Amabile Ferrazoli

Modeling Inflation Dynamics in the United States and Brazil: A Study of Structural and Unrestricted Econometric Approaches

São Paulo

2024

Amabile Ferrazoli

Modeling Inflation Dynamics in the United States and Brazil: A Study of Structural and Unrestricted Econometric Approaches

Dissertação apresentada ao programa de Mestrado em Economia como requisito parcial para obtenção do título de Mestre em Economia.

Orientador: Prof. Dr. Gino Abraham Olivares Leandro

Área de concentração: Economia

Linha de Pesquisa: Macroeconomia

Insper Instituto de Pesquisa

São Paulo

2024

FERRAZOLI, Amabile.

Modeling Inflation Dynamics in the United States and Brazil: A Study of Structural and Unrestricted Econometric Approaches

Amabile Ferrazoli; – São Paulo, 2024. 97 f.

Dissertação (Mestrado) – Insper, 2024.
Orientador: Gino Abraham Olivares Leandro

1. Inflação; 2. Modelagem Econométrica; 3. Modelos VAR e SVAR; 4. Brasil; 5. Estados Unidos

JEL: E31 | E24 | E30 | E52 | C32

Amabile Ferrazoli

Modeling Inflation Dynamics in the United States and Brazil: A Study of Structural and Unrestricted Econometric Approaches

Dissertação apresentado ao programa de Mestrado em Economia como requisito parcial para obtenção do título de Mestre em Economia.

Orientador: Prof. Dr. Gino Abraham Olivares Leandro

Área de concentração: Economia

Linha de Pesquisa: Macroeconomia

Banca Examinadora

_____

Prof. Dr. Gino Abraham Olivares Leandro

Insper

_____

Prof. Dr. Miguel Maria Charters de Oliveira Bandeira da Silva

Insper

_____

Marcelo Kfoury Muinhos

Fundação Getúlio Vargas (FGV)

Acknowledgements

I would like to thank my parents, Maurilio and Maria, who have always been the foundation of my life. Through their sacrifices, they provided me with the best education possible despite financial challenges. More importantly, they taught me invaluable lessons about respect, honor, and what truly matters in life.

I'm also deeply grateful to my brother, Enzo, whose support and cheerful spirit have always comforted me, especially during the most difficult times. His presence constantly reminds me that I am never alone.

Finally, I want to thank my fiancé, Norberto. Our story began during this academic journey, and I'm grateful every day that it did, because in you I found my partner for life.

Abstract

This thesis consists of two essays examining inflation dynamics through econometric modeling, with distinct analyses of the United States and Brazil, particularly during and after the COVID-19 pandemic.

The first essay analyzes inflation dynamics in the United States, benchmarking the Bernanke & Blanchard Structural Vector Autoregression with Exogenous Variables (SVAR-X) models against unrestricted Vector Autoregression (VAR-X) and modified SVAR frameworks. It specifically addresses the structural limitations highlighted by the Bernanke and Blanchard (2023, 2024) model, demonstrating that rigidity in standard model assumptions can obscure critical interactions among wage growth, price inflation, and inflation expectations. The findings indicate significant feedback loops and highlight how structural assumptions impact the perceived role of labor market dynamics, sectoral price shocks, and inflation expectations, especially under the unprecedented disruptions brought by the pandemic.

The second essay adapts and expands the modeling approach to Brazil's unique economic conditions, incorporating explicit adjustments for inflation expectations within an inflation-targeting regime. This essay demonstrates how structural factors—such as indexation, policy volatility, and expectation deviations from targets—significantly influence inflation persistence in an emerging market. The empirical results highlight Brazil's greater sensitivity to supply-side shocks and the critical role of wage-setting mechanisms. Methodological refinements, including the explicit modeling of policy credibility and labor market tightness through novel indicators, provide nuanced insights into the limitations of standard developed markets oriented econometric approaches when applied to emerging economies.

Keywords: Inflation; Econometric Modeling; VAR and SVAR Models; Brazil; United States

Resumo

Esta tese é composta por dois ensaios que examinam a dinâmica inflacionária por meio de modelagem econométrica, com análises distintas para os Estados Unidos e o Brasil, particularmente durante e após a pandemia da COVID-19.

O primeiro ensaio analisa a dinâmica da inflação nos Estados Unidos, utilizando como referência o modelo Estrutural de Vetores Autorregressivos com Variáveis Exógenas (SVAR-X) de Bernanke & Blanchard, comparado aos modelos irrestritos de Vetores Autorregressivos (VAR-X) e estruturas modificadas de SVAR. Especificamente, aborda as limitações estruturais destacadas pelo modelo de Bernanke e Blanchard (2023, 2024), demonstrando que a rigidez nas suposições padrão pode obscurecer interações críticas entre crescimento salarial, inflação de preços e expectativas inflacionárias. Os resultados apontam para ciclos significativos de retroalimentação e destacam como pressupostos estruturais influenciam a percepção sobre o papel das dinâmicas do mercado de trabalho, choques setoriais de preços e expectativas de inflação, especialmente diante das disrupções sem precedentes causadas pela pandemia.

O segundo ensaio adapta e expande essa abordagem de modelagem às condições econômicas específicas do Brasil, incorporando ajustes explícitos para expectativas inflacionárias dentro de um regime de metas de inflação. Este ensaio demonstra como fatores estruturais — como indexação, volatilidade de políticas e desvios das expectativas em relação às metas — influenciam significativamente a persistência inflacionária em uma economia emergente. Os resultados empíricos destacam a maior sensibilidade do Brasil a choques do lado da oferta e o papel crítico dos mecanismos de formação salarial. Refinamentos metodológicos, incluindo a modelagem explícita da credibilidade das políticas e do aperto do mercado de trabalho por meio de indicadores inovadores, fornecem percepções detalhadas sobre as limitações das abordagens econométricas tradicionais orientadas a mercados desenvolvidos, quando aplicadas a economias emergentes.

Palavras-chave: Inflação; Modelagem Econométrica; Modelos VAR e SVAR; Brasil; Estados Unidos

Summary of contents

List of tables

List of figures

1. STRUCTURAL AND UNRESTRICTED APPROACHES TO INFLATION MODELING IN THE US

1.1. INTRODUCTION

The pandemic-induced surge in global inflation starting in 2021 caught central bankers and economists largely off guard. Initially dismissed as transitory, inflation was underestimated despite unprecedented fiscal and monetary interventions. In advanced economies, such as the United States and the Eurozone, central banks maintained stable inflation forecasts, overlooking the inflationary risks posed by expansive fiscal relief and persistent supply-chain disruptions. Emerging economies, however, experienced compounded challenges, including volatile commodity prices, currency depreciation, and constrained policy flexibility, which amplified inflationary pressures.

Traditional economic theory links inflationary pressures to expansionary fiscal policies and labor market dynamics. While many argued that inflation risk was muted due to stable expectations and a flat Phillips curve, others warned that large-scale fiscal transfers and monetary easing could lead to overheating, steepening the Phillips curve, and destabilizing expectations. In hindsight, the interaction between robust aggregate demand, supply-side constraints, and price shocks in goods markets revealed critical gaps in understanding inflation dynamics, particularly during periods of structural disruption.

Recent studies, such as Bernanke and Blanchard (2023, 2024), provide a valuable framework for understanding pandemic-era inflation, attributing initial surges to price shocks with labor market tightness contributing to persistent inflation. However, these models rely on heavily restricted SVAR-X structures that may not fully capture the complexity of inflation dynamics, especially in emerging markets where structural factors, high indexation, and policy volatility dominate. The alternative modeling approaches employed in this study, including unrestricted VAR and modified SVAR-X frameworks, demonstrate how the rigidity of the benchmark model's assumptions can obscure critical feedback loops and context-specific interactions. This study addresses these gaps by proposing a more flexible modeling framework that relaxes restrictive assumptions, enabling a deeper exploration of inflation dynamics across diverse economic contexts.

1.2. LITERATURE REVIEW

The COVID-19 pandemic has sparked significant debate and analysis regarding the unprecedented surge in global inflation. Various scholars have attempted to decompose and explain the factors driving inflation across different economic contexts, offering new theories and revisiting existing models. Studies provide insights into how sectoral shocks, labor market tightness, and flaws in traditional inflation models contributed to these price dynamics. They also reveal the complex interaction of supply-side disruptions, fiscal and monetary policies, and nonlinear inflation patterns.

Ball et al. (2022) focus on the empirical decomposition of inflation during the pandemic, breaking it down into weighted median inflation and a residual component, defined as headline inflation minus median inflation. Their approach aims to remove large price spikes, including those from sectoral shortages, to better understand the inflation dynamics. They find that the surge in overall inflation primarily resulted from shocks to the residual component, with labor market tightness becoming an increasingly significant driver of median inflation. Their study highlights the complexities of inflation measurement and the importance of considering sectoral imbalances.

Guerrieri, Lorenzoni, Straub, and Werning (2022) present an innovative theory of Keynesian supply shocks. The authors investigate how shocks that reduce potential output in one sector can reduce demand in other sectors, ultimately causing aggregate economic activity to fall below its potential. They identify conditions under which these Keynesian supply shocks are more likely to occur: specifically, when the elasticity of substitution between sectors is low, the intertemporal elasticity of substitution is high, and markets are incomplete. The study also examines the implications for fiscal policy, suggesting that while fiscal multipliers might be smaller, the insurance benefits of fiscal transfers can be significant. The paper explores how firm's exits plus job destruction can amplify and propagate the economic impact of these shocks. This approach provides a distinct perspective on the interplay between supply and demand during the pandemic, highlighting the complex and interdependent nature of economic sectors and the potential for broader economic downturns resulting from sector-specific supply disruptions.

Gagnon and Sarsenbayev (2022) in their paper argue that the low and stable inflation observed in advanced economies for about 25 years before the COVID-19 pandemic came at the cost of consistently higher than necessary unemployment rates. They attribute this persistent policy error to the major flaw in standard macroeconomic models: the use of a linear Phillips curve. They contend that this flaw would have been less detrimental if central banks had aimed for a higher inflation

target. Their analysis supports the case for a moderately higher inflation target and emphasizes the need for central banks to use a broader range of economic models. Furthermore, they advocate for occasionally running the economy hot to identify emerging inflationary pressures before tightening policy, which would help central banks verify their estimates of the natural rate of unemployment more accurately.

Cecchetti et al. (2023) place the recent inflation in a historical context, utilizing a stripped-down model of the inflation process with a New Keynesian framework. They emphasize the importance of nonlinearities in the Phillips curve, arguing that these are crucial for explaining the recent inflation surge. Their analysis suggests that disinflation is likely to be costly and criticizes the Federal Reserve for not tightening monetary policy preemptively. They highlight the challenges of reducing inflation once it becomes entrenched and stress the need for timely policy interventions to prevent persistent inflationary pressures.

Benigno and Eggertsson (2023) propose a non-linear New Keynesian Phillips curve to explain the recent inflation surge, attributing it primarily to an exceptionally tight labor market. By measuring economic slack using the ratio of job vacancies to unemployed workers, they reveal significant nonlinearities in inflation dynamics, which traditional flat Phillips curve models failed to capture. Their model, incorporating search and matching frictions and wage rigidity, suggests that appropriate monetary policy can curb inflation without causing a major recession. They argue that policymakers underestimated inflation risks due to stable inflation expectations and misinterpretation of labor market conditions, influenced by the COVID-19 pandemic. Their findings imply that addressing inflation caused by labor shortages may be less costly than previously thought, emphasizing the need for recognizing nonlinearities in inflation for effective policy-making.

Gagliardone and Gertler (2023) explore the monetary-policy origins of recent inflation using a calibrated Dynamic Stochastic General Equilibrium (DSGE) model. They argue that the Federal Reserve's commitment to high employment, despite inflationary oil price shocks, led to a significant increase in price levels. Their study underscores the role of the Fed's policy framework and reaction function in exacerbating inflationary pressures by over-expanding aggregate demand during the pandemic recovery.

Koch and Noureldin (2023) conduct a post-mortem analysis of the International Monetary Fund's (IMF) failure to accurately forecast global inflation. They identify increased aggregate demand and pandemic-induced supply constraints as critical factors that triggered inflation. Their work points to the over-estimation of output gaps, which led to excessive economic stimulus as a

significant miscalculation. They emphasize the need for improved understanding of these dynamics to enhance future inflation forecasting accuracy. Their study also underscores the importance of considering global demand and supply factors in inflation analysis.

Bernanke and Blanchard (2023) develop and estimate a dynamic model of prices, wages, and inflation expectations to analyze the effects of product-market and labor-market shocks on prices and wages. They find that the inflation surge beginning in 2021 was primarily driven by price shocks, such as sharp increases in commodity prices and sectoral price spikes due to strong aggregate demand and supply constraints, rather than by overheated labor markets. This approach differs from other studies by emphasizing the impact of price shocks over labor market conditions on inflation. The study reveals that while labor market tightness has not been the main driver of inflation, its effects on nominal wage growth and inflation are more persistent. The authors provide a decomposition of the sources of pandemic-era inflation, highlighting the significant role of commodity prices and sectoral shortages. They conclude that controlling inflation will require balancing labor demand and supply, but the immediate pressures were mainly due to price shocks. This comprehensive analysis, considering both direct and indirect effects through inflation expectations, distinguishes their work from other studies focusing solely on labor market conditions or sectoral shocks.

In an update of the same model with an analysis of pandemic-era inflation across eleven economies, Bernanke and Blanchard (2024) extended their previous model used to study U.S. inflation to a global context. This paper evaluated the inflation dynamics in various advanced economies by applying a similar framework that accounts for consumer prices, wages, and inflation expectations. The findings highlighted that, similar to the U.S., initial inflation surges in these countries were driven predominantly by adverse relative price shocks and sectoral shortages rather than labor market tightness. As these shocks stabilized or reversed, the influence of tight labor markets on sustained inflation became more pronounced. However, the specifics varied by country, particularly in the relative importance of energy shocks, price shocks, and the effects of labor market pressures on wage and price inflation. This comprehensive approach underscored the necessity for some countries to implement labor market adjustments to achieve their inflation targets, emphasizing the diverse nature of inflationary pressures across different economic contexts.

1.3. METHODOLOGY

To investigate the dynamics of inflation during and after the pandemic, this study employs a multi-phase approach, integrating foundational models with alternative frameworks. The methodology aims to rigorously analyze inflation drivers across advanced and emerging economies, with particular emphasis on the United States and Brazil. By evaluating these models in distinct economic contexts, we seek to uncover insights that can inform both theoretical understanding and practical policy decisions.

An important limitation must be addressed. The model does not provide a comprehensive general equilibrium explanation for the origins of inflation because it treats several variables as exogenous. Specifically, it takes the relative price of energy, the relative price of food, the measure of shortages, productivity growth, and the degree of labor market slack as given. Since the analyzed economies are small in terms of price formation, results should not deviate much from a more comprehensive model.

1.3.1. Benchmarking the Bernanke & Blanchard (B&B) model

This analysis begins by adopting the Bernanke and Blanchard (2023, 2024) framework as a benchmark. Their model, built on a Structural Vector Autoregression with Exogenous Variables (SVAR-X), provides a structured approach to capturing the interplay between nominal wages, prices, and inflation expectations. The SVAR-X framework incorporates several key relationships.

The model consists of four equations that collectively determine nominal wages, prices, and short-term and long-term inflation expectations. Later, we will discuss the lack of data on the analyzed countries and manage proper proxies for the used variables.

Wages equation

The B&B model starts with an aggregate wage equation. It makes the standard assumption that nominal wages depend on the expected price level and the degree of labor market slack. In a departure from the standard specification, the model examines whether workers accept losses in

purchasing power resulting from unanticipated price shocks or if, in their wage bargaining, they try to "catch up" with prior inflation.

$$w = \mathbb{E}(p) + \omega^A + \beta x + \gamma(pty) \quad (1)$$

In the equation above, w is the log-level of the nominal wage, $\mathbb{E}(p)$ is the expected log-level of price for the quarter, ω^A is the the log-level aspiration real wage, the x is an indicator of the tightness of the labor market and the pty is the labor productivity.

As wages, prices and expected prices are in log-levels, differences are growth rates. The ω^A (aspiration real wage) of the model is a tool for modeling a possible catch-up effect of workers seeking to make up for past losses of purchasing power. That implies a degree of real-wage rigidity. The aspiration wage should be read as the real wage that workers believe is feasible. Alternatively, it can represent the long-run equilibrium real wage, toward which the actual real wage gradually adjusts.

The B&B model assumes that the aspiration real wage in each quarter is a weighted average of the previous quarter's aspiration wage and realized real wage, added to a shock term z^ω, standing for all the other factors that influence wage determination.

$$\omega^A = \alpha\omega^A_{-1} + (1-\alpha)(w_{-1} - p_{-1}) + z^\omega \quad (2)$$

Combining the equations above, we find:

$$w - w_{-1} = (\mathbb{E}(p) - p_{-1}) + \alpha(p_{-1} - \mathbb{E}(p)_{-1}) + \beta(x - \alpha x_{-1}) + z^w \quad (3)$$

These equations can yield two significant cases depending on the parameter α. If $\alpha = 0$, then, according to (2), the target real wage each quarter is simply the real wage from the previous quarter (adjusted for trend productivity growth in the empirical version of the model) plus an error term. Additionally, from (3), in the specific case where $\alpha = 0$, the change in nominal wages equals the expected rate of inflation from the previous quarter, $\mathbb{E}(p) - p_{-1}$, along with a term that reflects the degree of labor market tightness, x – essentially, a standard expectations-augmented wage Phillips curve. Conversely, if $\alpha \neq 0$, (3) indicates that one of the factors influencing nominal wage growth is the discrepancy between the previous period's actual price level and the expected price level for that period, $p_{-1} - \mathbb{E}(p)_{-1}$. This is referred to as the catch-up term. The presence of a catch-up term suggests that, during wage negotiations, workers seek compensation for the previous period's unexpected inflation. To the extent that workers' expectations or the focal points of their institutional representatives affect the wage bargaining process, the economy demonstrates a degree of real-wage

rigidity. Moreover, from (3), if $\alpha \neq 0$, the term related to labor market tightness can be expressed as $(1-\alpha)x + \alpha(x - x_{-1})$, suggesting that wages potentially depend on both the level and the change in labor market tightness.

The original quarterly empirical model that has been estimated in B&B has a wider lag structure. The equation is given by:

$$gw_t = \alpha + \sum_{k=1,2,3,4} \alpha_k^{gw} gw_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{iest} iest_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{vu} vu_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{catchup} catchup_{t-k} + \alpha^{gpty} ma[gpty]_{t-1} + \alpha^{d1} D2020{:}2 + \alpha^{d2} D2020{:}3 + u_t^{gw}$$

In the equation above, gw_t represents the wage inflation. Wage inflation depends on several factors, including lagged wage inflation gw_{t-k} for $k = 1,2,3,4$, lagged expected short-run inflation $iest_{t-k}$ for $k = 1,2,3,4$, and the lagged ratio of vacancies to unemployment vu_{t-k} for $k = 1,2,3,4$ – or a closely related variable if this ratio is not available for certain countries. Additionally, wage inflation is influenced by the lagged catch-up variable $catchup_{t-k}$ for $k = 1,2,3,4$, which is constructed as the sum of unexpected inflation over the previous four quarters. An 8-quarter moving average of productivity growth $ma[gpty]_{t-1}$ is also considered. Lastly, in some countries, dummy variables are included to capture the unusual movements in wages.

Prices equation

B&B model assumes that the price level p depends on the level of nominal wages (given wages) plus a shock term z^p that comprises the relative costs of nonlabor inputs, variations in markups and other factors influencing price-setting:

$$p = w + z^p \quad (4)$$

In first differences, we have:

$$p - p_{-1} = (w - w_{-1}) + \left(z^p - z_{-1}^p\right) \quad (5)$$

Empirically, the B&B model will expand on the shock term by incorporating variables such as commodity price shocks and supply-chain issues that raise prices relative to wages. Since prices should depend on unit labor costs rather than wages alone, the B&B model will also include the

productivity trend in the price equation during estimation. Producer markups will not be treated as an independent variable; however, B&B model notes that markups will endogenously rise when strong sectoral demand meets limited supply.

In the empirical model, it can be defined by:

$$gp_t = \beta + \sum_{k=1,2,3,4} \beta_k^{gp} gp_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{w} gw_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{shortage} shortage_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{grpe} grpe_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{grpf} grpf_{t-k} + \beta^{gpty} ma[gpty]_{t-1} + u_t^{gp}$$

In the equation above, gp_t represents price inflation. Price inflation depends on several factors, including lagged price inflation gp_{t-k} for $k = 1,2,3,4$, lagged wage inflation gw_{t-k} for $k = 1,2,3,4$, and lagged shortages $shortage_{t-k}$ for $k = 0,1,2,3,4$. Additionally, it considers lagged energy prices $grpe_{t-k}$ for $k = 0,1,2,3,4$ and lagged food prices $grpf_{t-k}$ for $k = 0,1,2,3,4$. The equation also includes an 8-quarter moving average of productivity growth $ma[gpty]_{t-1}$. Finally, the residuals u_t^{gp} capture the unexplained variation in price inflation.

Inflation expectations equation

B&B model is finished by explicating in the model the behavior of inflation expectations, both in short and long run.

$$\mathbb{E}(p) - p_{-1} = \delta\pi^* + (1-\delta)(p_{-1} - p_{-2}) \quad (6)$$

$$\pi^* = \gamma\pi^*_{-1} + (1-\gamma)(p_{-1} - p_{-2}) \quad (7)$$

The δ and γ capture the degree of anchoring of short and long-run inflation expectations. If they are close to 1, expectations are well anchored. The lower the δ, more persistent the dynamic effects of a price shock. Parameter γ affects long run dynamics, and particularly the effect of transitory shocks on long run inflation.

The analysis of the equations reveals that, in the long-run steady state, both inflation expectations and the inflation rate compatible with full employment are indeterminate. For any given value of long-run expected inflation (π^*), assuming that the output gap (x) is zero, the model solution indicates that short-run inflation expectations, wage inflation, and price inflation all converge to the chosen value of π^*. The value of π^*at any point in time is shaped by the historical inflation rates. A

period of higher inflation results in a higher steady-state inflation rate; the longer this period lasts, or the lower the parameter γ, the more pronounced the effect on steady-state inflation.

This concept can be understood as the "de-anchoring" of inflation expectations that some economists were concerned about at the onset of an inflationary period. De-anchoring can be interpreted as a decrease in either the parameter δ or γ. All else being equal, such de-anchoring would result in more pronounced and persistent inflation following an inflationary shock. In simpler terms, if people begin to expect higher inflation due to past inflation trends, and if the mechanisms that usually stabilize inflation (represented by δ and γ) become less effective, inflation is likely to rise more and persist for longer after an initial shock.

In the empirical model, these equations are defined by:

$$iest_t = \sum_{k=1,2,3,4} \phi_k^{iest}\, iest_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} ielt_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{gp}\, gp_{t-k} + u_t^{iest}$$

$$ielt_t = \sum_{k=1,2,3,4} \theta_k^{ielt}\, ielt_{t-k} + \sum_{k=0,1,2,3,4} \theta_k^{gp}\, gp_{t-k} + u_t^{ielt}$$

In the first equation, $iest_t$ represents short-term inflation expectations. Short-term inflation expectations depend on several factors, including lagged short-term inflation expectations $iest_{t-k}$ for $k = 1,2,3,4$, lagged long-term inflation expectations $ielt_{t-k}$ for $k = 0,1,2,3,4$, and lagged price inflation gp_{t-k} for $k = 0,1,2,3,4$. The residuals u_t^{iest} capture the unexplained variation in short-term inflation expectations.

In the second equation, $ielt_t$ represents long-term inflation expectations. Long-term inflation expectations depend on lagged long-term inflation expectations $ielt_{t-k}$ for $k = 1,2,3,4$ and lagged price inflation gp_{t-k} for $k = 0,1,2,3,4$. The residuals u_t^{ielt} capture the unexplained variation in long-term inflation expectations.

