, neighboring unit j influences unit i, and vice versa (Anselin e Bera, 1998; LeSage e Pace, 2009; El-Shagi e Tochkov, 2024).

2.4 Results

This section presents the estimates of the regional wage Phillips Curve for Brazil, based on different econometric specifications. The analysis begins with an OLS estimation that includes only the unemployment rate in the baseline specification. Subsequently, the models advance to include state and time fixed effects, as discussed in the literature by

(Levy, 2019; McLeay e Tenreyro, 2020; dos Santos Fernandes e Portugal, 2023). Next, nonlinearities are introduced to capture the effects of shifts in the conduct of economic policy and structural shocks. Subsequently, specifications incorporating spatial interactions are presented in line with the approaches of (Yesilyurt e Elhorst, 2014; Aginta, 2024; Lasarte-Navamuel et al., 2025).

2.4.1 Regional Wage Phillips Curve under Shocks

Equation (2.2) considers only the direct relationship between the wage growth rate π_{it}^{w} and the unemployment rate u_{it}.

$$\pi_{it}^{w} = \alpha + \beta u_{it} + \epsilon_{it} \tag{2.2}$$

Equation (2.3), to account for dynamics common to all states, μ_i state fixed effects were introduced to capture time-invariant individual characteristics specific to each state. Additionally, φ_t will be incorporated to disaggregate time fixed effects, enabling the analysis of the impact of specific shocks in each year.

$$\pi_{it}^{w} = \alpha + \beta u_{it} + \mu_i + \varphi_t + \epsilon_{it} \tag{2.3}$$

Table 7 presents the estimation results of Equations 2 and 3, which analyze the relationship between the unemployment rate and the wage growth rate, considering different specifications across columns (1) to (9). The periods are segmented into three samples: columns (1) to (3) cover the entire period from 2012 to 2023; columns (4) to (6) refer to the period between 2012 and 2015; and columns (7) to (9) correspond to the period from 2016 to 2023. The results indicate that the slope of the regional Phillips Curve varies across the analyzed periods. During the 2012-2015 period, the stabilizing relationship between wage growth and unemployment appears to have broken down, as the estimated coefficients are statistically insignificant. In contrast, during the 2016-2023 period, the expected relationship is reestablished: when controlling only for state fixed effects, the estimated coefficient for the unemployment rate is significant and negative (-0.24), indicating an active regional Phillips Curve. However, when time fixed effects, intended to proxy for temporal expectations and aggregate shocks, are introduced in columns (3) and (9), the estimated relationship becomes statistically insignificant. This indicates that the model may require the inclusion of further explanatory variables to adequately account for the dynamics of the regional wage Phillips Curve.

2.5 Regional Wage Phillips Curve under Policy Shifts and Shocks

To assess changes in the coefficients of the regional wage Phillips Curve resulting from shifts in economic policy, Equation (2.4) incorporates the interaction term between

Table 7 – Baseline Estimates of the Regional Wage Phillips Curve

	2012-2023			2012-2015			2016-2023		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Unemployment rate	-0,07***	-0,13***	-0,03	0,05	-0,14	0,20	-0,10***	-0,24***	-0,05
	(0,01)	(0,02)	(0,05)	(0,04)	(0,19)	(0,32)	(0,02)	(0,04)	(0,08)
Constant	2,40***			1,38***			2,80***		
	(0,13)			(0,31)			(0,22)		
R2 − Adj	0,03	-0,02	-0,13	0,00	-0,32	-0,37	0,05	-0,02	-0,18
N	324	324	324	108	108	108	216	216	216
State fixed effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Annual fixed effects	No	No	Yes	No	No	Yes	No	No	Yes

Source: Author's own elaboration. **Note**: The table reports summary statistics for the variables comprising the regional Phillips Curve specification across three distinct subsamples: the entire period (2012–2023), the period (2012–2015), and the period (2016–2023). "SD" denotes the standard deviation. All values are annual average constructed from quarterly data.

the policy shift and the unemployment rate, capturing potential nonlinearities in the inflation–unemployment relationship:

$$\pi_{it}^{w} = \alpha + \beta u_{it} + \lambda \text{shift}_t u_{it} + \mu_i + \varphi_t + \varepsilon_{it} \tag{2.4}$$

Table 8 presents the estimation results of Equation (2.4), which investigates the relationship between the unemployment rate, wage inflation, and shifts in the conduct of economic policy, based on three different specifications shown in columns (1) to (3). In column (2), the coefficient on the unemployment rate (β) is statistically significant at -0.25 when controlling only for state fixed effects. The regional wage Phillips Curve becomes more robust when time fixed effects are also included: column (3) reveals a negative and significant coefficient (λ) of -0.12.

