# Inflation targeting and inflation risk: empirical evidence in Latin America

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**Abstract**

We analyzed the effects of inflation targeting (IT) implementation and functioning through the reaction function of monetary authorities from Latin American inflation targeters (ITers), e.g., Brazil, Chile, Colombia, Mexico and Peru. We adapted the Value-at-Risk and CoVaR to the Inflation-at-Risk (*IaR*) and Co-Inflation-at-Risk (*CoIaR*), respectively, to estimate the inflation at the extremes of its probability density functions. The results suggested that the IT was able to reduce inflation risk for all ITers. Chile and Peru are further ahead in terms of inflationary control, whereas in Brazil, it is more difficult. We propose the IaR and CoIaR as additional risk-management tools.

*Keywords*: Inflation Targeting; Inflation at Risk; Latin America; CoIaR; IT Functioning.

JEL Code: E52; F33; D81.

Área 4 - Macroeconomia, Economia Monetária e Finanças.

# 1 Introduction

Macroeconomic policies, a subject of interest for academics and policymakers, are defined by the set of objectives and goals. They cover multiples elements and institutional framework in order to find a sustainable economic path. In this manner, an adequate economic policies framework must satisfy two fundamental conditions, which are consistency among operational goals and sustainability of long-term economic growth. Hence, policy makers should undertake macroeconomic and risk management policies, considering domestic economic issues from a global perspective (Montinari and Stracca, 2016). Among their most important decisions, inflation control and maintaining a stable inflationary dynamic are widely investigated.

The inflation targeting (IT) regime, for instance, consists of a management system to control inflation, mainly using the basic interest rate as the instrument. (Ardakani et al., 2018) observed that 27 countries, including both developed and developing countries, have adopted IT, i.e., have become inflation targeters (ITers). The adoption of this regime by some Latin American (LA) countries, e.g., Brazil, Chile, Colombia, Mexico and Peru, has brought current inflation below two-digit levels, although it should be noted that for some of these ITers, there are still periods of high price level acceleration. Thus, (Kim, 2008) state that some aspects of the macroeconomic tripod must be considered to increase monetary management accuracy.

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Whereas (Hall and Jaaskela, 2011), (Thornton, 2016) and (Ardakani et al., 2018) found no significant difference in terms of the inflation average and inflation volatility between ITers and non-ITers, (Carrasco and Ferreiro, 2014), (Sayari and Lajnaf, 2017), (Kose et al., 2018) and (Glenn et al., 2018) concluded that ITers experienced greater inflation decreases. However, their outcome was associated with increased inflation volatility, possibly as a consequence of the constrained flexibility of IT to accommodate adverse shocks. On the other hand, the monetary authorities' asymmetry preferences in ITers' countries have been reported by several studies (Svensson, 2003, 2008; Eyzaguirre, 1998; Gonzalez and Gonzalez-Garcia, 2006; Cukierman and Muscatelli, 2008; Sweidan, 2008; Strachman, 2013; Aragon and Medeiros, 2015). Nonetheless, since the early contributions of (Phillips, 1958), (Friedman, 1968) and (Phelps, 1967), few studies have provided evidence about extreme inflation values, volatility and its implications (Kim and Lin, 2012; Hossain, 2014; Rizvi et al., 2014; Barugahara, 2015; Eisenstat and Strachan, 2016).

In this sense, the main goal of this research is to evaluate the effects of IT implementation and functioning of selected ITers in terms of evidence of inflation risk and the monetary authorities' role under extreme conditions. Institutionally, the IT regime is only feasible with independence of the monetary authorities–in most cases, central banks. This means that ITers can decrease local inflation rates and make them less susceptible to political cycles. Rather than using the ordinary inflation volatility, we provide empirical evidence of the extreme inflation risk measures based on the Value-at-Risk (VaR) and Co-VaR. The VaR is a measure of the risk of loss for investments. Statistically, it represents the minimum or the maximum event observed associated with a probability of occurrence over a specific time frame. The CoVaR, developed by (Adrian and Brunnermeier, 2016), was adapted based on the Inflation-at-Risk (IaR) (Santos et al., 2010), following the bivariate specification of (Taylor, 1993).

Hence, the Co-Inflation-at-Risk (CoIaR) refers to the degree of effort (interest rate) required of the monetary policy maker to control the inflation under distress conditions, i.e., periods of extreme acceleration of inflation. This alternative framework based on Extreme Value Theory (EVT) (Embrechts et al., 1997) can estimate the risk associated with inflationary control for different quantiles, and for this reason, it can be more informative than other measures. Our main concern about extreme events, which are quite common in financial markets, implies that it is useful to investigate how the monetary policy makers of LA ITers behave under distress conditions. Such conditions could emerge from a lack of monetary-fiscal policy coordination (Dungey and Fry, 2009; Fragetta and Kirsanova, 2010; Davig and Leeper, 2011; Cebi, 2012; Cevik et al., 2014; Cazacu, 2015; Kliem et al., 2016; Jawadi et al., 2016), which usually impacts price acceleration.

This study is divided into five sections in addition to this brief introduction. section 2 emphasizes the effort of the LA ITers to control inflation and different stages of countries concerning this task. section 3 presents the econometric methods used in the estimations. section 4 provides information about how the data were prepared for analysis. section 5 addresses the estimated inflation risk measures. Finally, section 6 highlights the final conclusions.

## 2 Inflation and the IT regime in Latin America

The LA economy relies on the exportation of commodities from agricultural and mineral products, which are exported mainly to Europe, the United States of America (US) and China. Otherwise, the volume of trade between the LA countries is relatively low, especially due to the concentration in the roll of tradable products of the bloc, with low aggregate values. For this reason, institutional aspects make them risky in terms of investments. Another factor that generates restrictions on the economic development and commercial integration of LA countries is the lack of multimodal transportation and other infrastructure problems. Despite all these restrictions, trade between LA countries has been increasing over the years, being mainly influenced by the Common Market of the Southern Cone (Mercosur). It was established by the Treaty of Asunción between Argentina, Brazil, Paraguay and Uruguay on March 26, 1991.

Argentina, an important member state of Mercosur, entered into default in 2001 on about US$24 billion in international debts. After a long term under the rule of the Kirchner family (2003-2015), the country is still recovering in terms of several of its economic indicators. In 2016, the country had an inflation rate of 40%, similarly high interest rates and a high degree of dollarization. Furthermore, the Argentinian industry, which is concentrated in the provinces of Buenos Aires, Cordoba and Rosario, is still a great concern since almost two decades have passed with little progress being achieved. In this direction, inflation control is an important means to advance in terms of creating the necessary conditions to facilitate regional economic development, since Brazil, Chile, Colombia, Peru and Mexico together account for approximately 70% of the region's GDP (World Bank, 2017).

Thus, we analyzed the LA countries that have adopted IT, rather than sample the current member states of Mercosur, which include Argentina, Bolivia and Venezuela. This last country is facing a deep crisis: 1) its economy shrank by 10% in 2016; 2) inflation is estimated to be greater than 13,000% this year according to the IMF; 3) forecasts indicate that by 2018, the GDP will be 3/4 of what it was in 2013; and 4) as a consequence of this severe scenario, more than 1 million Venezuelans have left the country. This situation represents one of the larger refugee crisis worldwide. Brazil also faces political turbulence; e.g., in less than 30 years, two presidents were impeached as result of corruption. As stated by (Winter, 2008), the LA political scenario has deteriorated as whole, considering the strong interference of presidentialist regimes with the economic policies of the region, which is susceptible to populist regimes (Castro and Ronci, 1991).

