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MODELING THE TREND, PERSISTENCE, AND VOLATILITY OF INFLATION IN PACIFIC ALLIANCE COUNTRIES: AN EMPIRICAL APPLICATION USING A MODEL WITH INFLATION BANDS

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Modeling the Trend, Persistence, and Volatility of Inflation in Pacific Alliance Countries: An Empirical Application Using a Model with Inflation Bands*

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Abstract

This paper estimates and analyzes the dynamics of trend inflation, as well as the persistence and volatility of the inflation gap in the Pacific Alliance countries (Chile, Colombia, Mexico, and Peru). For this purpose, the econometric approach is based on methodologies proposed by Stock and Watson (2007) and Chan et al. (2013). Among these, the AR-Trend-Bound model considers the implications of inflation targeting in estimating the unobserved components of inflation. The results indicate that this model effectively allocates most of the permanent component to trend inflation. Additionally, a decreasing trend in inflation in the 1990s, stabilization in the first two decades of the 21st century, and a growing trend inflation following the onset of the COVID-19 pandemic are observed in all four countries. The low levels of inflation gap persistence prior to the pandemic reflect the effectiveness of central banks in maintaining inflation close to its trend level. Finally, the volatility of the inflation gap identifies the "Great Moderation" of inflation, with increases in volatility during the pandemic reaching levels similar to those estimated in the 1990s.

JEL Classification: C32, E32, E51.
Keywords: Inflation, Trend Inflation, Inflation Gap Persistence, Inflation Gap Volatility, Inflation Targets, Pacific Alliance.

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Modelando la Tendencia, Persistencia y Volatilidad de la Inflación en Países de la Alianza del Pacífico: Aplicación Empírica usando un Modelo con Bandas de Inflación*

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Resumen

Este artículo estima y analiza la dinámica de inflación tendencial, así como la persistencia y volatilidad de la brecha inflacionaria en los países de la Alianza del Pacífico (Chile, Colombia, México y Perú). Para ello, el enfoque econométrico se basa en las metodologías propuestas por Stock y Watson (2007) y Chan et al. (2013). Entre ellos, el modelo AR-Trend-Bound considera las implicaciones de las metas de inflación al estimar los componentes no observados de la inflación. Los resultados indican que este modelo efectivamente asigna la mayor parte del componente permanente a la inflación tendencial. Además, en los cuatro países se observa una tendencia decreciente de la inflación en la década de 1990, una estabilización en las dos primeras décadas del siglo XXI y una tendencia creciente de la inflación tras el inicio de la pandemia de COVID-19. Los bajos niveles de persistencia de la brecha de inflación antes de la pandemia reflejan la eficacia de los bancos centrales para mantener la inflación cerca de su nivel tendencial. Finalmente, la volatilidad de la brecha de inflación identifica la "Gran Moderación" de la inflación, con aumentos de la volatilidad durante la pandemia alcanzando niveles similares a los estimados en los años noventa.

Clasificación JEL: C32, E32, E51.
Palabras Clave: Inflación, Inflación Tendencial, Persistencia de Brecha de Inflación, Volatilidad de la Brecha de Inflación, Metas de Inflación, Alianza del Pacífico.

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1 Introduction

Macroeconomic literature has analyzed inflation behavior, showing that trend inflation, as well as the persistence and volatility of the inflation gap, vary over time. For instance, studies by Ramos-Francia and Torres (2008), Capistrán and Ramos-Francia (2009), Ysusi (2011), Humala and Rodriguez (2012), and De Oliveira and Petrassi (2014) reveal that trend inflation and inflation gap persistence in Latin American countries have decreased since the late 1990s. This is mainly attributed to the adoption of inflation targeting (IT) (Hyvonen, 2004; Vega and Winkelried, 2005; Mishkin and Schmidt-Hebbel, 2007), where central banks announce an inflation target range to anchor long-term inflation expectations (Mishkin and Savastano, 2001; Hammond, 2011). A stable trend inflation contributes to creating a sustainable and predictable economic environment. Furthermore, the persistence and volatility of the inflation gap provide valuable information for managing inflation-related risks.

Central banks primarily aim to maintain price stability, which involves constant monitoring of trend inflation and ensuring that inflation aligns with the target over the medium term. The IT framework allows economic agents to anchor their inflation expectations. Therefore, the level and variability of trend inflation can be considered as indicators of inflation expectations anchoring over time (Garnier et al., 2015). Under IT, changes in trend inflation should be close to zero during periods of anchored inflation expectations, whereas significant changes are to be expected during periods of unanchored expectations.

The inflation gap is defined as the difference between actual inflation and its trend. According to Morley et al. (2013), the inflation gap is the transitory element of inflation, on which central banks implement discretionary monetary policy tools, such as changes in the reference interbank interest rate, to stabilize the economy and influence short-term inflation. However, certain transitory inflation factors can persist over multiple periods, leading to changes in inflation gap persistence.

Central banks can implement measures to control changes in the volatility of the inflation gap. However, most volatility sources, such as global or supply-side factors, are beyond their direct control. If these factors do not affect inflation expectations and their impact on inflation is limited and transitory, central banks can maintain their monetary policy stance unchanged. In this context, a central bank's credibility, reputation, commitment, and communication are crucial to prevent an increase in inflation uncertainty for households and businesses (Hammond, 2011; Bordo and Siklos, 2015).

Estimating trend inflation, as well as the persistence and volatility of the inflation gap, provides important insights into inflation dynamics in Latin American countries. These three indicators are considered in the literature as the unobserved components of inflation. Analyzing them provides relevant information that enables central banks to implement effective monetary policies while offering greater certainty to households and businesses in their spending and investment decisions. Furthermore, studying inflation in Latin America is relevant due to the high inflation rates and economic instability experienced in the 1970s and 1980s, which had significant social and economic consequences.

This paper estimates and analyzes trend inflation, as well as the persistence and volatility of the inflation gap. The Latin American countries under study are Chile, Colombia, Peru, and Mexico, the members of the Pacific Alliance (PA), a political, trade, and economic regional integration initiative. Most theoretical and empirical research works estimate trend inflation as a random walk in state-space models, both univariate (Stock and Watson, 2007) and multivariate (Cogley and Sargent, 2005; Garnier et al., 2015). The random walk specification mainly suggests that there is no systematic pattern over time, implying that trend inflation changes randomly over sequential periods. However, literature indicates that IT central banks strive to maintain trend inflation close to the inflation target.

This research utilizes five models based on univariate Bayesian state-space methodologies by Stock and Watson (2007) and Chan et al. (2013). The main one is the AR-Trend-Bound model, which constrains the trend within bands suitable to each country's inflation target range. Likewise, inflation gap persistence is estimated using a first-order autoregressive process, limited between zero and one bands, to allow the reduction of the inflation gap over time. Volatility is estimated as the variability of the disturbances in the inflation gap. Other models used in this research are the AR-Trend, Trend-SV, Trend, and Trend-Bound models, which vary in the method for estimating trend inflation, as well as the persistence and volatility of the inflation gap.

The main results are summarized as follows: firstly, the AR-Trend-Bound model is capable of attributing the permanent component of trend inflation. Secondly, trend inflation in all PA countries declines in the 1990s, then stabilizes within the inflation target range in most periods during the first 20 years of the 21st century, and finally increases during the COVID-19 pandemic. Thirdly, inflation gap persistence reflects prolonged changes in the transitory component of inflation, maintaining low levels in the first 20 years of the 21st century. Fourthly, the volatility of the inflation gap responds to a context of abrupt changes in short-term inflationary pressures. Lastly, the robustness analysis supports the estimations and inferences of the AR-Trend-Bound model.

This paper is structured as follows. Section 2 provides a review of relevant literature. Section 3 explains the research methodology and the five models applied. Section 4 explains the properties of the trend specifications, describes the data for the countries under study; analyzes the results for trend inflation, as well as for the persistence and volatility of the inflation gap; and discusses the inefficiency factors and the robustness analysis. Finally, Section 5 presents the conclusions.

2 Literature

The empirical literature addressing the estimation of unobserved components of inflation presents a wide range of approaches. Cogley and Sbordone (2008) estimate trend inflation and inflation gap persistence in the US from 1960 to 2003 using Bayesian methods and Markov Chain Monte Carlo (MCMC) algorithms to model the Neo-Keynesian Phillips curve. The results show that trend inflation varies in response to changes in monetary policy behavior, with increases in the 1970s and decreases in the final period of the sample. The authors also demonstrate that inflation gap persistence mainly depends on changes in trend inflation.

Baxa et al. (2015) follow a similar methodological approach but set their study apart by incorporating the estimation of inflation volatility and examining Central European countries between 1995 and 2012. They demonstrate that effective monetary policies are crucial for reducing the persistence and volatility of the inflation gap, and that inflation targets alone do not suffice. Additionally, they find that trend inflation remains stable in a context of decreased inflation gap persistence and volatility. This behavior varies in magnitude across the countries studied, which is linked to institutional differences that determine price behavior and expectation formation in each country. In the PA countries, Ramos-Francia and Torres (2008) use moment methods and the Neo-Keynesian Phillips curve to describe Mexico's inflation dynamics from 1992 to 2007. Among their key findings, they show that inflation gap persistence plays a crucial role in inflation dynamics, despite an increasing number of firms setting prices based on expectations. Other studies also employed the Neo-Keynesian Phillips curve to analyze the unobserved components of inflation (Cogley and Sargent, 2005; Benati, 2008); Davig and Doh, 2008; Koop and Korobilis, 2012; Mavroeidis et al., 2014; Gemma et al., 2017).

The unobserved components of inflation can also be estimated from survey data on inflation expectations (Clark, 2011; Kozicki and Tinsley, 2012; Faust and Wright, 2013; Wright, 2013; Clark and Doh, 2014; Mertens, 2016; Nason and Smith, 2020). Clark and Davig (2008) estimate the US trend inflation from 1982 to 2008 and find that it is more closely related to long-term than short-term expectations. Furthermore, as Fed policy communication improves, trend inflation becomes more stable and inflation gap persistence decreases. Chan et al. (2018) estimate trend inflation via Bayesian econometrics and MCMC, utilizing long-term US inflation expectations surveys between 1980 and 2016. Their results indicate that the estimation of trend inflation is more precise when considering inflation expectations.

An alternative to these methodological approaches is to use a state-space model where the three unobserved components are estimated and time-varying, and volatility can be modeled based on trend inflation or the inflation gap. For example, Stock and Watson (2007) use an unobserved components model with stochastic volatility (SV) to predict inflation in the US, considering periods of low and high inflation volatility. They decompose inflation into a stochastic trend inflation and a transitory inflation gap without serial correlation, finding increases in the trend inflation variance during the 1970s and 1980s, followed by a decrease in subsequent decades, while the variance of the inflation gap shows minor changes over time.