Table 8 – Estimates of the Regional Wage Phillips Curve under Policy Shifts and Shocks

	(1)	(2)	(3)
Unemployment rate	-0.06**	-0.25***	0.10
	(0.02)	(0.05)	(0.07)
Shift of the unemployment rate	0.00	0.06***	-0.12**
	(0.02)	(0.02)	(0.05)
Constant	2.37***		
	(0.15)		
φ_{2013}			0.99***
			(0.29)
φ_{2014}			0.50*
			(0.30)
φ_{2015}			-0.11
			(0.39)
φ_{2016}			1.60***
			(0.49)
φ_{2017}			0.68
			(0.49)
φ_{2018}			0.65
			(0.50)
φ_{2019}			0.33
			(0.50)
φ_{2020}			1.39**
			(0.54)
φ_{2021}			0.00
			(0.57)
φ_{2022}			3.01***
			(0.48)
φ_{2023}			1.35***
			(0.48)
R2 – Adj	0.03	-0.01	0.21
N	324	324	324
State fixed effects	No	Yes	Yes
Annual fixed effects	No	No	Yes

Source: Author's own elaboration.
Note: Clustered standard errors are reported in parentheses, estimated according to Arellano (1987), allowing for correlation of errors within each federative unit. The stars ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. The table presents panel regressions under different specifications, ranging from column (1) to column (3). In column (1), the model was estimated using pooled OLS. In columns (2) and (3), the model was estimated using the within estimator with state fixed effects, including annual dummies in column (3). "N"refers to the number of observations in each column and "R2 – Adj"refers to the adjusted R-squared.

2.6 Regional Wage Phillips Curve under Policy Shifts, Shocks and Spatial Spillovers

With the objective of investigating possible spillovers in the regional wage Phillips Curve and capturing expectations formed at the regional level, equation (2.1) was employed, following the empirical model described in the adopted strategy. This approach includes the spatial lag term of the wage growth rate, $W\pi^w_{it}$, aiming to capture the impact of wage growth expectations in state i, influenced by higher wage growth rates in neighboring regions. The inclusion of spatial spillovers contributes to the literature on the regional wage Phillips Curve by accounting for interactions, interdependences and spillovers between regions, especially in emerging countries, as empirically demonstrated by Yesilyurt e Elhorst (2014) for Turkey and Aginta (2024) for Indonesia.

Table 9 presents the estimation results of Equation (2.1), with different specifications shown in columns (1) and (2). It can be observed that in the specification of column (2), which includes both state and time fixed effects, the coefficient λ is negative and significant at -0.13, indicating the presence of a downward-sloping wage Phillips Curve for Brazil. It is worth noting that the coefficient of β is not statistically significant, indicating that the wage Phillips Curve remained dormant until the shift in macroeconomic policy orientation that began in 2016 following the presidential impeachment.

Table 9 – Estimates of the Regional Wage Phillips Curve under Policy Shifts, Shocks and Spatial Spillovers

	(1)	(2)
Unemployment rate	-0.11**	0.11
	(0.06)	(0.09)
Shift of unemployment rate	0.02	-0.13**
	(0.02)	(0.06)
Spatial lag of wage inflation	0.21***	-0.13**
	(0.03)	(0.06)
φ_{2013}		1.33***
		(0.35)
φ_{2014}		0.67**
		(0.33)
φ_{2015}		-0.14
		(0.33)
φ_{2016}		1.87***
		(0.61)
φ_{2017}		0.66
		(0.61)
φ_{2018}		0.64
		(0.61)
φ_{2019}		0.18
		(0.61)
φ_{2020}		1.59**
		(0.65)
φ_{2021}		-0.25
		(0.64)
φ_{2022}		3.70***
		(0.67)
φ_{2023}		1.56***
		(0.59)
Pseudo-R2	0.22	0.33
N	324	324
State FE	Yes	Yes
Year FE	No	Yes