Given the devastating effects of such populist policies on inflation, inflation control proves to be one of the main conditions for LA's development. In empirical terms, inefficient policies manifest in the form of clusters of volatility in exchange rates and inflation, which negatively impact expectations, thus making it difficult for monetary policy makers to smooth its collateral effects on the level of economic activity. From an international perspective, the challenges have increased in the aftermath of the crisis of 2008. Unlike the crises that occurred in the 1990s, such as the Mexican crisis in 1995, which generated increases in international reserves, especially in developing countries, this last crisis has strongly impacted economies worldwide. Hence, (Coenen et al., 2012) point out that fiscal multipliers and public debt sustainability have again become a focus of discussions regarding optimal economic policies.

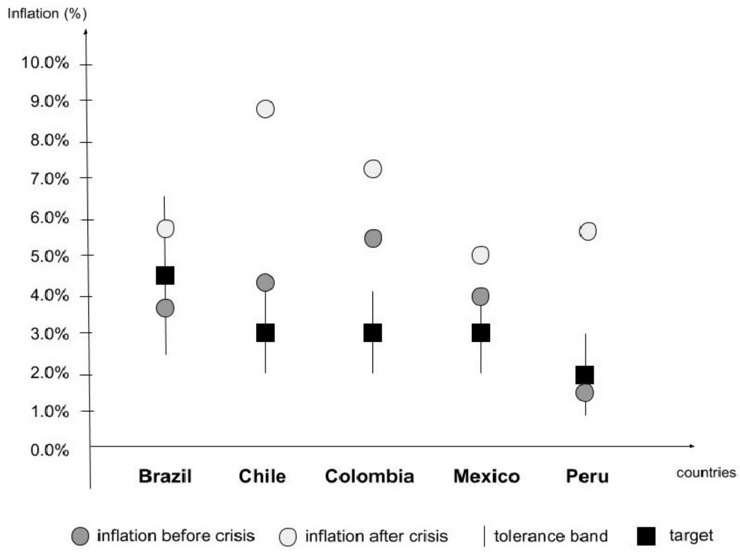
Other LA countries also exhibit characteristics of economic dollarization (Herrero and Glockler, 2000; Berg et al., 2002). Chile and Peru are ahead in terms of institutional development, i.e., the coordination policy level. The Central Bank of Chile (Banco Central de Chile - BCCh), for example, has been the Chilean monetary policy maker since its announcement in 1990, with full independence being adopted in September 1999 (Eyzaguirre, 1998; Larraín, 2007). In Peru, which has the lowest inflation target among LA ITers, 2%, the Central Bank (Banco Central de Reserva del Perú - BCRP) is the autonomous monetary policy maker. The BCRP, founded in 1931, establishes an inflation tolerance band between 1% and 3%. Noticeably, beyond impacting the average inflation rate, all these aspects also have deep consequences in terms of the trajectory of the variance in inflation. The greater the variance is, the less efficient the responses of monetary policy makers to protect the purchasing power of money.

The region faces great costs from (Fischer, 1981; Smal, 1998; Guerron-Quintana, 2011) and implications of (Fraga et al., 2004) inflation, which makes it important to evaluate the IT implementation and estimate the inflation risk. Endogenously, the deep institutional difficulties, mainly from fiscal and external points of view (Aizenman et al., 2011; Huang and Yeh, 2017; Soe and Kakinaka, 2018), could be improved by IT adoption (Hyvonen, 2004; Carrasco and Ferreiro, 2014; Sayari and Lajnaf, 2017; Kose et al., 2018; Glenn et al., 2018). In terms of game theory, the institutional conflicts between policies' goals and policy makers could be described by mechanism designs leading to different screening equilibrium. In the IT regime, the monetary authority's goal could be expressed by a metric, which express its reaction function in each given state of the economy. In practice, this regime establishes responsibilities to the monetary and fiscal policy makers.

As underlined by (Bernanke et al., 1999), the mechanism of monetary transmission is characterized by how the policy maker's decisions impact inflation and also the GDP. In this sense, Taylor's Rule expresses how the monetary authority decides the interest rate using the expectation of future inflation. In addition, it manages a loss function, which means the side effects of the reaction function on the investments and the GDP. The first function of IT is to coordinate the expectations, especially for the financial market, and the second is a guide to full transparency for the monetary policy management, which depends on the difference between the actual inflation and the established targets. (Lowenkron and Garcia, 2007) evaluates IT as one of the new consensuses about macroeconomic fundamentals, which establishes that the price stability is a necessary condition for economic growth.

Among the advantages of the IT, there are the transparency and credibility of monetary policy information for the economy, e.g., the accountability, flexibility and possibility of monitoring and evaluating the currency management. The main disadvantages of this regime are related to the variation in inflation, its degree of forecasting, and the definition and scope of the target, similar to the high degree of exchange rate flexibility (Arestis and Sawyer, 2003; Fraga et al., 2004). Once the target is established, the monetary policy maker must accomplish it. In addition, the institutional framework must be able to tolerate external shocks and establish the correct incentives to minimize them. Figure 1 reports the numerical inflation targets in place, their tolerance bands, and the observed inflation before and aftermath the crisis of 2008. The target indicates yearly inflation in the case of Brazil, where the current target has been 4.5% since 2005, and Colombia, where the target has been 3% since 2010. The situation is similar in Chile and Mexico, where the current targets have been 3% for approximately two years.

Figure 1: Inflation targets, tolerance bands, targets' centers and observed inflation before and after the crisis of 2008




Source: Elaborated from the central banks data of the selected countries.

Hence, aftermath the crisis of 2008, there was a dispersion and increase in the observed inflation in the sampled ITers in relation to the respective targets. This indicates that with the exception of Peru, all the studied ITers seems to exhibit changes in preferences of their monetary policy makers. Such changes may characterize the differences among economic cycles and the degree of influence of external prices. In Chile, where there was a inflation of 4.5% before the crisis, the average inflation increased to 9% after the crisis. This observation demonstrates that this economy is vulnerable to both imported inflation and deflation through tradable goods. We point out that the IT institutional framework attempts to maintain inflation between the tolerance bands. It also avoids deflation in order to efficiently calibrate the loss function, smoothing effects on the economic activity and pursuing the inflation target.

The symmetric tolerance band indicates that monetary policy makers avoid both inflation and deflation. Hence, CoIaR allows for the monetary policy maker to manage the inflation risk under extreme conditions by quantile and its costs in terms of higher interest rates. By using this information to smooth the loss function, the monetary policy maker could achieve low inflation without necessarily conflicting with the other policy instruments. Once inflation volatility is asymmetric, the IT plays symmetric tolerance bands. Thus, the measures of IaR and CoIaR provide us with some advantage, since the parameters are estimated according to the distributions for each investigated quantile. Consequently, they are obtained using quantile regression (QR), which was developed by (Koenker and Bassett-Jr., 1978). We also emphasize that the literature about such metrics (Embrechts et al., 1997) applied in the inflationary context is quite limited. In this sense, our empirical proposition have monetary-policy implications, since it is possible to use such measures in addition to or even rather than static and symmetric tolerance bands for inflation.