In this line of research, Chan et al. (2013) develop an inflation model that, unlike previous ones, incorporates bands for trend inflation and inflation gap persistence, and is compared with the model by Stock and Watson (2007)l. The model by Chan et al. (2013) was applied to US inflation and successfully characterized the behavior of trend inflation, as well as the persistence and volatility of the inflation gap, over time. Trend inflation is observed to be stable, gradually increasing in the 1970s and 1980s. Inflation gap persistence reflects that a large part of the inflationary process is assigned to the cyclical component, while inflation gap volatility illustrates the "Great Moderation" process and the Global Financial Crisis (GFC) of 2007.

The concept of core inflation also represents a benchmark for analyzing trend inflation. Bryan and Cecchetti (1994) define core inflation as the permanent component of inflation over a medium-term horizon after removing high and transitory price fluctuations. This specification aims to allow core inflation to reflect the relationship between inflation and the overall state of the economy while excluding the temporary volatility inherent in certain highly fluctuating prices.

While the most common measure of core inflation is inflation excluding food and energy, some researchers propose more sophisticated methods (Cutler, 2001; Rangasamy, 2009; Crone et al., 2013; Shiratsuka, 2015; Gamber and Smith, 2019). Clark (2001) estimates US core inflation by organizing goods and services in the Consumer Price Index (CPI) into 36 categories between 1967 and 1997 and removing the eight most volatile ones. Detmeister (2012) follows Clark's approach but identifies 200 categories between 1978 and 2009, excluding the sixty most volatile ones. On the other hand, Stock and Watson (2016) model US core inflation between 1995 and 2015 based on a weighted sum of inflation from major productive sectors, where the weights vary over time based on the persistence, volatility, and co-movement of inflation in these sectors.

In AP countries, research on trend inflation and the measure of core inflation follows an analysis similar to that of developed countries (Córdova et al., 2008; Ysusi, 2011; Carlomagno et al., 2021). Lahura and Vega (2011) use a wavelet-function methodology and multiresolution analysis to estimate core inflation in Peru and conclude that their estimation captures medium- and long-term movements of inflation and is useful for short-term predictions. Humala and Rodriguez (2012) estimate a measure called pure inflation in Peru using a dynamic factor decomposition model that isolates the effects of idiosyncratic relative price changes. They conclude that pure inflation is highly associated and correlated with alternative measures of core inflation, as both describe the historical behavior of trend inflation. For Mexico, Acosta (2018) estimates core inflation by grouping CPI goods into ten clusters according to their volatility level. The author finds that the measure of core inflation estimated with the five least volatile clusters closely resembles trend inflation.

Research identifies a reduction in inflation gap persistence following IT implementation. Capistrán and Ramos-Francia (2009) study the mean and persistence of inflation in PA countries between 1980 and 2007 and find that changes in the mean and persistence of inflation are frequent over time, and that inflation gap persistence decreases when changes in its mean are considered. De Oliveira and Petrassi (2014) examine inflation gap persistence in industrialized and emerging countries and find that it decreased in Peru and Chile, while slightly increasing in Colombia between 2001 and 2011. Chiquiar et al. (2010) perform a test of persistence change in Mexican inflation and identify a transition from a non-stationary to a stationary process between the end of 2000 and the beginning of 2001, consistent with IT adoption. Roache (2014) shows that countries that adopted IT have managed to reduce inflation gap persistence due to a gradual improvement in implementing monetary policy and anchoring inflation expectations. Other references include Cecchetti and Debelle (2006), Pincheira (2008), Noriega et al. (2013), and Belaire-Franch (2019).

Research on inflation volatility in PA countries identify the "Great Moderation" of inflation, namely the reduction in inflation volatility in the 1990s and early 2000s (Singh, 2006; Castillo et al., 2012; Castillo et al., 2016; Ha et al., 2019). Broto (2011) uses an autoregressive conditional heteroskedasticity model to analyze inflation volatility in the region and concludes that IT has led to a reduction in both the level of inflation and its volatility. Ferreira and Aparecida Palma (2016) use a model with time-varying parameters and stochastic volatility to assess the effects of uncertainty on inflation in Colombia, Mexico, and other Latin American countries from 1996 to 2015. They identify high levels of volatility at the beginning of the period analyzed. However, they observe that IT implementation has led to a reduction in volatility. They also highlight that IT has maintained a consistent performance in the face of external impacts such as the GFC.

None of the above-mentioned empirical studies for AP countries considers models that take into account the characteristics of the IT regime to estimate trend inflation, as well as the persistence and volatility of the inflation gap. Furthermore, these investigations do not estimate the three unobserved components simultaneously. This research is the first to analyze these characteristics in PA countries.

3 Methodology

3.1 Modeling the Trend, Persistence, and Volatility

Following Chan et al. (2013), inflation, denoted by π_t, can be decomposed as follows:

$$\pi_t = \tau_t + c_t, \tag{1}$$

where τ_t represents trend inflation and c_t is the inflation gap. Trend inflation and gap possess the following properties: $\lim\limits_{j\to\infty} E_t[\pi_{t+j}] = \lim\limits_{j\to\infty} E_t[\tau_{t+j}] = \tau_t$ with probability 1 and $\lim\limits_{j\to\infty} E_t[c_{t+j}] = 0$ with probability 1.

The inflation gap and the three unobserved components are specified as follows:

$$(\pi_t - \tau_t) = \rho_t(\pi_{t-1} - \tau_{t-1}) + \epsilon_t \exp(\frac{h_t}{2}), \tag{2}$$

$$\tau_t = \tau_{t-1} + \epsilon_t^\tau, \tag{3}$$

$$\rho_t = \rho_{t-1} + \epsilon_t^\rho, \tag{4}$$

$$h_t = h_{t-1} + \epsilon_t^h, \tag{5}$$

where ρ_t represents inflation gap persistence, h_t reflects the volatility of the inflation gap, and $\epsilon_t \sim \mathcal{N}(0,1)$, $\epsilon_t^h \sim \mathcal{N}(0, \sigma_h^2)$. The shocks affecting trend inflation are $\epsilon_t^\tau \sim \mathcal{TN}(a - \tau_{t-1}, b - \tau_{t-1}; 0, \sigma_\tau^2)$, where a and b are the trend bands, and $\mathcal{TN}(a, b; \mu, \sigma^2)$ represents a truncated Gaussian distribution between a and b with mean μ and variance σ^2. The conditional expectation of trend inflation one period ahead is influenced by the trend bands and satisfies the following property:

$$E_t[\tau_{t+1}] = \tau_t + \sigma_t \left[\frac{\phi\left(\frac{a-\tau_t}{\sigma_t}\right) - \phi\left(\frac{b-\tau_t}{\sigma_t}\right)}{\Phi\left(\frac{b-\tau_t}{\sigma_t}\right) - \Phi\left(\frac{a-\tau_t}{\sigma_t}\right)} \right], \text{ if } a \leq \tau_t \leq b, \tag{6}$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability density function and the cumulative density function of the standard Gaussian distribution, respectively.

The persistence shocks in the inflation gap are $\epsilon_t^{\rho} \sim \mathcal{TN}(a_\rho - \rho_{t-1}, b_\rho - \rho_{t-1}; 0, \sigma_\rho^2)$, where the persistence bands are $a_\rho = 0$ and $b_\rho = 1$. Thus, persistence is bounded ($0 < \rho_t < 1$) and the inflation gap converges to zero in the long term. The conditional expectation of persistence one period ahead follows this specification:

$$E_t[\rho_{t+1}] = \rho_t + \sigma_\rho \left[\frac{\phi\left(\frac{a_\rho-\rho_t}{\sigma_t}\right) - \phi\left(\frac{b_\rho-\rho_t}{\sigma_t}\right)}{\Phi\left(\frac{b_\rho-\rho_t}{\sigma_t}\right) - \Phi\left(\frac{a_\rho-\rho_t}{\sigma_t}\right)} \right], \text{ if } a_\rho \leq \rho_t \leq b_\rho. \tag{7}$$

The model described by equations (1) - (7) is referred to as the AR-Trend-Bound model. In this specification, the trend, persistence, and expectations are influenced by the inflation bands. This approach aligns with the monetary policy framework of PA central banks, which take measures when inflation or inflation expectations deviate from their targets.

3.2 Other Models

The AR-Trend-Bound model is compared with four other models: (i) the AR-Trend model, which does not have bands in trend or persistence, and all errors follow a Gaussian distribution; (ii) the Trend-SV model, which is a version of the model by Stock and Watson (2007), where the inflation gap shows no persistence and inflation is characterized by $\pi_t = \tau_t + \epsilon_t \exp(\frac{h_t}{2})$; this model specifies trend and volatility according to equations (3) and (5), respectively, with trend errors $\epsilon_t^{\tau} \sim \mathcal{N}(0, \exp(g_t))$, thereby incorporating SV components characterized by $g_t = g_{t-1} + \epsilon_t^g$, where $\epsilon_t^g \sim \mathcal{N}(0, \sigma_g^2)$, into trend inflation variance; (iii) the Trend model, which adheres to the specifications of the Trend-SV model but excludes the SV component of trend inflation, where $\epsilon_t^{\tau} \sim \mathcal{N}(0, \sigma_\tau^2)$; and (iv) the Trend-Bound model, similar to the Trend model but incorporating the same trend inflation bands a y b as specified in the AR-Trend-Bound model.

4 Empirical Results

4.1 Properties of Trend Inflation Under Different Specifications

This section examines the properties of trend inflation specifications by comparing trend estimations across the AR-Trend-Bound, Trend, and Trend-SV models. The estimation of equation (3) and the error modeling described in Sections 3.1 and 3.2 are employed for this analysis. The predictive density of future trends τ_{T+k}, where $k = 20$, is simulated. Two trend band specifications for the AR-Trend-Bound model are considered: AR-Trend-Bound-1 (with bands $a = 1$ and $b = 4.5$) and AR-Trend-Bound-2 (with bands $a = 0$ and $b = 5$), to determine if the trend bands introduce biases in trend estimation.

Following Chan et al. (2013), the priors for the error components are set as $\sigma_\tau = 0.141$, $\sigma_h = 0.224$, and $g_\tau = -3$. Four different specifications for τ_T are proposed, namely $\tau_T = 1, 2, 3, 4$.

For each specification of τ_T, τ_{T+1}, τ_{T+2}, ..., τ_{T+k} (and $g_{T+1}, \ldots, g_{T+k}$ for the Trend and Trend-SV models) are generated. This process is repeated 10,000 times for each model.

Figure 1 displays the predictive density distributions for each specification according to the AR-Trend-Bound-1 (blue), AR-Trend-Bound-2 (red), Trend (orange), and Trend-SV (purple) models. The Trend-SV model exhibits significant dispersion in the estimations, including extreme values due to the SV component in the trend. For instance, setting $\tau_T = 3$ exogenously, the Trend-SV model is the only one that yields trend estimations ranging between 0 and 6, far from the medium-term trend. This pattern repeats for the other three exogenous trends.

The AR-Trend-Bound-1 model shows a rightward bias and truncation when $\tau_T = 1$, as the trend estimation is confined by very narrow bands. In contrast, the AR-Trend-Bound-2 model does not generate biases in any τ_T estimations due to broader bands. Lastly, the Trend model displays neither bias nor high variance issues but does not account for inflation gap persistence or the existence of bands that could influence trend dynamics.