Constraints equations

Given all the resulting equations above, the model determines the evolution of four endogenous variables: π^*, $\mathbb{E}(p)$, w and p. These equations are constrained by homogeneity restrictions, which imply no long-term tradeoff between inflation and activity:

$$\sum_{k=1,2,3,4} \alpha_k^{gw} + \sum_{k=1,2,3,4} \alpha_k^{iest} = 1$$

$$\sum_{k=1,2,3,4} \beta_k^{gp} + \sum_{k=0,1,2,3,4} \beta_k^{gw} = 1$$

$$\sum_{k=1,2,3,4} \phi_k^{iest} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} + \sum_{k=0,1,2,3,4} \phi_k^{gp} = 1$$

$$\sum_{k=1,2,3,4} \theta_k^{ielt} + \sum_{k=0,1,2,3,4} \theta_k^{gp} = 1$$

It's worth noting that, in the original paper, authors imposed the constraints above as homogeneity restrictions. These estimates implies that, in the long run, a given change in inflation implies an equal change in short-run and long-run inflation expectations. Alternatively, the restriction can be interpreted as requiring that the long-run Phillips curve be vertical. Under either interpretation, the restriction seems economically justified. The restriction is not rejected at the 5 percent level for the wage and price equations but is rejected at the 2 percent level for the two expectations' equations. However, even in the latter case, the estimates under the restriction are very close to the unrestricted estimates. Consequently, the restriction had no material effect on the main results of the original paper.

1.3.2. Exploring alternative modelling frameworks

Unrestricted VAR model with two-stage regression

To robustly analyze the dynamic interactions between macroeconomic variables while accounting for external shocks, we propose estimating a Vector Autoregressive Model with Exogenous Variables (VAR-X). This approach serves as a benchmark to evaluate the results derived from a Structural Vector Autoregressive Model with Exogenous Variables (SVAR-X), which imposes multiple zero constraints to identify structural shocks. By comparing these two models, we can assess the validity and impact of the restrictions imposed in the SVAR-X framework.

Our estimation strategy follows a two-stage procedure designed to effectively isolate exogenous influences while capturing the endogenous interdependencies among the variables of interest. In the first stage, we estimate a series of regression models where each endogenous variable is regressed against a comprehensive set of exogenous predictors. Formally, let y_{it} denote the i-th endogenous variable at time t, and let X_t represent the vector of exogenous variables, which include commodity price shocks, supply-chain disruptions, and labor market indicators, among others. The first-stage regression takes the form:

$$y_{it} = \alpha_i + \beta_i' X_t + \in_{i_t},$$

where α_i is a constant term, β_i is a vector of coefficients capturing the direct effects of the exogenous predictors, and $\in_{it}$ represents the residual component, which captures the variation in y_{it} unexplained by the exogenous regressors. The key intuition behind this first step is to remove the direct influence of exogenous shocks from the endogenous variables, thereby isolating the residual variation that can be attributed to endogenous dynamics. These residuals $\in_{it}$ are used as inputs for the second-stage estimation, where we specify an unrestricted VAR model. The residuals are stacked into the vector $\in_t = (\in_{1t}, \in_{2t}, \dots \in_{Nt})'$ and modeled as:

$$\in_t = A_1 \in_{t-1} + A_2 \in_{t-2} + \cdots + A_p \in_{t-p} + u_t,$$

where A_j (for $j = 1, \dots, p$) are coefficient matrices capturing the autoregressive dynamics, and is a vector of innovations.

This second-stage VAR captures the endogenous interactions and feedback effects among the macroeconomic variables, allowing us to analyze the propagation of shocks through the system. Unlike the SVAR-X model, which imposes a priori zero constraints to achieve identification, the unrestricted VAR framework remains agnostic about the structure of the system, providing a useful benchmark to assess the role of these constraints.

Through this two-stage estimation approach, we can disentangle the direct effects of exogenous shocks from the endogenous interactions governing the macroeconomic variables. This methodological distinction enables a clearer interpretation of the dynamics at play and provides a rigorous comparison between the unrestricted VAR-X and the constrained SVAR-X specifications.

Modified SVAR-X Frameworks

A key feature of the modified SVAR-X framework is its use of alternative structural relationships between key variables. Unlike the original Bernanke and Blanchard model, which assumes that wage inflation drives price inflation, the modified framework explores whether price inflation could exert a causal influence on wages. This adjustment reflects the possibility of reverse causality in inflationary processes, particularly in contexts where supply-side shocks dominate.

By changing the assumptions of the original SVAR-X model, the modified versions aim to capture a broader range of inflationary dynamics. The first alternative specification relaxes the assumption that only wages affect inflation, incorporating feedback mechanisms where inflation expectations and sectoral price shocks play a more significant role. The second alternative model further adjusts the contemporaneous relationships between variables, allowing for bidirectional causality between wages and prices while also introducing more flexible lag structures. These modifications enable the framework to provide a richer understanding of the interplay between wages, prices, and expectations under different economic conditions.

Below, we outline the structural modifications in the equations, highlighting the specific components that have been altered in each model.

Modified wages equation

Under this framework, the modification in the wages equation for both alternative models (alt1 and alt2) replaces the expectations component with an indexation component. This adjustment allows the models to capture the role of past inflation indexation in driving wage dynamics, rather than relying solely on forward-looking expectations.

Bernanke & Blanchard original wages equation (**'bb' model**):

$$gw_t = \alpha + \sum_{k=1,2,3,4} \alpha_k^{gw} gw_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{iest} iest_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{vu} vu_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{catchup} catchup_{t-k} + \alpha^{gpty} ma[gpty]_{t-1} + \alpha^{d1} D2020{:}2 + \alpha^{d2} D2020{:}3 + u_t^{gw}$$

'Alternative 1' and 'Alternative 2' wages equation (**alt1** and **alt2** models):

$$gw_t = \alpha + \sum_{k=1,2,3,4} \alpha_k^{gw} gw_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{gp} gp_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{vu} vu_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{catchup} catchup_{t-k} + \alpha^{gpty} ma[gpty]_{t-1} + \alpha^{d1} D2020{:}2 + \alpha^{d2} D2020{:}3 + u_t^{gw}$$

Modified price equation

Under this framework, the modification introduced in the prices equation for both alternative models (alt1 and alt2) replaces the wages component with an expectations component. This adjustment allows the models to evaluate the extent to which inflation expectations, rather than wage dynamics, directly influence price formation.

Bernanke & Blanchard original prices equation (**'bb' model**):

$$gp_t = \beta + \sum_{k=1,2,3,4} \beta_k^{gp} gp_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{w} gw_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{shortage} shortage_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{grpe} grpe_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{grpf} grpf_{t-k} + \beta^{gpty} ma[gpty]_{t-1} + u_t^{gp}$$

'Alternative 1' and 'Alternative 2' prices equation (**alt1** and **alt2** models):

$$gp_t = \beta + \sum_{k=1,2,3,4} \beta_k^{gp} gp_{t-k} + \sum_{k=1,2,3,4} \alpha_k^{iest} iest_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{shortage} shortage_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{grpe} grpe_{t-k} + \sum_{k=0,1,2,3,4} \beta_k^{grpf} grpf_{t-k} + \beta^{gpty} ma[gpty]_{t-1} + u_t^{gp}$$

Modified inflation expectations equation

Under this framework, the equation for expectations in the 'alternative 1' model (alt1) remains identical to that of the original 'bb' model. The key modification introduced in the 'alternative 2' model (alt2) involves replacing the lagged inflation component in both the short-term and long-term expectations equations with lagged wage inflation. This adjustment aims to assess the extent to which wage dynamics, rather than past inflation alone, drive inflation expectations over time.

Bernanke & Blanchard **and** 'Alternative 1' expectations equation (**'bb' model** and **alt1** model):

$$iest_t = \sum_{k=1,2,3,4} \phi_k^{iest}\, iest_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} ielt_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{gp}\, gp_{t-k} + u_t^{iest}$$

$$ielt_t = \sum_{k=1,2,3,4} \theta_k^{ielt}\, ielt_{t-k} + \sum_{k=0,1,2,3,4} \theta_k^{gp}\, gp_{t-k} + u_t^{ielt}$$

'Alternative 2' expectations equation (**alt2** model):

$$iest_t = \sum_{k=1,2,3,4} \phi_k^{iest}\, iest_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} ielt_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{gw}\, gw_{t-k} + u_t^{iest}$$

$$ielt_t = \sum_{k=1,2,3,4} \theta_k^{ielt}\, ielt_{t-k} + \sum_{k=0,1,2,3,4} \theta_k^{gw}\, gw_{t-k} + u_t^{ielt}$$

Modified constraints' equations

Finally, the constraints have been adjusted to ensure that the sum of the current and lagged endogenous components in each equation equals 1.

Bernanke & Blanchard original constraints' equations (**'bb' model**):

$$\sum_{k=1,2,3,4} \alpha_k^{gw} + \sum_{k=1,2,3,4} \alpha_k^{iest} = 1$$

$$\sum_{k=1,2,3,4} \beta_k^{gp} + \sum_{k=0,1,2,3,4} \beta_k^{gw} = 1$$

$$\sum_{k=1,2,3,4} \phi_k^{iest} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} + \sum_{k=0,1,2,3,4} \phi_k^{gp} = 1$$

$$\sum_{k=1,2,3,4} \theta_k^{ielt} + \sum_{k=0,1,2,3,4} \theta_k^{gp} = 1$$

'Alternative 1' constraints' equations (**alt1** model):

$$\sum_{k=1,2,3,4} \alpha_k^{gw} + \sum_{k=0,1,2,3,4} \alpha_k^{gp} = 1$$

$$\sum_{k=1,2,3,4} \beta_k^{gp} + \sum_{k=1,2,3,4} \beta_k^{iest} = 1$$

$$\sum_{k=1,2,3,4} \phi_k^{iest} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} + \sum_{k=0,1,2,3,4} \phi_k^{gp} = 1$$

$$\sum_{k=1,2,3,4} \theta_k^{ielt} + \sum_{k=0,1,2,3,4} \theta_k^{gp} = 1$$

'Alternative 2' constraints' equations (**alt2** model):

$$\sum_{k=1,2,3,4} \alpha_k^{gw} + \sum_{k=0,1,2,3,4} \alpha_k^{gp} = 1$$

$$\sum_{k=1,2,3,4} \beta_k^{gp} + \sum_{k=1,2,3,4} \beta_k^{iest} = 1$$

$$\sum_{k=1,2,3,4} \phi_k^{iest} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} + \sum_{k=0,1,2,3,4} \phi_k^{gw} = 1$$

$$\sum_{k=1,2,3,4} \theta_k^{ielt} + \sum_{k=0,1,2,3,4} \theta_k^{gw} = 1$$

The structural modifications implemented in the alternative SVAR-X specifications (alt1 and alt2) significantly broaden the analytical scope of the original Bernanke and Blanchard framework. By explicitly proposing different directions on the causality between wages and prices, as well as redefining the roles of inflation expectations and indexation, these alternative models offer nuanced insights into inflationary processes, particularly under supply-side dominated scenarios. Additionally, the adjustments to constraints ensure both theoretical coherence and empirical flexibility, making the modified SVAR-X framework especially valuable for understanding the complex interplay among wage dynamics, price formation, and expectations across varying economic contexts.

1.3.3. Data sources

Overall headline price data were sourced from the Bureau of Labor Statistics (BLS) Consumer Price Index (CPI). The food and energy indexes were constructed to align with international classifications, ensuring consistency and comparability across analyses. Wage data utilized in this study correspond to the nominal Employment Cost Index (ECI) average, also provided by the BLS.

Short-term inflation expectations were derived from the Federal Reserve Bank of Cleveland's Focus Survey of Expectations, specifically utilizing the 12-month accumulated inflation expectation one year ahead. Long-term inflation expectations were similarly sourced from this survey. The 'catch-up' term is defined as an adjustment in nominal wage growth, capturing the discrepancy between the realized price level and previously held inflation expectations. This metric reflects workers' attempts, typically through wage negotiations, to compensate for unexpected inflation experienced in the prior period.

The variable denoted as 'vu' is constructed as a supply-demand indicator, calculated using the ratio between job openings from the Job Openings and Labor Turnover Survey (JOLTS) and the unemployment level, both obtained from the BLS. Additionally, the shortage measure employed in this analysis is represented by the New York Federal Reserve's Global Supply Chain Pressure Index. Lastly, trend productivity growth estimates were sourced directly from the BLS.

1.4. RESULTS

In this results chapter, we analyze and discuss the empirical findings derived from the estimated VAR coefficients across each equation. The summary tables presented herein illustrate the aggregated impact of lagged coefficients, offering a concise synthesis of the primary determinants influencing CPI growth, wage growth, and short- and long-term inflation expectations.

Subsequently, we explore the implications of various economic shocks within the Structural Vector Autoregressions (SVARs), examining the dynamic responses of the core variables. This analysis sheds light on the underlying transmission mechanisms and interactions within each model, providing critical insights into inflationary dynamics and the relative significance of each explanatory factor.

For readers seeking a more granular examination of the results, including coefficient estimates for individual lag periods, detailed analyses can be found in Appendix. This structure is intended to facilitate both clarity and depth, enabling comprehensive interpretation within the main text while preserving technical rigor in the supplementary appendices.

Please note that for SVAR-X modelling, Bernanke & Blanchard original model (with no changes to the authors' framework) will be represented by 'bb', while the two alternative models will be represented by alt1 and alt2.

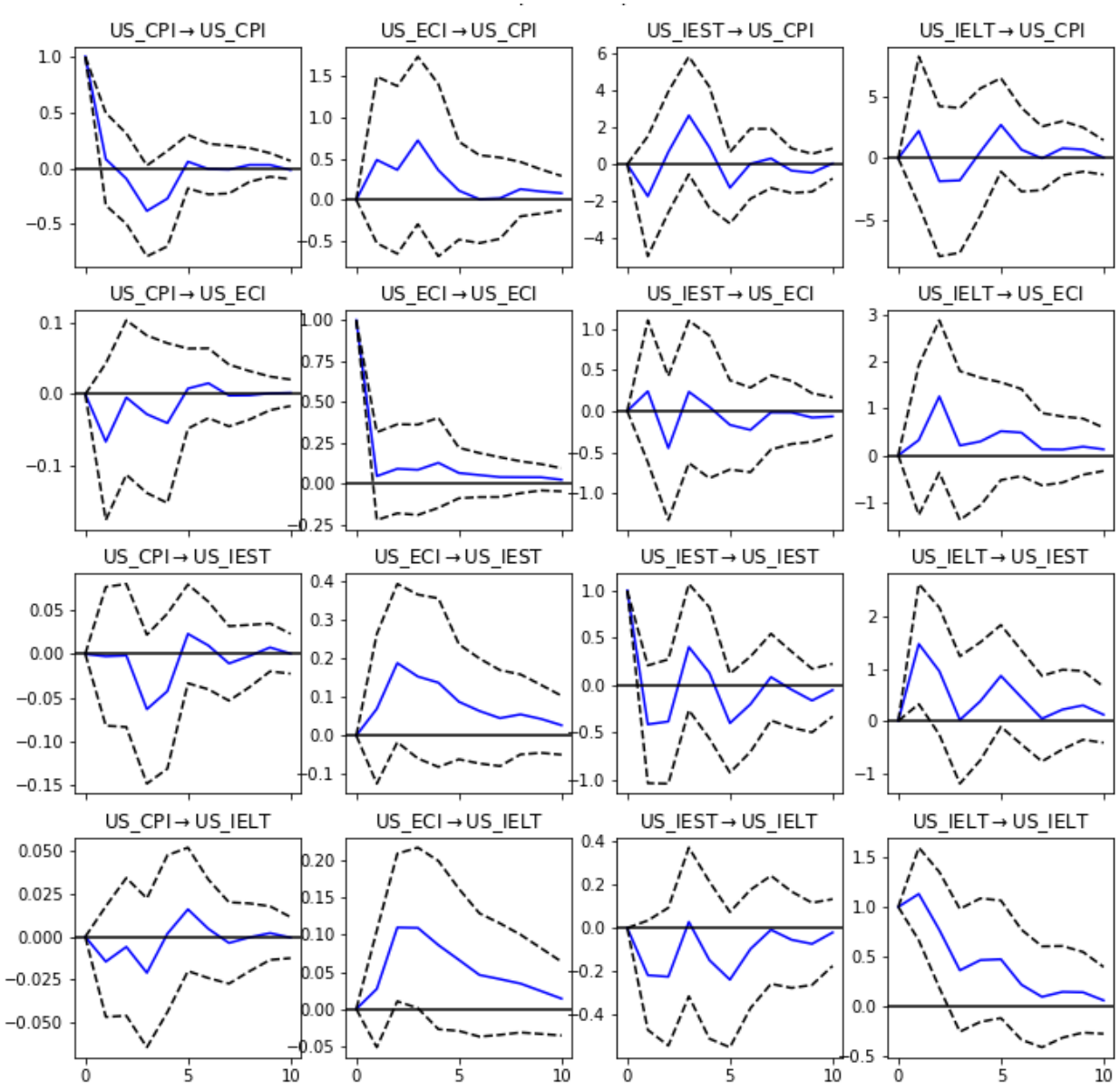
1.4.1. Unrestricted VAR-X

The VAR estimates indicate a generally intuitive, though statistically subdued, relationship between the cost measures, inflation expectations, and realized inflation. In the US_CPI equation, the coefficients on the Employment Cost Index (US_ECI) lags are predominantly positive, aligning with the traditional view that rising labor costs can exert upward pressure on prices. However, none of these coefficients are statistically significant at conventional levels, suggesting that direct wage-related cost pass-through into inflation may be more muted in this sample. Of particular interest is the borderline significance of the third lag of US_CPI itself, which implies some delayed autoregressive component in price growth—an effect that, while modest, is consistent with inflation's tendency to exhibit persistence over time.

In the equations for inflation expectations (US_IEST and US_IELT), the results offer hints that cost dynamics and realized inflation feed into both short- and long-term outlooks, albeit in complex ways. The strongest finding emerges in the US_IELT equation, where lagged US_IELT carries a large, positive, and highly significant coefficient, underscoring the persistence of long-term expectations once they have been formed. Moreover, US_ECI exerts a statistically significant positive influence on long-term expectations at a two-quarter lag, a result that conforms with economic theory suggesting that perceived wage or cost pressures eventually shift the public's longer-horizon inflation outlook. Meanwhile, short-term expectations (US_IEST) appear similarly linked to lagged long-term expectations (US_IELT), reinforcing the notion that households and firms calibrate their immediate price forecasts in response to the prevailing sentiment about inflation's longer-run path.

Taken together, these patterns convey an overarching message: while wage costs and inflation expectations demonstrate the expected signs—higher labor costs tending to nudge inflation upward, and entrenched long-run expectations shaping subsequent inflation sentiment—the immediate pass-through effects on CPI itself are not strongly identified in this particular sample. Instead, the data emphasize the interdependencies within the expectation channels, revealing how short-term and long-term outlooks reinforce one another. This interplay is consistent with theoretical models where expectations, once they become anchored, act as an enduring driver of future inflation dynamics.

Figure 1-1: Impulse-response figures for a VAR-X (US)



Source: Author's elaboration

1.4.2. Structural VAR-X

Prices equation

In the 'bb' model, coefficient estimates align closely with economic theory, particularly highlighting wage growth (gw) as a significant determinant of CPI growth, with an aggregated coefficient of 0.59. Lagged CPI growth (gcpi) and shortage indicators also yield intuitive economic

results, displaying coefficients of 0.41 and 0.17, respectively. Productivity growth (magpty) exhibits a negative relationship with CPI growth, consistent with theoretical expectations that higher productivity mitigates inflationary pressures. Alternative Model 1 (alt1) introduces short-term inflation expectations (iest) in place of wage growth, slightly enhancing explanatory power as indicated by an improved R-squared (from 90.6% in the 'BB' model to 91.1%). However, this structural adjustment notably alters the influence of other variables; the shortage coefficient rises substantially from 0.17 to 0.61, while the effects of energy and food price growth (grpe and grpf) marginally decline. Alternative Model 2 (alt2) is identical to Alternative Model 1 (alt1), producing the same coefficients and explanatory power. These findings underscore the critical roles of inflation expectations and shortages in driving CPI dynamics, with contemporaneous energy price changes consistently significant across all models.

Table 1-1: Coefficients sum for gcpi model (US)

gcpi	**bb**	**alt1**	**alt2**
gw	0,59		
gcpi	0,41	0,45	0,45
iest		0,55	0,55
magpty	-0,09	-0,07	-0,07
grpe	0,08	0,07	0,07
grpf	0,06	0,00	0,00
shortage	0,17	0,61	0,61
intercept	-0,05	0,18	0,18
r-squared	90,6%	91,1%	91,1%
observations	71	71	71

Source: Author's elaboration

Wages equation

In the 'bb' model, coefficients adhere closely to theoretical expectations, with past wage growth (gw) demonstrating strong persistence, reflected by an aggregated coefficient of 0.74. Inflation expectations (iest) also significantly influence wage growth dynamics, represented by a coefficient of 0.26. Productivity growth (magpty) positively contributes with a coefficient of 0.12, aligning with theoretical predictions. In Alternative Model 1 (alt1), the exclusion of inflation expectations and the inclusion of lagged CPI growth (gcpi) significantly reshape coefficient distributions: wage growth persistence rises to 0.83, productivity's role diminishes to 0.05, and the explanatory power of the vacancies-to-unemployment ratio (vu) sharply decreases from 0.16 to 0.02. Consequently, the model fit improves notably, with R-squared increasing from 62.5% to 67.5%. Alternative Model 2 (alt2) remains identical to Alternative Model 1 (alt1), underscoring that

integrating lagged CPI growth at the expense of inflation expectations can enhance model explanatory power while altering the significance of labor market and productivity indicators.

Table 1-2: Coefficients sum for gw model (US)

gw	**bb**	**alt1**	**alt2**
gw	0,74	0,83	0,83
gcpi		0,18	0,18
iest	0,26		
vu	0,16	0,02	0,02
catch up	-0,02	0,00	0,00
magpty	0,12	0,05	0,05
intercept	-0,03	0,00	0,00
r-squared	62,5%	67,5%	67,5%
observations	71	71	71

Source: Author's elaboration

Short-run inflation expectations equation

Within the 'bb' model framework, short-term inflation expectations (iest) predominantly explain their dynamics, featuring a high coefficient of 0.72. Long-term inflation expectations (ielt) provide substantial additional explanatory power (0.20), while lagged CPI growth (gcpi) plays a minor but relevant role (0.08). Alternative Model 1 (alt1), being structurally identical to the 'bb' model, yields unchanged coefficients and explanatory power (R-squared of 91.0%). Alternative Model 2 (alt2) incorporates wage growth (gw), resulting in only a minimal contribution (0.06) and slightly reducing the short-term inflation expectations coefficient to 0.71. However, this inclusion reduces the model's fit significantly, as indicated by an R-squared decrease to 83.1%, highlighting that wage growth introduces more noise than additional explanatory capacity.

Table 1-3: Coefficients sum for iest model (US)

iest	**bb**	**alt1**	**alt2**
gw			0,06
gcpi	0,08	0,08	
iest	0,72	0,72	0,71
ielt	0,20	0,20	0,20
r-squared	91,0%	91,0%	83,1%
observations	71	71	71

Source: Author's elaboration

Long-run inflation expectations equation

In the 'bb' model, long-term inflation expectations (ielt) exhibit near-autoregressive dynamics with a substantial coefficient of 0.99. Lagged CPI growth (gcpi) has a marginal influence (0.01), aligning with expectations that short-run inflation factors exert limited impact on long-term expectations. Alternative Model 1 (alt1) maintains an identical structure, resulting in unchanged coefficients and explanatory power (R-squared of 89.4%), reinforcing the robustness of the original specification. Alternative Model 2 (alt2) introduces wage growth (gw), though its impact remains minimal (0.02), while slightly decreasing the long-term expectations coefficient to 0.98. This adjustment also reduces explanatory power, as indicated by a drop in R-squared to 83.4%. Thus, long-term inflation expectations remain the primary determinant of their dynamics, with wage growth inclusion offering little additional insight.