# 3 Methodological procedures

Value-at-Risk (VaR), initially proposed by JP Morgan, is a method for risk estimation used in financial markets (Jorion, 2007). It is an alternative risk estimator that can quantify the volatility among different quantiles, i.e., from i-th quantile probability distribution functions. Regularly, this framework is used to represent the expected potential losses associated with stochastic processes during a period of time, according to the desired probability of occurrence. For a random variable $X_t$, define $\text{VaR}_q^{X_t}$ as the value of $X_t$, such that the probability of obtaining a value equal to or less than $X_t$ given by $q\%$, i.e., $\text{VaR}_q$ is described as the quantile $q\%$, such that

$$\Pr(X_t \leq \text{VaR}_q^{X_t}) = q\% \tag{1}$$

By assuming $\text{VaR}_q$ as a positive number when $q > 50\%$, a higher risk is associated with superior $\text{VaR}_q$. The metric called Inflation-at-Risk (IaR) is based on the VaR concept but focused on inflation analysis in the following manner:

$$\Pr(\pi_t \leq \text{IaR}_q^{\pi_t}) = q\% \tag{2}$$

in which $\pi_t$ denotes the inflation. Intuitively, the $\text{IaR}_q^{\pi_t}$ indicates the value of $\pi_t$ such that the probability of obtaining a value equal to or less than $\pi_t$ is given by $q\%$. Furthermore, because $\Pr(\pi_t \leq \text{IaR}_q^{\pi_t})$ is the cumulative distribution function, $F$, of the random process $\pi_t$, one can also write

$$F(\text{IaR}_q^{\pi_t}) = q\% \tag{3}$$

such that solving for $\text{IaR}_q^{\pi_t}$ results in

$$\text{IaR}_q^{\pi_t} = F^{-1}(q\%) \tag{4}$$

which is also known as the $q\%$-quantile of $\pi_t$. The regression model for quantile level $q\%$ is

$$Q_q(y_i) = \beta_0(q) + \beta_1(q)x_{i1} + \ldots + \beta_p(q)x_{ip}, \quad i = 1, 2, \ldots, n \tag{5}$$

where $q$ denotes the quantile level, $Q_q(y_i) = Q_q(Y|X)$ is the conditional quantile of $y_i$ given $x_{ip}$, and the $\beta_i(q)$ are estimated by solving the following minimization problem:

$$\min_{\beta_0(q),\ldots,\beta_n(q)} \sum_{i=1}^{n} \rho_q \left( y_i - \beta_0(q) - \sum_{i=1}^{p} x_{ij}\beta_j(q) \right) \tag{6}$$

where $\rho_q = q\max(q,0) + (1-q)\max(-q,0)$ is the *check loss* function.

The IaR provides the risk measure of inflation, as very first estimated in (Santos et al., 2010). Estimation using quantile regression enables analyzing the stochastic processes studied from different desirable quantiles $q\%$ of the distribution. In this direction, it could be used to evaluate observed events in the tails, i.e., extreme occurrences (Embrechts et al., 1997). However, $\text{IaR}_q$ is a univariate metric that does not consider the marginal impact of the stochastic process $j$ on process $i$, or vice versa. In this context, (Adrian and Brunnermeier, 2016) argue that the identification of the marginal contribution of the risk of $j$ in the stochastic process $i$ could provide important information. In this context, $\text{CoVaR}_q^{j|\mathbb{C}(X_t^i)}$ is defined as the VaR estimation for the stochastic process $j$, conditioned by some event $\mathbb{C}(X_t^i)$, referring to the stochastic process $i$, such that

$$\Pr\left(X_t^j \leq \text{CoVaR}_q^{j|\mathbb{C}(X_t^i)} | \mathbb{C}(X_t^i) = \text{VaR}_q^i\right) = q\% \tag{7}$$

In other words, $\text{CoVaR}_q^{j|\mathbb{C}(X_t^i)}$ is implicitly defined by the quantile $q\%$ of the conditional probability distribution. Intuitively, this quantity represents the marginal impact of the risk of stochastic process $j$ on $i$. From this measure, (Adrian and Brunnermeier, 2016) developed the $\Delta\text{CoVaR}^{j|i}$, which can be described as follows:

$$\Delta\text{CoVaR}^{j|i} = \text{CoVaR}_q^{j|X_t^i=\text{VaR}_q^i} - \text{CoVaR}_q^{j|X_t^i=\text{VaR}_{50\%}^i} \tag{8}$$

where $\text{CoVaR}_q^{j|X_t^i=\text{VaR}_q^i} = \text{VaR}_q^j|\text{VaR}_q^i$ and $\text{CoVaR}_q^{j|X_t^i=\text{VaR}_{50\%}^i} = \text{VaR}_q^j|\text{VaR}_{50\%}^i$. Equation 8 define the conditional value at risk using the ΔCoVaR definition. As suggested by the aforementioned authors, the multivariate measure is an estimate of CoVaR using the QR. In the current research, we used a bivariate functional form based on (Taylor, 1993, 1995) to estimate the marginal effect of interest rates on inflation, but different from other empirical studies, we considered extreme inflation occurrences. Defining the interest rate as $(r_t)$ and inflation as $(\pi_t)$, the reduced form of Taylor's Rule that will be estimated for the distribution extremes may be expressed by the following specification:

$$r_t = \bar{r} + \alpha_q(\pi_t - \pi_t^*) + \varepsilon_t \tag{9}$$

in which $\bar{r}$ denotes the real interest rate, $\alpha_\pi$ is the elasticity of interest rate response with respect to inflation deviations from target, and $\varepsilon_t$ represents the stochastic error term $i.i.d(0,1)$. This empirical evidence is important in the context of how monetary policy makers face risks in decision making processes; the specification used to estimate the CoIaR (marginal impact of $\pi_t$ over $r_t$) is

$$\Delta\text{CoIaR}_q^{r_t|\pi_t} \tag{10}$$

Thus, to obtain $\Delta\text{CoIaR}_q^{r_t|\pi_t}$, $\text{VaR}_q^{r_t}$ is first estimated, conditioned to $\text{VaR}_q^{\pi_t}$ using the QR. Consider the predicted value of a QR of $r_t$ on $\pi_t$ for the $q^{\text{th}}$–quantile:

$$\hat{X}_q^{r_t,\pi_t^i} = \hat{\alpha}_q^{\pi_t^i} + \hat{\beta}_q^{\pi_t}\pi_t^i \tag{11}$$

where $\hat{X}_q^{r_t,\pi_t^i}$ denotes the predicted value for a particular quantile conditional on $\pi_t$ process. From the definition of VaR, it follows that

$$\hat{X}_q^{r_t,\pi_t^i} = \text{VaR}_q^{r_t}|\pi_t^i \tag{12}$$

That is, the value predicted from the quantile regression of $j$ on $i$ gives the VaR of $j$ conditional on $i$. Hence, the definition of the VaR of $r_t$ conditioned to $\pi_t$, the $\text{CoIaR}^{r_t|\pi_t}$ for the $q$-th quantile of the distribution, is

$$\text{CoIaR}^{r_t|\pi_t=\text{VaR}_q^{\pi_t}} = \hat{\alpha}_q^{\pi_t} + \hat{\beta}_q^{\pi_t}\text{VaR}_q^{\pi_t} \tag{13}$$

Finally, $\Delta\text{CoVaR}_q^{r_t|\pi_t}$ is estimated by the Equation 14 as follows:

$$\Delta\text{CoVaR}_q^{r_t|\pi_t} = \beta_q^{\pi_t} \cdot \left(\text{VaR}_{q\%}^{\pi_t} - \text{VaR}_{50\%}^{\pi_t}\right) \quad (14)$$

The QR, a method that was initially proposed by (Koenker and Bassett-Jr., 1978) enables the estimating of parameters based on the various quantiles of the sample, which include the median itself or any other desired quantile under analysis. CoIaR is an adapted version of this measure that can be used to estimate any desirable inflation quantile of the distributions. The quantiles of 75%, 80%, 85%, 90% and 95% were used for our purpose, different from the analysis employed in financial markets, which usually consider the left-hand tail of the distribution, i.e., the return losses in quantiles of 25%, 10%, 5% and 1% of the distribution; these values cannot not be obtained using the ordinary least squares method (OLS), which instead provides estimates for the conditional average of the inflation. According to (Koenker, 2005), ColaR lead to a more complete statistical analysis of the stochastic relation between the studied variables.