The evidence indicates that trend inflation estimations using the AR-Trend-Bound model are accurate and unbiased if the appropriate bands are chosen to circumvent truncation issues. Moreover, this model proves to be efficient compared to other models analyzed in terms of trend inflation estimation.

4.2 Data

The PA countries studied have a significant presence in Latin America, representing 35% of the population, 36% of GDP, and 47% of the region's imports. Furthermore, according to Spillan and Virzi (2017), they share similar economic structures and exhibit significant trade openness. From a monetary policy perspective, the PA countries initially adopted an implicit IT scheme between 1991 and 1995, followed by explicit IT.

Following Faust and Wright (2013) and Garnier et al. (2015), each country's monthly CPI is seasonally adjusted using the X-12 filter proposed by the US Census Bureau. This statistical adjustment is employed to remove seasonal patterns in price data. The annualized monthly inflation rate is calculated as $\pi_t = 1200 \times \left[\frac{IPC_t - IPC_{t-1}}{IPC_{t-1}}\right]$. Unlike annual variations, monthly variations adjusted for seasonality are not affected by annual base effects, allowing for a clearer analysis of the contemporaneous pressures on inflation. The sample used begins in the year when PA countries adopted implicit IT and extends until October 2022. Figure 2 displays the monthly annualized (blue) and annual (red) inflation rates for each PA country. At the beginning of the analysis period, PA countries exhibited very high inflation rates, surpassing 20% in Colombia and Mexico, and more than 10% in Chile and Peru. Towards the end of the 1990s, inflation sharply declined, and stable levels were maintained since the beginning of the 21st century, first in Chile and Peru, followed by Mexico and Colombia. Notably, inflation rates increased in 2021 and 2022 following the onset of the COVID-19 pandemic, mainly due to rising fuel prices and supply chain challenges. These inflation levels are the highest in the last 20 years for PA countries.

Table 1 shows the years of implicit and explicit IT implementation and target levels over time. The information was drawn from announcements by central banks and from Vega and Winkelried (2005). The table indicates that Chile was the first PA country to adopt implicit IT and the second in the world after New Zealand (Broto, 2011). Later, Colombia in 1995, Mexico following the 1994 financial crisis, and Peru shortly after launching structural reforms in 1994, implemented implicit IT. In 1999, PA countries adopted explicit IT, except for Peru, which did three years later. The table also shows that all four countries initially had high inflation target ranges due to high inflation rates, with implicit inflation targets close to 20%. Subsequently, these were gradually reduced until stable and long-lasting target ranges were achieved, most of them effective from the mid-first decade of the 21st century.

4.3 The Priors

The unobserved components of inflation, as described in equations (3), (4), and (5), are initialized as follows: $\tau_1 \sim \mathcal{TN}(a, b; \tau_0, \omega_\tau^2)$, $\rho_1 \sim \mathcal{TN}(a_\rho, b_\rho; \rho_0, \omega_\rho^2)$, and $h_1 \sim \mathcal{N}(h_0, \omega_h^2)$, where τ_0, ω_τ^2, ρ_0, ω_ρ^2, h_0 and ω_h^2 are known constants. Different hyperparameters are used for each country due to varying initial inflation rates. The trend prior mean is $\tau_0 = 4$ for Chile, $\tau_0 = 5$ for Colombia, $\tau_0 = 5$ for Mexico, and $\tau_0 = 4$ for Peru. The hyperparameters for persistence and volatility are $\rho_0 = h_0 = 0$, and the variances of the unobserved components are $\omega_\tau^2 = \omega_h^2 = 10$ and $\omega_\rho^2 = 1$. These prior variances are comparatively large, allowing for relatively non-informative initial distributions.

The remaining parameters are defined by $\theta = (\sigma_h^2, \sigma_\rho^2, \sigma_\tau^2)'$ and the specific model priors by $p(\theta) = p(\sigma_h^2)p(\sigma_\rho^2)p(\sigma_\tau^2)$. These parameters are distributed as follows: $\sigma_\tau^2 \sim \mathcal{IG}(\underline{\mathrm{v}}_\tau, \underline{\mathrm{S}}_\tau^2)$, $\sigma_\rho^2 \sim \mathcal{IG}(\underline{\mathrm{v}}_\rho, \underline{\mathrm{S}}_\rho^2)$, and $\sigma_h^2 \sim \mathcal{IG}(\underline{\mathrm{v}}_h, \underline{\mathrm{S}}_h^2)$, where $\mathcal{IG}$ denotes an Inverse-Gamma distribution. The hyperparameters for the priors use the following degrees of freedom: $\underline{\mathrm{v}}_\tau = \underline{\mathrm{v}}_\rho = \underline{\mathrm{v}}_h = 10$, $\underline{\mathrm{S}}_\tau^2 = 0.18$, $\underline{\mathrm{S}}_\rho^2 = 0.009$, and $\underline{\mathrm{S}}_h^2 = 0.45$. For detailed information on this section, please refer to Appendix A of Chan et al. (2013).

4.4 The Posteriors

The conditional posterior distributions of the unobserved components and parameters are estimated using an MCMC algorithm, where $\pi = (\pi_t, \ ..., \pi_T)'$, $\tau = (\tau_t, ..., \tau_T)'$, $\rho = (\rho_t, ..., \rho_T)'$ and $h = (h_t, ..., h_T)'$. The sequence for estimating the AR-Trend-Bound model is as follows: (i) proposing initial values from the priors in Section 4.3; (ii) setting $j = 1$ and $J = 50,000$ as the total number of estimations; (iii) obtaining the posterior distribution $p(\tau \mid \pi,\ h,\ \rho,\ \theta)$, where inequality constraints in (6) lead to a non-standard conditional distribution that prevents using conventional Bayesian inference methods, necessitating the algorithm developed by Chan and Strachan (2012) for approximating $p(\tau \mid \pi,\ h,\ \rho,\ \theta)$ using an Independence Chain Metropolis-Hastings approach based on candidate estimates generated by the Chan and Jeliazkov (2009) algorithm; these estimations are subsequently subject to an Acceptance-Rejection process within the Metropolis-Hastings algorithm; (iv) obtaining the distribution $p(h \mid \pi,\ \tau,\ \rho,\ \theta)$ using the posterior distribution algorithm of trend inflation; (v) achieving the distribution $p(\rho \mid \pi,\ h,\ \tau,\ \theta)$ using the posterior distribution algorithm of trend inflation; (vi) calculating the distribution $p(\sigma_h^2, \sigma_\rho^2, \sigma_\tau^2 \mid \pi,\ \tau,\ h,\ \rho,\ \theta) = p(\sigma_h^2 \mid \pi,\ h,\ \rho,\ \theta)p(\sigma_\rho^2 \mid \pi,\ h,\ \rho,\ \theta)p(\sigma_\tau^2 \mid \pi,\ h,\ \rho,\ \theta)$, where the posterior distributions $p(\sigma_\tau^2 \mid \pi,\ h,\ \rho,\ \theta)$ and $p(\sigma_\rho^2 \mid \pi,\ h,\ \rho,\ \theta)$ follow non-standard densities, utilizing the Metropolis-Hastings algorithm with a proposed Inverse Gamma density, while $p(\sigma_h^2 \mid \pi,\ h,\ \rho,\ \theta)$ has a standard density and is an Inverse Gamma distribution; (vii) if $j < J$, setting $j + 1$ and returning to the third step; otherwise, proceeding to the next step; (viii) performing a burn-in of the first 5,000 estimations to minimize initial value effects. Details of the implementation and modifications of this sequence for other models are in Appendix A of Chan et al. (2013).

4.5 Results for Trend, Persistence, and Volatility

This section presents the results of estimating the unobserved components of inflation. Firstly, the results of each component are analyzed, followed by obtaining the inefficiency factors of each parameter. Then, the model that best represents the dynamics of the unobserved components of inflation is suggested. Subsequently, a robustness analysis of the suggested model is conducted to assess the sensitivity of the estimations.

It is important to note that the trend bands in the AR-Trend-Bound model are consistent with the information on PA countries' inflation target ranges. To avoid the bias problems detailed in Section 4.1, the trend bands in the AR-Trend-Bound model consider the results of the AR-Trend model. The bands established for each country are as follows: Chile, $a = 1$ and $b = 10$; Colombia, $a = 1$ and $b = 10$; Mexico, $a = 1$ and $b = 9$; and Peru, $a = 0$ and $b = 8$.

4.5.1 Trend

Trend inflation is a critical indicator of core inflation, influenced by long-term structural factors such as inflation targets (Ireland, 2007; Garnier et al., 2015), the economic structure (Cogley et al., 2010), inflation expectations (Chan et al., 2018), and the demographics of the working-age population (Juselius and Takáts, 2018). Hence, trend inflation is defined as the level towards which inflation converges following the dissipation of transitory shocks (Behera and Patra, 2022), such as demand and supply shocks, and idiosyncratic changes in relative prices.

Figure 3 presents the median of the posterior distribution of trend inflation for five models: AR-Trend-Bound (blue), AR-Trend (red), Trend-SV (green), Trend (purple), and Trend-Bound (black), alongside the explicit inflation target range (gray area). The Trend and Trend-SV models reveal a highly fluctuating trend, closely mirroring inflation with rapid shifts over short periods, which does not align with the trend concept described in Section 3.1. Furthermore, a marked difference is evident in the trends of these models compared to the Trend-Bound model. This disparity is attributable to the inclusion of trend bands that constrain the dynamics to more plausible levels.

Comparing the Trend-Bound model to models including an autoregressive component in the inflation gap (AR-Trend and AR-Trend-Bound), it is evident that this additional component facilitates estimation of a more stable trend, closely aligned with the definition of trend. Including inflation gap persistence in the model introduces the condition of inflation converging to a stable trend, associated with the concept of anchoring long-term inflation expectations. These findings suggest that since the inception of IT, permanent inflation factors have a minor impact on the observed increase in inflation.

Figure 4 shows the median (blue line) and the credibility intervals at the 16th and 84th percentiles (dotted blue line) of the posterior distribution of trend inflation in the AR-Trend-Bound model, along with the explicit inflation target range (gray area) for each country. The trend exhibits a gradual decline, remaining below the high inflation rates of the late 1990s. In 2002, trend inflation in Chile, Mexico, and Peru stabilized at annual averages of 3.1%, 4.9%, and 2.7%, respectively. In Colombia, trend inflation in the same year continued to exhibit a gradually declining behavior with an annual average of 6.2%. Notably, trend inflation in Chile, Mexico, Peru, and Colombia are very close to their respective inflation targets of 3%, 4.5%, 2.5%, and 6%, respectively. Subsequently, between 2002 and 2004, trend inflation mostly remained within the inflation target range of each country, indicating a stable trend during this period.

