Central bank credibility and the expectations channel: Evidence based on a new credibility index

Grégory Levieuge*, Yannick Lucotte† and Sébastien Ringuedé‡§

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*Banque de France and University of Orléans, Laboratoire d'Economie d'Orléans, UMR CNRS 7322, Rue de Blois, BP 26739, 45067 Orléans Cedex 2, France

†Corresponding author, PSB Paris School of Business, Department of Economics, 59 Rue Nationale, 75013 Paris, France. Email : ylucotte@esgms.fr

‡Université d'Orléans, Laboratoire d'Economie d'Orléans, UMR CNRS 7322.

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Abstract

This article investigates the relationship between central bank credibility and the volatility of the key monetary policy instrument. First, we propose a time-varying measure of central bank credibility based on the gap between inflation expectations and the official inflation target. While this new index addresses the main limitations of the existing indicators, it also appears particularly suited to assess the monetary experiences of a large sample of inflation-targeting emerging countries. Second, by means of EGARCH estimations, we formally prove the existence of a negative effect of credibility on the volatility of the short-term interest rate. In line with the expectations channel of monetary policy, the higher the credibility of the central bank, the lower the need to move its instruments to efficiently fulfill its objective.

Keywords: Credibility, Inflation targeting, Emerging countries, EGARCH, Expectations.
JEL Codes: E43, E52, E58.

1 Introduction

"*In a word, credibility matters in the theory and it is certainly believed to matter in practice – although empirical evidence on this point is hard to come by because credibility is not easy to measure*" (Blinder (2000, p.1421)). This quotation perfectly sums up the complex issues surrounding the concept of central bank credibility. Credibility is an issue of critical importance in modern central banking (González-Páramo (2007)), and is viewed as a precious asset not to be squandered (Blinder (1998)). Nonetheless, despite the growing interest of policymakers and academics in this concept, no clear consensus has emerged on what central bank credibility really means, how it can be established, and especially how it can be measured. The survey conducted by Blinder (2000) indicates that the definition of credibility is not the same for central bankers as it is for academics. In particular, the former more closely relate inflation aversion to credibility than the latter[1].

According to Blinder (1998, 2000), such differences in view between practitioners and academics stems from the fact that the former have a definition of credibility in mind that differs from that formalized within the traditional time-consistency literature originating from Kydland & Prescott (1977) and Barro & Gordon (1983a, 1983b)[2]. Looking back on his experience as a central banker, Blinder (1998) argues that central bankers consider themselves to be credible if their announcements are believed by people, even though they are not bound by a rule that ties their hands. In other words, a monetary authority is said to be credible if "*people believe it will do what it says*" (Blinder (2000)), i.e. if deeds are expected to match words. This short and intuitive definition is close to that considered by Cukierman & Meltzer (1986) in their theoretical work. They define credibility as the absolute value of the difference between the central banks planned monetary policy and the private sectors beliefs about these plans. They define in this way the "average credibility of announcements".

On these grounds, in an inflation-targeting framework, credibility means that people believe that the central bank has the willingness, and also the ability to reach the previously announced inflation target. In particular, this means that private sector inflation expectations are anchored on the target and that people do not over-react to target misses. Based on this statement, several scholars have developed measures for assessing the degree of credibility of a central bank. To the best of our knowledge, the first paper that inves-

[1]Nonetheless, practitioners and academics agree with the reasons why credibility is important, and how to build it. Similar results are obtained by Waller & de Haan (2004) using an updated version of the questionnaire initiated by Blinder (2000).

[2]See, notably, Walsh (2010) for an analytical review of this literature.

tigated this issue is Svensson (1993). He compares *ex post* target-consistent real interest rates with market real interest rates on real bonds to assess whether the inflation-targeting framework is credible or not in Canada, New Zealand and Sweden[3]. However, such an indirect approach considers credibility to be a one/zero variable (credible or not, respectively), while in practice, there exist intermediate degrees of credibility (Blinder (1998)). With the increasing availability of survey data on inflation expectations, the next contributions have instead relied on more direct measures of central bank credibility.

Direct credibility measures may be divided into two main categories. The first is based on the Bomfim & Rudebusch (2000) methodology, which consists of assessing the weight attached by the private sector to the inflation target in the formation of their inflation expectations. To this point, if the latter are based on the target, then the central bank is considered to be credible. The second category of central bank credibility measures refers to the gap between the inflation expectations of the private sector and the inflation target (or the inflation target range). The well-known index of Cecchetti & Krause (2002), who define credibility as an inverse function of this gap, belongs to this category. Such an index has been extended by De Mendonça (2007) and De Mendonça & de Guimarães e Souza (2009), who replace the inflation target point with a target range and consider the possibility of a loss of credibility for negative deviations[4].