This method has been used for over the last few years, emerging as an alternative approach for statistical analysis of data through linear models, expanding toward nonlinear models, hence increasing the capabilities of the regression methods. (Koenker and Bassett-Jr., 1978) consider that an advantage of using QR rather than OLS to estimate the median is that the result of it may be more robust in response to outliers, or to platykurtic distributions, in addition to being related to the absence of distributional assumptions about the residual term[1]. There is also a body of literature that uses and evaluates the CoVaR, such as (Lopez-Espinosa et al., 2012), (Girardi and Ergu, 2013), (Almeida and Frascaroli, 2014), and (Mainik and Schaanning, 2014), among others. In addition, it is important to analyze the changes in the estimated parameters, e.g., IaR and CoIaR, and test the results according to the adoption of the IT. In this manner, we used the Chow Test, developed by (Chow, 1960), which considers the structural changes exogenously determined to represent structural break points, given by two relevant events: the country's IT adoption and the financial crisis that started in 2008. Intuitively, this test divides the sample into $k$ subsamples, and then, after performing individual regressions for each sample division, an $F$ test is performed to test the parameters' significance. Formally, we have

$$Q_q(y_i) = \mathbf{x}'\lambda(\mathbf{q}) \quad \text{for } n_1 \quad (15)$$

$$Q_q(y_i) = \mathbf{x}'\gamma(\mathbf{q}) \quad \text{for } n_2 \quad (16)$$

$$Q_q(y_i) = \mathbf{x}'\beta(\mathbf{q}) \quad \text{for } n = n_1 + n_2 \quad (17)$$

where $\lambda(q)$ and $\gamma(q)$ are the estimated coefficient vectors for the first and second sub-samples ($n_1$ and $n_2$, respectively) and $\beta(q)$ is the estimated coefficient vector for the full sample ($n = n_1 + n_2$). The parameters stability Chow Test use the sum of the square of the residuals (SQR) of the different estimated models. The null hypothesis of the test ($H_0$) is that the parameters are stable, i.e., there is no structural change in the estimations. The $F$ statistic calculated from the models with the critical value $F_{(k,n1+n2-2.k)}$ is compared.

Following the differences among economic, political and institutional factors of the LA ITers, the inflation averages and estimated parameters led us to define three subsets of countries: (a) Chile and Peru, (b) Brazil, Colombia and Mexico and (c) the non-ITer LA countries. Thus, we considered model (I), specified using the whole time frame sample, including the period before and the aftermath of IT adoption, and model (II), regarding the estimations using the sub-sample after the adoption of IT. Seeking robust results, first, we estimate the inflation conditional risk considering contemporaneous relations; this form is denoted (i). We also estimated a one-period-lagged specification between inflation and interest rates (ii). This last specification is a typical backward-looking functional form and diverges from the proposition of (Lucas,

[1] Se (Lima et al., 2011) for the VaR case.

1976). The specification tentatives are important to test the effects of the central banks' reaction function over time. Robust empirical evidence is also obtained by testing (A) the adoption of the IT regimes and (B) how the crisis of 2008 impacted on the central banks' reaction functions. In this sense, to understand those effects, four other models also with functional forms (i) and (ii) were estimated.

# 4 Sample Design and Data Processing

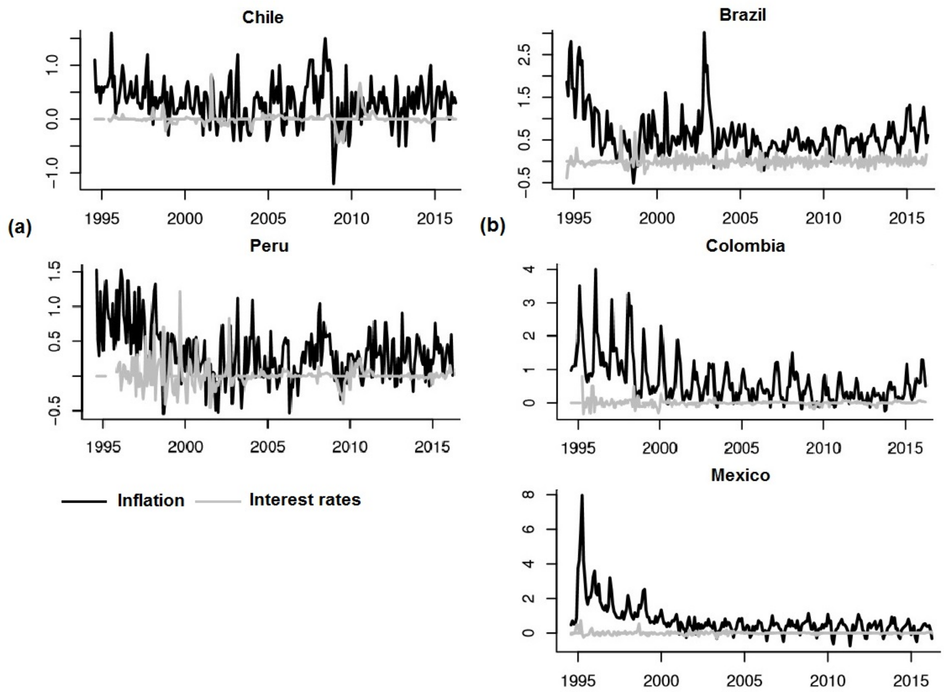
The inflation and interest monthly data cover the period from January 1994 through April 2016. We used the software *R Statistics*, and seeking robustness, the results were controlled from different perspectives. Our estimations considered the periods of IT adoption to test the effectiveness of IT in terms of reducing the average inflation and the inflation risk. Furthermore, we also estimate the IaR for a subset of non-ITer LA countries. Hence, for counterfactual comparative analysis, we set this group as (c). As pointed out by the Table 1 and Figure 2, the highest monthly inflation rate was registered in Mexico, followed by Colombia and Brazil, respectively. We observed that inflation volatility was highest in Mexico, Colombia and Brazil, in this order, indicating significant variance in the decrease in inflation over time.