According to Labán and Larraín (1994), Calvo and Mendoza (1999), and Rosende and Tapia (2015), the disinflation process in PA countries is attributed to both global and domestic factors. On the global front, a focal point is the international disinflation process, given the increase in the supply of goods due to the participation of China, India, and Russia in world trade, as well as the inflow of external capital into Latin America. Domestically, noteworthy factors include the independence of central banks established in constitutional mandates, the adoption of currency stabilization as the primary objective of central banks, the implementation of monetary policies aimed at maintaining high reference interest rates, and greater fiscal discipline.

Trend inflation in Colombia between 2001 and 2005 continued to decline, consistent with the change in the inflation target range. During these years, trend inflation decreased by an average of

0.4 percentage points (p.p.) annually. However, during the years of high oil prices between 2006 and 2008, upward pressures on trend inflation slowed the annual reduction to 0.2 p.p. Average trend inflation in Colombia in 2007 was 4.6%, exceeding the inflation target range for the first time since 2002.

Between 2005 and 2008, trend inflation increased in Chile, Mexico, and Peru, amid a rapid rise in commodity prices significantly affecting the region's economic structure.[1] In Peru, companies recorded improvements in their financial indicators, increased liquidity facilitated collections and payments, financial constraints decreased, and foreign investments increased (BCRP, 2006; Pereda, 2012). Households witnessed an increase in incomes, a surge in employment opportunities, and improvements in consumer confidence indicators (Asencios and Castellares, 2021). Governments increased their tax revenues and royalties, reduced fiscal risk, and gained greater financing access (Ocampo, 2017; Jiménez and Montoro, 2018). In Chile, trend inflation rose from 3.0% to 3.5% between September 2004 and February 2008, while in Peru, it increased from 2.5% to 2.9% between February 2005 and June 2008. Despite an average increase of 0.5 p.p. in both countries, trend inflation remained within the target range. Trend inflation in Mexico rose from 4.1% to 4.4% from January 2006 to July 2008, exceeding the upper limit of the inflation target range by 0.4 p.p.

From the second half of 2008, trend inflation in the PA countries returned to its stable behavior, coinciding with the beginning of corrections in commodity prices. This adjustment occurred in the context of a recession in the US and European economies due to the GFC. Subsequently, the rapid recovery of the Chinese economy in 2010 and 2011 raised commodity prices; however, this new increase was transitory and did not significantly affect the region's economic structure and trend inflation.

The findings highlight a notable rise in trend inflation across PA countries since the beginning of the COVID-19 pandemic, amid challenges like supply chain disruptions, increased oil prices due to capped production, and escalating fertilizer costs resulting from the Ukraine-Russia conflict. From August 2020 to October 2022, the region experienced an average uptick in trend inflation of 0.7 p.p. The onset of the pandemic in February 2020 led to a shift from restricted economic activities to a surge in expenditure, further straining production chains and intensifying external inflationary pressures. PA countries experienced inflation escalations due to these factors, compounded by rising prices of tradable goods and increased costs in production, transportation, and distribution. Notably, even as oil prices dipped into the negatives in April 2020, subsequent OPEC-induced production cuts from May pushed oil prices upward through 2020 and 2021.

Economic structure transformations persisted into 2022. Surges in COVID-19 cases in China resulted in mobility restrictions and sustained supply chain interruptions. Additionally, the ongoing Ukraine-Russia conflict from February 2022 inflated international energy, fertilizer, and food prices. These inflationary trends were further fueled by the historic high reached by oil prices in June 2022, a consequence of OPEC's production cuts. Post-lockdown, continuous cost restructuring by companies, alongside surging global demand, led to significant shifts in economic structures, impacting trend inflation, relative pricing, and inflation expectations.

The analysis indicates a rise of 0.5 p.p. in Chile's trend inflation and 0.4 p.p. in Colombia's from March 2020 to October 2023, with both remaining within their target ranges. In contrast, Mexico and Peru's trend inflation exceeded their targets by 2.0 p.p and 0.4 p.p., respectively. Notably, Mexico's trend inflation has been above target since April 2017. Furthermore, Mexico experienced periods of inflation expectations surpassing the target range in several months of previous years, notably from January 2016 to February 2017, January and April 2018, and from January to June

[1]For example, the price of copper increased from 140 to 380 dollars per pound between January 2005 and July 2008, with Chile, Peru, and Mexico being among the top ten copper exporters worldwide.

2019.

4.5.2 Persistence

Inflation gap persistence refers to the extent to which transitory shocks deviate inflation from its trend for an extended period (Roache, 2014). Increased persistence means that a transitory shock has a more pronounced effect on the current and future inflation gap, implying that inflation will be impacted over a longer period. This complicates the central bank's task of controlling inflation, requiring a greater monetary policy effort, which in turn creates a larger trade-off on the output gap.

Figure 5 shows the median estimation (solid line) and the credibility intervals at the 16th and 84th percentiles (dotted line) of the posterior distribution of inflation gap persistence for the AR-Trend (red) and AR-Trend-Bound (blue) models. The results for both models are similar, with a few exceptions in the early years of the sample. The AR-Trend-Bound model's inflation gap persistence shows levels below one in all percentiles when considering trend and persistence bands. These findings align with the concept of reducing the inflation gap in the medium term, as described in Section 3.1.

The AR-Trend-Bound model results indicate a decrease in inflation gap persistence in all four countries during the early years of the sample. In Chile, persistence fell from 0.55 to 0.25; in Colombia, from 0.90 to 0.53; in Mexico, from 0.90 to 0.43; and in Peru, from 0.62 to 0.34. This decline coincides with the implementation of monetary policies designed to reduce inflation inertia.

Inflation gap persistence decreased to a lesser extent in most countries between 1997 and 1998, in a context characterized by natural phenomena and government regulations. Colombia experienced inflationary inertia in agricultural products due to the "Guatemalan moth" plague and the 1998 El Niño phenomenon. Peru also had persistent inflationary effects from El Niño, but these were partially offset by falling prices of non-tradable foods and fuels. Conversely, Mexico recorded high persistence in a context of greater inflationary inertia due to wage indexation to inflation, with two 15% minimum wage increases in 1998. Moreover, the increase in government-regulated prices, such as tortillas and gasoline, contributed to greater inflation gap persistence.

An increase in inflation gap persistence was observed in all four countries between 2005 and 2007. The changes in persistence were more pronounced in Chile, increasing from 0.34 to 0.50; in Colombia, from 0.54 to 0.63; and in Peru, from 0.35 to 0.45. These countries faced inflationary pressures due to the dynamism of their trade partners and high prices of food and fuels. In contrast, Mexico experienced a more moderate increase in persistence, from 0.43 to 0.46, in a context of inflationary pressures from the aforementioned prices and disinflationary pressures from reduced economic activity of its main trading partner, the US.

From mid-2008, inflation gap persistence decreased in PA countries in an environment of less persistent inflationary pressures, such as the correction of commodity prices, the 2008 GFC, and recessions in their main trading partners. In particular, Chile experienced a larger decrease in persistence compared to other countries, in the context of a marked reduction in demand-driven inflationary pressures.

In Mexico and Peru, persistence increased from the early months of the COVID-19 pandemic in 2020, while in Chile and Colombia, this pattern was present from months earlier. This difference is related to the initial conditions of each country in 2019. In Chile, persistence increased due to inflationary inertia associated with social protests. In Colombia, persistence continued to rise in a context of adverse climatic conditions, such as the El Niño phenomenon and prolonged droughts in several areas.

The findings reveal an escalation in inflation gap persistence from June 2020 to October 2022, attributed to sustained inflationary pressures linked to transitory factors. During this period, persistence levels in Chile and Colombia experienced comparable increases, rising by 0.16 and 0.15, respectively. In contrast, the rise in persistence in Mexico and Peru was more modest, at 0.10 and 0.07, respectively. PA countries contended with ongoing external shocks, such as surges in oil and fertilizer prices and supply chain disruptions, along with domestic currency depreciation. However, the rebound in domestic demand, currency depreciation, and the output gap were more pronounced in Chile and Colombia compared to Mexico and Peru. This led to heightened inflation persistence in the former two countries.

4.5.3 Volatility

Volatility is defined as the level of fluctuation in the inflation gap over time, where price instability leads to increased inflation uncertainty (Rother 2004). An increase in the volatility of the inflation gap makes inflation forecasts less precise (Hall and Jäskelä 2011), impacting the purchasing power of households and businesses. Moreover, volatility can cause fluctuations in the values of financial assets and liabilities, increasing risk premiums.

Changes in volatility primarily stem from sudden supply shocks, such as an unexpected scarcity of goods, or changes in demand without variations in supply. Global factors, such as changes in input prices affecting production costs, can also modify volatility, as can changes in economic uncertainty and IT (Carriero et al. 2022; Arsic et al. 2022; Arespa and Alegre 2022).

Figure 6 shows the median of the posterior distribution of inflation gap volatility estimates for five models: AR-Trend-Bound (blue), AR-Trend (red), Trend-SV (green), Trend (purple), and Trend-Bound (black). The Trend-SV model exhibits the lowest levels of volatility as the trend's volatility retains most of the inflation variability. In contrast, the Trend and Trend-Bound models show the highest levels of volatility because they do not account for inflation gap persistence and model it as a stochastic process.

The results for the AR-Trend and AR-Trend-Bound models indicate volatility levels between that of the Trend-SV model (the lowest) and the Trend and Trend-Bound models (the highest). This is due to the specification of the AR-Trend and AR-Trend-Bound models, where the volatility of the disturbance of the inflation gap's autoregressive process is estimated as described in (2). This specification allows trend inflation and inflation gap persistence to exhibit non-volatile behavior over time, facilitating the identification of structural economic changes in trend inflation and isolating short-term variations in the estimation of persistence. Furthermore, given the importance of considering inflation bands in estimating results related to trend inflation and inflation gap persistence, the dynamics of the volatility of the AR-Trend-Bound model are analyzed.

Figure 7 shows the median (blue line) and the credibility intervals at the 16th and 84th percentiles (dotted blue line) of the posterior distribution of inflation gap volatility in the AR-Trend-Bound model. The results align with Latin American economic literature on the "Great Moderation" of inflation in PA countries. This body of research indicates that most PA countries have experienced a reduction in the volatility of the inflation gap since the introduction of implicit IT, with some exceptions related to the GFC and the onset of the COVID-19 pandemic. The "Great Moderation" process in Mexico was slightly affected in 1998, in the context of unexpected exchange rate depreciation due to the Asian and Russian crises, and fluctuations in fruit and vegetable prices caused by rainfall cycles and floods. In Colombia, volatility shows a growing trend, where transport strikes generated variability in inflationary pressures on the supply side.

The results in PA countries indicate that the volatility of the inflation gap temporarily increased between 2002 and 2003, primarily due to transitory fluctuations in fuel and food prices. The reduction in both prices generated negative inflation rates in Chile and Peru. However, the correction of these prices allowed inflation to return to the target range.

Volatility increased during the 2007 GFC, interrupting the "Great Moderation" process. The increase in risk and uncertainty resulted in a sharp decrease in international prices of metals, oil, and food, while expansive monetary and fiscal policies prevented deflation scenarios. Volatility in PA countries reached its highest levels in the second half of 2009, in a context of economic recovery in China and high prices of metals, fuels, and food. During this period, Chile recorded the highest volatility, with a sharp change in inflation in 2009 from 9.9% in October to -2.3% in November, associated with demand-side deflationary pressures.