Table 1-4: Coefficients sum for ielt model (US)

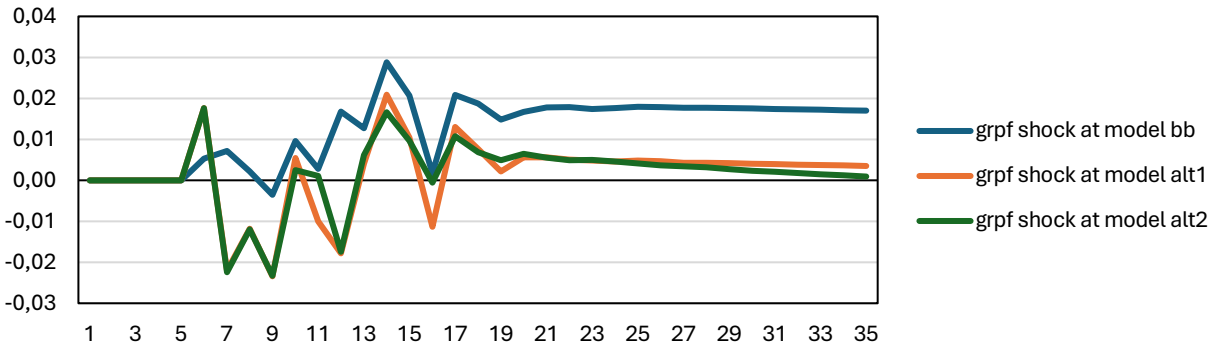
ielt	**'bb'**	**alt1**	**alt2**
gw			0,02
gcpi	0,01	0,01	
ielt	0,99	0,99	0,98
r-squared	89,4%	89,4%	83,4%
observations	71	71	71

Source: Author's elaboration

Impulse-response functions

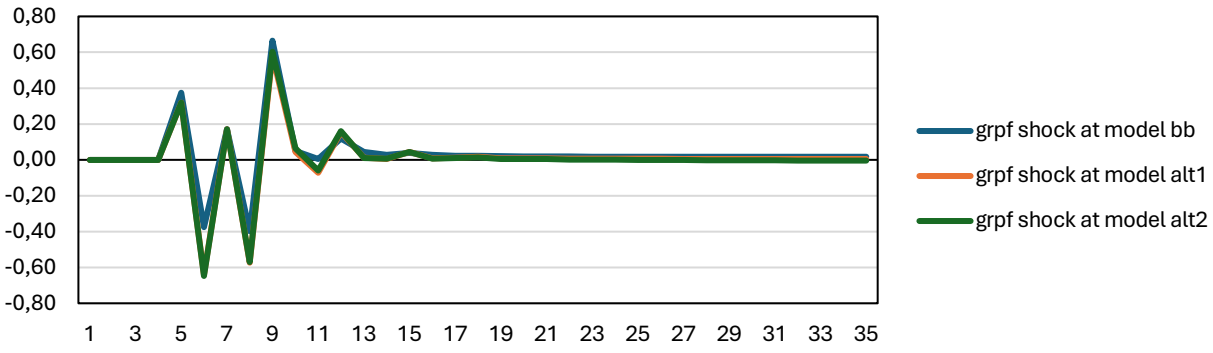
Figures 1-2 through 1-9 illustrate impulse responses for various shocks, emphasizing distinct variations across model specifications. Specifically, the 'bb' model demonstrates pronounced sensitivity to shocks in the vacancies-to-unemployment ratio (v/u), aligning with Bernanke and Blanchard's foundational insights regarding labor market centrality. The shortage shock similarly exhibits marked variability in response across models. All shocks are standardized to two standard deviations, with the v/u shock modeled as permanent and other shocks as transitory, lasting only one quarter.

Figure 1-2: Impact of Food Shock on wages (US)



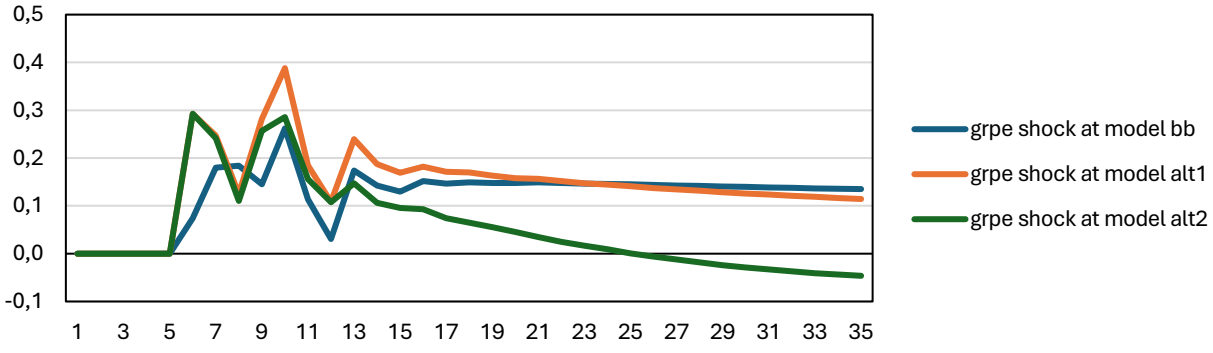
Source: Author's elaboration

Figure 1-3: Impact of Food Shock on CPI (US)



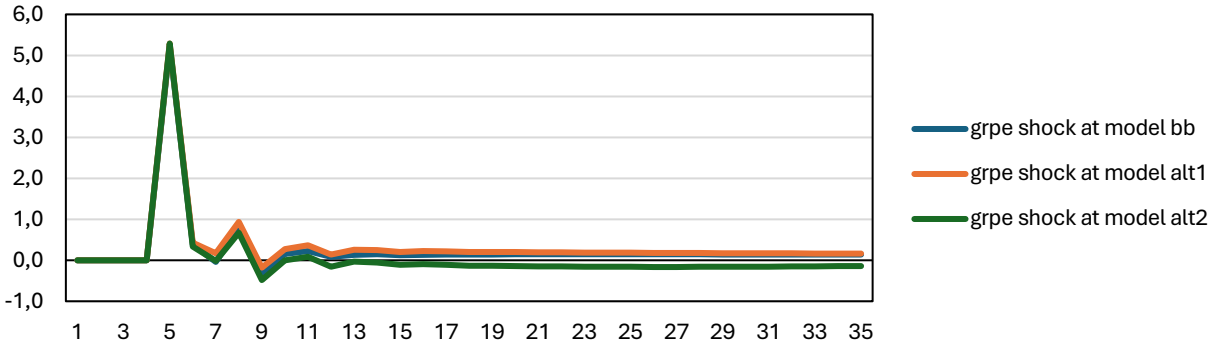
Source: Author's elaboration

Figure 1-4: Impact of Energy Shock on wages (US)



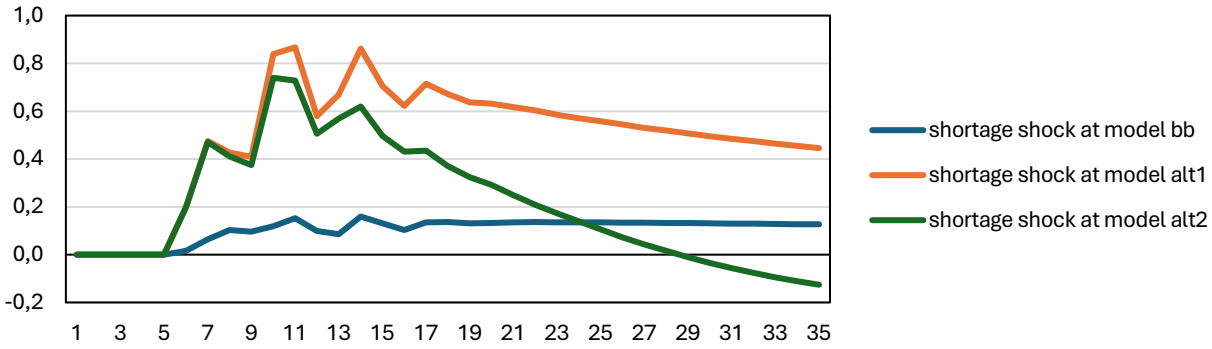
Source: Author's elaboration

Figure 1-5: Impact of Energy Shock on CPI (US)



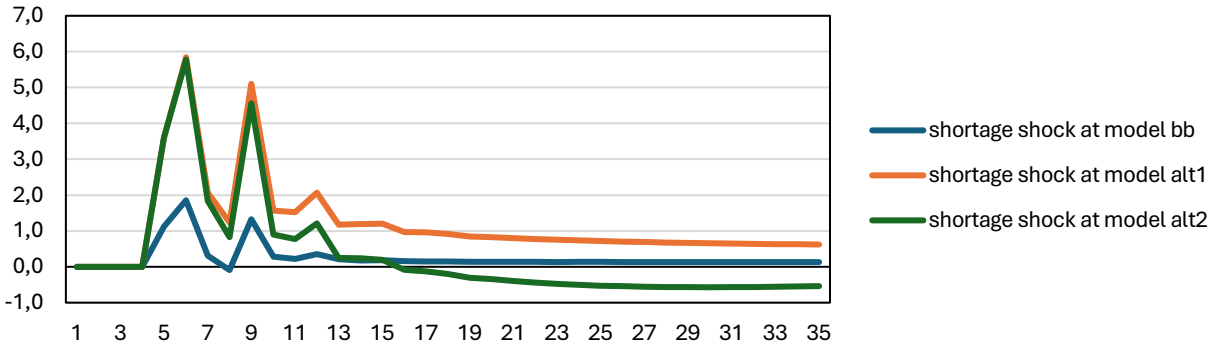
Source: Author's elaboration

Figure 1-6: Impact of Shortage Shock on wages (US)



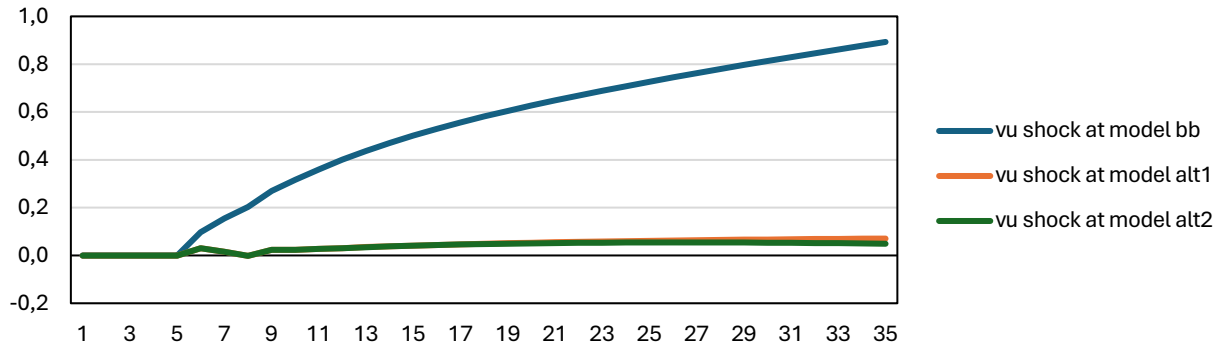
Source: Author's elaboration

Figure 1-7: Impact of Shortage Shock on CPI (US)



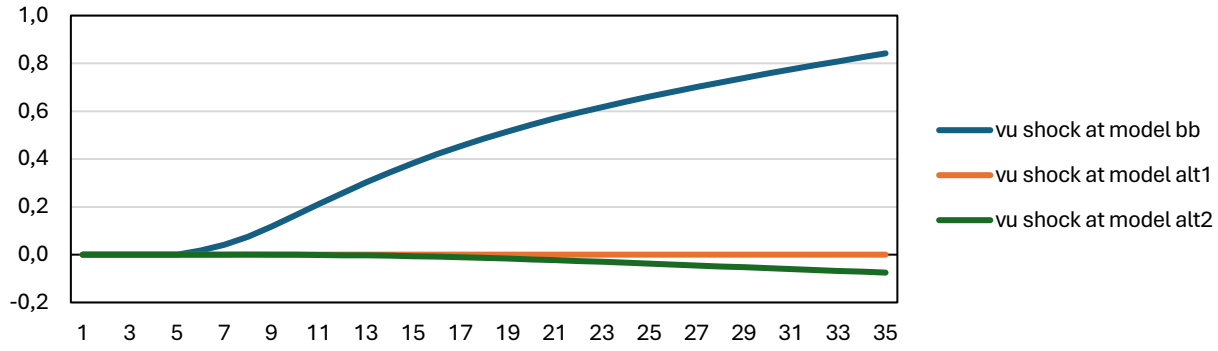
Source: Author's elaboration

Figure 1-8: Impact of V/U Shock on wages (US)



Source: Author's elaboration

Figure 1-9: Impact of V/U Shock on CPI (US)



Source: Author's elaboration

Collectively, the Original Benchmark Model 'bb', Alternative Model 1 (alt1), and Alternative Model 2 (alt2) frameworks provide complementary perspectives on CPI inflation (gcpi), wage growth (gw), and short- and long-term inflation expectations (iest and ielt). Lagged inflation effects consistently emerge significant across models, though subtle shifts in coefficients highlight the nuanced interactions captured in alternative specifications. For example, the lag-4 CPI growth coefficient transitions from positive in the 'BB' model to negative in alternatives, suggesting potential dampening effects with extended lags. Likewise, R-squared values modestly improve from 90.6% in the 'bb' model to 91.1% in alternatives, indicating enhanced inflation dynamics modeling.

For wage growth (gw), persistent positive coefficients across models underscore wage growth inertia, with alternatives introducing moderation at higher lags and improving explanatory power from 62.5% to 67.5%. Short-term inflation expectations (iest) models display a trade-off

between structural detail and fit: introducing additional lags stabilizes coefficients but lowers R-squared from 91.0% to 83.1%. Similarly, long-term expectations (ielt) models experience declining explanatory power (89.4% to 83.4%) when additional variables, such as wage growth, are included.

Ultimately, the comparative analysis highlights how alternative structural specifications yield distinct interactions and feedback loops among variables, each offering reasonable explanatory power. This underscores the importance of evaluating multiple models to gain comprehensive insights into inflation dynamics.

1.5. Conclusion

This study highlights the complexities and sensitivities inherent in modeling inflation dynamics, particularly during periods of economic disruption such as the COVID-19 pandemic. While the Bernanke and Blanchard (2023, 2024) framework served as a valuable benchmark for understanding inflationary pressures, the findings emphasize its limitations when applied to diverse economic contexts. Specifically, the study reveals that modifications to this benchmark model, particularly through adjustments in contemporaneity assumptions and variable structures, can yield significantly different results in terms of magnitudes and dynamics of inflationary impacts.

One of the benchmark model's key findings was the identification of divergent inflation trajectories under varying scenarios of the vacancies-to-unemployment (v/u) ratio, highlighting the centrality of labor market dynamics in shaping inflation outcomes. However, this conclusion is highly sensitive to the model's structure and assumptions. Alternative approaches that modify contemporaneity or expand feedback mechanisms could lead to significantly different interpretations of the relationship between v/u dynamics and inflation. This underscores the importance of testing multiple frameworks to ensure robust conclusions, particularly when using these models to inform policy decisions.

The alternative modeling approaches employed, including unrestricted VAR and modified SVAR-X frameworks, demonstrate how the rigidity of the benchmark model's assumptions can obscure critical feedback loops and context-specific interactions. Discrepancies in results across these alternative specifications further underscore the sensitivity of inflation modeling to structural and methodological choices.

Future research should explore the development of alternative SVAR models with structures that diverge further from the one proposed in this study. This could include experimenting with different contemporaneity assumptions, incorporating nonlinear dynamics, and allowing for more robust feedback mechanisms between key variables. Such investigations would help address the limitations identified and provide deeper insights into inflationary processes, particularly in economies with unique structural characteristics. These efforts could advance the adaptability and accuracy of inflation models, offering more precise tools for policymakers navigating complex economic environments.

2. INFLATION DYNAMICS IN BRAZIL

2.1. INTRODUCTION

Inflation modeling in Brazil requires a nuanced approach due to the country's historical inflationary patterns, high indexation, and policy volatility. Traditional econometric models, often designed for advanced economies, may not fully capture these complexities, leading to misinterpretations of inflation dynamics and challenges in designing effective monetary policies. Given Brazil's susceptibility to both demand and supply-side shocks, as well as the persistence of inflation expectations, a more flexible econometric framework is needed to analyze its inflationary processes accurately.

Building on the methodological foundation developed in the first part of this thesis, presenting the *Structural and Unrestricted Approaches to Inflation Modeling in the US*, this essay applies the modified frameworks to examine inflation dynamics in Brazil. The modifications introduced in the alternative models relax key assumptions of the Bernanke and Blanchard (2023, 2024) approach to better reflect Brazil's structural characteristics. Specifically, this study tests: (i) the possibility of reverse causality between price inflation and wages, (ii) the role of indexation mechanisms in wage-setting, and (iii) adjusted constraints to improve model identification. By refining these components, the framework aims to provide deeper insights into inflation persistence and the effectiveness of monetary policy in Brazil.

The objective of this study is to assess how these modifications influence inflation estimates and contribute to a more comprehensive understanding of Brazil's inflationary environment. By identifying the key drivers of inflation—whether from expectations, structural constraints, or external shocks—this analysis offers insights that can guide more effective policy interventions.

2.2. LITERATURE REVIEW

Brazil's historical struggle with high inflation and its transition toward price stability have been prominent topics in economic research. The studies reviewed here highlight the central role played by inertial inflation, indexation mechanisms, and the subsequent adoption of structured monetary frameworks like inflation targeting.

Arida and Lara-Resende (1985) provide one of the earliest systematic explorations of Brazil's *inertial inflation* phenomenon, attributing much of the country's chronic price instability to widespread indexation mechanisms embedded in contracts, wages, and financial instruments. They argue that conventional monetary tightening alone was not enough to break inertia; instead, Brazil required a comprehensive reform addressing both indexation and the need for greater policy credibility.

In their work on disinflation dynamics, Bonomo and Garcia (1994) propose a theoretical framework in which the *frequency of price and wage adjustments* and the *extent of indexation* either perpetuate or weaken inflationary inertia. Their findings underscore that reducing indexation can help stabilize prices, but policy credibility and consistency are crucial to achieving a sustainable low-inflation trajectory.

Shifting to the *inflation-targeting era*, Minella, de Freitas, Goldfajn, and Muinhos (2003) examine the adoption of this policy framework in Brazil and highlight the importance of robust central bank independence and strong fiscal underpinnings. By reinforcing transparency and communication, the inflation-targeting regime helped shape inflation expectations, underscoring that clear policy signals are essential for credibility.

Mendonça (2007) reinforces these insights, demonstrating that *inflation targeting* significantly contributed to reducing inflation volatility and anchoring expectations in Brazil. Through empirical analysis, Mendonça illustrates that while establishing inflation targets can enhance credibility, such frameworks must be paired with sound fiscal discipline and ongoing policy vigilance.

Cerisola and Gelos (2009) examine the determinants of *inflation expectations* using econometric methods, finding that coherent monetary policy actions and a commitment to macroeconomic stability strongly influence private-sector outlooks. Their study underscores the value of consistent policy signals—particularly relating to interest rates—and points to the crucial role of effective central bank communication in shaping expectations.

From a broader Latin American perspective, de Mello and Moccero (2009) investigate *monetary policy and inflation expectations* in the region, including Brazil. Their research shows that central banks that adopt explicit inflation targets tend to experience lower inflation persistence over time, with expectations becoming more firmly anchored. The study emphasizes that transparent communication and a systematic response to inflationary pressures are vital to sustaining long-term price stability.

Taken together, these works illustrate Brazil's path from high-inertia inflation to a framework grounded in inflation targeting. By tackling indexation, bolstering policy consistency, and focusing on expectation management, the Brazilian experience underscores how structural reforms and credible monetary policies can collectively help achieve and maintain price stability.

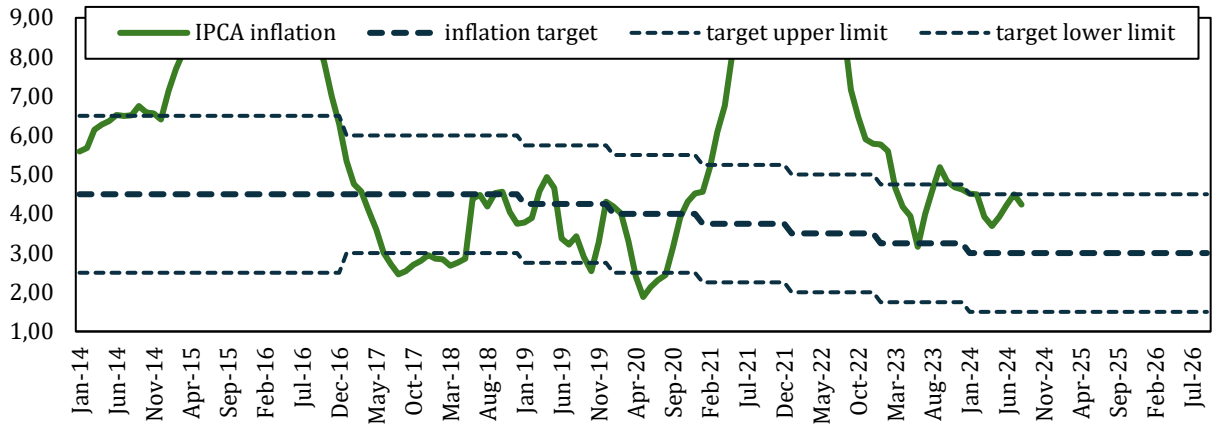
2.3. METHODOLOGY

To examine inflation dynamics in Brazil during and after the COVID-19 pandemic, this essay employs econometric methods specifically adapted to the Brazilian economic context. Building upon the foundational approach established in first essay of this thesis for the United States, the current analysis introduces two targeted adjustments tailored to capture Brazil's unique economic conditions more accurately.

Given Brazil's inflation-targeting framework history, the modeling of inflation expectations explicitly incorporates deviations from the Central Bank's inflation target as exogenous variables. This adjustment allows the model to more precisely isolate how such deviations influence short-term and long-term inflation expectations. By doing so, it avoids misattributing changes in expectations—driven primarily by shifts in the inflation target—to other explanatory variables within the model.

It is important to note that Brazil experienced systematic reductions in its inflation target from 4.5% in 2017 to 3.0% by 2024. These target reductions significantly influenced the observed inflation expectations during this period. Consequently, the inflation expectation equations might have adjusted specifically to distinguish between structural changes caused by the declining inflation targets and fluctuations attributable to deviations from those targets. The inflation target itself is therefore explicitly included as an exogenous variable in the modeling framework.

Figure 2-1: Inflation target in Brazil (2014 to 2026)



Source: BCB

The adjusted equations for inflation expectations (now expressed as deviations from the target) are:

Bernanke & Blanchard **and** 'Alternative 1' expectations equation (**'bb' model** and **alt1** model):

$$iestdev_t = \sum_{k=1,2,3,4} \phi_k^{iest}\, iestdev_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} ieltdev_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{gp}\, gp_{t-k} + u_t^{iest}$$

$$ieltdev_t = \sum_{k=1,2,3,4} \theta_k^{ielt}\, ieltdev_{t-k} + \sum_{k=0,1,2,3,4} \theta_k^{gp}\, gp_{t-k} + u_t^{ielt}$$

'Alternative 2' expectations equation (**alt2** model):

$$iestdev_t = \sum_{k=1,2,3,4} \phi_k^{iest}\, iestdev_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{ielt} ieltdev_{t-k} + \sum_{k=0,1,2,3,4} \phi_k^{gw}\, gw_{t-k} + u_t^{iest}$$

$$ieltdev_t = \sum_{k=1,2,3,4} \theta_k^{ielt}\, ieltdev_{t-k} + \sum_{k=0,1,2,3,4} \theta_k^{gw}\, gw_{t-k} + u_t^{ielt}$$

The other equations remain consistent with those outlined in Essay 1 for the United States. However, for simulations involving equations that include inflation expectations as explanatory variables, the model explicitly accounts for these adjustments to accurately reflect Brazil's inflation-targeting framework.

$$iest_t = iestdev_t + target_t^{st}$$

$$ielt_t = ieltdev_t + target_t^{lt}$$

In addition, considering the relatively shorter quarterly time-series data available for Brazil, the methodology employs Ridge and Lasso regularization techniques to enhance model stability and reduce overfitting. Ridge regression helps manage multicollinearity and stabilizes parameter estimates by reducing overly large coefficients. Meanwhile, Lasso regression efficiently selects relevant variables by shrinking less important coefficients toward zero, thereby increasing model interpretability and reliability.

Together, these methodological adjustments provide a nuanced understanding of Brazil's inflation dynamics, effectively accommodating data limitations and delivering robust, actionable insights for economic policy.

2.3.1. Data sources

For Brazil, overall headline inflation data was sourced from IBGE's IPCA (Índice de Preços ao Consumidor Amplo). The food and energy price indices were specifically structured to align with the international COICOP classification. Food inflation is measured using all subcategories within the "food at home" group, excluding alcoholic beverages. The energy index comprises domestic fuels, residential electricity, automotive lubricants, and vehicle fuels.