Table 1: Descriptive statistics regarding the variables for the ITer countries

| **Statistics** | **(a)** | | | | **(b)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Chile** | | **Peru** | | **Brazil** | | **Colombia** | | **Mexico** | |
| | **Infl.** | **Δ Inter.** | **Infl.** | **Δ Inter.** | **Infl.** | **Δ Inter.** | **Infl.** | **Δ Inter.** | **Infl.** | **ΔJuros** |
| Average | 0.32 | 0.00 | 0.33 | 0.01 | 0.62 | 0.00 | 0.64 | 0.00 | 0.71 | 0.00 |
| Stand. Dev. | 0.39 | 0.11 | 0.39 | 0.18 | 0.52 | 0.13 | 0.68 | 0.11 | 0.94 | 0.10 |
| Variance | 0.16 | 0.01 | 0.15 | 0.03 | 0.27 | 0.02 | 0.46 | 0.01 | 0.89 | 0.01 |
| Median | 0.30 | 0.00 | 0.29 | 0.00 | 0.51 | -0.02 | 0.46 | 0.00 | 0.51 | 0.00 |
| Max | 1.60 | 0.83 | 1.53 | 1.22 | 3.02 | 0.82 | 4.01 | 0.79 | 7.97 | 0.73 |
| Min | -1.20 | -0.44 | -0.54 | -0.46 | -0.51 | -0.39 | -0.26 | -0.35 | -0.74 | -0.30 |
| Amplitude | 2.80 | 1.27 | 2.07 | 1.68 | 3.53 | 1.21 | 4.27 | 1.14 | 8.71 | 1.03 |
| Q25% | 0.10 | -0.01 | 0.06 | -0.04 | 0.32 | -0.07 | 0.19 | -0.03 | 0.25 | -0.04 |
| Q75% | 0.60 | 0.02 | 0.54 | 0.04 | 0.78 | 0.07 | 0.92 | 0.02 | 0.86 | 0.01 |
| Kurtosis | 0.87 | 21.23 | 0.68 | 12.58 | 4.76 | 8.51 | 4.70 | 17.36 | 17.96 | 18.48 |
| Skewness | -0.06 | 2.30 | 0.62 | 2.17 | 1.84 | 1.66 | 1.86 | 2.39 | 3.39 | 2.93 |

Source: Elaborated from the central banks data of the selected countries.

Figure 2: Trajectories of the inflation and interest rates of sampled ITers




Source: Elaborated from the central banks data of the selected countries.

In the case of Mexico, it also reflects the crisis that occurred in 1995, which had many negative consequences for indicators beyond inflation (Gonzalez and Gonzalez-Garcia, 2006). In Brazil, after uncertainties in the political scenario in 2002, the inflation volatility decreased and then increased, although with considerably less variation after 2013. In contrast, in Colombia and Mexico, inflation seems to be stable at more than 1% per month. We also observe an excess of observations in the right-hand tail of the distribution in Colombian case. This may indicate the persistence of the Colombian central bank to decrease inflation several times to almost zero. On the other hand, Chile and Peru (a) appeared as cases in which inflation averages are lower, 0.32% and 0.33% each, whereas the variance presented values of 0.16 and 0.15, respectively.

# 5 Results

Arguments alongside the empirical analysis are divided into the following categories: 1) institutional, which indicates that political risk are significant in some studied ITers, e.g., there are difficulties supporting the central banks' independent decisions; 2) a univariate measure of the inflation risk; 3) the analysis of the reaction function under distress conditions, provided by the CoIaR; and 4) control variables and specification tests, such as the crisis of 2008 as a proxy of ITers' external vulnerability to shocks. The IaR estimated parameters conditioned to different quantiles are highlighted in Table 2.

For the 95% quantile, Mexico and Colombia presented superior values of 2.44% and 1.89%, respectively, for IaR, higher than the other ITers. This result means that whereas Mexico has a 95% probability of monthly inflation being smaller than 2.44%, Colombia has analogous probability of registering inflation less than 1.89%. We find that in 13 episodes ($\approx$ 4.85%), the monthly inflation exceeded the extreme value estimated by the IaR. Note that its value is superior to the tolerance band indicated in Figure 1. In contrast, the estimated IaR values were 1.00% and 1.12% for Chile and Peru, respectively. This group (a) exhibited the lowest estimated values of inflation risk conditioned to the 95% quantile. In other words, the probability of the monthly variation of Chilean inflation is less than 1% in 95% of occurrences in our sample. In a similar situation, Peru presented an $IaR_{95\%}$ of approximately 1.12%, in which only 13 observations of monthly inflation were superior or at least equal to the extreme value given by IaR. Different from (Gonçalves and Salles, 2008), this result suggests a low inflation volatility, i.e., low inflation risk compared to the subset (b) and even lower compared to the non-ITer subset (c).

Table 2: Estimations of the IaR

| **Group** | **Country** | $IaR_{95\%}$ | $IaR_{90\%}$ | $IaR_{85\%}$ | $IaR_{80\%}$ | $IaR_{75\%}$ |
|---|---|---|---|---|---|---|
| **(a)** | Chile | 1.00*<br>[12.31] | 0.80*<br>[15.55] | 0.70*<br>[15.31] | 0.60*<br>[14.45] | 0.60*<br>[23.57] |
| | Peru | 1.12*<br>[11.98] | 0.81*<br>[8.14] | 0.64*<br>[11.99] | 0.57*<br>[15.84] | 0.54*<br>[19.28] |
| **(b)** | Brazil | 1.57*<br>[6.96] | 1.24*<br>[10.47] | 1.02*<br>[12.63] | 0.86*<br>[12.43] | 0.78*<br>[13.92] |
| | Colombia | 1.89*<br>[7.27] | 1.51*<br>[9.46] | 1.19*<br>[12.19] | 1.09*<br>[12.11] | 0.92*<br>[14.45] |
| | Mexico | 2.44*<br>[6.037] | 1.62*<br>[6.80] | 1.17*<br>[8.25] | 0.93*<br>[9.08] | 0.86*<br>[11.64] |
| **(c)** | Argentina | 1.45*<br>[3.43] | 1.24*<br>[10.78] | 1.12*<br>[17.88] | 0.93*<br>[18.03] | 0.87*<br>[19.48] |
| | Bolivia | 3.11*<br>[14.20] | 2.13*<br>[8.48] | 1.65*<br>[9.43] | 1.34*<br>[11.63] | 1.22*<br>[13.37] |
| | Ecuador | 5.06*<br>[5.57] | 2.89*<br>[5.84] | 2.32*<br>[10.69] | 1.80*<br>[9.37] | 1.52*<br>[8.05] |
| | Paraguay | 2.06*<br>[9.50] | 1.71*<br>[13.94] | 1.50*<br>[16.87] | 1.33*<br>[14.54] | 1.10*<br>[13.08] |
| | Uruguay | 3.11*<br>[14.20] | 2.13*<br>[8.48] | 1.65*<br>[9.43] | 1.34*<br>[11.63] | 1.22*<br>[13.37] |

(*) Statistically significant at 5%. Source: Elaborated from the central banks data of the selected countries.

From the perspective of IaR, Brazil is a hybrid case (a-b), relatively close to the subset with the highest $IaR_{q\%}$, although with a negative trend in long-term inflation. This result reflects the monthly inflation volatility risk of 1.57% for the quantile of 95%, i.e., lower than the tolerance band of 2%. In addition, the estimations for the other quantiles were somehow proportional. On average, the Brazilian parameter was 0.78%, also near the values for Mexico and Colombia (c). The only exception occurred for the parameter in Mexico for the 75% quantile, 0.86%, lower than for Colombia, which registered 0.92%. We also report that Chile's effort to keep inflation within the tolerance band is higher, with 42 violations, compared to Peru, with 65 in total. Otherwise, its magnitudes were small, which strongly suggests macroeconomic fine-tuning.