Source: Author's own elaboration.
Note: Stars ***, **, * indicate significance at 1%, 5%, and 10% levels. Standard errors in parentheses. Column (1) includes state fixed effects. Column (2) includes state and year fixed effects. Estimations performed using maximum likelihood via the spml function from the splm package in R. Inverse distance matrix based on Euclidean distance.

2.7 Robustness Check

Table 10 presents the estimation results of Equation (2.1) as a robustness check, using several neighborhood matrices to construct the spatial weights, replacing the inverse distance matrix employed in the main results. This alternative specification allows for investigating whether the spatial influence among directly neighboring states alters the previously obtained conclusions.

Table 10 – Estimates of the Regional Wage Phillips Curve under Policy Shifts, Shocks, and Spatial Spillovers using the Queen Contiguity and Alternative Nearest Neighbor Matrices

	Queen Contiguity	**5 Nearest Neighbors**	**6 Nearest Neighbors**
Unemployment rate	0,09	0,11	0,11
	(0,09)	(0,09)	(0,09)
Shift of the unemployment rate	-0,11**	-0,12*	-0,12*
	(0,06)	(0,06)	(0,06)
Spatial lag of the wage inflation rate	-0,12*	-0,21**	-0,22**
	(0,06)	(0,10)	(0,11)
φ_{2013}	1,12***	1,20***	1,21***
	(0,32)	(0,33)	(0,34)
φ_{2014}	0,53	0,61*	0,61*
	(0,32)	(0,33)	(0,33)
φ_{2015}	-0,11	-0,08	-0,08
	(0,33)	(0,33)	(0,33)
φ_{2016}	1,66***	1,72***	1,72***
	(0,60)	(0,60)	(0,60)
φ_{2017}	0,70	0,60	0,60
	(0,62)	(0,62)	(0,62)
φ_{2018}	0,59	0,57	0,55
	(0,61)	(0,61)	(0,61)
φ_{2019}	0,25	0,18	0,15
	(0,61)	(0,61)	(0,61)
φ_{2020}	1,46**	1,43**	1,44**
	(0,65)	(0,65)	(0,65)
φ_{2021}	-0,11	-0,24	-0,24
	(0,63)	(0,64)	(0,64)
φ_{2022}	3,27***	3,50***	3,50***
	(0,60)	(0,62)	(0,63)
φ_{2023}	1,34**	1,45**	1,43**
	(0,59)	(0,59)	(0,59)
Pseudo-R2	0,33	0,34	0,33
N	324	324	324
State fixed effects	Yes	Yes	Yes
Annual fixed effects	Yes	Yes	Yes

Source: Author's own elaboration.

Note: The stars ***, **, * denote statistical significance at the 1%, 5%, and 10% levels, respectively. The columns present different neighbor specifications, ranging from the two to the six nearest neighbors. In all columns, the model was estimated using the within estimator with state fixed effects, additionally including annual dummies. Estimations were annual dummies were included estimations were performed using maximum likelihood via the spml function from the splm package in R. The spatial weights matrix adopted was constructed based on queen contiguity. "N"refers to the number of observations in each column. The "Pseudo-R^2"refers to a measure of model fitness that indicates how well the independent variables explain the variability of the dependent variable in spatial models.

The coefficient of the unemployment rate shift (λ) is negative and statistically significant, corroborating the existence of a negatively sloped regional Phillips Curve in the Brazilian context. Notably, the coefficient β is not statistically significant, indicating that the regional wage Phillips Curve was dormant prior to the macroeconomic policy shift.