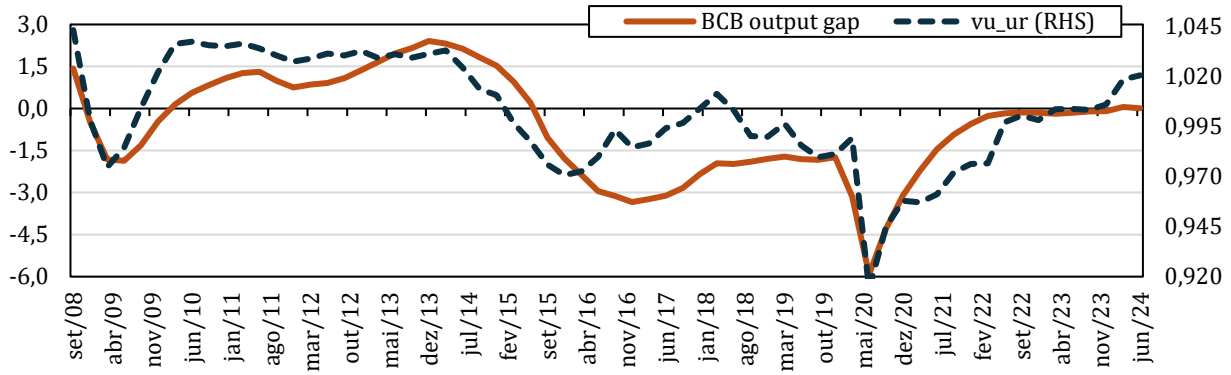
Wage data utilized in the analysis represents average nominal usual wages obtained from IBGE's PNAD survey and the now-discontinued PME survey.

Inflation expectations, both short-term and long-term, were derived from the Brazilian Central Bank's Focus Survey of Expectations. Short-term expectations refer to the projected inflation over a rolling 12-month period one year ahead, whereas long-term expectations are based on year-end projections four years ahead.

The "catch-up" term used in the analysis follows the same methodology as applied to the United States.

The variable "vu" is constructed as a labor market tightness indicator using the employment expectation index (IAEmp) from Fundação Getúlio Vargas (FGV), seasonally adjusted via the X-13 method. This index captures hiring intentions across various sectors (labor demand), combined with the unemployment rate (labor supply), also seasonally adjusted. The "vu" indicator is calculated by standardizing (z-score) both series and then summing these standardized values with an offset of 50 to avoid negative values.

Figure 2-2: BZ Variable 'vu' and the output gap measured by BCB (RTI jun'24)



Source: BCB; author's elaboration.

The robustness of the "vu" indicator was tested through Granger-causality analyses against the Brazilian Central Bank's official output gap estimate. Results demonstrated significant bidirectional Granger causality, indicating that changes in the "vu" measure predict changes in the output gap and vice versa. Consequently, the "vu" indicator serves as a reliable measure of labor market conditions and is appropriately included in the wage equation.

Table 2-1: Granger causality test results (BZ BCB output gap causes BZ VU)

LAG	SSR F-TEST	SSR CHI-SQUARED TEST	LIKELIHOOD RATIO TEST	PARAMETERS F-TEST
1	21.2150 (P=2.2392E-05)	22.2937 (P=2.3397E-06)	19.0447 (P=1.2769E-05)	21.2150 (P=2.2392E-05)
2	28.6771 (P=2.6607E-09)	62.4752 (P=2.7144E-14)	43.0152 (P=4.5643E-10)	28.6771 (P=2.6607E-09)
3	19.7328 (P=1.0159E-08)	67.0171 (P=1.8570E-14)	44.9986 (P=9.2590E-10)	19.7328 (P=1.0159E-08)
4	15.2086 (P=3.3523E-08)	71.7846 (P=9.5302E-15)	46.9649 (P=1.5508E-09)	15.2086 (P=3.3523E-08)

Source: Author's elaboration

Table 2-2: Granger causality test results (BZ VU causes BZ BCB output gap)

LAG	SSR F-TEST	SSR CHI-SQUARED TEST	LIKELIHOOD RATIO TEST	PARAMETERS F-TEST
1	12.4397 (P=8.2064E-04)	13.0723 (P=2.9970E-04)	11.8616 (P=5.7302E-04)	12.4397 (P=8.2064E-04)
2	18.7326 (P=5.9028E-07)	40.8104 (P=1.3745E-09)	31.2465 (P=1.6402E-07)	18.7326 (P=5.9028E-07)
3	12.6723 (P=2.3323E-06)	43.0378 (P=2.4159E-09)	32.4451 (P=4.2166E-07)	12.6723 (P=2.3323E-06)
4	9.5449 (P=8.1811E-06)	45.0520 (P=3.8781E-09)	33.4739 (P=9.5526E-07)	9.5449 (P=8.1811E-06)

Source: Author's elaboration

The shortage indicator utilized in the analysis is the New York Fed's Global Supply Chain indicator.

Trend productivity growth data was sourced from the Productivity Observatory at FGV. The productivity measure used in the analysis is GDP per worker (Y/L), based on the dataset published by Andrade & Considera on the FGV IBRE blog. This productivity measure underwent seasonal adjustment followed by HP filtering to extract the underlying trend component.

2.4. RESULTS

In this results chapter, we analyze and discuss the empirical findings derived from the estimated VAR coefficients across each equation, but now for Brazil. The summary tables presented herein illustrate the aggregated impact of lagged coefficients, offering a concise synthesis of the primary determinants influencing CPI growth, wage growth, and short- and long-term inflation expectations.

Subsequently, we explore the implications of various economic shocks within the Structural Vector Autoregressions (SVARs), examining the dynamic responses of the core variables. This analysis sheds light on the underlying transmission mechanisms and interactions within each model, providing critical insights into inflationary dynamics and the relative significance of each explanatory factor.

For readers seeking a more granular examination of the results, including coefficient estimates for individual lag periods, detailed analyses can be found in Appendix. This structure is intended to facilitate both clarity and depth, enabling comprehensive interpretation within the main text while preserving technical rigor in the supplementary appendices.

Please note that the Bernanke & Blanchard original model (with no changes to the authors' framework) will be represented by 'bb', while the two alternative models will be represented by alt1 and alt2.

2.4.1. Unrestricted VAR-X

The Brazilian VAR estimates reveal notable dynamics between inflation, labor costs, and both short-term and long-term inflation expectations. In the BZ_CPI equation, the large, positive, and statistically significant coefficient on the first lag of BZ_IEST underscores how short-term inflation expectations serve as an immediate driver of realized inflation. By contrast, the negative coefficient on the first lag of BZ_IELT—also significant—suggests a more complex interplay between current price movements and long-term expectations, which could reflect the possibility that a rise in long-term inflation forecasts prompts countervailing policy or market responses that dampen near-term price pressures. At the same time, the third lag of the Employment Cost Index (BZ_ECI) exerts a

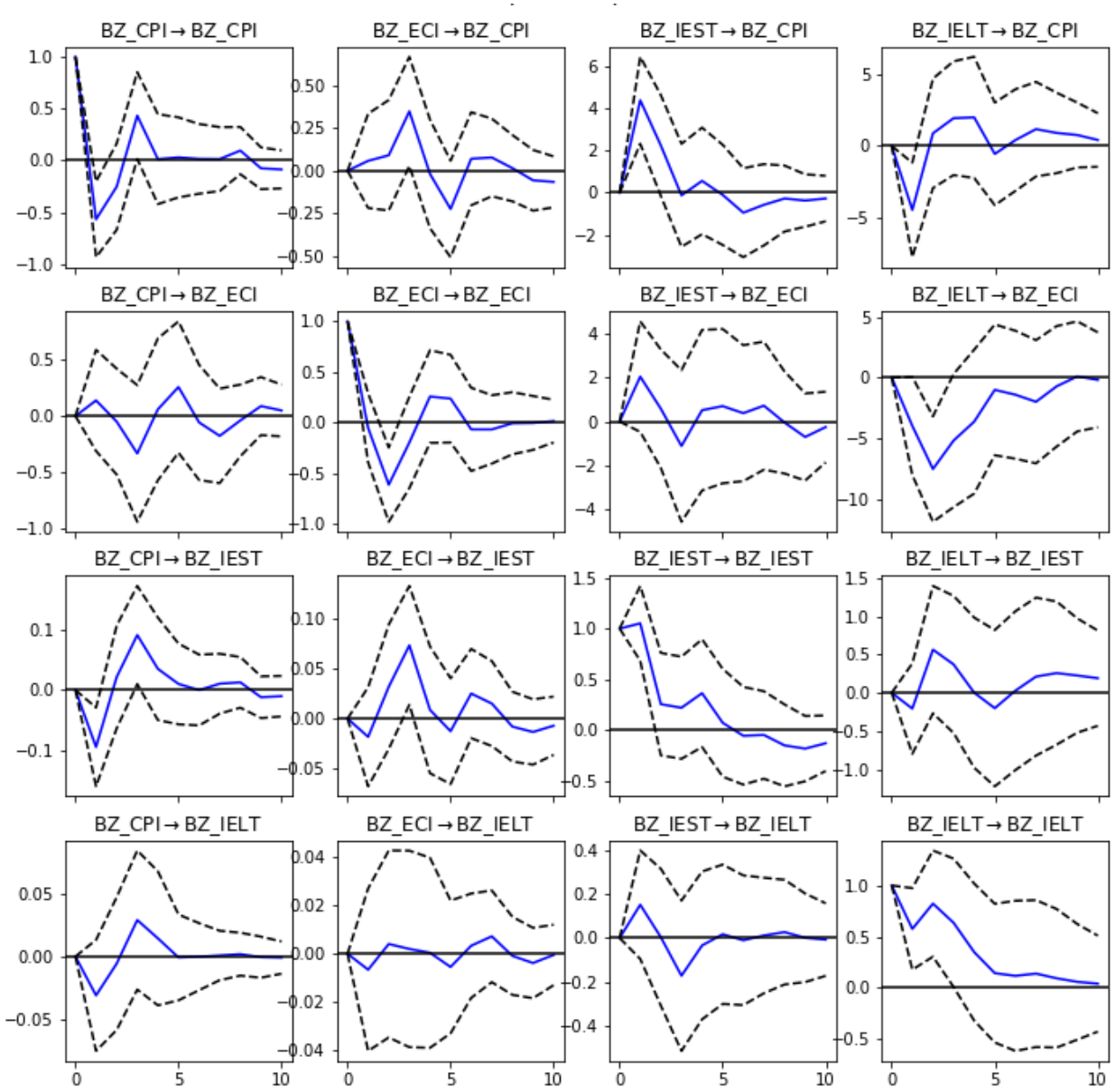
positive and significant influence on current inflation, in line with the view that labor costs, once they filter through the production chain, eventually manifest as higher consumer prices.

In the BZ_ECI equation itself, the second lag of BZ_ECI is both negative and statistically significant, pointing to partial mean-reversion in labor costs or a delayed feedback mechanism. Although some lags of inflation expectations appear with intuitive signs—such as the borderline negative effect of long-term expectations on ECI—many are statistically weaker, hinting that wage or labor-cost adjustments do not immediately incorporate anticipated long-run inflation, but rather unfold over several quarters.

Short-term inflation expectations (BZ_IEST) exhibit strong persistence, as evidenced by the high and significant coefficient on the first lag of BZ_IEST in its own equation. This finding aligns well with standard theories arguing that once elevated short-run expectations take hold, they can sustain or even exacerbate ongoing inflation episodes unless a clear corrective signal changes the public's immediate outlook. Interestingly, the coefficient on the first lag of BZ_CPI in the BZ_IEST equation is negative and significant, suggesting that higher inflation in the preceding quarter may prompt a near-term downward revision in expectations—possibly reflecting that rapid price increases trigger policy moves or market adjustments that temper inflation sentiment going forward.

Long-term expectations (BZ_IELT) also exhibit a degree of inertia, shown by the positive and significant coefficient on their own lag. This result concurs with the widely held view that once long-run beliefs about inflation become anchored, they remain relatively stable absent a substantial shock. However, the overall patterns—particularly the contrasting signs on short- versus long-run expectations in the BZ_CPI equation—emphasize the nuanced ways in which households and firms reconcile immediate price conditions with their broader inflationary outlook. These interactions, where short-run expectations evidently have a more pronounced direct impact on current prices, underscore the importance of monitoring not only wage costs but also the shifting balance between near-term and long-term inflation sentiments in shaping Brazil's inflation trajectory.

Figure 2-3: Impulse-response figures for a VAR-X (BZ)



2.4.2. Structural VAR-X

Prices equation

The 'bb' model shows that CPI growth (*gcpi*) is mainly driven by its own past values, exhibiting strong persistence with a coefficient of 0.78. Wage growth (*gw*) also contributes notably, holding a coefficient of 0.24. The 'bb' model achieves an R-squared of 86.3%, suggesting a robust but not fully optimal explanatory power.

In Alternative Model 1 (alt1), introducing inflation expectations (*iest*) and revised productivity measures (*magpty*) significantly changes the dynamics. The role of lagged CPI growth diminishes substantially, with its coefficient decreasing to 0.42, signaling reduced persistence. Conversely, productivity gains prominence with a coefficient jumping to 0.46, reflecting a more significant role in explaining CPI movements. Additionally, inflation expectations enter the model strongly, with a coefficient of 0.57, helping elevate the R-squared to 91.6%, thus considerably enhancing the model's explanatory power.

An intriguing yet counterintuitive finding emerges regarding shortages. Both the 'bb' model (-0.14) and the alternative models (-0.58) present negative coefficients for shortages, implying that increasing shortages correlate with lower CPI growth. This outcome contradicts traditional economic theory, where shortages typically exert upward pressure on prices due to supply constraints. Such unexpected results could reflect potential model misspecification, data issues, or particular sample-specific factors, such as policy interventions or demand shocks coinciding with shortages and suppressing inflationary pressures.

Productivity also exhibits contrasting roles across models. The 'bb' model shows only a minimal positive relationship (0.01), consistent with the interpretation that improved productivity may slightly ease cost pressures and dampen inflation. However, in alt1 and Alternative Model 2 (alt2), the productivity coefficient increases notably (0.46), suggesting that higher productivity might coincide with stronger economic activity, thus driving demand and, consequently, CPI growth upward. This differing interpretation highlights how model assumptions or data contexts can significantly impact results.

Alternative Model 2 (alt2) mirrors alt1, presenting identical coefficients and explanatory power.

Overall, the improvements in alt1 and alt2 underscore the value of integrating inflation expectations and updated productivity measures, providing a richer and more accurate representation of CPI growth dynamics. These adjustments also reshape the contributions from shortages and lagged inflation within the model framework.

Table 2-3: Coefficients sum for gcpi model (BZ)

gcpi	**bb**	**alt1**	**alt2**
gw	0,24		
gcpi	0,78	0,42	0,42
iest (iestdev+target)		0,57	0,57
magpty	0,01	0,46	0,46
grpe	0,12	0,12	0,12
grpf	0,01	0,04	0,04
shortage	-0,14	-0,58	-0,58
intercept	-0,12	0,31	0,31
r-squared	86,3%	91,6%	91,6%
observations	53	53	53

Source: Author's elaboration

Wages equation

In the 'bb' model, the estimated coefficients align closely with economic theory. Short-term inflation expectations (*iest*) dominate wage growth (*gw*), reflected by a high coefficient of 0.97, underscoring their significant influence. Productivity (*magpty*) and the vacancies-to-unemployed ratio (*vu*) also play crucial roles, indicated by large coefficients of 1.82 and 1.51, respectively, while the "catch-up" variable adds meaningfully with a coefficient of 0.43. Nevertheless, the relatively modest R-squared of 64.2% suggests that some variation in wage growth remains unexplained by the model.

In Alternative Model 1 (alt1), excluding short-term inflation expectations (*iest*) causes considerable shifts in the coefficients and leads to a notable reduction in explanatory power, as reflected by the decline in the R-squared to 53.3%. Wage growth becomes more dependent on its own lags (0.57), while lagged CPI growth (*gcpi*) gains prominence with a coefficient increasing to 0.44. Conversely, productivity and the vacancies-to-unemployed ratio lose significance, with their coefficients decreasing substantially to 0.25 and 0.31, respectively. The catch-up variable also sees a reduced influence, falling to a coefficient of 0.16.

Alternative Model 2 (alt2) mirrors alt1 precisely, presenting identical coefficients and explanatory power without additional modifications.

Table 2-4: Coefficients sum for gw model (US)

gw	**bb**	**alt1**	**alt2**
gw	0,03	0,57	0,57
gcpi	0,00	0,44	0,44
iest (iestdev+target)	0,97		
vu	1,51	0,31	0,31
catch up	0,43	0,16	0,16

magpty	1,82	0,25	0,25
intercept	0,13	0,07	0,07
r-squared	64,2%	53,3%	53,3%
observations	53	53	53

Source: Author's elaboration

Short-run inflation expectations equation

In the 'bb' model, the estimated coefficients align closely with economic theory, highlighting the dominant role of deviations in short-term inflation expectations (*iestdev*), which strongly drive their own dynamics with a high coefficient of 0.85. Deviations in long-term inflation expectations (*ieltdev*) also play a role, albeit more modestly, carrying a coefficient of 0.13. Lagged CPI growth (*gcpi*) adds minimal explanatory value, consistent with its limited theoretical relevance to expectation deviations. Overall, the 'bb' model achieves an impressive fit, as indicated by an R-squared of 94.1%.

Alternative Model 1 (alt1) introduces no changes relative to the 'bb' model, maintaining identical coefficients and explanatory power.

Alternative Model 2 (alt2) includes wage growth (*gw*) as an additional variable, but its contribution is negligible, with a coefficient of -0.03. Incorporating wage growth slightly reshapes the model's dynamics, increasing the influence of short-term expectations deviations (*iestdev*) to 0.97 and diminishing the impact of long-term expectations deviations (*ieltdev*) to just 0.04. However, the addition of wage growth reduces the overall explanatory power, with the R-squared declining to 89.9%. This suggests that wage growth introduces more noise than explanatory value, emphasizing the central importance of short-term inflation expectation deviations and illustrating how sensitive the model is to changes in specification.

Table 2-5: Coefficients sum for iestdev model (BZ)

iestdev	**bb**	**alt1**	**alt2**
gw			-0,03
gcpi	0,01	0,01	
iestdev	0,85	0,85	0,97
ieltdev	0,13	0,13	0,04
r-squared	94,1%	94,1%	89,9%
observations	53	53	53

Source: Author's elaboration

Long-run inflation expectations equation

In the 'bb' model, deviations in long-term inflation expectations (*ieltdev*) are almost entirely driven by their own past dynamics. This is evidenced by a coefficient of 1.00 for lagged long-term

expectations (*ielt*), highlighting a nearly perfect autoregressive process. Lagged CPI growth (*gcpi*) contributes minimally, with a negligible coefficient of 0.00, aligning with its limited theoretical role in influencing long-term expectations deviations. The 'bb' model achieves an R-squared of 77.1%, suggesting a moderately strong explanatory power.

Alternative Model 1 (alt1) introduces no modifications, maintaining the exact coefficients and R-squared values of the 'bb' model, reflecting stability and robustness.

Alternative Model 2 (alt2) includes wage growth (*gw*) in the specification, yet its impact remains insignificant, as indicated by a coefficient of 0.00. This addition slightly decreases the R-squared to 76.6%, marginally weakening the model's overall explanatory power. These results reinforce the conclusion that long-term inflation expectations deviations predominantly follow their own dynamics, unaffected by wage growth or lagged CPI growth.

Table 2-6: Coefficients sum for ieltdev model (BZ)

ieltdev	**bb**	**alt1**	**alt2**
gw			0,00
gcpi	0,00	0,00	
ieltdev	1,00	1,00	1,00
r-squared	77,1%	77,1%	76,6%
observations	53	53	53

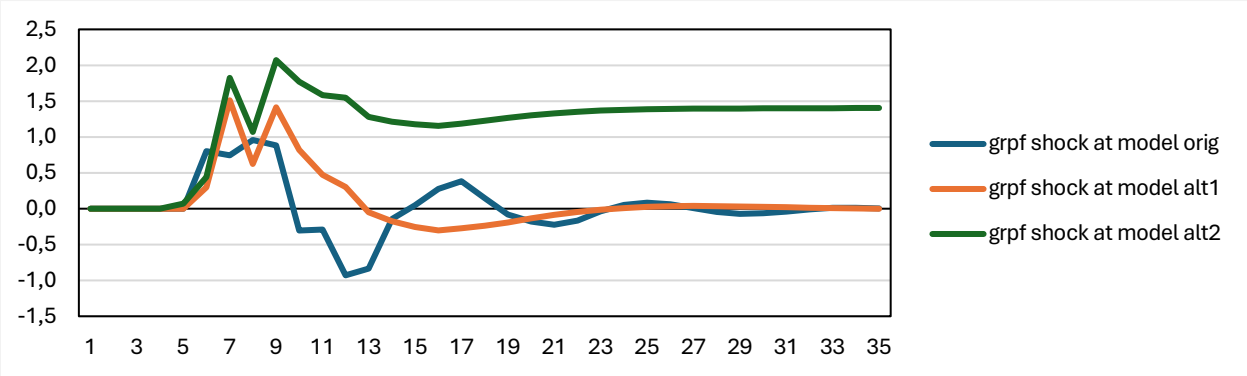
Source: Author's elaboration

Impulse-response functions

Consistent with the insights obtained from impulse response analysis for the United States, the Brazilian models exhibit considerable variability in responses depending on the structural specifications adopted. Notably, the 'bb' model for Brazil responds less aggressively to shocks in the vacancies-to-unemployed ratio (*v/u*) compared to its U.S. counterpart. Similarly, significant divergence arises in responses to shortage shocks, underscoring the sensitivity of the models to structural assumptions.

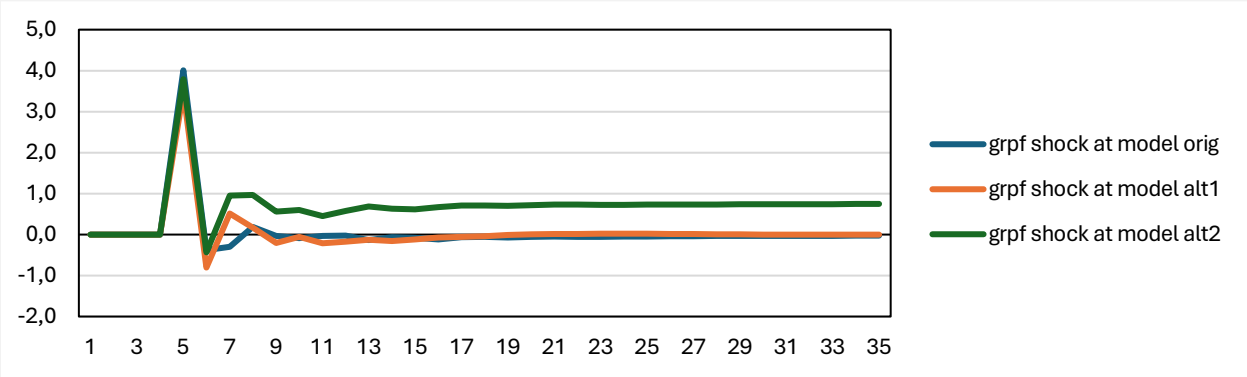
Importantly, these Brazilian models assume an exogenously determined inflation target, explicitly modeling deviations in inflation expectations from this target. This methodological choice enables a nuanced representation of how agents' expectations evolve following economic shocks, offering a more comprehensive perspective on the interactions between labor market dynamics and inflation.