Furthermore, Colombia and Mexico were similar in terms of violation of their targets' tolerance bands, despite highlighting some differences between the estimated IaR values. Colombia has higher parameters for three of the considered quantiles, with the exception of the 95% values. However, in the Mexican case, there is a significant decrease in inflation after the adoption of IT, which was observed for all cases. Turning the analysis to subset (c), it is possible to observe that in general, they have a much higher inflation risk, highlighted by Ecuador, which registered 5.06% inflation risk at the 95% quantile, followed by Bolivia and Uruguay, both with 3.11%. We verified a significant decrease (42.89%) in Ecuador's IaR between the 95% and 90% quantiles, reinforcing the idea of high inflation volatility risk also indicated by the changes of the IaR among these quantiles. Finally, Argentina (1.45%) and Paraguay (2.06%) are the non-ITer countries with the lowest levels of inflation risk. However, such cases are not monetary policy fine-tuning due their magnitudes, as mentioned previously.

Moreover, the results presented by IaR of subset (c) suggest that the lack of solid rules in institutional response relative to price increases are an open avenue for inflation mismanagement. On the other hand, the results also indicate that countries that are under IT frameworks are more able to control the average inflation, in addition to reducing its volatility. In order to empirically test the higher performance of ITer countries in terms of inflation control, we estimate the Chow Test on the IaR parameters, with the breakpoint given by IT adoption. Table 3 presents the results of the structural changes test. We report significant changes in the IaR parameters after the adoption of IT for all investigated ITers, whereas for all analyzed quantiles, with the exception of Chile in the 95% and 90% percentiles, it was not possible to reject the null hypothesis of parameter stability.

The estimations indicated that the IT was successful in the control of inflation, an outcome also in line with (Carrasco and Ferreiro, 2014), (Sayari and Lajnaf, 2017), (Kose et al., 2018) and (Glenn et al., 2018). The subsequent reductions of inflation volatility were, on average, approximately 50%. The three best performances in terms of inflation risk reduction were, in descending order, Mexico, Colombia and Brazil, from group (b) of ITers. Before IT adoption in Mexico, the IaR parameter was 4.18% at the 95% quantile, compared with 0.83% in the aftermath of the adoption of IT. Specifically, Mexico reduced the inflation volatility risk by approximately 75%, whereas Colombia decreased it by approximately 60%; in Brazil, the inflation risk was reduced to half of that observed in the period before IT adoption in 1999.

Table 3: Estimations of the IaR considering parameter changes after the adoption of IT

| | (a) | | | | | | (b) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **-** | **Chile** | | | **Peru** | | | **Brazil** | | | **Colombia** | | | **Mexico** | | |
| **Quantile** $q$ | **(1)** $IaR_q$ | **\|F\| Chow** | **(2)** $IaR_q$ | **(1)** $IaR_q$ | **\|F\| Chow** | **(2)** $IaR_q$ | **(1)** $IaR_q$ | **\|F\| Chow** | **(2)** $IaR_q$ | **(1)** $IaR_q$ | **\|F\| Chow** | **(2)** $IaR_q$ | **(1)** $IaR_q$ | **\|F\| Chow** | **(2)** $IaR_q$ |
| 95% | 1.00* [6.39] | 0.00 | 1.00* [11.77] | 1.37* [19.44] | 93.1 | 0.76* [8.12] | 2.62* [11.81] | -26.7 | 1.24* [5.18] | 3.11* [7.95] | 92.4 | 1.20* [8.70] | 4.18* [3.52] | 113.0 | 0.83* [11.02] |
| 90% | 0.80* [4.07] | 0.00 | 0.80* [11.16] | 1.24* [15.11] | 16.3 | 0.60* [14.19] | 2.26* [8.14] | -44.8 | 0.92* [10.09] | 2.60* [5.83] | 75.3 | 1.02* [13.23] | 3.20* [4.40] | 54.2 | 0.72* [15.23] |
| 85% | 0.80* [6.87] | 44.9 | 0.60* [12.55] | 1.09* [9.80] | 57.1 | 0.55* [14.64] | 1.70* [6.16] | -18.8 | 0.82* [6.16] | 2.21* [6.09] | 64.2 | 0.84* [10.76] | 2.53* [6.33] | 59.9 | 0.67* [18.03] |
| 80% | 0.70* [9.93] | 9.1 | 0.60* [13.83] | 0.91* [8.33] | 34.3 | 0.51* [15.63] | 1.53* [6.47] | -39.9 | 0.77* [18.40] | 1.84* [6.69] | 146.5 | 0.71* [6.69] | 2.20* [6.62] | 80.4 | 0.60* [19.48] |
| 75% | 0.60* [9.25] | 56.8 | 0.50* [12.53] | 0.76* [7.13] | 10.6 | 0.45* [14.34] | 1.34* [5.98] | -20.9 | 0.71* [22.29] | 1.65* [6.06] | 137.1 | 0.61* [10.19] | 2.04* [7.27] | 105.0 | 0.55* [18.53] |

Note: (*) Statistically significant at 5%.
(**) Chow Tests performed considering the statistic F(1.259).
Source: Elaborated from the central banks data of the selected countries.

Regardless, Brazil exhibits the highest IaR, and it holds for all other estimations. In contrast with the Mexican estimated parameters, these results for Brazil indicated the constrained flexibility reported by (Gonçalves and Salles, 2008). Such outcomes even suggest that (1) IT seems to be related to institutional factors, as emphasized by (Emara, 2012) and (Hove et al., 2017); (2) whereas the other studied ITers reduced the inflation target to 3%, Brazil missed this opportunity and kept the target at 4.5% at year. The significant presence of presidentialism in Brazil may have led to a negative impact of the political cycle on economic decisions, mainly as a consequence of a type of *Neo-Populism* in the country[2]. At this stage of the research, the estimated CoIaR parameters revealed some advantages relative to other multivariate frameworks, in which parameter estimations are conditioned to inflation events' average values. QR allows for us to estimate the marginal impact of interest rates on inflation, considering different extreme quantiles.

Table 4 and Table 5 illustrate the point that for most part of the investigated ITers and quantiles, the central banks' responses are statistically significant at 5%. The best specification for the central banks' reaction functions was (ii), i.e., the backward-looking functional form. The parameters were superior compared to those estimated in (i), considering contemporary effects between interest rates and inflation. Nonetheless, some of the estimated parameters were not statistically significant for both specifications (i) and (ii). Some

[2]This so-called Neo-Populism was based on *fiscal trickeries*, i.e., the loss of the macroeconomic tripod, which brought inflation and more than 14 million people unemployed since 2013.

of these outcomes demonstrate that there are distinct levels of efforts by the ITers' central banks, in addition to problems due to asymmetric preferences.

Table 4: Estimations of the CoIaR

| - | Brazil | | Chile | | Colombia | | Peru | | Mexico | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Quant.** $q$ | $\Delta CoIaR_q$ | $\beta^i_q$ | $\Delta CoIaR_q$ | $\beta^i_q$ | $\Delta CoIaR_q$ | $\beta^i_q$ | $\Delta CoIaR_q$ | $\beta^i_q$ | $\Delta CoIaR_q$ | $\beta^i_q$ |
| 95% | -0.0127 | -0.012 [0.31] | 0.0155 | 0.0222 [0.44] | 0.1604* | 0.1122* [4.19] | 0.0177 | 0.0213 [0.23] | 0.2023* | 0.1048* [7.51] |
| 90% | -0.0050 | -0.0068 [0.25] | 0.0107 | 0.0214 [0.84] | 0.0525* | 0.050* [4.81] | 0.0359 | 0.069 [0.90] | 0.1057* | 0.0952* [10.29] |
| 85% | 0.0021 | 0.0041 [0.20] | 0.0133 | 0.0333 [1.41] | 0.0278* | 0.0381* [3.58] | 0.0309 | 0.0882 [1.44] | 0.0380* | 0.0575* [6.41] |
| 80% | 0.0042 | 0.0119 [0.5961] | 0.0094* | 0.0312* [2.70] | 0.0205* | 0.0326* [4.95] | 0.0169* | 0.0602* [2.12] | 0.0143* | 0.0341* [6.14] |
| 75% | 0.0031 | 0.0116 [0.55] | 0.0079* | 0.0263* [2.76] | 0.0138* | 0.0300* [5.59] | 0.0167* | 0.0667* [4.57] | 0.0078* | 0.0223* [7.14] |

Source: Elaborated from the central banks data of the selected countries.
(*) Statistically significant at 5%.%.