The indicators developed by Cecchetti & Krause (2002), De Mendonça (2007), and De Mendonça & de Guimarães e Souza (2009) have two main advantages. They are intuitive and easy to compute. However, they are not discriminating enough. Indeed, they rely on an *ad hoc* parameter for expected inflation, set to 20%, beyond which the credibility of a central bank is considered to be null. Such a threshold is unjustified, considering the single-digit inflation rates and the decreasing inflation targets in the concerned countries over the last decade. When the target is low, these indicators improperly underestimate the effect of large positive deviations of inflation expectations from the target on credibility, particularly when the target is far from 20%.

[3]Kupfer (2015) recently used the methodology proposed by Svensson (1993) to assess the monetary policy credibility of the European Central Bank, while Amisano & Tronzano (2010) extended this methodology inside a Bayesian econometric framework.

[4]Another category of measures assumes that the current credibility of a central bank is a self-reinforcing process that can be proxied by past inflation performance. In this view, a central bank is expected to gain additional credibility by reaching its publicly announced target repeatedly, i.e., by having "a history of doing what it says it will do" (Blinder (2000)). Considering this assumption, De Mendonça & de Guimarães e Souza (2009) and Neuenkirch & Tillmann (2014) propose alternative measures of central bank credibility based on the past deviations of inflation from the target. Such backward-looking indicators are particularly relevant for developing countries, for which inflation expectations data are often unavailable.

Against this background, the first purpose of this paper is to propose a new simple time-varying measure of central bank credibility that addresses the main limitation of the existing indexes. Because we believe that in practice, negative deviations of inflation expectations from the target are less likely to compromise credibility than positive deviations, we provide an asymmetric measure of credibility based on the linear exponential (LINEX) function. Furthermore, our indicator does not depend on any *ad hoc* threshold. We compute our index for all emerging countries that adopted an inflation-targeting framework, except for Ghana, for which data on inflation expectations are not available. We then analyze how the credibility of monetary policy has evolved in these economies.

This question of monetary policy credibility is particularly relevant for emerging inflation-targeting countries. A credible central bank is expected to improve the efficiency of monetary policy transmission through two channels: the expectations channel and the interest rate channel. Indeed, if a central bank is credible, people believe that the announced target will be realized. From the observed and expected inflation rate, agents can infer the future path of interest rates. Monetary policy is then easily transmitted along the yield to maturity curve. Moreover, wages and prices are set accordingly. Disinflation is then less costly. Finally, changes in the policy rates are less likely to be considered to be temporary by the banking sector, which is then more prone to pass monetary policy impulses on retail interest rates (Mojon (2001)). At the extreme, the speeches of the governor become an instrument *per se*, and are sufficient for governing the stance of monetary policy. It is not necessary to frequently change the level of key interest rates. Consequently, central bank credibility is a self-reinforcing process that emerging economies should seek to strengthen. For this reason, the second purpose of this paper is to evaluate, in the light on our new indicator, the effect of credibility on interest rate volatility. As far as we know, our study is the first that investigates this issue for a large sample of emerging inflation-targeting countries.

The remainder of the paper is structured as follows. Section 2 provides an overview of the existing measures of central bank credibility. Section 3 presents our new index. Section 4 compares our index with previous indicators and analyzes the evolution of central bank credibility in emerging inflation-targeting countries. Section 5 is devoted to the impact of credibility on interest rate volatility. Section 6 concludes the paper.

2 The existing measures of central bank credibility

Two main types of credibility measures have been developed in the literature. The first refers to the Bomfim & Rudebusch (2000) approach. It consists of assessing the weight the private sector attaches to the inflation target when forming their inflation expectations. More precisely, this approach considers that inflation expectations are determined as a weighted average of the current inflation target and the past inflation rates:

$$\pi^e_{t|T} = \lambda \bar{\pi}_t + (1 - \lambda)\, \tilde{\pi}_{t-q} \tag{1}$$

with $\pi^e_{t|T}$ representing the inflation expectations of the private sector formed at time t for the period T, $\bar{\pi}_t$ representing the inflation target, and $\tilde{\pi}_{t-q}$ representing the average of past inflation rates over the q periods considered ($\tilde{\pi}_{t-q} = \frac{\pi_{t-1}+...\pi_{t-q}}{q}$). The parameter λ ($0 \leq \lambda \leq 1$) measures the degree to which expectations are anchored on the target. The higher λ is, the higher the weight attached by the economic agents to the target when forming their expectations, and the higher the central bank credibility. As Bomfim & Rudebusch (2000) argue, with representative agents, λ may be interpreted as the subjective probability that an agent attaches to the future achievement of the target. With heterogeneous agents, λ may represent the fraction of the population believing that the target will be achieved. However, the Bomfim & Rudebusch (2000) approach has received little coverage in the empirical literature, except for the paper of Lysiak, Mackiewicz & Stanisławska (2007) in the case of Poland and those of Demertzis, Marcellino & Viegi (2009) for some industrialized inflation-targeting countries.