Figure 2-4: Impact of Food Shock on wages (BZ)



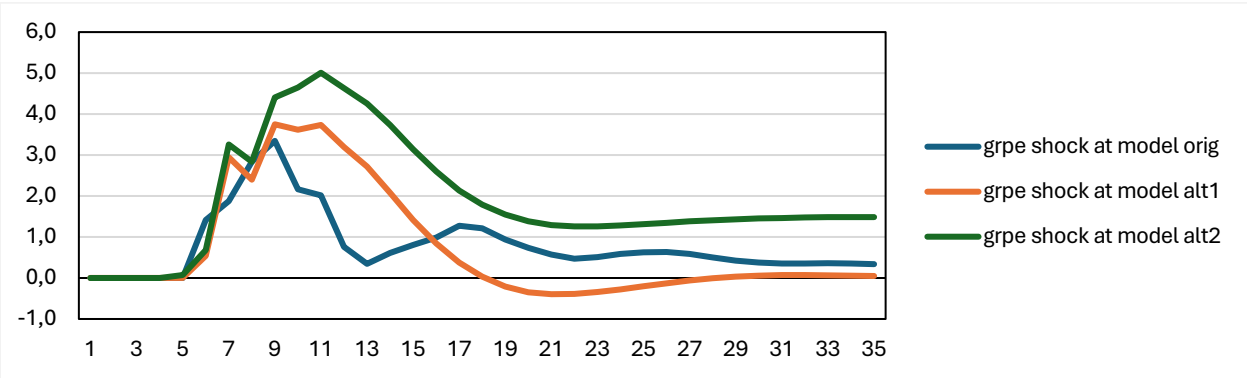
Source: Author's elaboration

Figure 2-5: Impact of Food Shock on CPI (BZ)



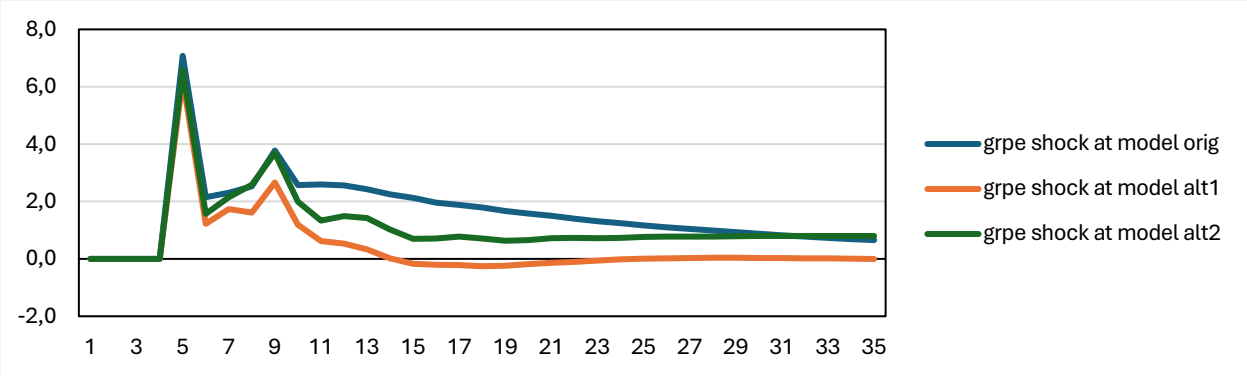
Source: Author's elaboration

Figure 2-6: Impact of Energy Shock on wages (BZ)



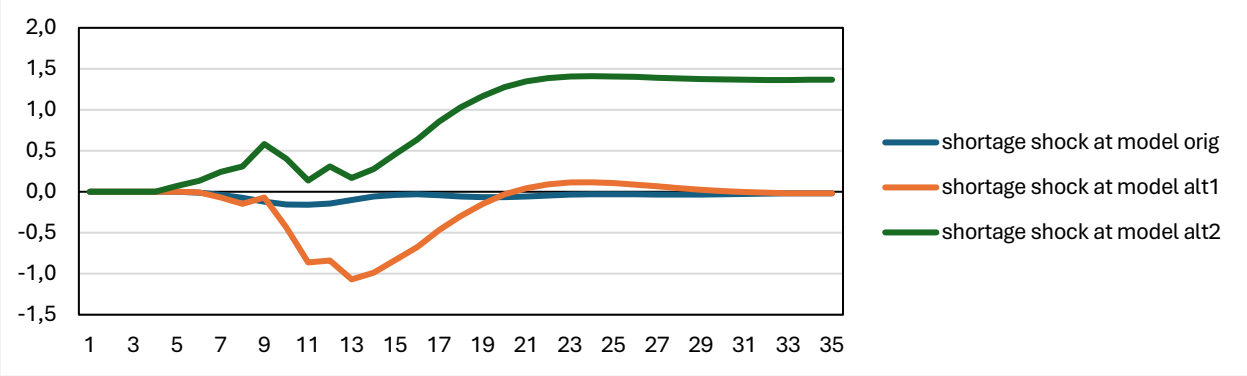
Source: Author's elaboration

Figure 2-7: Impact of Energy Shock on CPI (BZ)



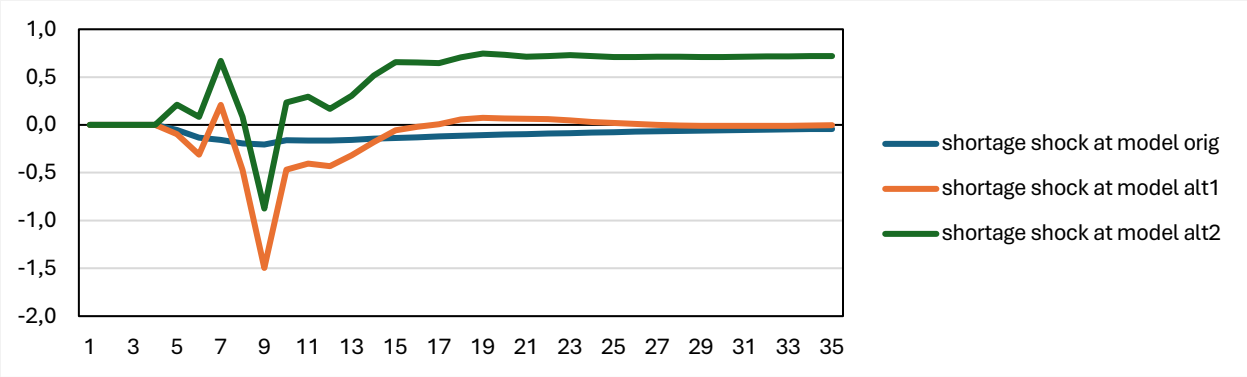
Source: Author's elaboration

Figure 2-8: Impact of Shortage Shock on wages (BZ)



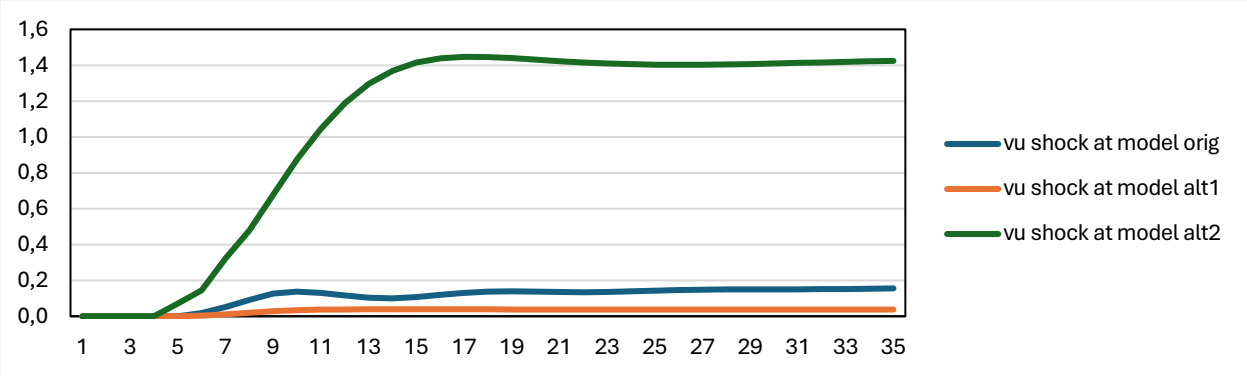
Source: Author's elaboration

Figure 2-9: Impact of Shortage Shock on CPI (BZ)



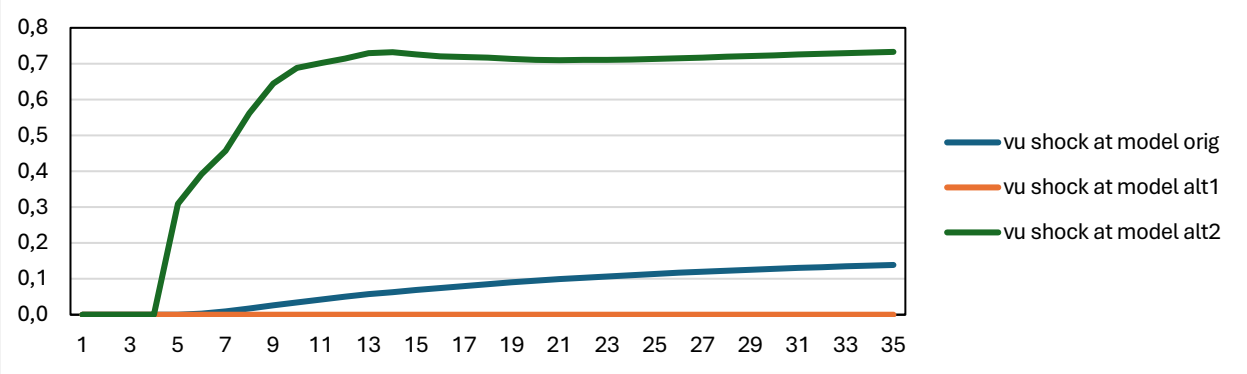
Source: Author's elaboration

Figure 2-10: Impact of V/U Shock on wages (BZ)



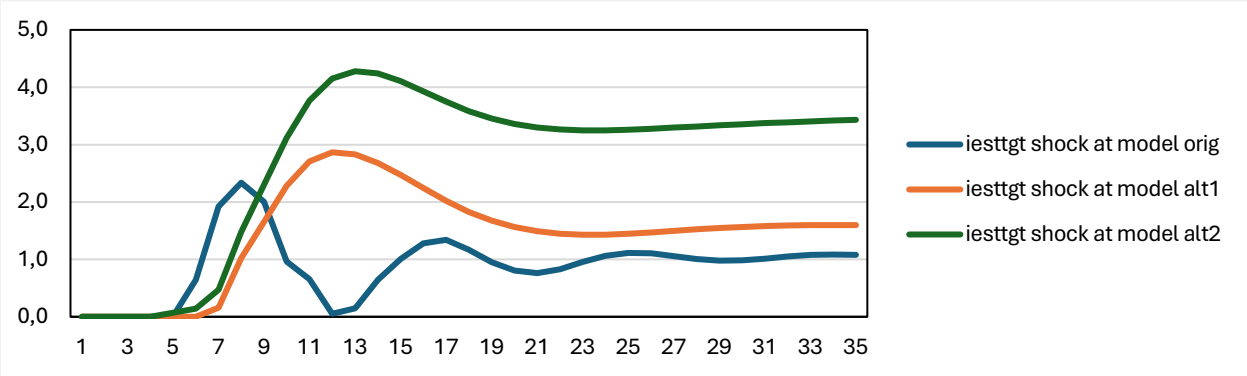
Source: Author's elaboration

Figure 2-11: Impact of V/U Shock on CPI (BZ)



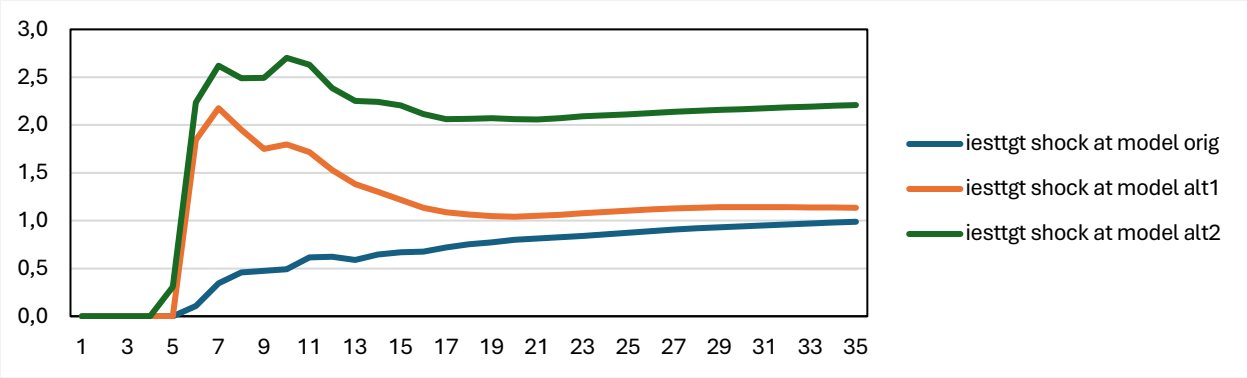
Source: Author's elaboration

Figure 2-12: Impact of Inflation Target Shock on wages (BZ)



Source: Author's elaboration

Figure 2-13: Impact of Inflation Target Shock Shock on CPI (BZ)



Source: Author's elaboration

Collectively, the benchmark Brazilian model 'bb', Alternative Model 1 (alt1), and Alternative Model 2 (alt2) frameworks offer complementary perspectives on CPI inflation (*gcpi*), wage growth (*gw*), and deviations in short-term (*iestdev*) and long-term (*ieltdev*) inflation expectations.

Lagged inflation effects (*gcpi*) consistently remain significant across models, though shifts in coefficients indicate nuanced structural differences. For instance, the lag-4 CPI growth coefficient transitions from positive (0.16) in the 'bb' model to zero in both alt1 and alt2, suggesting reduced relevance of extended lags in alternative specifications. The explanatory power notably improves, with R^2 rising from 86.3% in 'bb' to 91.6% in alternatives.

For wage growth (*gw*), models diverge more markedly. While the lag-1 wage coefficient consistently indicates strong inertia across models, alternative specifications reverse and moderate higher-lag effects, causing explanatory power to decline from 64.2% ('bb') to 53.3% (alt1, alt2).

Short-term inflation expectations deviations (*iestdev*) models illustrate the trade-off between structural detail and model fit: alternative models introduce previously omitted lags, providing deeper insight into expectations dynamics while modestly decreasing explanatory power from 94.1% ('bb') to 89.9% (alt2).

Similarly, modeling of long-term expectations deviations (*ieltdev*) reveals slight reductions in explanatory power—from 77.1% ('bb') to 76.6% (alt1, alt2)—as alternative specifications add complexity through additional lagged variables.

Ultimately, comparing these structural models emphasizes the inherent trade-offs in complexity versus explanatory fit, highlighting the value of multiple specifications to comprehensively capture Brazil's inflation and wage dynamics.

2.5. Conclusion

This study deepens the understanding of inflation dynamics in Brazil by adapting and expanding the Bernanke and Blanchard (2023, 2024) model, allowing for an analysis more aligned with the structural specificities of the Brazilian economy. The conclusions highlight that the rigidity of the original model, particularly regarding the causality between wages and prices and the formation of inflation expectations, underestimates critical factors for understanding inflation in Brazil.

Incorporating inflation expectations as exogenous variables within an inflation-targeting regime proved essential for a more realistic modeling approach. Adjusting the models to reflect deviations from the inflation target allowed for capturing the interaction between monetary policy credibility and wage dynamics, a factor often overlooked by standardized approaches. The results indicate that unanchored expectations play a central role in Brazil's persistent inflation, underscoring the need for transparent and credible monetary policy to mitigate this phenomenon.

Moreover, introducing alternative indexation mechanisms into the model demonstrated how inflationary inertia in Brazil differs substantially from that observed in advanced economies. While recent inflationary pressures in the United States have primarily resulted from supply shocks and labor market rigidity, in Brazil, inflation persistence is strongly linked to indexed wage adjustments and the volatility of economic agents' expectations.

The "vu" indicator, constructed from the FGV employment expectations index and the unemployment rate, proved robust in capturing these dynamics, suggesting that future models should consider similar metrics to better measure inflationary pressures through the labor market.

Finally, this study highlights the need for flexible econometric models that can be adapted to the specificities of emerging economies. Experimenting with alternative structures, including different contemporaneity relationships between variables and adjustments in indexation mechanisms, proved to be a fruitful strategy for improving the understanding of inflation in Brazil. Future studies should explore nonlinear models and further investigate the interaction between monetary policy credibility and expectation formation, allowing for more precise and effective modeling of inflation dynamics in the country.

3. REFERENCES

Andrade, E., & Considera, C. (2024, July). *Hiato do produto no 1º tri de 2024 se mantém positivo, pelo 5º trimestre consecutivo*. Retrieved from Blog do Ibre: https://blogdoibre.fgv.br/posts/hiato-do-produto-no-1o-tri-de-2024-se-mantem-positivo-pelo-5o-trimestre-consecutivo

Arida, P., Lara-Resende, & A. (1985). *Inertial Inflation and Monetary Reform in Brazil*. Retrieved from Paper prepared for the Conference "Inflation and Indexation", Institute of International Economics, Washington, DC: https://www.econ.puc-rio.br/uploads/adm/trabalhos/files/td85.pdf

Ball, L. M., Leigh, D., & Mishra, P. (2022, October). *Understanding U.S. Inflation During the COVID Era*. Retrieved from National Bureau of Economic Research: https://www.nber.org/papers/w30613

Benigno, P., & Eggertsson, G. (2023, April). *It's Baaack: The Surge in Inflation in the 2020s and the Return of the Non-Linear Phillips Curve*. Retrieved from National Bureau of Economic Research: https://www.nber.org/system/files/working_papers/w31197/w31197.pdf

Bernanke, B. S., & Blanchard, O. J. (2023, June). *National Bureau of Economic Research*. Retrieved from What Caused the US Pandemic-Era Inflation?: https://www.nber.org/papers/w31417

Bernanke, B. S., & Blanchard, O. J. (2024, May). *Pandemic-Era Inflation Across Eleven Economies: An Updated Analysis*. Retrieved from The Brookings Institution: https://www.brookings.edu/wp-content/uploads/2024/05/WP91_Bernanke-Blanchard.pdf

Bonomo, M., & Garcia, R. (1994). *Indexation, Staggering, and Disinflation*. Retrieved from Journal of Development Economics: https://www.econ.puc-rio.br/uploads/adm/trabalhos/files/td281.pdf

Cecchetti, S., Feroli, M., Hooper, P., Mishkin, F. S., & Schoenholtz, K. L. (2023, April). *DP18068 Managing Disinflations*. Retrieved from Centre for Economic Policy Research: https://cepr.org/publications/dp18068

Cerisola, M., Gelos, & G. (2009). *What Drives Inflation Expectations in Brazil? An Empirical Analysis*. Retrieved from IMF: https://www.imf.org/en/Publications/WP/Issues/2016/12/31/What-Drives-Inflation-Expectations-in-Brazil-An-Empirical-Analysis-18254

de Mello, L., & Moccero, D. (2009). *Monetary Policy and Inflation Expectations in Latin America: Long-Run Effects and Volatility Linkages*. Retrieved from Journal of Money, Credit and Banking: https://onlinelibrary.wiley.com/doi/10.1111/j.1538-4616.2009.00275.x

Gagliardone, L., & Gertler, M. (2023, May). *National Bureau of Economic Research*. Retrieved from Oil Prices, Monetary Policy and Inflation Surges: https://www.nber.org/papers/w31263

Gagnon, J. E., & Sarsenbayev, M. (2022, October). *25 years of excess unemployment in advanced economies: Lessons for monetary policy*. Retrieved from Peterson Institute for International Economics: https://www.piie.com/sites/default/files/2022-10/wp22-17.pdf

Guerrieri, V., Lorenzoni, G., Ludwig, S., & Werning, I. (2020, April). *Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages?* Retrieved from National Bureau of Economic Research: https://www.nber.org/papers/w26918

Heise, S., Pearce, J., & P., W. J. (2024, October). *Wage Growth and Labor Market Tightness*. Retrieved from Federal Reserve Bank of New York: https://www.newyorkfed.org/research/staff_reports/sr1128.html

Koch, C., & Noureldin, D. (2023, March). *How we missed the recent inflation surge*. Retrieved from International Monetary Fund: https://www.imf.org/en/Publications/fandd/issues/2023/03/how-we-missed-the-recent-inflation-surge-koch-noureldin

Mendonça, H. F. (2007). *Towards Credibility from Inflation Targeting: The Brazilian Experience*. Retrieved from Applied Economics: https://doi.org/10.1080/00036840600707324

Minella, A., de Freitas, P. S., Goldfajn, I., & Muinhos, M. K. (2003). *Inflation Targeting in Brazil: Lessons and Challenges*. Retrieved from BIS: https://www.bis.org/publ/bppdf/bispap19d.pdf

4. Appendix A: VAR-X model

```
VAR Results Summary:
  Summary of Regression Results
==================================
Model:                         VAR
Method:                        OLS
Date:           Thu, 20, Mar, 2025
Time:                     19:09:27
--------------------------------------------------------------------
No. of Equations:         4.00000    BIC:                   -4.26516
Nobs:                     75.0000    HQIC:                  -5.52737
Log likelihood:          -118.943    FPE:                  0.00177439
AIC:                     -6.36635    Det(Omega_mle):     0.000783685
--------------------------------------------------------------------
Results for equation US_CPI
================================================================================
                coefficient       std. error           t-stat            prob
--------------------------------------------------------------------------------
const             -0.015220         0.247980           -0.061           0.951
L1.US_CPI          0.081789         0.211084            0.387           0.698
L1.US_ECI          0.486199         0.516304            0.942           0.346
L1.US_IEST        -1.728575         1.652472           -1.046           0.296
L1.US_IELT         2.220747         3.057609            0.726           0.468
L2.US_CPI         -0.039467         0.211054           -0.187           0.852
L2.US_ECI          0.362569         0.514923            0.704           0.481
L2.US_IEST         0.456746         1.691739            0.270           0.787
L2.US_IELT        -2.154169         3.710649           -0.581           0.562
L3.US_CPI         -0.364089         0.211059           -1.725           0.085
L3.US_ECI          0.760518         0.536366            1.418           0.156
L3.US_IEST         2.202807         1.641633            1.342           0.180
L3.US_IELT        -0.559326         3.640249           -0.154           0.878
L4.US_CPI         -0.224441         0.214194           -1.048           0.295
L4.US_ECI          0.419616         0.541103            0.775           0.438
L4.US_IEST         1.078875         1.630350            0.662           0.508
L4.US_IELT        -1.555482         2.882713           -0.540           0.589
================================================================================
```

Results for equation US_ECI

	coefficient	std. error	t-stat	prob
const	0.007287	0.065923	0.111	0.912
L1.US_CPI	-0.066661	0.056114	-1.188	0.235
L1.US_ECI	0.045246	0.137254	0.330	0.742
L1.US_IEST	0.240091	0.439291	0.547	0.585
L1.US_IELT	0.324229	0.812831	0.399	0.690
L2.US_CPI	0.009134	0.056106	0.163	0.871
L2.US_ECI	0.094949	0.136887	0.694	0.488
L2.US_IEST	-0.406138	0.449730	-0.903	0.366
L2.US_IELT	0.665202	0.986435	0.674	0.500
L3.US_CPI	-0.017750	0.056108	-0.316	0.752
L3.US_ECI	0.024680	0.142587	0.173	0.863
L3.US_IEST	0.433431	0.436410	0.993	0.321
L3.US_IELT	-0.655247	0.967720	-0.677	0.498
L4.US_CPI	-0.043493	0.056941	-0.764	0.445
L4.US_ECI	0.085363	0.143846	0.593	0.553
L4.US_IEST	0.139808	0.433410	0.323	0.747
L4.US_IELT	-0.047475	0.766337	-0.062	0.951

Results for equation US_IEST

	coefficient	std. error	t-stat	prob
const	-0.011123	0.047577	-0.234	0.815
L1.US_CPI	-0.002650	0.040499	-0.065	0.948
L1.US_ECI	0.069329	0.099058	0.700	0.484
L1.US_IEST	-0.412895	0.317044	-1.302	0.193
L1.US_IELT	1.472074	0.586634	2.509	0.012
L2.US_CPI	0.023346	0.040493	0.577	0.564
L2.US_ECI	0.175033	0.098793	1.772	0.076
L2.US_IEST	-0.253917	0.324578	-0.782	0.434
L2.US_IELT	-0.119583	0.711927	-0.168	0.867
L3.US_CPI	-0.047825	0.040494	-1.181	0.238
L3.US_ECI	0.065243	0.102907	0.634	0.526
L3.US_IEST	0.477157	0.314964	1.515	0.130
L3.US_IELT	-0.412342	0.698420	-0.590	0.555
L4.US_CPI	-0.031288	0.041095	-0.761	0.446
L4.US_ECI	0.070642	0.103816	0.680	0.496
L4.US_IEST	0.195158	0.312800	0.624	0.533
L4.US_IELT	-0.160052	0.553079	-0.289	0.772

Results for equation US_IELT

	coefficient	std. error	t-stat	prob
const	-0.006101	0.019302	-0.316	0.752
L1.US_CPI	-0.014444	0.016430	-0.879	0.379
L1.US_ECI	0.027093	0.040188	0.674	0.500
L1.US_IEST	-0.217973	0.128626	-1.695	0.090
L1.US_IELT	1.130589	0.238000	4.750	0.000
L2.US_CPI	0.012896	0.016428	0.785	0.432
L2.US_ECI	0.100236	0.040081	2.501	0.012
L2.US_IEST	-0.099970	0.131683	-0.759	0.448
L2.US_IELT	-0.164902	0.288832	-0.571	0.568
L3.US_CPI	-0.012980	0.016429	-0.790	0.429
L3.US_ECI	0.029512	0.041750	0.707	0.480
L3.US_IEST	0.141367	0.127783	1.106	0.269
L3.US_IELT	-0.087897	0.283352	-0.310	0.756
L4.US_CPI	0.009681	0.016673	0.581	0.561
L4.US_ECI	0.024845	0.042119	0.590	0.555
L4.US_IEST	-0.089140	0.126904	-0.702	0.482
L4.US_IELT	0.059170	0.224387	0.264	0.792