Table 5: Estimations of the CoIaR considering one lag

| - | Brazil | | Chile | | Colombia | | Peru | | Mexico | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Quant.** $q$ | $CoIaR_q\%$ | $\beta^i_q$ | $CoIaR_q\%$ | $\beta^i_q$ | $CoIaR_q\%$ | $\beta^i_q$ | $CoIaR_q\%$ | $\beta^i_q$ | $CoIaR_q\%$ | $\beta^i_q$ |
| 95% | -0.0273 | -0.02 [-0.84] | 0.0200 | 0.02 [0.49] | 0.2571* | 0.17* [18.42] | 0.1916* | 0.23* [2.33] | 0.2106* | 0.10* [23.12] |
| 90% | -0.0076 | -0.01 [-0.37] | 0.0100 | 0.02 [0.54] | 0.0819* | 0.07* [4.90] | 0.1051* | 0.20* [4.15] | 0.0699* | 0.06* [5.48] |
| 85% | 0.0023 | 0.00 [0.25] | 0.0133 | 0.03 [1.55] | 0.0429* | 0.05* [7.47] | 0.0365* | 0.10* [2.13] | 0.0240* | 0.03* [8.10] |
| 80% | 0.0000 | 0.00 [0.00] | 0.0094* | 0.03* [1.98] | 0.0221* | 0.03* [4.34] | 0.0260* | 0.09* [4.67] | 0.0097* | 0.02* [6.18] |
| 75% | 0.0000 | 0.00 [0.00] | 0.0067* | 0.02* [2.33] | 0.0132* | 0.02* [4.76] | 0.0169* | 0.06* [3.17] | 0.0053* | 0.01* [5.23] |

Source: Elaborated from the central banks data of the selected countries.
(*) Statistically significant at 5%.

Similar to the IaR, the CoIaR could also be a consequence of the small number of observations in each of the analyzed quantiles. After the studied countries become ITers, this made the analysis difficult, depending on the extreme right-hand quantile. Independent of the specifications, the magnitudes of the estimated $\Delta CoIaR$ parameters suggested that the central banks usually decide to smooth the interest rate trajectories, as a consequence of management of the loss function. Apparently, the concave form of their reaction function reveals less-elastic responses in periods of extreme inflation, which may impact its own reputation. For the Brazilian case, we note that for both (i) and (ii), statistical significance of the $\Delta CoIaR$ was not verified. This outcome indicates the difficulty of estimating the reaction function of the central bank, depending on the extreme quantiles.

Parameters with negative signals in the 95% and 90% quantiles were estimated, considering the mentioned aspects of their reaction functions' concavities. This result suggests that the Brazilian central bank does not exhibit elastic responses to extreme inflation, which registered 10.67% in 2015. The monetary policy makers from the investigated ITers from group (b) are not as independent as necessary for efficient calibration of Taylor's Rule and well functioning of the IT regime. The exceptions were Chile and Peru from (a), in which the volatility was very close to zero, as also estimated by (Larraín, 2007) for the Chilean case. These ITers do not register statistical significance for the $\Delta CoIaR$ at the 95%, 90% and 85% quantiles of the distribution, mainly due to the absence of observations in these quantiles. However, in quantiles 80% and 75%, the parameters were statistically different from zero. These outcomes indicate that the central banks from (a) are relatively influenced by inflation's extreme events. In this case, the inflation volatility could be consequence of the constrained flexibility and external factors, maybe with no elastic responses to interest rates.

Colombia and Mexico from (b) presented parameters with statistically significant positive signs, suggesting evidence for central banks' positive reaction to extreme inflation events, even in small-scale terms, i.e., fine-tuning. This verification suggests that the ITers that made more institutional policy coordination efforts were able to decrease inflation more intensely without necessarily overuse of the interest rates. The Chow Tests for specifications (A) and (B), considering (i) and (ii), with the likelihood ratios and $F$ statistics in brackets, are presented in Table 6 and Table 7, in section 6. It was not possible to reject the $H_0$ hypothesis for all ITers whose $\Delta CoIaR_{Chow}$ were denoted by dashes. This finding means that the $F$ statistic was lower than the density percentile $F(k, n_1 + n_2 - 2k)$. On the other hand, the values indicated by stars indicate differences in the parameters estimated; thus, $H_0$ was rejected. For all cases, considering both functional forms, with the exception of Colombia and Mexico for the highest quantiles, the $\Delta CoIaR_{Chow}$ parameters were superior for the subsamples considering the period after IT adoption (A), although, the parameters estimated at quantiles 90% and 95% have negative signs.

For (B), the most affected was Mexico, followed by Chile. With the US as the main trading partner, it is possible to associate this outcome with imported inflation, since the Mexican economy is directly linked to the international crude oil price variation. Meanwhile, the Chilean inflation risk is also vulnerable to exogenous shocks according to the crisis of 2008 tests. However, Chile faces imported inflation through tradable goods, as also pointed out in (Aizenman et al., 2011; Huang and Yeh, 2017; Soe and Kakinaka, 2018). In other cases, such as Brazil, the structural change was statistically insignificant. Hence, Brazilian IT's framework depends more on structural domestic conditions. According to targets and the averages of inflation displayed in Figure 1, Peru, followed by Chile, Mexico, Colombia and Brazil, in this order, are likely to be more aligned with the commitments arising from the IT regime.

The IaR and the CoIaR vary considerably depending on the 210 tested specifications. In general, whereas Brazil is the lowest-ranked country in terms of efficient IT functioning, Chile and Peru (a) have better outcomes. The parameters obtained using the functional form (ii) were superior to those resulting from (i), suggesting that the central banks from studied ITers take a month on average to respond to extreme inflationary episodes. However, the longer it takes the central bank to react to extreme inflation, the higher the costs in terms of interest rates' elasticity responses. In summary, the results seem to indicate deep differences among economies and institutional development, mainly among the studied ITers from group (b). This requires efficient policy coordination with special attention to the independence of central banks. Principles such as fiscal balance, transparency and accountability, in addition to financial development (Huang and Yeh, 2017), are among the main conditions for proper functioning of IT.

According to the identified characteristics, Chile and Peru were better placed in terms of IT functioning, whereas Mexico and Brazil, in the opposite condition, are still in transition in terms of the regime's adoption. In Brazil, the inflation and interest rates were consequences of the domestic fiscal crisis and the loss of the macroeconomic tripod. The use of public expenditure to push government's electoral agenda, mainly during the period from 2007 to 2012, was the principal source of Brazilian performance. This deteriorated due to increasing corruption, leading the country to a serious domestic crisis since 2013, as previously mentioned. As pointed out by (Castro and Ronci, 1991) and (Winter, 2008), the political risk is also one of the great barriers for the development of LA countries. Therefore, we observed that the management of monetary instruments is diffuse, as also reported in (Svensson, 2003), (Svensson, 2008), (Arestis and Sawyer, 2003), (Cukierman and Muscatelli, 2008) and (Sweidan, 2008).