2.8 Concluding Remarks

In a nutshell, the impeachment of a president, the drastic shift in macroeconomic policy orientation, the economic crisis, and a series of internal and external shocks such as the pandemic and international conflicts turned Brazil into a large laboratory for analyzing the behavior of the Phillips Curve under extreme conditions. It can be argued that amid this turbulence and multiple disruptions, the Phillips Curve finally woke up. This natural macroeconomic experiment enabled the empirical identification of the trade-off between wage growth and unemployment. Such identification may have only been feasible because Brazil is an emerging economy, subject to the challenges and uncertainties characteristic of this group of countries. It is worth noting that in developed economies, where macroeconomic frameworks tend to be more rigid and institutional arrangements more stable, the likelihood of such abrupt and unexpected shifts is considerably lower.

The use of regional data variation was also crucial for the identification of the Phillips Curve, as it allowed the incorporation of an additional dimension of expectation formation namely, the spatial spillovers from neighboring regions' wage growth rates. Furthermore, this approach made it possible to account for the specificities and structural characteristics of local labor markets in their responses to shifts in macroeconomic policy.

Finally, this study opens avenues for future research. In particular, further developments may incorporate additional spatial mechanisms into DSGE models, including the role of inflation and productivity in neighboring regions within the wage-setting process. In this context, it is possible to assume that a share of households that do not adjust wages may index them according to expectations regarding wages in neighboring regions. By integrating regional empirical evidence with structural macroeconomic modeling, this thesis may, in future research, contribute to advancing the literature on inflation dynamics and the Phillips Curve in emerging economies.

Appendix

Table 11-Initials and Names of Federative Units and Macro-Regions

Macro-Region or State		**Macro-Region or State**	
Macro-Region or State	**Initials**	**Macro-Region or State**	**Initials**
North	N	**Southeast**	SE
Rondônia	RO	Minas Gerais	MG
Acre	AC	Espírito Santo	ES
Amazonas	AM	Rio de Janeiro	RJ
Roraima	RR	São Paulo	SP
Pará	PA		
Amapá	AP		
Tocantins	TO	**South**	S
Northeast	NE	Paraná	PR
Maranhão	MA	Santa Catarina	SC
Piauí	PI	Rio Grande do Sul	RS
Ceará	CE		
Rio Grande do Norte	RN		
Paraíba	PB	**Center-West**	CW
Sergipe	SE	Mato Grosso do Sul	MS
Bahia	BA	Mato Grosso	MT
Alagoas	AL	Goiás	GO
Pernambuco	PE	Distrito Federal	DF

Source: Author's own elaboration.

Conclusions

This thesis investigated the Phillips Curve in the Brazilian economy through complementary empirical approaches that explicitly incorporated regional heterogeneity and changes in the macroeconomic policy regime. By combining regional BVAR models with panel and spatial econometric techniques, the study sought to provide a broader understanding of the relationship between unemployment, wage inflation, and macroeconomic dynamics in Brazil.

The results of the first essay demonstrated that the relationship between unemployment and wage inflation is not homogeneous across Brazilian federative units. The BVAR estimations revealed substantial regional heterogeneity in the responses of wage inflation to unemployment gap shocks, both in the aggregate labor market and when distinguishing between formal and informal sectors. These findings suggest that local labor market structures, informality, and regional economic conditions play an important role in shaping wage dynamics. In this sense, the evidence indicates that analyses based solely on aggregate national data may overlook relevant asymmetries in the transmission of labor market shocks across regions.

The second essay showed that the conduct of macroeconomic policy is crucial for understanding the behavior of the Phillips Curve in Brazil. The findings indicate that the wage Phillips Curve became statistically significant only after the shift from a predominantly 2012-2015 to 2016-2023 macroeconomic policy regime beginning in 2016. This result suggests that the apparent inactivity of the Phillips Curve in previous years may have been associated not necessarily with the disappearance of the inflation–unemployment trade-off itself, but rather with the specific institutional and policy environment prevailing during that period. Moreover, the spatial panel estimations highlighted the importance of regional spillovers, indicating that wage dynamics and expectation formation are influenced not only by local economic conditions but also by developments in neighboring regions.