Correlation matrix of residuals

	US_CPI	US_ECI	US_IEST	US_IELT
US_CPI	1.000000	0.298794	0.735312	0.437660
US_ECI	0.298794	1.000000	0.215936	0.089836
US_IEST	0.735312	0.215936	1.000000	0.812046
US_IELT	0.437660	0.089836	0.812046	1.000000

VAR Results Summary:

Summary of Regression Results

Model:	VAR		
Method:	OLS		
Date:	Thu, 20, Mar, 2025		
Time:	20:10:46		
No. of Equations:	4.00000	BIC:	-0.899385
Nobs:	57.0000	HQIC:	-2.38948
Log likelihood:	-160.422	FPE:	0.0383143
AIC:	-3.33671	Det(Omega_mle):	0.0134876

Results for equation BZ_CPI

	coefficient	std. error	t-stat	prob
const	-0.264460	0.221618	-1.193	0.233
L1.BZ_CPI	-0.569603	0.186472	-3.055	0.002
L1.BZ_ECI	0.058401	0.141628	0.412	0.680
L1.BZ_IEST	4.363135	1.047851	4.164	0.000
L1.BZ_IELT	-4.457325	1.682604	-2.649	0.008
L2.BZ_CPI	-0.311234	0.194398	-1.601	0.109
L2.BZ_ECI	0.177889	0.137160	1.297	0.195
L2.BZ_IEST	0.684845	1.405695	0.487	0.626
L2.BZ_IELT	2.047500	1.972040	1.038	0.299
L3.BZ_CPI	0.096209	0.197857	0.486	0.627
L3.BZ_ECI	0.369454	0.141729	2.607	0.009
L3.BZ_IEST	-0.030612	1.414552	-0.022	0.983
L3.BZ_IELT	2.372334	1.975175	1.201	0.230
L4.BZ_CPI	0.006267	0.201358	0.031	0.975
L4.BZ_ECI	0.015611	0.131206	0.119	0.905
L4.BZ_IEST	-2.281089	1.215168	-1.877	0.060
L4.BZ_IELT	4.691259	1.957633	2.396	0.017

Results for equation BZ_ECI

	coefficient	std. error	t-stat	prob
const	0.274613	0.271811	1.010	0.312
L1.BZ_CPI	0.138934	0.228705	0.607	0.544
L1.BZ_ECI	-0.052796	0.173705	-0.304	0.761
L1.BZ_IEST	2.046177	1.285170	1.592	0.111
L1.BZ_IELT	-3.973121	2.063682	-1.925	0.054
L2.BZ_CPI	0.108826	0.238425	0.456	0.648
L2.BZ_ECI	-0.611837	0.168224	-3.637	0.000
L2.BZ_IEST	-1.462298	1.724058	-0.848	0.396
L2.BZ_IELT	-4.409360	2.418671	-1.823	0.068
L3.BZ_CPI	-0.493238	0.242668	-2.033	0.042
L3.BZ_ECI	-0.384548	0.173828	-2.212	0.027
L3.BZ_IEST	1.079859	1.734922	0.622	0.534
L3.BZ_IELT	-3.299825	2.422516	-1.362	0.173
L4.BZ_CPI	-0.312673	0.246962	-1.266	0.205
L4.BZ_ECI	-0.257293	0.160922	-1.599	0.110
L4.BZ_IEST	2.146115	1.490381	1.440	0.150
L4.BZ_IELT	-4.251856	2.401001	-1.771	0.077

Results for equation BZ_IEST

	coefficient	std. error	t-stat	prob
const	-0.019659	0.039754	-0.495	0.621
L1.BZ_CPI	-0.094782	0.033449	-2.834	0.005
L1.BZ_ECI	-0.018295	0.025405	-0.720	0.471
L1.BZ_IEST	1.051741	0.187964	5.595	0.000
L1.BZ_IELT	-0.206787	0.301826	-0.685	0.493
L2.BZ_CPI	0.063517	0.034871	1.821	0.069
L2.BZ_ECI	0.054462	0.024604	2.214	0.027
L2.BZ_IEST	-0.366684	0.252154	-1.454	0.146
L2.BZ_IELT	0.406194	0.353745	1.148	0.251
L3.BZ_CPI	0.049143	0.035492	1.385	0.166
L3.BZ_ECI	0.033410	0.025423	1.314	0.189
L3.BZ_IEST	0.109149	0.253742	0.430	0.667
L3.BZ_IELT	0.083891	0.354307	0.237	0.813
L4.BZ_CPI	0.045147	0.036120	1.250	0.211
L4.BZ_ECI	0.000463	0.023536	0.020	0.984
L4.BZ_IEST	-0.426438	0.217977	-1.956	0.050
L4.BZ_IELT	0.384288	0.351160	1.094	0.274

Results for equation BZ_IELT

	coefficient	std. error	t-stat	prob
const	-0.010081	0.026766	-0.377	0.706
L1.BZ_CPI	-0.030930	0.022522	-1.373	0.170
L1.BZ_ECI	-0.006574	0.017105	-0.384	0.701
L1.BZ_IEST	0.152146	0.126556	1.202	0.229
L1.BZ_IELT	0.575575	0.203220	2.832	0.005
L2.BZ_CPI	0.009861	0.023479	0.420	0.674
L2.BZ_ECI	0.012058	0.016566	0.728	0.467
L2.BZ_IEST	-0.095747	0.169776	-0.564	0.573
L2.BZ_IELT	0.359105	0.238177	1.508	0.132
L3.BZ_CPI	0.026750	0.023897	1.119	0.263
L3.BZ_ECI	-0.005735	0.017118	-0.335	0.738
L3.BZ_IEST	-0.162844	0.170846	-0.953	0.341
L3.BZ_IELT	-0.080342	0.238556	-0.337	0.736
L4.BZ_CPI	0.000316	0.024319	0.013	0.990
L4.BZ_ECI	0.000317	0.015847	0.020	0.984
L4.BZ_IEST	0.093498	0.146764	0.637	0.524
L4.BZ_IELT	-0.097529	0.236437	-0.412	0.680

Correlation matrix of residuals

	BZ_CPI	BZ_ECI	BZ_IEST	BZ_IELT
BZ_CPI	1.000000	-0.285132	0.345306	-0.225441
BZ_ECI	-0.285132	1.000000	-0.186726	-0.047484
BZ_IEST	0.345306	-0.186726	1.000000	0.469200
BZ_IELT	-0.225441	-0.047484	0.469200	1.000000

5. Appendix B: SVAR-X coefficients estimations comparison

Table 4-1: United States: OLS regressions coefficients summary

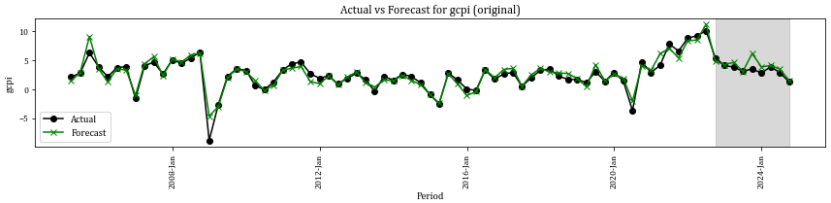
gcpi	bb	alt1	alt2
gw	0,17		
l1.gw	0,13		
l2.gw	0,14		
l3.gw	0,07		
l4.gw	0,08		
gcpi			
l1.gcpi	0,10	0,12	0,12
l2.gcpi	0,10	0,12	0,12
l3.gcpi	0,18	0,24	0,24
l4.gcpi	0,03	-0,03	-0,03
ielt			
l1.ielt			
l2.ielt			
l3.ielt			
l4.ielt			
iest			
l1.iest		0,14	0,14
l2.iest		0,15	0,15
l3.iest		0,18	0,18
l4.iest		0,08	0,08
magpty			
l1.magpty	-0,09	-0,07	-0,07
l2.magpty			
l3.magpty			
l4.magpty			
vu			
l1.vu			
l2.vu			
l3.vu			
l4.vu			
diffcpiiest			
l1.diffcpiiest			
l2.diffcpiiest			
l3.diffcpiiest			
l4.diffcpiiest			
grpe	0,11	0,11	0,11
l1.grpe	0,00	-0,01	-0,01
l2.grpe	-0,01	-0,01	-0,01
l3.grpe	-0,01	-0,01	-0,01
l4.grpe	-0,01	-0,01	-0,01
grpf	0,05	0,04	0,04
l1.grpf	-0,06	-0,10	-0,10
l2.grpf	0,02	0,03	0,03
l3.grpf	-0,06	-0,08	-0,08
l4.grpf	0,11	0,11	0,11
shortage	0,06	0,19	0,19
l1.shortage	0,09	0,28	0,28
l2.shortage	0,00	0,04	0,04
l3.shortage	-0,03	-0,05	-0,05
l4.shortage	0,05	0,15	0,15
dummy_covid_1			
dummy_covid_2			
intercept	-0,05	0,18	0,18
R-squared	90,6%	91,1%	91,1%
Observations	71	71	71

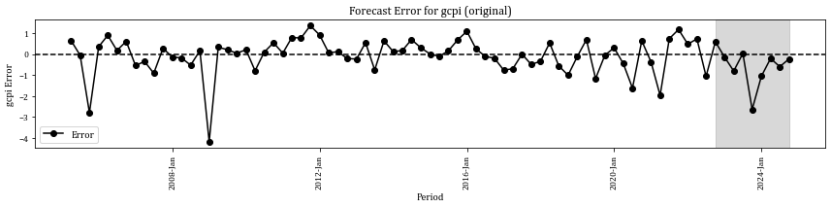
gw	bb	alt1	alt2
gw			
l1.gw	0,25	0,22	0,22
l2.gw	0,28	0,31	0,31
l3.gw	0,15	0,19	0,19
l4.gw	0,06	0,11	0,11
gcpi		0,08	0,08
l1.gcpi		0,08	0,08
l2.gcpi		0,03	0,03
l3.gcpi		-0,02	-0,02
l4.gcpi		0,01	0,01
ielt			
l1.ielt			
l2.ielt			
l3.ielt			
l4.ielt			
iest			
l1.iest	0,20		
l2.iest	0,04		
l3.iest	0,00		
l4.iest	0,02		
magpty			
l1.magpty	0,12	0,05	0,05
l2.magpty			
l3.magpty			
l4.magpty			
vu			
l1.vu	0,10	0,03	0,03
l2.vu	0,03	-0,02	-0,02
l3.vu	0,01	-0,02	-0,02
l4.vu	0,02	0,03	0,03
diffcpiiest			
l1.diffcpiiest	-0,05	-0,09	-0,09
l2.diffcpiiest	0,08	0,11	0,11
l3.diffcpiiest	0,02	0,05	0,05
l4.diffcpiiest	-0,07	-0,07	-0,07
grpe			
l1.grpe			
l2.grpe			
l3.grpe			
l4.grpe			
grpf			
l1.grpf			
l2.grpf			
l3.grpf			
l4.grpf			
shortage			
l1.shortage			
l2.shortage			
l3.shortage			
l4.shortage			
dummy_covid_1	0,03	0,04	0,04
dummy_covid_2	-0,05	-0,05	-0,05
intercept	-0,03	0,00	0,00
R-squared	62,5%	67,5%	67,5%
Observations	71	71	71

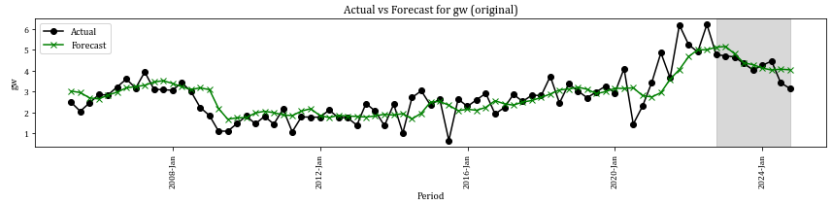
iest	bb	alt1	alt2
gw			0,08
l1.gw			-0,04
l2.gw			0,01
l3.gw			0,00
l4.gw			0,01
gcpi	0,09	0,09	
l1.gcpi	0,04	0,04	
l2.gcpi	-0,01	-0,01	
l3.gcpi	-0,02	-0,02	
l4.gcpi	-0,02	-0,02	
ielt	1,39	1,39	2,49
l1.ielt	-0,48	-0,48	-2,01
l2.ielt	-0,21	-0,21	0,01
l3.ielt	0,09	0,09	0,11
l4.ielt	-0,59	-0,59	-0,40
iest			
l1.iest	0,18	0,18	0,51
l2.iest	0,08	0,08	-0,02
l3.iest	0,17	0,17	0,09
l4.iest	0,29	0,29	0,13
magpty			
l1.magpty			
l2.magpty			
l3.magpty			
l4.magpty			
vu			
l1.vu			
l2.vu			
l3.vu			
l4.vu			
diffcpiiest			
l1.diffcpiiest			
l2.diffcpiiest			
l3.diffcpiiest			
l4.diffcpiiest			
grpe			
l1.grpe			
l2.grpe			
l3.grpe			
l4.grpe			
grpf			
l1.grpf			
l2.grpf			
l3.grpf			
l4.grpf			
shortage			
l1.shortage			
l2.shortage			
l3.shortage			
l4.shortage			
dummy_covid_1			
dummy_covid_2			
intercept			
R-squared	91,0%	91,0%	83,1%
Observations	71	71	71

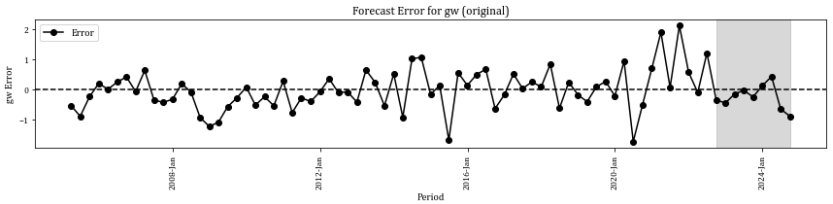
ielt	bb	alt1	alt2
gw			0,03
l1.gw			0,01
l2.gw			0,02
l3.gw			-0,01
l4.gw			-0,03
gcpi	0,03	0,03	
l1.gcpi	-0,01	-0,01	
l2.gcpi	0,00	0,00	
l3.gcpi	-0,01	-0,01	
l4.gcpi	0,00	0,00	
ielt			
l1.ielt	1,10	1,10	1,04
l2.ielt	-0,35	-0,35	-0,42
l3.ielt	0,41	0,41	0,42
l4.ielt	-0,17	-0,17	-0,06
iest			
l1.iest			
l2.iest			
l3.iest			
l4.iest			
magpty			
l1.magpty			
l2.magpty			
l3.magpty			
l4.magpty			
vu			
l1.vu			
l2.vu			
l3.vu			
l4.vu			
diffcpiiest			
l1.diffcpiiest			
l2.diffcpiiest			
l3.diffcpiiest			
l4.diffcpiiest			
grpe			
l1.grpe			
l2.grpe			
l3.grpe			
l4.grpe			
grpf			
l1.grpf			
l2.grpf			
l3.grpf			
l4.grpf			
shortage			
l1.shortage			
l2.shortage			
l3.shortage			
l4.shortage			
dummy_covid_1			
dummy_covid_2			
intercept			
R-squared	89,4%	89,4%	83,4%
Observations	71	71	71

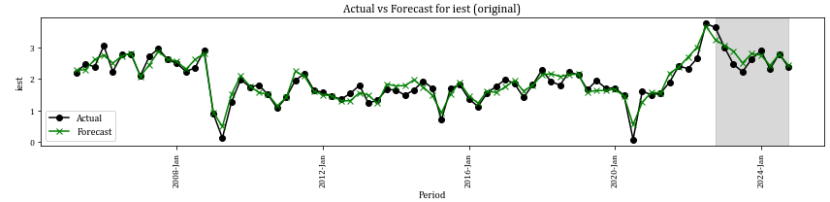
United States: forecasts (**bb model**)

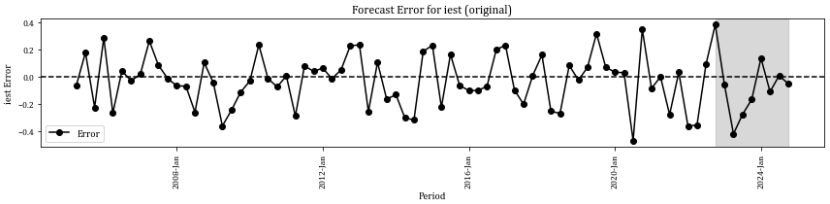


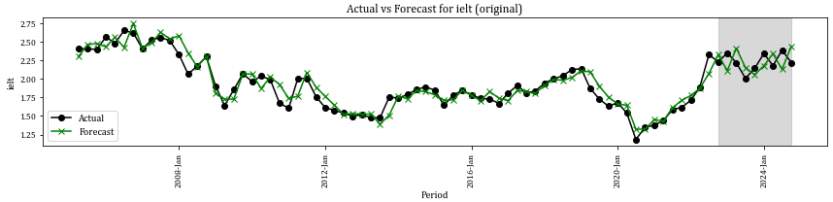


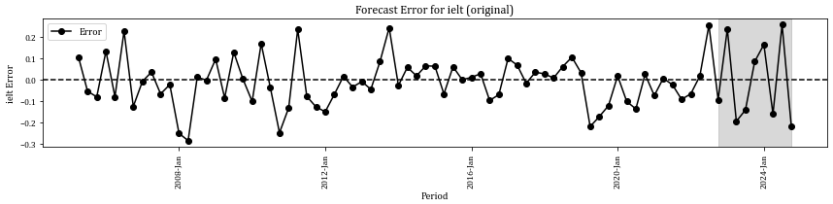




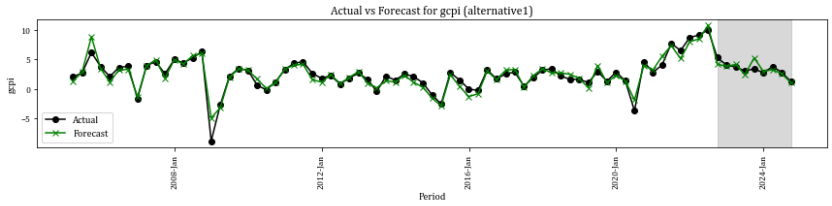


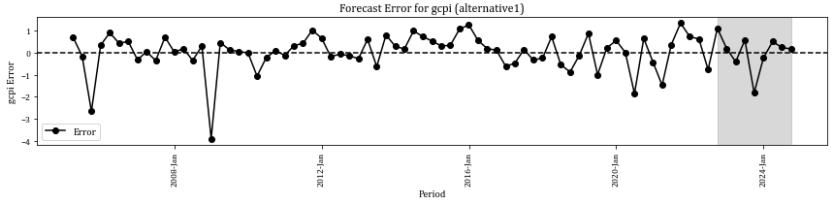


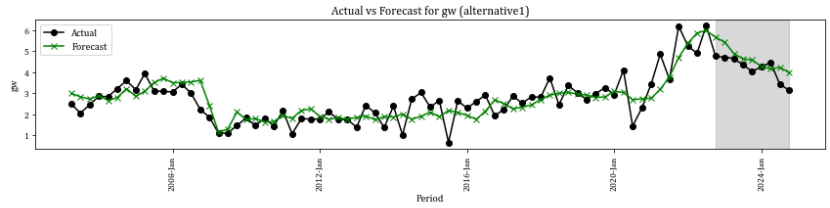


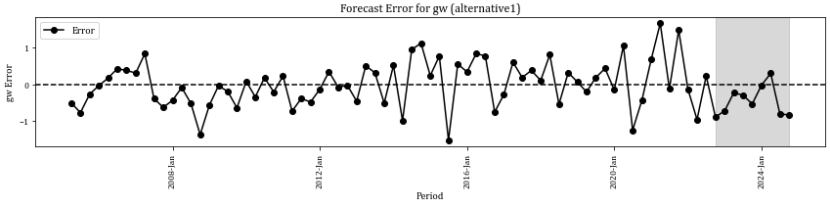


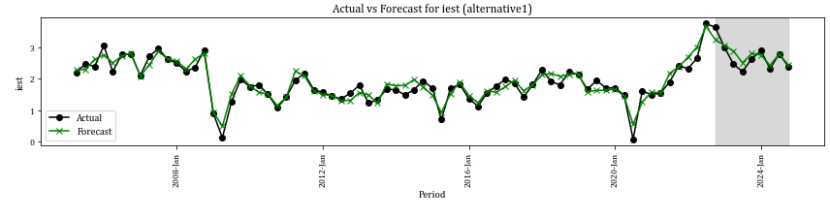
United States: forecasts (**alternative model 1**)

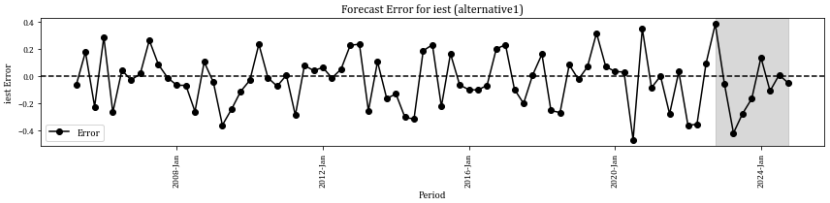


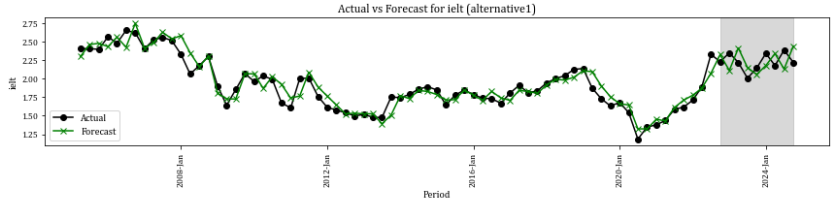


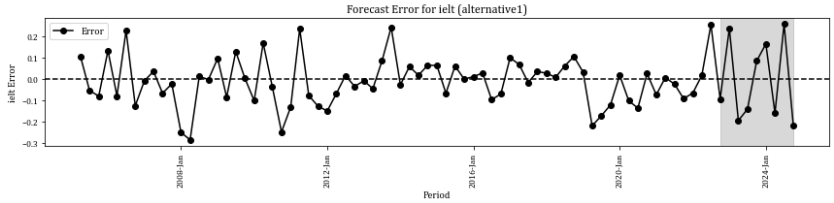




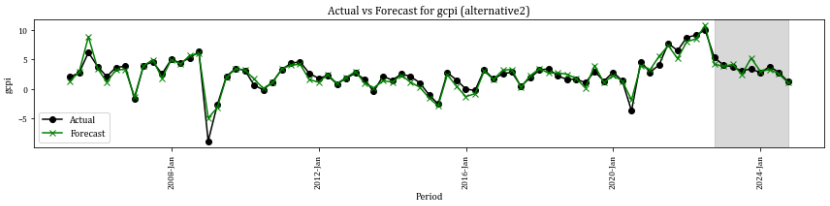


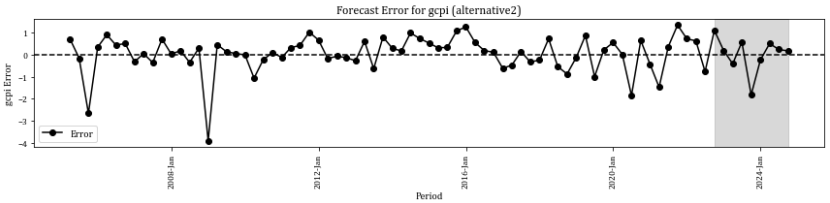


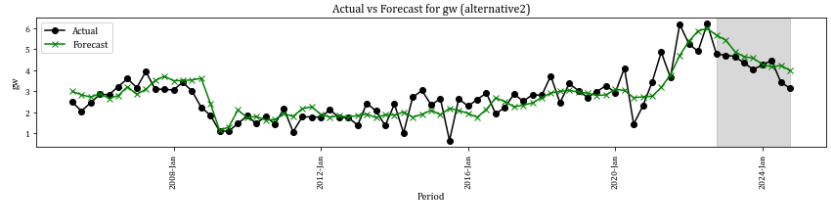


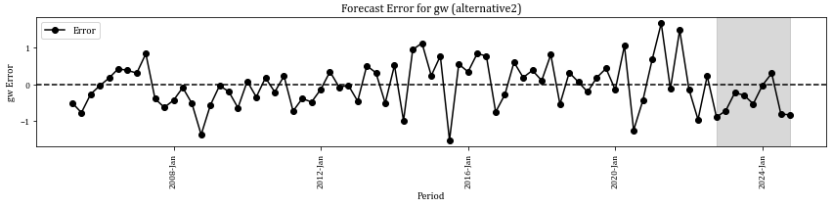


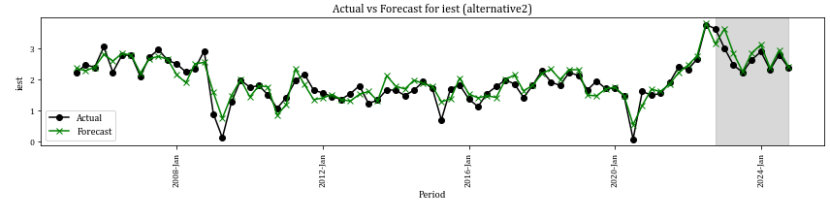
United States: forecasts (**alternative model 2**)