Inflation gap volatility in PA countries returned to “Great Moderation” levels after the GFC and before the onset of the COVID-19 pandemic. During this period, Colombia experienced a temporary increase in volatility in 2016, in a scenario of currency depreciation and transport strikes. Meanwhile, volatility in Peru temporarily increased in the second half of 2017 and the first half of 2018, in a scenario of sudden drops in the prices of electricity and food items such as sugar, meat, and potatoes. This led to a decrease in inflation, from 3.2% in August 2017 to 0.4% in March 2018, moving from above to below the target range within six months.

The “Great Moderation” period experienced a new interruption with the onset of the COVID-19 pandemic in 2020. During this period, the volatility of the inflation gap reached its highest levels since 1995 in all four countries. These results reflect the uncertainty surrounding inflation in a context characterized by abrupt changes in fuel and service prices, international freight costs, and inflationary pressures due to sudden demand shifts.

4.5.4 Inefficiency Factors

The efficiency of the MCMC method is evaluated using the inefficiency factor, defined as $1 + 2\sum_{l=1}^{L}\phi_l$, where ϕ_l is the sample autocorrelation at lag l, and L should be large enough for autocorrelation to decrease. Ideally, the inefficiency factor is 1, meaning that posterior simulations are independent. For instance, an inefficiency factor of 5 indicates that 500 posterior simulations are required to obtain the information of 10 independent simulations. Therefore, more efficient models produce estimates that are not highly autocorrelated.

Table 2 presents the inefficiency factors of unobserved components and parameters estimated in the five models. Each component has T inefficiency factors, i.e., one for each month, as the components change over time, and $45,000$ simulations are presented. Given the large number of inefficiency factors, the 25th, 50th, and 75th percentiles are presented. The remaining estimated parameters do not change over time, so a single inefficiency factor is presented for each one.

In general, the AR-Trend and AR-Trend-Bound models have the lowest inefficiency factors for all parameters. The Trend-Bound model presents the highest inefficiency factors in trend inflation and the trend inflation variance in the four countries, and the highest values in inflation gap volatility for Mexico and Peru. The Trend-SV model generates the second highest inefficiency factors in trend inflation in most countries, while the Trend model yields the highest values in volatility and variances for Colombia. Unlike the AR-Trend model, the AR-Trend-Bound model considers the characteristics of IT to estimate the trend, persistence, and volatility (Section 3.1). Therefore, we conclude that the AR-Trend-Bound model is the most efficient in modeling the unobserved components of inflation in PA countries.

4.5.5 Robustness Analysis

The robustness analysis assesses the stability of the results obtained using the AR-Trend-Bound model. This involves examining the reliability of these results by modifying the initial assumptions and identifying potential bias sources. To achieve this, new estimates are conducted by changing the hyperparameters of priors related to trend inflation and inflation gap persistence.

Figure 8 displays the median results of the posterior distribution corresponding to different values of the hyperparameters for the trend inflation expectation at $t = 0$, where $\tau_0 = 0$ (blue), $\tau_0 = 3$ (orange), $\tau_0 = 4$ (yellow), $\tau_0 = 5$ (purple), and $\tau_0 = 6$ (green). The findings show that the estimations of trend, persistence, and volatility do not undergo significant changes when varying the trend inflation hyperparameters, as long as the hyperparameter accurately reflects the disinflation process observed in the 1990s. In this context, trend inflation estimations during the initial periods tend to show biases towards lower values when a prior not considering the high inflation levels at the start of the sample is used. For instance, the results indicate that trend inflation exhibits an upward behavior in the early years of the sample when $\tau_0 = 0$ is considered, contradicting the observable disinflation process of the 1990s.

On the other hand, estimations based on the other four priors show minor differences that tend to diminish over time. At $t = 0$, the average discrepancy between trend estimations with $\tau_0 = 3$ and $\tau_0 = 6$ is 0.6 p.p. However, when modifying the analysis period from January 2001 to October 2022, the new average discrepancy is reduced to 0.2 p.p. Therefore, the disparity observed at $t = 0$ in Figure 8 originates from the high inflation rates recorded in the 1990s.

Figure 9 presents the results obtained using different hyperparameters of priors for the variance of inflation gap persistence, represented by $\omega_\rho^2 = 1$ (blue), $\omega_\rho^2 = 2$ (orange), $\omega_\rho^2 = 5$ (yellow), and $\omega_\rho^2 = 10$ (purple). This robustness analysis implies that as the value of ω_ρ^2 increases, the variance of the prior for the first estimated value also increases, making the initial distribution less informative. Consequently, the influence of the prior on the estimations decreases, giving greater weight to the data in the estimation of the posterior distribution.

The results indicate that the estimations of trend, persistence, and volatility are robust to changes in the inflation gap persistence hyperparameters. However, there are subtle exceptions, indicating differences in the estimation of persistence during the initial months of the sample period. In the case of Chile and Peru, the discrepancy in the estimation of persistence between the hyperparameters $\omega_\rho^2 = 1$ and $\omega_\rho^2 = 10$ is 0.1 p.p. in 1991 and 1994, respectively. This difference dissipates over time and becomes insignificant three years later. Additionally, in Colombia and Mexico, the discrepancies between the results obtained with these hyperparameters are negligible.

5 Conclusions

This study estimates and describes trend inflation, as well as the persistence and volatility of the inflation gap in PA countries, employing the methodologies proposed by Stock and Watson (2007) and Chan et al. (2013). This framework incorporates IT features into the estimation unobserved components of inflation.

The AR-Trend-Bound model emerges as the best suited for representing unobserved components of inflation, based on the inefficiency factors, historical inflation behavior, central bank annual reports, and economic literature. This study emphasizes the importance of jointly estimating trend inflation, as well as the persistence and volatility of the inflation gap, for a thorough understanding of inflation dynamics. The results emphasize the importance of specifying the inflation gap in the methodology, as suggested by Cogley et al. (2010) and Chan et al. (2013). The estimation of persistent inflation gaps is crucial, facilitating an accurate behavior of trend inflation. Moreover, the inclusion of inflation gap volatility enables the characterization of trend inflation and inflation gap persistence without excessive fluctuation.

The findings show a gradual decrease in trend inflation throughout the 1990s, stabilizing within the inflation target range until 2004. This trend reflects the disinflation process influenced by global structural factors (Calvo and Mendoza, 1995; Rosende and Tapia, 2015), as well as domestic institutional issues specific to each country (Ireland, 2007; Garnier et al., 2015). Between 2005 and 2008, trend inflation in most PA countries increased during a period marked by shifts in their economic structures due to high commodity prices, as proposed by Cogley et al. (2010) for developed countries. Following the onset of the COVID-19 pandemic, trend inflation increased in all four countries, exceeding the inflation target ranges in Mexico and Peru by 2.0 p.p. and 0.4 p.p., respectively. This took place in a context of changes in regional economic structures driven by production chain restrictions, high oil and fertilizer prices due to OPEC's prolonged restrictions, and the Ukraine-Russia conflict.

Inflation gap persistence decreased in all four countries during the initial years of the sample, aligning with a period marked by the implementation of monetary policies aimed at reducing inflation inertia (Roache, 2014). From 2005 and leading up to the GFC, persistence increased amid high food and fuel prices, followed by a reduction from mid-2008 in a context characterized by lower persistent inflationary pressures, such as recessions in the main trading partners of PA countries. Persistence was notably higher in Colombia and Chile than in Mexico and Peru during the COVID-19 pandemic, aligning with the initial conditions in 2019, which created upward pressures on persistence, like social protests in Chile and climatic events in Colombia.

Volatility in the inflation gap across most PA countries diminished in the 1990s and early 2000s, illustrating the "Great Moderation" in inflation (Singh, 2006; Castillo et al., 2012; Castillo et al., 2016; Ha et al., 2019). This reduced volatility in subsequent years reflects the performance of central banks adhering to IT, as suggested by Arsić et al. (2022) for emerging countries in Europe and Central Asia. However, volatility increased during the 2007 GFC and the two first years of the COVID-19 pandemic, interrupting the "Great Moderation" process due to fluctuations in international prices of food, oil, and minerals, in line with the findings of Carriero et al. (2022) for developed countries.

The robustness analysis solidifies the main findings against alternative specifications in trend inflation and inflation gap persistence priors. For example, the dynamics of trend, persistence, volatility, and inefficiency factors remains quantitatively similar.

Future research could consider alternatives for estimating the three unobserved components from the Neo-Keynesian Phillips curve, as suggested by Baxa et al. (2015), and incorporate the role of IT into the model. Including additional variables, such as inflation expectations, could enhance the estimation of the unobserved components, as proposed by Chan et al. (2018), and link it to improved communication from central banks, as detailed by Clark and David (2008). Additionally, it is recommended to compare the results of trend inflation with other measures of core inflation using, for instance, the methodological approaches suggested by Lahura and Vega (2011), Humala and Rodriguez (2012), and Stock and Watson (2016). Finally, it is suggested to explore the implications of the reduction in the economically active population due to the COVID-19 pandemic on trend inflation, considering the approach by Juselius and Takáts (2018).

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Table 1. Implicit Inflation Targeting (IIT) and Explicit Inflation Targeting (EIT) for each Country

Country	IIT regime introduction date	EIT regime introduction date	Inflation Targets		
Chile	1991	1999	1991: 15% - 20%	1995: 8%	1999: 4.3%
			1992: 13% - 16%	1996: 6.5%	2002 - 2018: 3% ± 1%
			1993: 10% - 12%	1997: 5.5%	
			1994: 9% - 11%	1998: 4.5%	
Colombia	1995	1999	1992 - 1993: 22%	1999: 15%	2006: 4% - 5%
			1994: 19%	2000: 10%	2007 - 2008: 3.5% - 4.5%
			1995: 18%	2001: 8%	2009: 4.5% - 5.5%
			1996: 17%	2002: 6%	2010 - 2018: 3% ± 1%
			1997: 18%	2003 - 2004: 5% - 6%	
			1998: 16%	2005: 4.5% - 5.5%	
Mexico	1995	1999	1995: 19%	1998: 12%	2001: 6.5%
			1996: 10%	1999: 13%	2002: 4.5%
			1997: 15%	2000: 10%	2003 - 2018: 3% ± 1%
Peru	1994	2002	1994: 15% - 20%	1998: 7.5% - 9%	2002 - 2006: 2.5% ± 1%
			1995: 9% - 11%	1999: 5% - 6%	2007 - 2018: 2% ± 1%
			1996: 9.5% - 11.5%	2000: 3.5% - 4%	
			1997: 8% - 10%	2001: 2.5% - 3.5%	

Source: Bank of Mexico, Bank of the Republic of Colombia, Central Bank of Chile, Central Reserve Bank of Peru, Galindo and Ros (2005), Gómez, Uribe and Vargas (2002), Mishkin and Schmidt-Hebbel (2001), Vega and Winkelried (2005)