Taken together, the findings of this thesis suggest that the Phillips Curve in Brazil cannot be understood as a stable and homogeneous relationship. Instead, its behavior depends on regional labor market characteristics, the institutional and macroeconomic policy environment, and spatial interactions affecting wage formation. The evidence also indicates that regional heterogeneity and spillover effects are important dimensions for understanding inflation dynamics in a large and diverse emerging economy such as Brazil.

From a policy perspective, the results highlight the challenges faced by a centralized monetary authority operating within a highly heterogeneous economy. Since labor market conditions and wage dynamics differ substantially across regions, uniform monetary policy responses may generate asymmetric effects throughout the country. Therefore, the thesis reinforces the importance of incorporating regional information into macroeconomic analysis and policy evaluation.

REFERENCES

Abreu, D. S. e Silva Lopes, A. (2021). How to disappear completely: nonlinearity and endogeneity in the new keynesian wage phillips curve. *Applied Economics Letters*, 28(9):774–778.

Aginta, H. (2024). Inflation and spatial spillovers in a large archipelago: Evidence from indonesia. *Economic Papers: A journal of applied economics and policy*, 43(1):91–103.

Anselin, L. e Bera, A. K. (1998). Spatial dependence in linear regression models with an introduction to spatial econometrics. *Statistics textbooks and monographs*, 155:237–290.

Aragón, E. e Medeiros, G. (2017). Estimação da curva de phillips novo-keynesiana para o brasil: uma análise econométrica robusta a problemas de identificação. *45 Encontro Nacional de Economia-ANPEC*.

Arellano, M. (1987). Computing robust standard errors for within-groups estimators. *Oxford Bulletin of Economics & Statistics*, 49(4).

Beraja, M., Hurst, E. e Ospina, J. (2019). The aggregate implications of regional business cycles. *Econometrica*, 87(6):1789–1833.

Blanchard, O. (2016). The phillips curve: back to the'60s? *American Economic Review*, 106(5):31–34.

Cavallo, A. (2018). More amazon effects: online competition and pricing behaviors. Relatório técnico, National Bureau of Economic Research.

De Campos, M. J. C., Lima, R. C. e de Campos, L. H. R. (2010). Investigação sobre o relacionamento do desemprego, dos salários e da inflação no brasil pós-real. *Revista Economia & Desenvolvimento*, 9(1):109–148.

De Mendonça, H. F. e de Siqueira Galveas, K. A. (2013). Transparency and inflation: What is the effect on the brazilian economy? *Economic Systems*, 37(1):69–80.

dos Santos Fernandes, G. e Portugal, M. S. (2023). Flattening of the phillips curve in brazil after inflation targeting: evidence from a multi-region model with time-varying parameters. Relatório técnico, Tech. rep., Unpublished manuscript. 5.1.

Dovì, M.-S., Koester, G. e Nickel, C. (2021). Addressing the endogeneity of slack in phillips curves.

El-Shagi, M. e Tochkov, K. (2024). Regional heterogeneity and the provincial phillips curve in china. *Economic Analysis and Policy*, 81:1036–1044.

Ferreira, D. e Palma, A. A. (2015). Forecasting inflation with the phillips curve: A dynamic model averaging approach for brazil. *Revista Brasileira de Economia*, 69(4):451–465.

Fitzgerald, T., Jones, C., Kulish, M. e Nicolini, J. P. (2024). Is there a stable relationship between unemployment and future inflation? *American Economic Journal: Macroeconomics*, 16(4):114–142.

Forbes, K. J. (2019). Inflation dynamics: Dead, dormant, or determined abroad? *NBER Working paper*, (w26496).

Gabriel, R. D. (2023). Monetary policy and the wage inflation-unemployment tradeoff. *European Economic Review*, 159:104565.

Gao, L., Abbas, S. K. e Lan, H. (2024). Globalization and inflation dynamics: evidence from emerging economies. *Applied Economics*, 56(42):5072–5089.

Hazell, J., Herreno, J., Nakamura, E. e Steinsson, J. (2022). The slope of the phillips curve: evidence from us states. *The Quarterly Journal of Economics*, 137(3):1299–1344.

IBGE (2014). Pesquisa nacional por amostra de domicílios contínua: Notas metodológicas. Relatório Técnico 1, Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro.