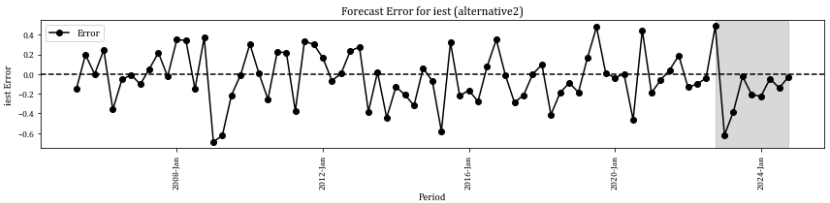


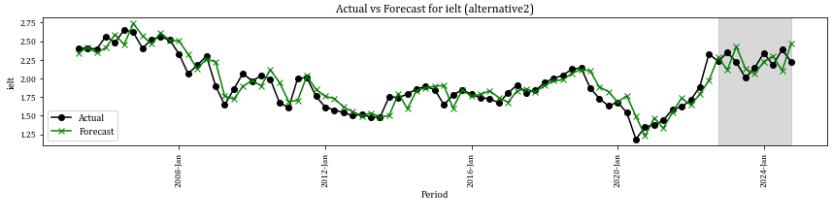












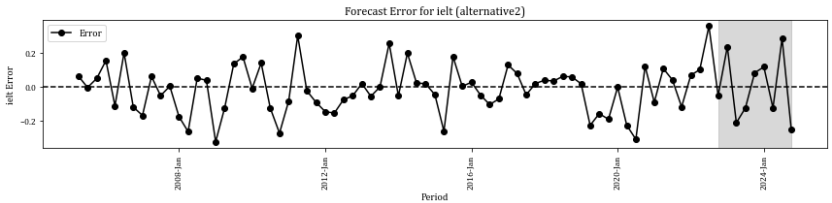


Table 4-2: Brazil: OLS regressions coefficients summary

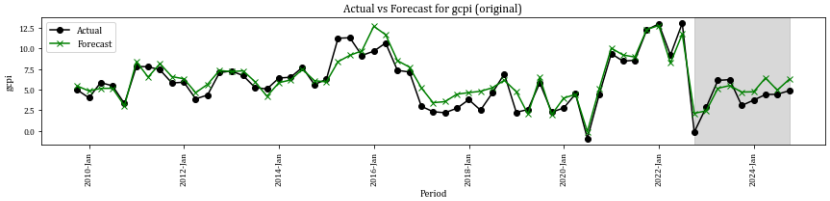
gcpi	**bb**	**alt1**	**alt2**
gw	0,17		
l1.gw	0,00		
l2.gw	-0,05		
l3.gw	0,07		
l4.gw	0,05		
gcpi			
l1.gcpi	0,26	0,18	0,18
l2.gcpi	0,19	0,10	0,10
l3.gcpi	0,17	0,14	0,14
l4.gcpi	0,16	0,00	0,00
ielt			
l1.ielt			
l2.ielt			
l3.ielt			
l4.ielt			
iest			
l1.iest		1,84	1,84
l2.iest		-0,19	-0,19
l3.iest		-0,59	-0,59
l4.iest		-0,49	-0,49
magpty			
l1.magpty	0,01	0,46	0,46
l2.magpty			
l3.magpty			
l4.magpty			
vu			
l1.vu			
l2.vu			
l3.vu			
l4.vu			
diffcpiiest			
l1.diffcpiiest			
l2.diffcpiiest			
l3.diffcpiiest			
l4.diffcpiiest			
grpe	0,11	0,10	0,10
l1.grpe	0,00	-0,01	-0,01
l2.grpe	0,00	0,01	0,01
l3.grpe	0,00	0,00	0,00
l4.grpe	0,01	0,02	0,02
grpf	0,16	0,13	0,13
l1.grpf	-0,06	-0,07	-0,07
l2.grpf	-0,04	0,01	0,01
l3.grpf	-0,02	-0,02	-0,02
l4.grpf	-0,03	-0,01	-0,01
shortage	-0,02	-0,03	-0,03
l1.shortage	-0,04	-0,09	-0,09
l2.shortage	-0,03	0,10	0,10
l3.shortage	-0,03	-0,15	-0,15
l4.shortage	-0,02	-0,41	-0,41
dummy_covid_1			
dummy_covid_2			
intercept	-0,12	0,31	0,31
R-squared	86,3%	91,6%	91,6%
Observations	53	53	53

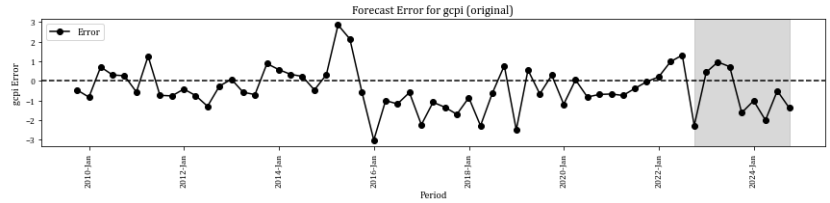
gw	**bb**	**alt1**	**alt2**
gw			
l1.gw	0,55	0,58	0,58
l2.gw	-0,20	0,01	0,01
l3.gw	0,00	0,06	0,06
l4.gw	-0,32	-0,08	-0,08
gcpi		-0,17	-0,17
l1.gcpi		0,07	0,07
l2.gcpi		0,38	0,38
l3.gcpi		-0,03	-0,03
l4.gcpi		0,19	0,19
ielt			
l1.ielt			
l2.ielt			
l3.ielt			
l4.ielt			
iest			
l1.iest	0,65		
l2.iest	0,90		
l3.iest	-0,21		
l4.iest	-0,37		
magpty			
l1.magpty	1,82	0,25	0,25
l2.magpty			
l3.magpty			
l4.magpty			
vu			
l1.vu	0,32	0,08	0,08
l2.vu	0,45	0,08	0,08
l3.vu	0,40	0,08	0,08
l4.vu	0,34	0,07	0,07
diffcpiiest			
l1.diffcpiiest	0,66	0,08	0,08
l2.diffcpiiest	-0,55	0,01	0,01
l3.diffcpiiest	0,56	0,05	0,05
l4.diffcpiiest	-0,24	0,02	0,02
grpe			
l1.grpe			
l2.grpe			
l3.grpe			
l4.grpe			
grpf			
l1.grpf			
l2.grpf			
l3.grpf			
l4.grpf			
shortage			
l1.shortage			
l2.shortage			
l3.shortage			
l4.shortage			
dummy_covid_1	-0,16	0,00	0,00
dummy_covid_2	0,97	0,03	0,03
intercept	0,13	0,07	0,07
R-squared	64,2%	53,3%	53,3%
Observations	53	53	53

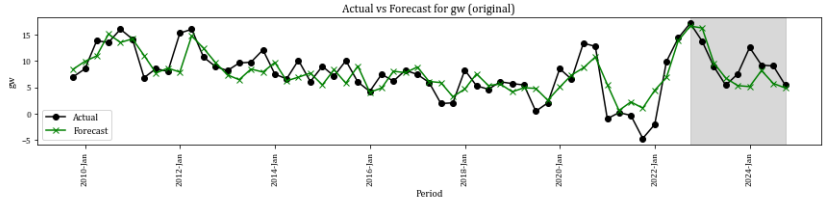
iestdev	**bb**	**alt1**	**alt2**
gw			-0,03
l1.gw			0,01
l2.gw			-0,02
l3.gw			0,01
l4.gw			0,00
gcpi	0,06	0,06	
l1.gcpi	-0,04	-0,04	
l2.gcpi	0,03	0,03	
l3.gcpi	-0,01	-0,01	
l4.gcpi	-0,03	-0,03	
ieltdev	0,38	0,38	0,50
l1.ieltdev	-0,13	-0,13	-0,22
l2.ieltdev	-0,37	-0,37	-0,38
l3.ieltdev	-0,14	-0,14	-0,35
l4.ieltdev	0,39	0,39	0,49
iestdev			
l1.iestdev	1,16	1,16	1,34
l2.iestdev	-0,56	-0,56	-0,67
l3.iestdev	0,53	0,53	0,69
l4.iestdev	-0,28	-0,28	-0,39
magpty			
l1.magpty			
l2.magpty			
l3.magpty			
l4.magpty			
vu			
l1.vu			
l2.vu			
l3.vu			
l4.vu			
diffcpiiest			
l1.diffcpiiest			
l2.diffcpiiest			
l3.diffcpiiest			
l4.diffcpiiest			
grpe			
l1.grpe			
l2.grpe			
l3.grpe			
l4.grpe			
grpf			
l1.grpf			
l2.grpf			
l3.grpf			
l4.grpf			
shortage			
l1.shortage			
l2.shortage			
l3.shortage			
l4.shortage			
dummy_covid_1			
dummy_covid_2			
intercept			
R-squared	94,1%	94,1%	89,9%
Observations	53	53	53

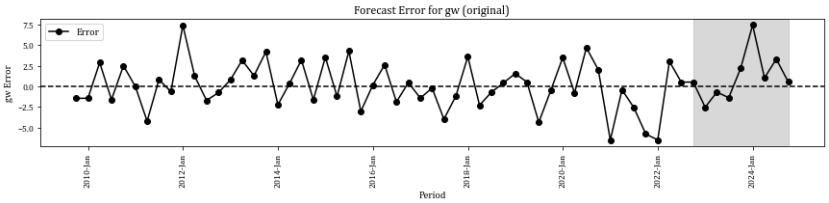
ieltdev	**bb**	**alt1**	**alt2**
gw			0,00
l1.gw			0,00
l2.gw			0,00
l3.gw			0,00
l4.gw			0,00
gcpi	-0,01	-0,01	
l1.gcpi	0,00	0,00	
l2.gcpi	0,00	0,00	
l3.gcpi	0,01	0,01	
l4.gcpi	0,00	0,00	
ieltdev			
l1.ieltdev	1,05	1,05	1,06
l2.ieltdev	-0,17	-0,17	-0,22
l3.ieltdev	-0,02	-0,02	0,01
l4.ieltdev	0,14	0,14	0,15
iestdev			
l1.iestdev			
l2.iestdev			
l3.iestdev			
l4.iestdev			
magpty			
l1.magpty			
l2.magpty			
l3.magpty			
l4.magpty			
vu			
l1.vu			
l2.vu			
l3.vu			
l4.vu			
diffcpiiest			
l1.diffcpiiest			
l2.diffcpiiest			
l3.diffcpiiest			
l4.diffcpiiest			
grpe			
l1.grpe			
l2.grpe			
l3.grpe			
l4.grpe			
grpf			
l1.grpf			
l2.grpf			
l3.grpf			
l4.grpf			
shortage			
l1.shortage			
l2.shortage			
l3.shortage			
l4.shortage			
dummy_covid_1			
dummy_covid_2			
intercept			
R-squared	77,1%	77,1%	76,6%
Observations	53	53	53

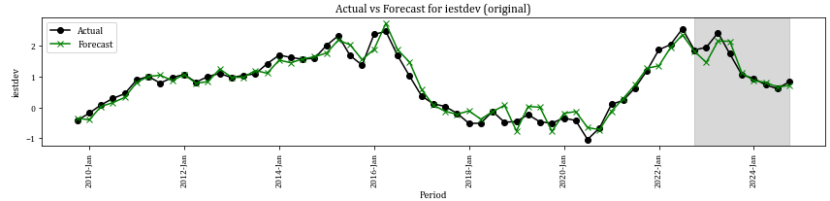
Brazil: forecasts (**bb model**)

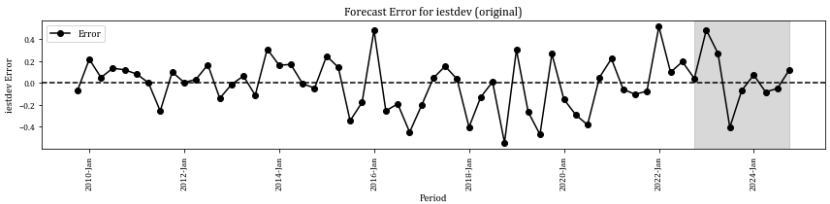


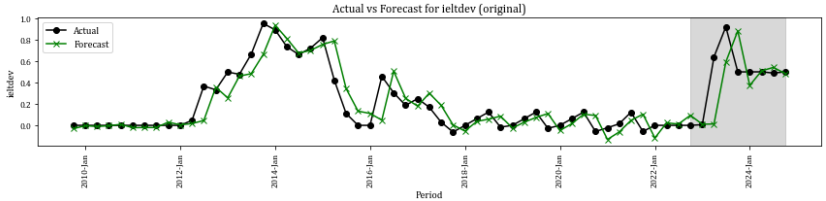


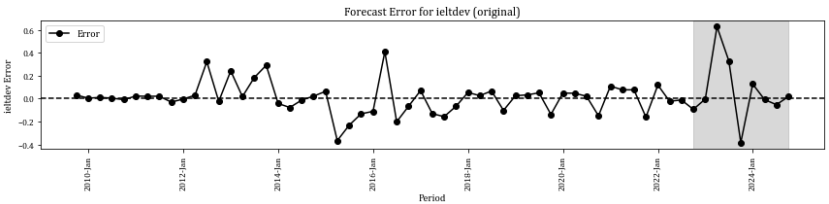




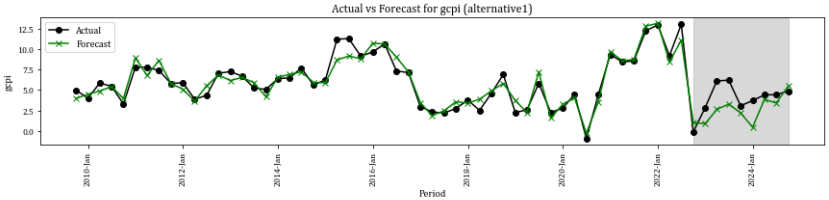


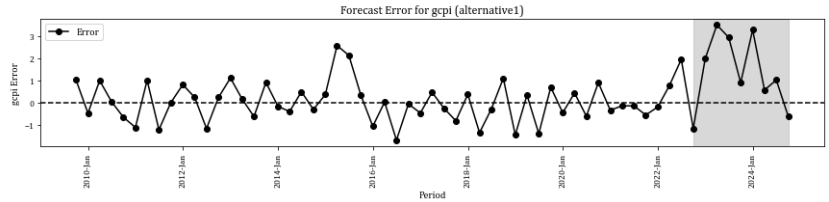


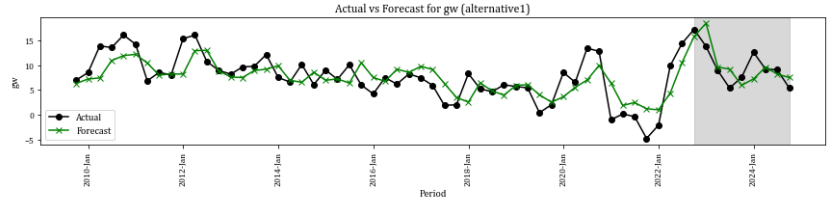


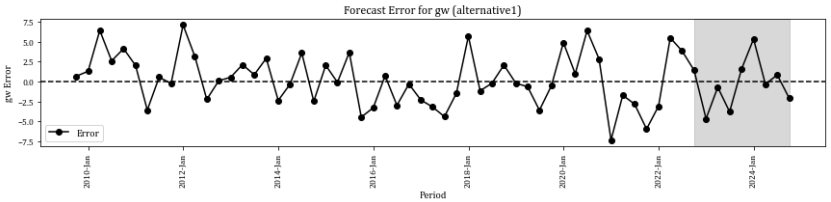


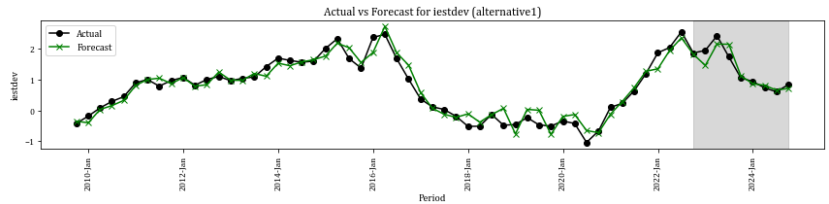
Brazil: forecasts (**alternative model 1**)

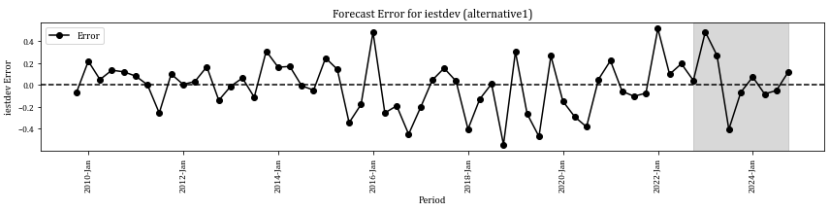


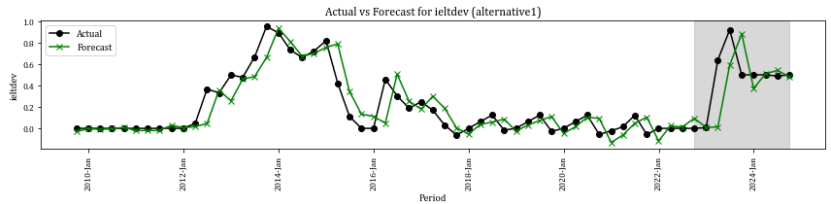


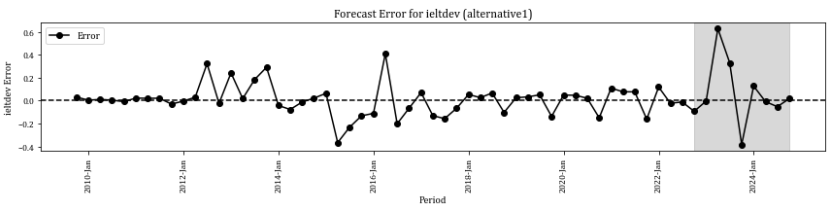




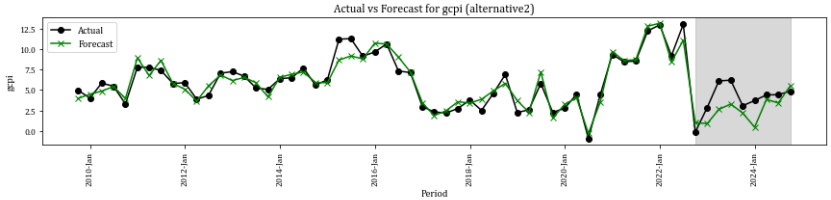


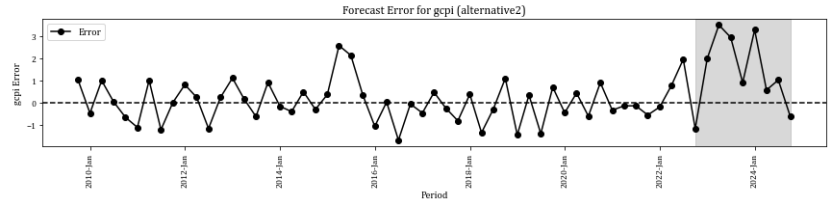


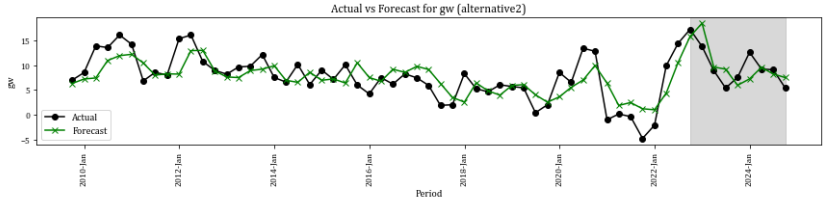


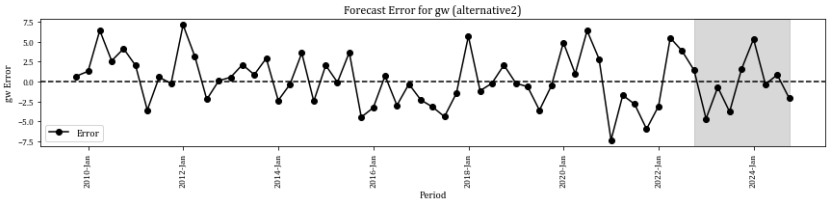


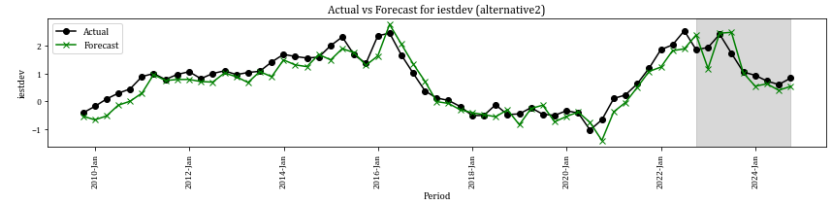
Brazil: forecasts (**alternative model 2**)

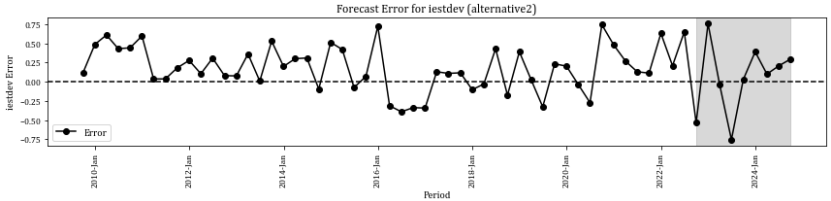


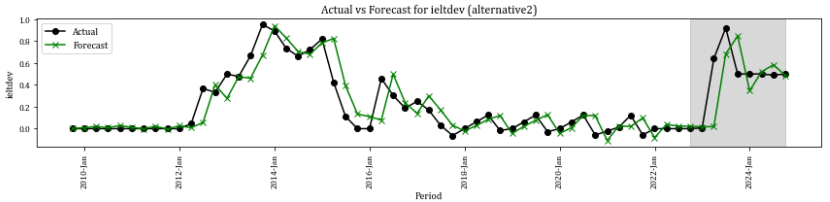


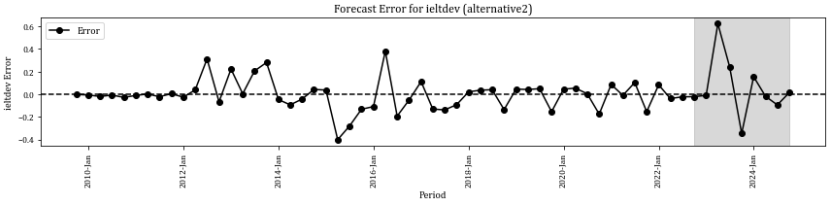












6. Appendix C: SVAR-X coefficients estimations details

US gcpi bb	beta	se	p-value	significance
l1.magpty	-0,09378	0,179074	0,603063	
l1.gcpi	0,098999	0,194849	0,613877	
l2.gcpi	0,09897	0,203002	0,628247	
l3.gcpi	0,180513	0,210793	0,396341	
l4.gcpi	0,027627	0,194134	0,887473	
gw	0,173575	0,276708	0,533641	
l1.gw	0,133342	0,300136	0,658975	
l2.gw	0,139984	0,326809	0,670449	
l3.gw	0,071522	0,308672	0,817816	
l4.gw	0,075468	0,268693	0,780097	
grpe	0,107141	0,007644	0	***
l1.grpe	-0,00308	0,021479	0,886677	
l2.grpe	-0,013	0,021586	0,549886	
l3.grpe	-0,00515	0,022419	0,819337	
l4.grpe	-0,01418	0,021148	0,505927	
grpf	0,052844	0,11204	0,639452	
l1.grpf	-0,05845	0,125092	0,642548	
l2.grpf	0,023843	0,127052	0,851982	
l3.grpf	-0,06317	0,13626	0,645156	
l4.grpf	0,105018	0,105415	0,324462	
shortage	0,057904	0,356877	0,871834	
l1.shortage	0,089802	0,450882	0,843027	
l2.shortage	0,000131	0,450556	0,99977	
l3.shortage	-0,02765	0,418048	0,947557	
l4.shortage	0,046371	0,38934	0,905726	
intercept	-0,05159	0,916827	0,955379	
R-squared	0,905663			
Number of observations	71			