Table 2. Ineffienciency Factors of Selected Parameters

Parameter	Trend-SV	Trend	Trend-Bound	AR-Trend	AR-Trend Bound	Trend-SV	Trend	Trend-Bound	AR-Trend	AR-Trend Bound
	Chile					Colombia				
$\tau_{(25\%)}$	4.9	1.6	21.6	1.3	9.0	10.2	27.3	1097.8	1.7	6.7
$\tau_{(50\%)}$	11.9	3.0	30.9	2.3	11.8	26.9	144.3	1258.1	3.4	8.4
$\tau_{(75\%)}$	27.7	8.9	42.5	4.5	17.0	69.0	625.3	1387.1	5.9	9.8
$\rho_{(25\%)}$	-	-	-	1.5	19.4	-	-	-	2.0	12.5
$\rho_{(50\%)}$	-	-	-	2.5	35.7	-	-	-	2.9	19.4
$\rho_{(75\%)}$	-	-	-	3.5	82.8	-	-	-	6.3	31.0
$h_{(25\%)}$	14.8	2.7	4.6	2.5	3.3	95.8	368.3	34.7	4.7	4.6
$h_{(50\%)}$	24.1	3.6	6.2	3.3	4.2	178.4	821.6	64.4	6.7	6.5
$h_{(75\%)}$	49.3	4.8	8.6	4.4	5.6	300.3	1257.9	105.0	10.5	8.4
σ^2_τ	-	84.1	250.7	56.8	107.9	-	1138.2	1383.2	46.1	36.6
σ^2_ρ	-	-	-	49.0	49.5	-	-	-	23.9	130.4
σ^2_h	177.7	33.0	23.4	46.1	30.1	633.5	705.9	23.4	55.9	68.5
σ^2_g	335.6	-	-	-	-	707.8	-	-	-	-
	Mexico					Peru				
$\tau_{(25\%)}$	8.0	2.4	867.1	5.9	21.6	3.7	1.7	340.1	2.2	8.4
$\tau_{(50\%)}$	20.5	3.4	1058.9	9.3	37.1	8.1	3.2	430.7	3.5	10.5
$\tau_{(75\%)}$	54.4	5.3	1246.5	13.3	81.5	18.6	7.5	526.4	6.5	14.5
$\rho_{(25\%)}$	-	-	-	6.6	56.4	-	-	-	1.8	8.0
$\rho_{(50\%)}$	-	-	-	8.0	104.5	-	-	-	2.9	10.3
$\rho_{(75\%)}$	-	-	-	10.9	205.8	-	-	-	4.8	13.9
$h_{(25\%)}$	29.9	10.9	44.3	28.0	19.8	7.8	2.2	12.7	2.5	2.7
$h_{(50\%)}$	68.9	13.1	86.4	38.6	25.5	13.1	2.9	20.3	3.4	3.4
$h_{(75\%)}$	150.7	16.2	169.9	57.6	33.1	25.7	4.6	29.0	4.3	4.4
σ^2_τ	-	43.0	855.5	38.5	96.4	-	80.5	1267.5	66.9	71.1
σ^2_ρ	-	-	-	37.8	152.8	-	-	-	28.7	51.6
σ^2_h	155.1	42.6	480.8	139.3	119.7	104.1	34.3	36.7	29.2	33.3
σ^2_g	776.6	-	-	-	-	464.9	-	-	-	-

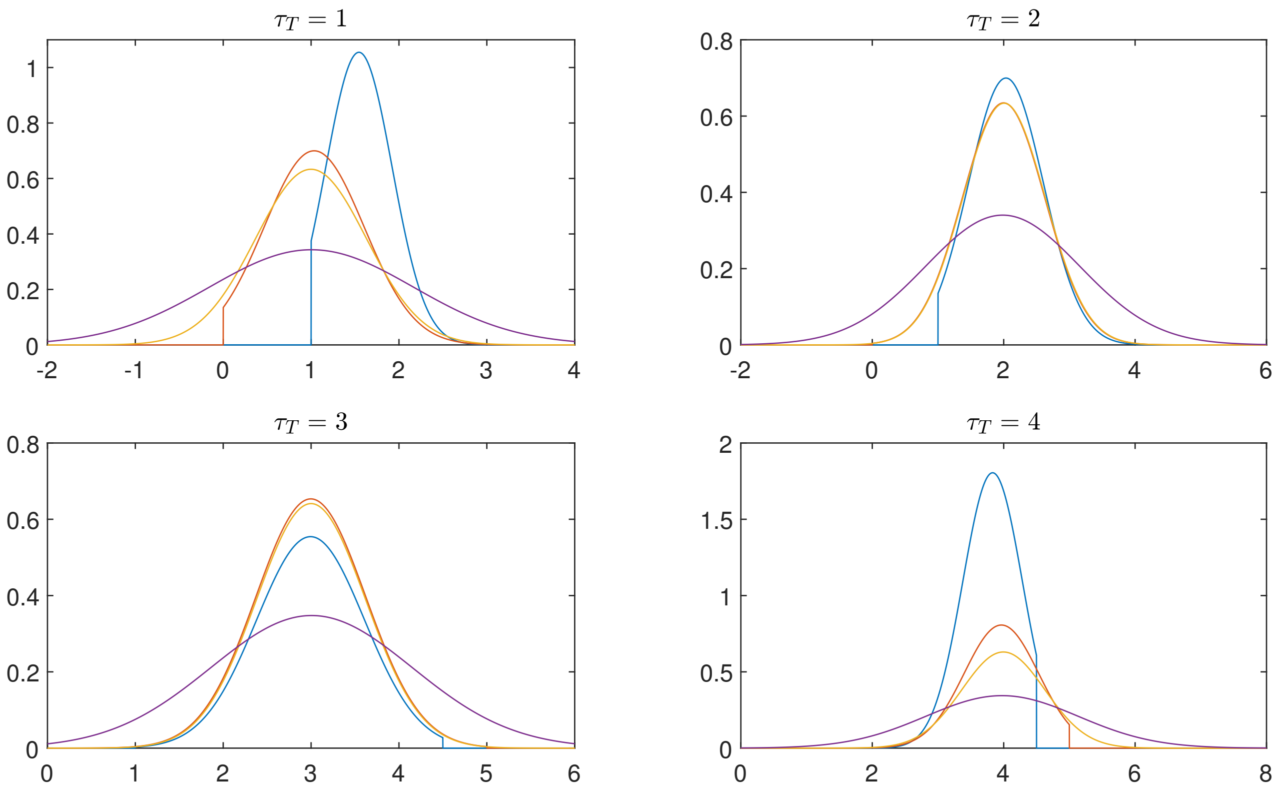

Figure 1. Predictive Densities for τ_{t+k} under the *AR-Trend-Bound-1* (blue, with bounds $a = 1$ and $b = 4.5$), *AR-Trend-Bound-2* (red, with bounds $a = 0$ and $b = 5$), *Trend* (orange) and *Trend-SV* (purple); $k = 20$.

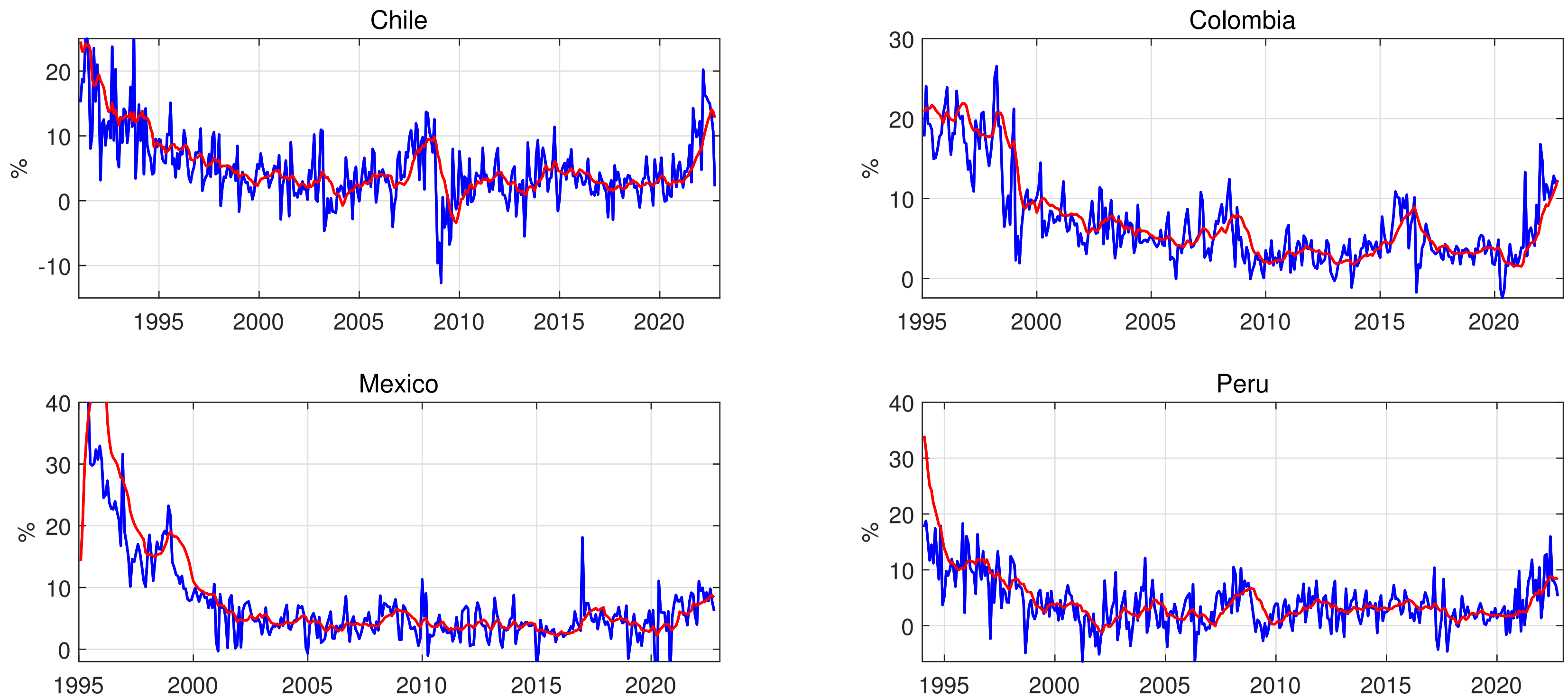

Figure 2. Annualized Inflation (blue, $\pi_t = 1200 \times \left[\frac{IPC_t - IPC_{t-1}}{IPC_{t-1}}\right]$) and Annual Inflation Rates (red, $\pi_t = 100 \times \left[\frac{IPC_t - IPC_{t-12}}{IPC_{t-12}}\right]$).