Kapetanios, G., Price, S., Tasiou, M. e Ventouri, A. (2021). State-level wage phillips curves. *Econometrics and Statistics*, 18:1–11.

Kumar, A. e Orrenius, P. M. (2016). A closer look at the phillips curve using state-level data. *Journal of Macroeconomics*, 47:84–102.

Lasarte-Navamuel, E., Pérez-Rivero, J. L. e Montania, C. (2025). An empirical analysis of regional phillips curve with spatial dependence. *Regional Science Policy & Practice*, 17(2):100162.

LeSage, J. e Pace, R. K. (2009). *Introduction to spatial econometrics*. Chapman and Hall/CRC.

Levy, A. (2019). The euro area phillips curve: identification with regional data. *Unpublished manuscript, Department of Economics, Massachusetts Institute of Technology*, 9.

Litterman, R. B. (1980). *Bayesian procedure for forecasting with vector autoregressions*. Massachusetts Institute of Technology.

Machado, V. d. G. e Portugal, M. S. (2014). Phillips curve in brazil: an unobserved components approach. *Estudos Econômicos (São Paulo)*, 44:787–814.

Mansilla, F. M., Arruda, E. F. e Ferreira, R. T. (2020). Trade openness and inflation dynamics in brazil". *Economics Bulletin*, 40(3):1948–1957.

McLeay, M. e Tenreyro, S. (2020). Optimal inflation and the identification of the phillips curve. *NBER macroeconomics annual*, 34(1):199–255.

Mendes, I. M. B. R., Lima, R., Aragón, E. K. S. B. e Medeiros, G. B. (2023). Identifying the new keynesian phillips curve with monetary shocks for brazil. Em *50 Encontro Nacional de Economia - ANPEC*.

Mineva, A. e Popivanov, D. (1996). Method for single-trial readiness potential identification, based on singular spectrum analysis. *Journal of neuroscience methods*, 68(1):91–99.

Miranda-Agrippino, S. e Ricco, G. (2018). Bayesian vector autoregressions. Discussion Paper 1808, Centre for Macroeconomics (CFM).

Murphy, A. (2018). The death of the phillips curve?

Nobrega, W. C. L., da Nóbrega Besarria, C. e de Oliveira, F. A. (2020). Unemployment rate and wage growth in brazil: Evidence from a markov-switching model. *Economia Aplicada*, 24(2):171.

Oliveira, L. e Feijó, F. T. (2015). Curva de phillips com mudança de regime markoviano: Uma análise da economia brasileira para o período 1995-2014. *XLIII Encontro Nacional de Economia, Florianópolis*, 8:a11.

Ponzoni, G. A. e Zilli, J. B. (2015). Unemployment and inflation: An estimated phillips curve for brazil (2002-2014). *Journal of Finance and Economics*, 3(5):77–85.

Powell, J. H. (2018). Monetary policy and risk management at a time of low inflation and low unemployment. *Business Economics*, 53(4):173–183.

Sachsida, A. (2009). Reexaminando a curva de phillips brasileira com dados de seis regiões metropolitanas. Relatório técnico, Texto para Discussão.

Sachsida, A., Schettini, B. P. e Gouvêa, R. R. (2017). Inflação, desemprego e choques cambiais: estimativas var para a economia brasileira. *Análise Econômica*, 35(67).

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica: journal of the Econometric Society*, páginas 1–48.

Tombini, A. A. e Alves, S. A. L. (2006). The recent brazilian disinflation process and costs. *Central Bank of Brazil Working Paper Series*, 109.

Triches, D. e Feijó, F. T. (2017). Uma estimação da curva de phillips híbrida para o brasil no regime de metas de inflação. *Economia Aplicada*, 21(1):29–43.

Xavier, A. A. C. X. e de Moura, F. R. (2023). Curva de phillips salarial novo-keynesiana para o brasil: novas evidências com dados regionais. *Revista Brasileira de Estudos Regionais e Urbanos*, 17(2):262–290.

Yesilyurt, F. e Elhorst, J. P. (2014). A regional analysis of inflation dynamics in turkey. *The Annals of regional science*, 52(1):1–17.