US gw bb	beta	se	p-value	significance
l1.gw	0,246978	0,18769	0,194098	
l2.gw	0,281966	0,189721	0,143378	
l3.gw	0,152723	0,190567	0,42661	
l4.gw	0,057939	0,189785	0,76139	
l1.iest	0,198308	0,250436	0,432115	
l2.iest	0,041427	0,286408	0,885563	
l3.iest	-0,00094	0,283533	0,997379	
l4.iest	0,021594	0,262881	0,934853	
l1.magpty	0,117473	0,099973	0,245431	
l1.vu	0,096546	1,059283	0,927736	
l2.vu	0,032792	1,58019	0,983524	
l3.vu	0,005559	1,638759	0,997307	
l4.vu	0,021211	1,130405	0,985102	
l1.diffcpiiest	-0,05098	0,153126	0,74056	
l2.diffcpiiest	0,077579	0,208564	0,711459	
l3.diffcpiiest	0,020827	0,21474	0,923116	
l4.diffcpiiest	-0,06802	0,162123	0,67658	
dummy_covid_1	0,025282	0,873426	0,977021	
dummy_covid_2	-0,04618	0,893757	0,958995	
intercept	-0,02565	0,491453	0,958576	
R-squared	0,62495			
Number of observations	71			

US iest bb	beta	se	p-value	significance
l1.iest	0,179047	0,1467	0,227304	
l2.iest	0,084721	0,145615	0,562985	
l3.iest	0,171367	0,141817	0,231895	
l4.iest	0,29135	0,121891	0,020164	**
ielt	1,386849	0,244549	4,94E-07	***
l1.ielt	-0,47622	0,460191	0,305123	
l2.ielt	-0,20664	0,491915	0,676016	
l3.ielt	0,088621	0,48389	0,855335	
l4.ielt	-0,59443	0,307873	0,058493	*
gcpi	0,08756	0,013397	1,88E-08	***
l1.gcpi	0,03854	0,01952	0,053195	*
l2.gcpi	-0,00906	0,019972	0,65177	
l3.gcpi	-0,01695	0,02015	0,403629	
l4.gcpi	-0,02476	0,019255	0,203678	
R-squared	0,91048			
Number of observations	71			

US ielt bb	beta	se	p-value	significance
l1.ielt	1,095288	0,126319	2,74E-12	***
l2.ielt	-0,34861	0,187698	0,068019	*
l3.ielt	0,408914	0,195552	0,040626	**
l4.ielt	-0,17218	0,126805	0,17943	
gcpi	0,034779	0,005788	1,08E-07	***
l1.gcpi	-0,00771	0,007762	0,324582	
l2.gcpi	0,000281	0,00774	0,971111	
l3.gcpi	-0,01268	0,007687	0,10403	
l4.gcpi	0,001918	0,006548	0,770549	
R-squared	0,894067			
Number of observations	71			

US gcpi alt1	beta	se	p-value	significance
l1.gcpi	0,1192	0,17816	0,506801	
l2.gcpi	0,119673	0,186701	0,524711	
l3.gcpi	0,235964	0,184474	0,20727	
l4.gcpi	-0,03017	0,177582	0,865836	
l1.iest	0,137133	0,592042	0,817855	
l2.iest	0,152286	0,559898	0,786847	
l3.iest	0,184205	0,557112	0,742416	
l4.iest	0,08171	0,507919	0,872899	
shortage	0,185888	0,320012	0,564157	
l1.shortage	0,275886	0,423644	0,518143	
l2.shortage	0,036905	0,445003	0,934265	
l3.shortage	-0,04869	0,423705	0,909019	
l4.shortage	0,153441	0,402207	0,704591	
grpe	0,108331	0,007495	0	***
l1.grpe	-0,0061	0,018824	0,74754	
l2.grpe	-0,01421	0,018559	0,447814	
l3.grpe	-0,01274	0,018142	0,485939	
l4.grpe	-0,00983	0,017859	0,584687	
grpf	0,044959	0,091299	0,624751	
l1.grpf	-0,09679	0,104105	0,35734	
l2.grpf	0,029695	0,106754	0,782137	
l3.grpf	-0,08307	0,105185	0,433709	
l4.grpf	0,114836	0,093001	0,223185	
l1.magpty	-0,0656	0,171031	0,703085	
intercept	0,175979	0,974798	0,85753	
R-squared	0,910948			
Number of observations	71			

US gw alt1	beta	se	p-value	significance
l1.gw	0,22246	0,181777	0,226762	
l2.gw	0,313681	0,180644	0,08864	*
l3.gw	0,187377	0,181689	0,307361	
l4.gw	0,107672	0,174486	0,539981	
gcpi	0,076186	0,044156	0,090634	*
l1.gcpi	0,078448	0,044304	0,082707	*
l2.gcpi	0,025733	0,046935	0,585939	
l3.gcpi	-0,02493	0,046693	0,595723	
l4.gcpi	0,013375	0,046147	0,773137	
l1.vu	0,030367	0,961171	0,974922	
l2.vu	-0,02237	1,477076	0,987978	
l3.vu	-0,02253	1,524531	0,988267	
l4.vu	0,027473	1,073516	0,979685	
l1.diffcpiiest	-0,0925	0,142666	0,5197	
l2.diffcpiiest	0,109038	0,193812	0,576223	
l3.diffcpiiest	0,049661	0,197962	0,802951	
l4.diffcpiiest	-0,06808	0,149086	0,649917	
l1.magpty	0,047288	0,094789	0,620057	
dummy_covid_1	0,040843	0,826917	0,960804	
dummy_covid_2	-0,04829	0,883945	0,956647	
intercept	0,004759	0,374824	0,989919	
R-squared	0,674847			
Number of observations	71			

US iest alt1	beta	se	p-value	significance
l1.iest	0,179047	0,1467	0,227304	
l2.iest	0,084721	0,145615	0,562985	
l3.iest	0,171367	0,141817	0,231895	
l4.iest	0,29135	0,121891	0,020164	**
ielt	1,386849	0,244549	4,94E-07	***
l1.ielt	-0,47622	0,460191	0,305123	
l2.ielt	-0,20664	0,491915	0,676016	
l3.ielt	0,088621	0,48389	0,855335	
l4.ielt	-0,59443	0,307873	0,058493	*
gcpi	0,08756	0,013397	1,88E-08	***
l1.gcpi	0,03854	0,01952	0,053195	*
l2.gcpi	-0,00906	0,019972	0,65177	
l3.gcpi	-0,01695	0,02015	0,403629	
l4.gcpi	-0,02476	0,019255	0,203678	
R-squared	0,91048			
Number of observations	71			

US ielt alt1	beta	se	p-value	significance
l1.ielt	1,095288	0,126319	2,74E-12	***
l2.ielt	-0,34861	0,187698	0,068019	*
l3.ielt	0,408914	0,195552	0,040626	**
l4.ielt	-0,17218	0,126805	0,17943	
gcpi	0,034779	0,005788	1,08E-07	***
l1.gcpi	-0,00771	0,007762	0,324582	
l2.gcpi	0,000281	0,00774	0,971111	
l3.gcpi	-0,01268	0,007687	0,10403	
l4.gcpi	0,001918	0,006548	0,770549	
R-squared	0,894067			
Number of observations	71			

US gcpi alt2	beta	se	p-value	significance
l1.gcpi	0,1192	0,17816	0,506801	
l2.gcpi	0,119673	0,186701	0,524711	
l3.gcpi	0,235964	0,184474	0,20727	
l4.gcpi	-0,03017	0,177582	0,865836	
l1.iest	0,137133	0,592042	0,817855	
l2.iest	0,152286	0,559898	0,786847	
l3.iest	0,184205	0,557112	0,742416	
l4.iest	0,08171	0,507919	0,872899	
shortage	0,185888	0,320012	0,564157	
l1.shortage	0,275886	0,423644	0,518143	
l2.shortage	0,036905	0,445003	0,934265	
l3.shortage	-0,04869	0,423705	0,909019	
l4.shortage	0,153441	0,402207	0,704591	
grpe	0,108331	0,007495	0	***
l1.grpe	-0,0061	0,018824	0,74754	
l2.grpe	-0,01421	0,018559	0,447814	
l3.grpe	-0,01274	0,018142	0,485939	
l4.grpe	-0,00983	0,017859	0,584687	
grpf	0,044959	0,091299	0,624751	
l1.grpf	-0,09679	0,104105	0,35734	
l2.grpf	0,029695	0,106754	0,782137	
l3.grpf	-0,08307	0,105185	0,433709	
l4.grpf	0,114836	0,093001	0,223185	
l1.magpty	-0,0656	0,171031	0,703085	
intercept	0,175979	0,974798	0,85753	
R-squared	0,910948			
Number of observations	71			

US gw alt2	beta	se	p-value	significance
l1.gw	0,22246	0,181777	0,226762	
l2.gw	0,313681	0,180644	0,08864	*
l3.gw	0,187377	0,181689	0,307361	
l4.gw	0,107672	0,174486	0,539981	
gcpi	0,076186	0,044156	0,090634	*
l1.gcpi	0,078448	0,044304	0,082707	*
l2.gcpi	0,025733	0,046935	0,585939	
l3.gcpi	-0,02493	0,046693	0,595723	
l4.gcpi	0,013375	0,046147	0,773137	
l1.vu	0,030367	0,961171	0,974922	
l2.vu	-0,02237	1,477076	0,987978	
l3.vu	-0,02253	1,524531	0,988267	
l4.vu	0,027473	1,073516	0,979685	
l1.diffcpiiest	-0,0925	0,142666	0,5197	
l2.diffcpiiest	0,109038	0,193812	0,576223	
l3.diffcpiiest	0,049661	0,197962	0,802951	
l4.diffcpiiest	-0,06808	0,149086	0,649917	
l1.magpty	0,047288	0,094789	0,620057	
dummy_covid_1	0,040843	0,826917	0,960804	
dummy_covid_2	-0,04829	0,883945	0,956647	
intercept	0,004759	0,374824	0,989919	
R-squared	0,674847			
Number of observations	71			

US iest alt2	beta	se	p-value	significance
l1.iest	0,510974	0,144935	0,000842	***
l2.iest	-0,01513	0,158851	0,92443	
l3.iest	0,093053	0,162111	0,568222	
l4.iest	0,133612	0,125072	0,289897	
ielt	2,49041	0,27223	8,85E-13	***
l1.ielt	-2,00526	0,56647	0,000805	***
l2.ielt	0,011882	0,671325	0,98594	
l3.ielt	0,111204	0,676823	0,870074	
l4.ielt	-0,39509	0,40916	0,338315	
gw	0,079451	0,053269	0,141344	
l1.gw	-0,04268	0,057352	0,459777	
l2.gw	0,013742	0,064265	0,831435	
l3.gw	0,004315	0,061221	0,944057	
l4.gw	0,009531	0,057239	0,86834	
R-squared	0,831103			
Number of observations	71			

US ielt alt2	beta	se	p-value	significance
l1.ielt	1,042763	0,133557	8,54E-11	***
l2.ielt	-0,42121	0,192044	0,032044	**
l3.ielt	0,424624	0,197037	0,03505	**
l4.ielt	-0,05807	0,137645	0,674597	
gw	0,025661	0,025511	0,318384	
l1.gw	0,00563	0,027329	0,83746	
l2.gw	0,020013	0,02993	0,506192	
l3.gw	-0,00676	0,028059	0,81051	
l4.gw	-0,03266	0,0275	0,239558	
R-squared	0,833961			
Number of observations	71			

BZ gcpi bb	beta	se	p-value	significance
l1.magpty	0,007338	0,358163	0,983806	
l1.gcpi	0,258226	0,258789	0,327224	
l2.gcpi	0,185288	0,304698	0,5482	
l3.gcpi	0,165799	0,306029	0,592416	
l4.gcpi	0,155104	0,246891	0,535134	
gw	0,166089	0,12052	0,179483	
l1.gw	-0,00247	0,15052	0,98705	
l2.gw	-0,05196	0,132569	0,698165	
l3.gw	0,074881	0,12979	0,568761	
l4.gw	0,049041	0,126023	0,700224	
grpe	0,11114	0,02337	5,87E-05	***
l1.grpe	0,001353	0,035713	0,970066	
l2.grpe	0,002055	0,036917	0,95601	
l3.grpe	-0,00056	0,036985	0,987939	
l4.grpe	0,01073	0,034163	0,755874	
grpf	0,155235	0,037868	0,00034	***
l1.grpf	-0,05995	0,055157	0,286696	
l2.grpf	-0,04112	0,063177	0,520667	
l3.grpf	-0,01737	0,066749	0,796647	
l4.grpf	-0,02906	0,065371	0,660178	
shortage	-0,01613	0,602644	0,97884	
l1.shortage	-0,03709	0,729937	0,959844	
l2.shortage	-0,03319	0,855404	0,969338	
l3.shortage	-0,03375	0,805323	0,966879	
l4.shortage	-0,02371	0,612099	0,96939	
intercept	-0,12244	1,295496	0,925402	
R-squared	0,863416			
Number of observations	53			

BZ gw bb	beta	se	p-value	significance
l1.gw	0,545926	0,205525	0,012077	**
l2.gw	-0,20293	0,210654	0,342388	
l3.gw	0,001246	0,223298	0,995581	
l4.gw	-0,31714	0,228982	0,175346	
l1.iest	0,645443	1,906287	0,737066	
l2.iest	0,902191	3,2034	0,779982	
l3.iest	-0,20804	3,059691	0,946201	
l4.iest	-0,3667	1,889736	0,847329	
l1.magpty	1,821681	0,945912	0,062775	*
l1.vu	0,322025	52,5083	0,995144	
l2.vu	0,453923	59,65605	0,993975	
l3.vu	0,403697	64,26956	0,995026	
l4.vu	0,344984	51,51281	0,994697	
l1.diffcpiiest	0,656493	1,208858	0,590732	
l2.diffcpiiest	-0,54963	2,14059	0,798954	
l3.diffcpiiest	0,559878	1,959176	0,776839	
l4.diffcpiiest	-0,24399	1,119498	0,828816	
dummy_covid_1	-0,16407	4,64789	0,972053	
dummy_covid_2	0,968803	4,453597	0,829133	
intercept	0,128307	35,30593	0,997122	
R-squared	0,642395			
Number of observations	53			

BZ iestdev bb	beta	se	p-value	significance
l1.iestdev	1,15778	0,145984	1,17E-09	***
l2.iestdev	-0,55514	0,237234	0,024492	**
l3.iestdev	0,526374	0,238905	0,033549	**
l4.iestdev	-0,27856	0,160167	0,089888	*
ieltdev	0,376401	0,30391	0,222924	
l1.ieltdev	-0,12946	0,427958	0,76387	
l2.ieltdev	-0,37293	0,439349	0,401155	
l3.ieltdev	-0,13788	0,429992	0,750186	
l4.ieltdev	0,393814	0,313789	0,216937	
gcpi	0,059295	0,016569	0,000943	***
l1.gcpi	-0,03625	0,024587	0,148467	
l2.gcpi	0,03019	0,026252	0,257141	
l3.gcpi	-0,00723	0,026961	0,789991	
l4.gcpi	-0,0264	0,025321	0,303459	
R-squared	0,940841			
Number of observations	53			

BZ ielt bb	beta	se	p-value	significance
l1.ieltdev	1,050496	0,154876	2,38E-08	***
l2.ieltdev	-0,17361	0,219507	0,433245	
l3.ieltdev	-0,02062	0,222265	0,926493	
l4.ieltdev	0,144204	0,156821	0,362824	
gcpi	-0,00857	0,007601	0,265867	
l1.gcpi	0,003472	0,010817	0,749745	
l2.gcpi	0,002063	0,011161	0,854219	
l3.gcpi	0,006577	0,011729	0,577797	
l4.gcpi	-0,00401	0,010117	0,693394	
R-squared	0,771039			
Number of observations	53			

BZ gcpi alt1	beta	se	p-value	significance
l1.gcpi	0,178449	0,22286	0,430033	
l2.gcpi	0,104895	0,237031	0,6615	
l3.gcpi	0,140564	0,263866	0,598437	
l4.gcpi	-0,00068	0,260794	0,997937	
l1.iest	1,843232	0,819784	0,032605	**
l2.iest	-0,18665	1,551823	0,905122	
l3.iest	-0,586	1,548	0,707877	
l4.iest	-0,49382	1,109208	0,659601	
shortage	-0,03025	0,488461	0,951062	
l1.shortage	-0,08751	0,567644	0,878593	
l2.shortage	0,096301	0,630403	0,879682	
l3.shortage	-0,14554	0,602326	0,810824	
l4.shortage	-0,41459	0,495366	0,409719	
grpe	0,098384	0,015598	8,03E-07	***
l1.grpe	-0,00859	0,023453	0,716813	
l2.grpe	0,007596	0,023716	0,751128	
l3.grpe	-0,00138	0,024429	0,955478	
l4.grpe	0,02307	0,022466	0,313273	
grpf	0,134853	0,030863	0,000155	***
l1.grpf	-0,06916	0,042822	0,117505	
l2.grpf	0,00913	0,044859	0,840185	
l3.grpf	-0,01693	0,044739	0,708053	
l4.grpf	-0,01352	0,048205	0,781129	
l1.magpty	0,464933	0,326568	0,165584	
intercept	0,309443	2,428509	0,899518	
R-squared	0,915599			
Number of observations	53			

BZ gw alt1	beta	se	p-value	significance
l1.gw	0,584786	0,255365	0,02876	**
l2.gw	0,006213	0,264749	0,981423	
l3.gw	0,057265	0,267013	0,831544	
l4.gw	-0,08334	0,247414	0,738444	
gcpi	-0,17307	0,290543	0,555586	
l1.gcpi	0,06671	0,341062	0,846165	
l2.gcpi	0,381199	0,395735	0,342635	
l3.gcpi	-0,03017	0,46934	0,949146	
l4.gcpi	0,190401	0,422347	0,655162	
l1.vu	0,077376	61,61042	0,999006	
l2.vu	0,078854	70,66744	0,999117	
l3.vu	0,076376	73,77816	0,99918	
l4.vu	0,074229	55,25584	0,998936	
l1.diffcpiiest	0,076429	1,49968	0,959671	
l2.diffcpiiest	0,013632	2,440321	0,995578	
l3.diffcpiiest	0,050283	2,217498	0,98205	
l4.diffcpiiest	0,024023	1,284462	0,985195	
l1.magpty	0,250622	0,906854	0,784046	
dummy_covid_1	0,004085	5,271434	0,999386	
dummy_covid_2	0,026492	5,275284	0,996024	
intercept	0,071759	38,14479	0,998511	
R-squared	0,533042			
Number of observations	53			

BZ iestdev alt1	beta	se	p-value	significance
l1.iestdev	1,15778	0,145984	1,17E-09	***
l2.iestdev	-0,55514	0,237234	0,024492	**
l3.iestdev	0,526374	0,238905	0,033549	**
l4.iestdev	-0,27856	0,160167	0,089888	*
ieltdev	0,376401	0,30391	0,222924	
l1.ieltdev	-0,12946	0,427958	0,76387	
l2.ieltdev	-0,37293	0,439349	0,401155	
l3.ieltdev	-0,13788	0,429992	0,750186	
l4.ieltdev	0,393814	0,313789	0,216937	
gcpi	0,059295	0,016569	0,000943	***
l1.gcpi	-0,03625	0,024587	0,148467	
l2.gcpi	0,03019	0,026252	0,257141	
l3.gcpi	-0,00723	0,026961	0,789991	
l4.gcpi	-0,0264	0,025321	0,303459	
R-squared	0,940841			
Number of observations	53			

BZ ieltdev alt1	beta	se	p-value	significance
l1.ieltdev	1,050496	0,154876	2,38E-08	***
l2.ieltdev	-0,17361	0,219507	0,433245	
l3.ieltdev	-0,02062	0,222265	0,926493	
l4.ieltdev	0,144204	0,156821	0,362824	
gcpi	-0,00857	0,007601	0,265867	
l1.gcpi	0,003472	0,010817	0,749745	
l2.gcpi	0,002063	0,011161	0,854219	
l3.gcpi	0,006577	0,011729	0,577797	
l4.gcpi	-0,00401	0,010117	0,693394	
R-squared	0,771039			
Number of observations	53			

BZ gcpi alt2	beta	se	p-value	significance
l1.gcpi	0,178449	0,22286	0,430033	
l2.gcpi	0,104895	0,237031	0,6615	
l3.gcpi	0,140564	0,263866	0,598437	
l4.gcpi	-0,00068	0,260794	0,997937	
l1.iest	1,843232	0,819784	0,032605	**
l2.iest	-0,18665	1,551823	0,905122	
l3.iest	-0,586	1,548	0,707877	
l4.iest	-0,49382	1,109208	0,659601	
shortage	-0,03025	0,488461	0,951062	
l1.shortage	-0,08751	0,567644	0,878593	
l2.shortage	0,096301	0,630403	0,879682	
l3.shortage	-0,14554	0,602326	0,810824	
l4.shortage	-0,41459	0,495366	0,409719	
grpe	0,098384	0,015598	8,03E-07	***
l1.grpe	-0,00859	0,023453	0,716813	
l2.grpe	0,007596	0,023716	0,751128	
l3.grpe	-0,00138	0,024429	0,955478	
l4.grpe	0,02307	0,022466	0,313273	
grpf	0,134853	0,030863	0,000155	***
l1.grpf	-0,06916	0,042822	0,117505	
l2.grpf	0,00913	0,044859	0,840185	
l3.grpf	-0,01693	0,044739	0,708053	
l4.grpf	-0,01352	0,048205	0,781129	
l1.magpty	0,464933	0,326568	0,165584	
intercept	0,309443	2,428509	0,899518	
R-squared	0,915599			
Number of observations	53			

BZ gw alt2	beta	se	p-value	significance
l1.gw	0,584786	0,255365	0,02876	**
l2.gw	0,006213	0,264749	0,981423	
l3.gw	0,057265	0,267013	0,831544	
l4.gw	-0,08334	0,247414	0,738444	
gcpi	-0,17307	0,290543	0,555586	
l1.gcpi	0,06671	0,341062	0,846165	
l2.gcpi	0,381199	0,395735	0,342635	
l3.gcpi	-0,03017	0,46934	0,949146	
l4.gcpi	0,190401	0,422347	0,655162	
l1.vu	0,077376	61,61042	0,999006	
l2.vu	0,078854	70,66744	0,999117	
l3.vu	0,076376	73,77816	0,99918	
l4.vu	0,074229	55,25584	0,998936	
l1.diffcpiiest	0,076429	1,49968	0,959671	
l2.diffcpiiest	0,013632	2,440321	0,995578	
l3.diffcpiiest	0,050283	2,217498	0,98205	
l4.diffcpiiest	0,024023	1,284462	0,985195	
l1.magpty	0,250622	0,906854	0,784046	
dummy_covid_1	0,004085	5,271434	0,999386	
dummy_covid_2	0,026492	5,275284	0,996024	
intercept	0,071759	38,14479	0,998511	
R-squared	0,533042			
Number of observations	53			

BZ iestdev alt2	beta	se	p-value	significance
l1.iestdev	1,336	0,155635	1,6E-10	***
l2.iestdev	-0,66701	0,266635	0,016669	**
l3.iestdev	0,686978	0,264029	0,013037	**
l4.iestdev	-0,385	0,161203	0,021865	**
ieltdev	0,498404	0,385553	0,203721	
l1.ieltdev	-0,21676	0,546896	0,694017	
l2.ieltdev	-0,37604	0,550008	0,498209	
l3.ieltdev	-0,35215	0,539712	0,517916	
l4.ieltdev	0,493009	0,36487	0,184421	
gw	-0,0252	0,015019	0,10134	
l1.gw	0,013023	0,01744	0,459706	
l2.gw	-0,01639	0,017773	0,361982	
l3.gw	0,008	0,018028	0,659688	
l4.gw	0,003145	0,016832	0,85273	
R-squared	0,899326			
Number of observations	53			

BZ ieltdev alt2	beta	se	p-value	significance
l1.ieltdev	1,06235	0,155337	1,97E-08	***
l2.ieltdev	-0,22024	0,218794	0,319617	
l3.ieltdev	0,007485	0,218554	0,972834	
l4.ieltdev	0,14934	0,152101	0,331544	
gw	0,002895	0,005044	0,568941	
l1.gw	-0,00328	0,007036	0,643353	
l2.gw	0,002488	0,006975	0,722966	
l3.gw	-0,00034	0,007158	0,962299	
l4.gw	-0,00069	0,005733	0,904321	
R-squared	0,766235			
Number of observations	53			