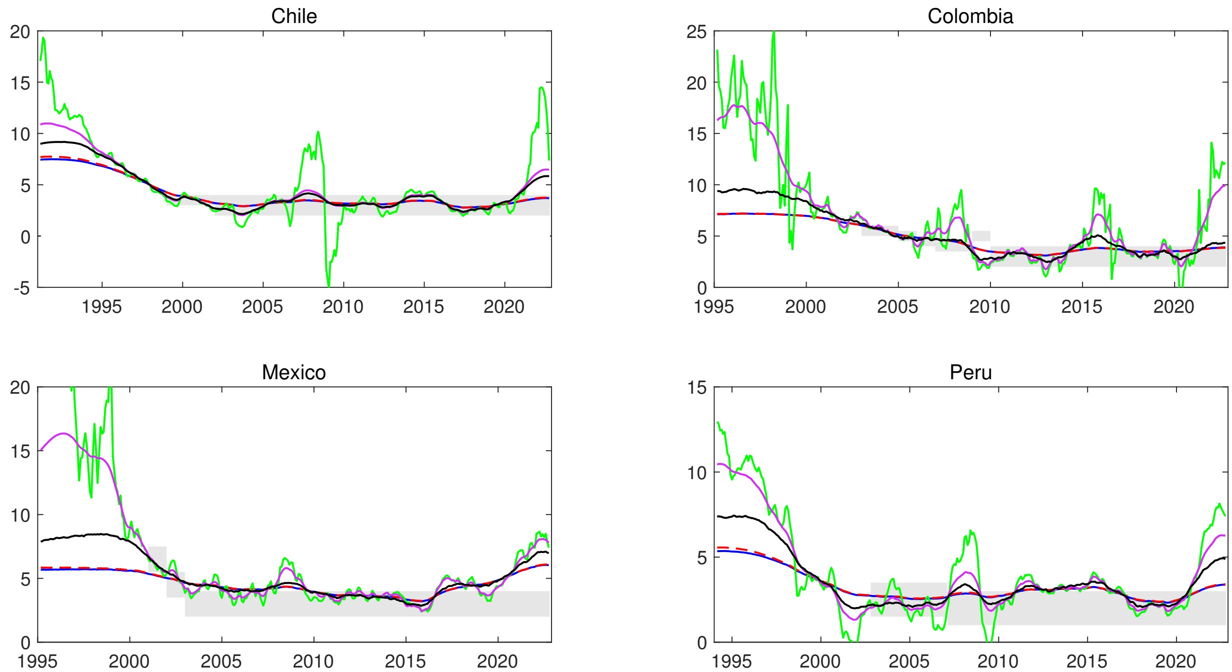

Figure 3. Posterior Mean of τ_t under the *AR-Trend-Bound* (blue), *AR-Trend* (red), *Trend-SV* (green), *Trend* (purple), *Trend-Bound* (black) Models and Explicit Target Range for Inflation (shaded grey bands).

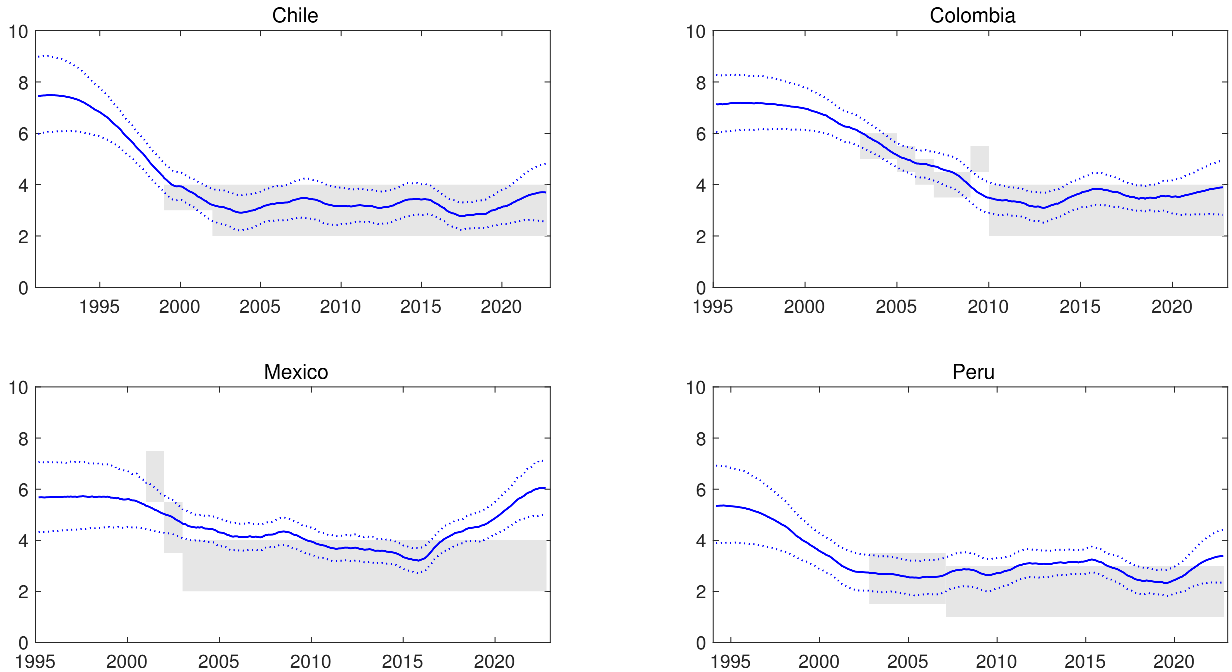

Figure 4. Posterior Mean (blue line), 16th and 84th percentiles (blue dotted line) of τ_t under the *AR-Trend-Bound* Model and Explicit Target Range for Inflation (shaded grey bands).

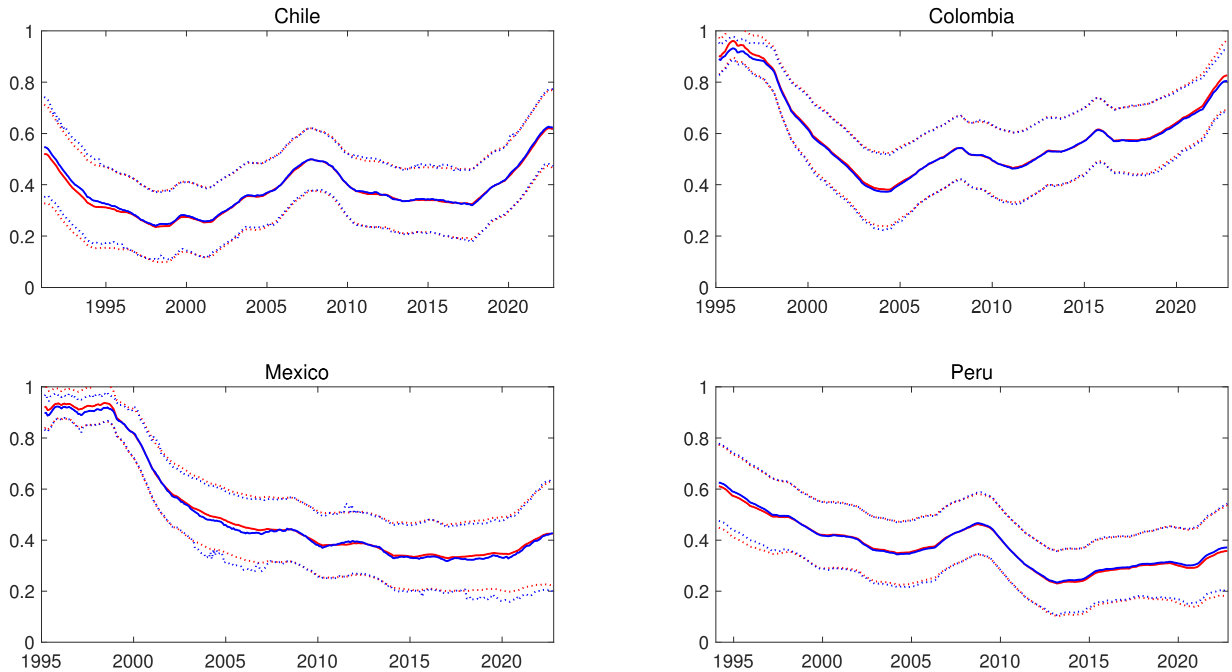

Figure 5. Posterior Mean (line), 16th and 84th percentiles (dotted line) of ρ_t under the *AR-Trend-Bound* (blue) and *AR-Trend* (red) Models.

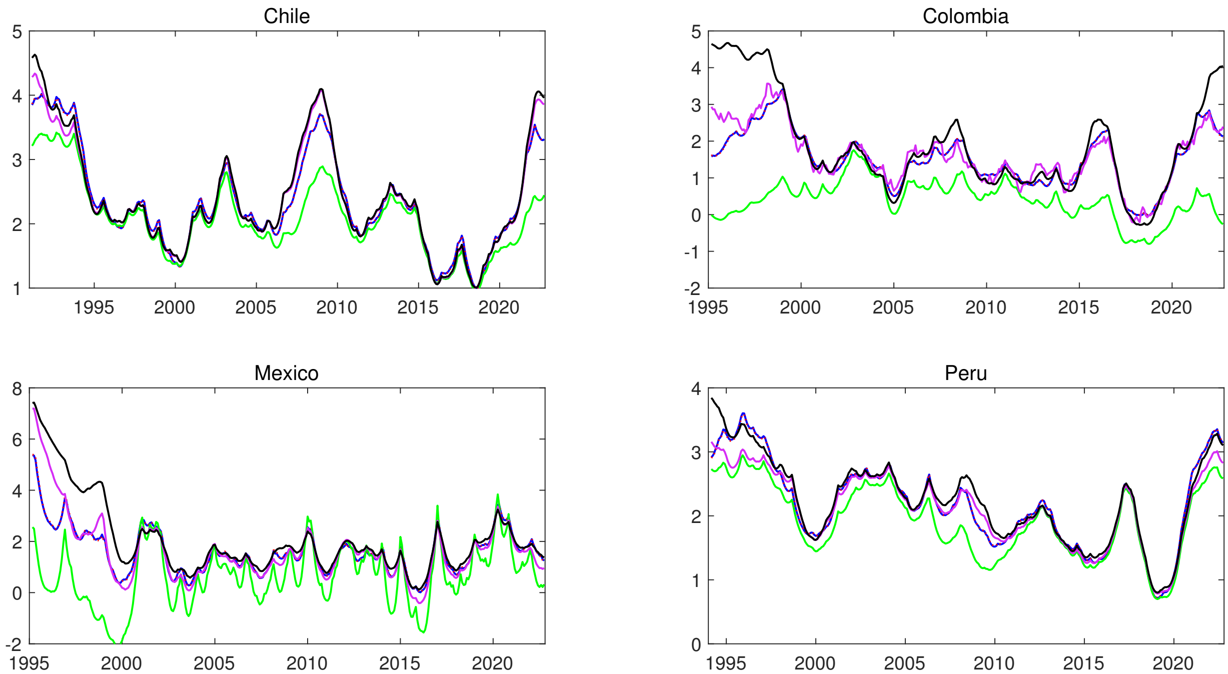

Figure 6. Posterior Mean of h_t under the *AR-Trend-Bound* (blue), *AR-Trend* (red), *Trend-SV* (green), *Trend* (purplue), *Trend-Bound* (black) Models.