# 6 Conclusion

We analyze the implementation and the functioning of IT, focused on inflation, its targets and tolerance bands, in addition to empirical measures of the inflation risk. The IaR and the CoIaR estimated measures for Brazil, Chile, Colombia, Mexico and Peru were computed by using historical data combined with theoretical and institutional factors for this purpose. We also estimated parameters considering the vulnerability to institutional and external shocks by testing multiple specifications for inflation risks. The results indicated high numbers of internal uncertainties among the studied ITers, despite the decreased inflation, suggesting that the ITers are in distinct IT development stages.

The alternative measure provided by the IaR and CoIaR based on EVT reinforce the importance of maintain an orderly process of formation of expectations and prices. First, the IaR outcomes demonstrated that IT reduced the inflation volatility in all of the investigated cases. Furthermore, the CoIaR underlined that the responses of the ITers' central banks to extreme inflationary events were limited. This may be a consequence of the preferences of the LA central banks for smoothed interest rates, minimizing, in this manner, the loss function side effects. Nonetheless, the presented literature and the empirical evidence of inflation risk address the asymmetry of the LA central banks' preferences, which could be motivated by the strong presence of presidentialism in the region. In this sense, the diagnosis is quite similar among LA countries: urgent in-depth reforms toward more accommodative public decision stances, in particular, the better use of fiscal instruments to reduce current distortionary tax effects.

Besides, the intra-regional aspects of LA, the economies' openness, and the heterogeneity of domestic interests rates must be considered for coordinated monetary policy decisions. From an institutional point of view, Chile and Peru are better placed in terms of the performance of inflationary control, whereas Mexico and Brazil are still in transition in terms of the whole implementation of the IT regime. Comparing the IT benefits and costs between ITers and the other investigated LA countries, the empirical evidence suggests that it could be a tool to reduce domestic inflation and its risks. Hence, as already mentioned, we propose using such measures, possibly in addition to the static and symmetric tolerance bands for inflation in the IT regime. For future investigations, we indicate the use of CoIaR to provide empirical evidence of inflation for other subsets of ITers and compare it with other inflation risk measures.

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Appendix A

Table 6: Estimations of the CoIaR considering parameter changes

| (A) Estimations of the CoIaR considering parameters change after the adoption of the IT | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | Brazil | | | Chile | | | Colombia | | | Peru | | | Mexico | | |
| **Quant.-$q$** | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ |
| 95% | -0.012 | 0.18 [1.13] | - | 0.015 | 0.08 [0.24] | - | 0.160* | -0.15 [-0.56] | - | 0.017 | 0.17 [0.79] | - | 0.202* | -0.15 [-1.24] | - |
| 90% | -0.005 | 0.04 [0.28] | - | 0.010 | -0.06 [-0.49] | - | 0.052* | 0.05 [0.22] | - | 0.035 | 0.09 [0.51] | - | 0.105* | -0.09* [-1.88] | 0.003* |
| 85% | 0.002 | 0.03 [0.50] | - | 0.013 | -0.07* [-1.96] | -0.015* | 0.027* | 0.00 [0.02] | - | 0.030 | 0.08 [0.67] | - | 0.038* | -0.10 [-1.72] | - |
| 80% | 0.004 | 0.02 [0.62] | - | 0.009* | -0.04 [-0.66] | - | 0.020* | 0.00 [0.28] | - | 0.016* | 0.09 [1.00] | - | 0.014* | -0.06 [-0.93] | - |

| (B) Estimations of the CoIaR considering parameters change after the crisis of 2008 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | Brazil | | | Chile | | | Colombia | | | Peru | | | Mexico | | |
| **Quant.-$q$** | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ |
| 95% | -0.012 | 0.07 [0.63] | - | 0.015 | -0.12 [-0.55] | - | 0.160* | - | - | 0.017 | -0.15 [1.13] | - | 0.202* | -0.32 [0.98] | - |
| 90% | -0.005 | -0.03 [-0.52] | - | 0.010 | 0.013 [0.17] | - | 0.052* | -0.05 [-0.77] | - | 0.035 | -0.04 [-0.19] | - | 0.105* | -0.10*[-2.85] | -0.008 |
| 85% | 0.002 | -0.04 [-1.27] | - | 0.013 | 0.00 [0.17] | - | 0.027* | -0.02 [-0.70] | - | 0.030 | -0.10 [-0.99] | - | 0.038* | -0.06* [-2.40] | -0.007 |
| 80% | 0.004 | -0.03 [-1.03] | - | 0.009* | 0.00 [0.22] | - | 0.020* | -0.01 [-0.56] | - | 0.016* | -0.06 [-0.74] | - | 0.014* | -0.04 [1.66] | - |

Table 7: Estimations of the CoIaR considering one lag and parameter changes

| (A) Estimations of the CoIaR considering parameters change after the adoption of the IT | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | Brazil | | | Chile | | | Colombia | | | Peru | | | Mexico | | |
| **Quant.-$q$** | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ |
| 95% | -0.0273 | 0.23 [1.55] | - | 0.0200 | -0.18 [-0.65] | - | 0.2571* | -0.08 [-0.34] | - | 0.1916* | -0.22 [-0.46] | - | 0.2106* | 0.00 [0.01] | - |
| 90% | -0.0076 | 0.08 [0.62] | - | 0.0100 | -0.08 [-0.42] | - | 0.0819* | 0.06 [0.26] | - | 0.1051* | 0.14 [0.95] | - | 0.0699* | 0.00 [0.03] | - |
| 85% | 0.0023 | 0.03 [0.33] | - | 0.0133 | 0.02 [0.26] | - | 0.0429* | 0.03 [0.18] | - | 0.0365* | 0.15 [0.80] | - | 0.0240* | 0.02 [0.34] | - |
| 80% | 0.0000 | 0.03 [0.95] | - | 0.0094* | 0.01 [0.15] | - | 0.0221* | 0.01 [0.46] | - | 0.0260* | 0.11 [1.40] | - | 0.0097* | 0.03 [1.38] | - |
| **(B) Estimations of the CoIaR considering parameters change after the crisis of 2008** | | | | | | | | | | | | | | | |
| - | Brazil | | | Chile | | | Colombia | | | Peru | | | Mexico | | |
| **Quant.-$q$** | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ | $\Delta CoIaR$ | ***Chow Test*** | $\Delta CoIaR_{Chow}$ |
| 95% | -0.0273 | 0.18 [1.29] | - | 0.0200 | -0.02 [-0.07] | - | 0.2571* | -0.10 [-0.69] | - | 0.1916* | -0.48 [-1.51] | - | 0.2106* | 0.00 [0.01] | - |
| 90% | -0.0076 | 0.10* [2.19] | 0.0718 | 0.0100 | 0.06 [0.63] | - | 0.0819* | -0.01 [-0.20] | - | 0.1051* | -0.21 [-1.15] | - | 0.0699* | 0.00 [0.03] | - |
| 85% | 0.0023 | 0.06 [1.09] | - | 0.0133 | 0.03 [1.14] | - | 0.0429* | -0.01 [-0.18] | - | 0.0365* | -0.10 [-1.16] | - | 0.0240* | 0.02 [0.34] | - |
| 80% | 0.0000 | 0.06 [1.09] | - | 0.0094* | 0.01 [0.45] | - | 0.0221* | 0.03 [1.06] | - | 0.0260* | -0.03 [-0.55] | - | 0.0097* | 0.03 [1.38] | - |