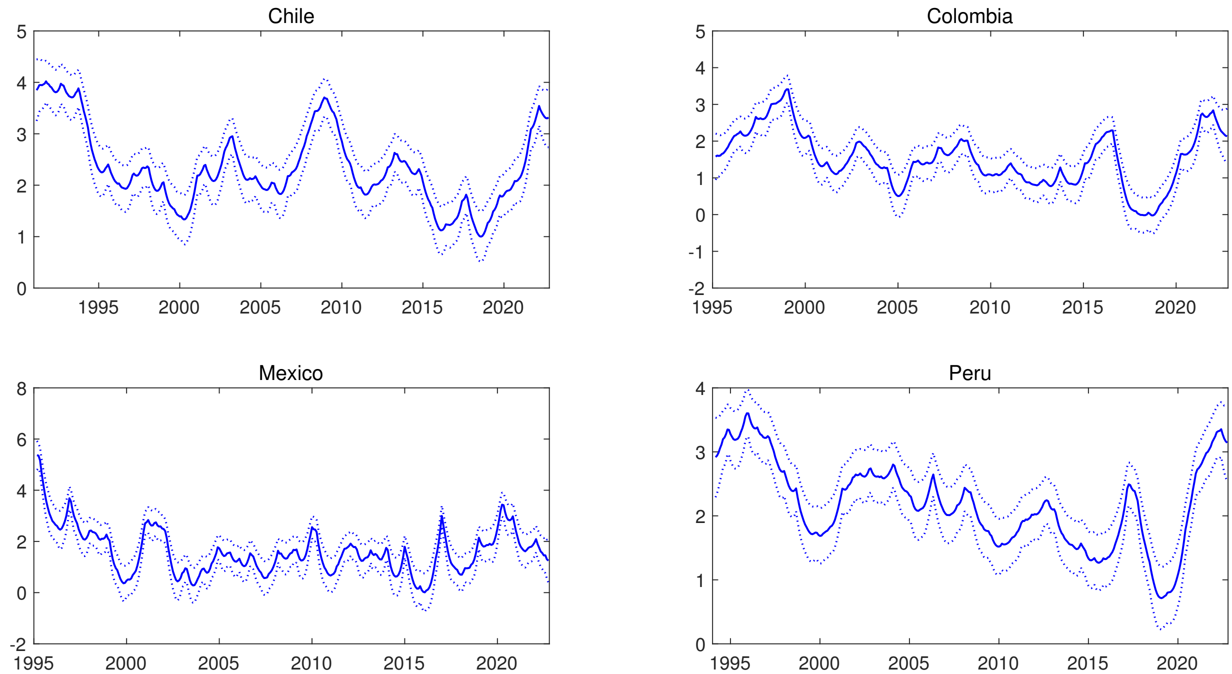

Figure 7. Posterior Mean (blue line), 16th and 84th percentiles (blue dotted line) of h_t under the *AR-Trend-Bound* Model.

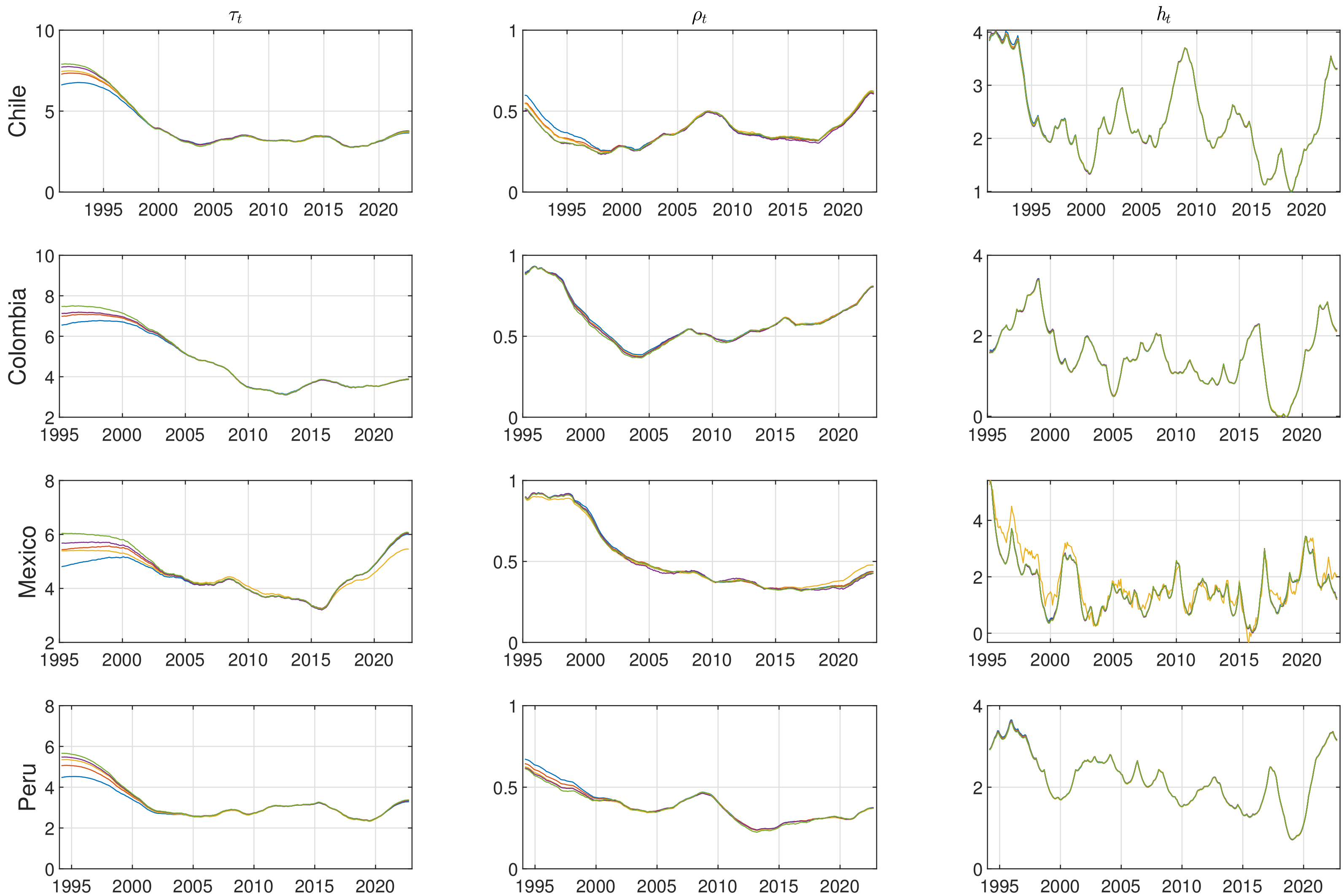

Figure 8. Posterior Mean of τ_t, ρ_t and h_t under the *AR-Trend-Bound* Model with $\tau_0 = 0$ (blue), $\tau_0 = 3$ (orange), $\tau_0 = 4$ (yellow), $\tau_0 = 5$(purple) and $\tau_0 = 6$ (green).

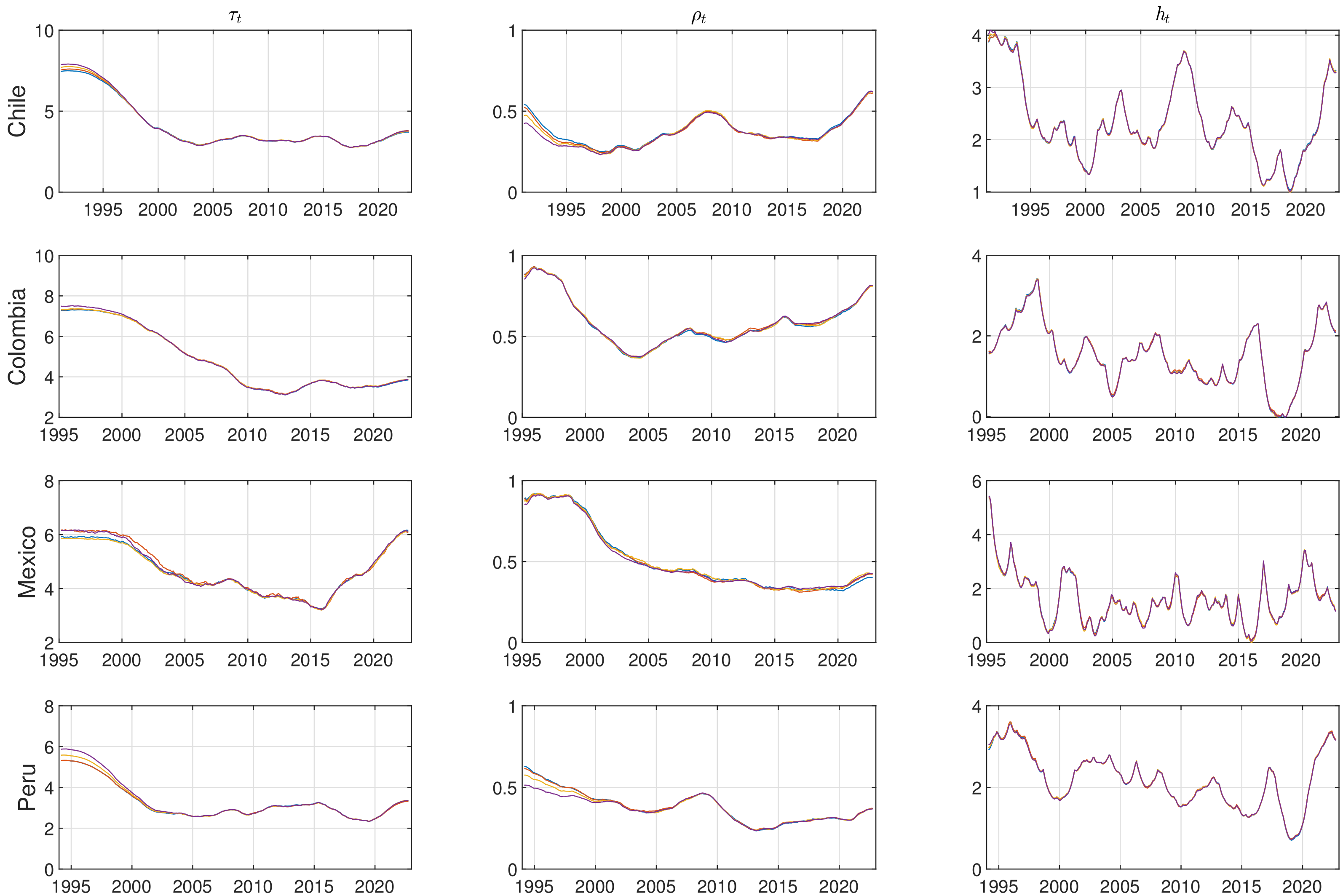

Figure 9. Posterior Mean of τ_t, ρ_t and h_t under the *AR-Trend-Bound* Model with $\omega_\rho^2 = 1$ (blue), $\omega_\rho^2 = 2$ (orange), $\omega_\rho^2 = 5$ (yellow) and $\omega_\rho^2 = 10$ (purple).

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