The second type of measures refers to the gap between inflation expectations and the inflation target. It considers any deviations of expectations from the target as a loss of central bank credibility. The index developed by Cecchetti & Krause (2002) belongs to this category. Taking values from 0 (no credibility) to 1 (full credibility), it is defined as follows:

$$CRED_{CK} = \begin{cases} 1 & \text{if} \quad \pi^e \leq \bar{\pi}_t \\ 1 - \dfrac{1}{20\% - \bar{\pi}_t}\left[\pi^e - \bar{\pi}_t\right] & \text{if} \quad \bar{\pi}_t < \pi^e < 20\% \\ 0 & \text{if} \quad \pi^e \geqslant 20\% \end{cases} \tag{2}$$

with $\bar{\pi}_t$ representing the inflation target pursued by the central bank and π^e representing the inflation rate expected by the private sector. The central bank is considered to be fully credible ($CRED_{CK} = 1$) if expected annual inflation is lower than or equal to the inflation target. On the contrary, it is non-credible ($CRED_{CK} = 0$) if expected annual inflation is equal to or higher than 20%. Between these two limits, the value of the index decreases linearly as expected inflation increases. This index was first extended by De Mendonça (2007), considering that 1) not only positive, but also negative deviations of inflation expectations from the target can imply a loss of credibility and that 2) in practice the target is not a single value but a range. The following indicator is then suggested by De Mendonça (2007):

$$CRED_{DM} = \begin{cases} 1 & \text{if} \quad \pi^e = \bar{\pi}_t^{mid} \\ 1 - \dfrac{1}{\bar{\pi}_t - \bar{\pi}_t^{mid}} \left[\pi^e - \bar{\pi}_t^{mid}\right] & \text{if} \quad \bar{\pi}_t^{min} < \pi^e < \bar{\pi}_t^{max} \\ 0 & \text{if} \quad \pi^e \geqslant \bar{\pi}_t^{max} \quad \text{or} \quad \pi^e \leqslant \bar{\pi}_t^{min} \end{cases} \tag{3}$$

with π^e representing the inflation expectations of the private sector, $\bar{\pi}_t^{mid}$ representing the midpoint inflation target pursued by the central bank, and $\bar{\pi}_t^{min}$ and $\bar{\pi}_t^{max}$ representing the lower and upper bounds of the inflation target range, respectively. $\bar{\pi}_t$ in the denominator corresponds to the lower bound $\bar{\pi}_t^{min}$ if $\pi^e < \bar{\pi}^{mid}$ and to the upper bound $\bar{\pi}_t^{max}$ if $\pi^e > \bar{\pi}_t^{mid}$. As in Cecchetti & Krause (2002), the index is defined between 0 (no credibility) and 1 (full credibility). While its maximum (full credibility) is obtained when the expected inflation is exactly equal to the midpoint of the inflation range, the index decreases symmetrically and linearly when expectations deviate from the target point.

However, in focusing on the midpoint, this index is too restrictive, and can therefore lead to misleading conclusions. Full credibility is not only reached when inflation expectations are exactly equal to the midpoint target. One can reasonably consider that credibility also occurs when private expectations belong to the range. Taking this into consideration, De Mendonça & de Guimarães e Souza (2009) proposed this alternative index:

$$CRED_{DMGS} = \begin{cases} 1 & \text{if} \quad \bar{\pi}^{min} \leqslant \pi^e \leqslant \bar{\pi}^{max} \\ 1 - \dfrac{1}{20\% - \bar{\pi}_t^{max}} \left[\pi^e - \bar{\pi}_t^{max}\right] & \text{if} \quad \bar{\pi}_t^{max} < \pi^e < 20\% \\ 1 - \dfrac{1}{-\bar{\pi}_t^{min}} \left[\pi^e - \bar{\pi}_t^{min}\right] & \text{if} \quad 0 < \pi^e < \bar{\pi}_t^{min} \\ 0 & \text{if} \quad \pi^e \geqslant 20\% \quad \text{or} \quad \pi^e \leqslant 0 \end{cases} \tag{4}$$

with π^e representing the inflation rate expected by the private sector and $\bar{\pi}_t^{min}$ and $\bar{\pi}_t^{max}$ representing the lower and the upper bounds of the inflation target range, respectively.

A central bank is viewed as non-credible ($CRED_{DMGS} = 0$) if expected annual inflation is equal or greater than 20% or lower than or equal to 0% and as fully credible ($CRED_{DMGS} = 1$) if inflation expectations belong to the target range. Between these two limits, the value of the index decreases linearly.

Figure 1 illustrates the profile of $CRED_{CK}$ and $CRED_{DMGS}$ in the case of a single-digit inflation target equal to 2% (with +/- 0.5% point tolerance intervals) and in the case of a double-digit inflation target equal to 14% (with +/- 0.5% point tolerance intervals)[5].

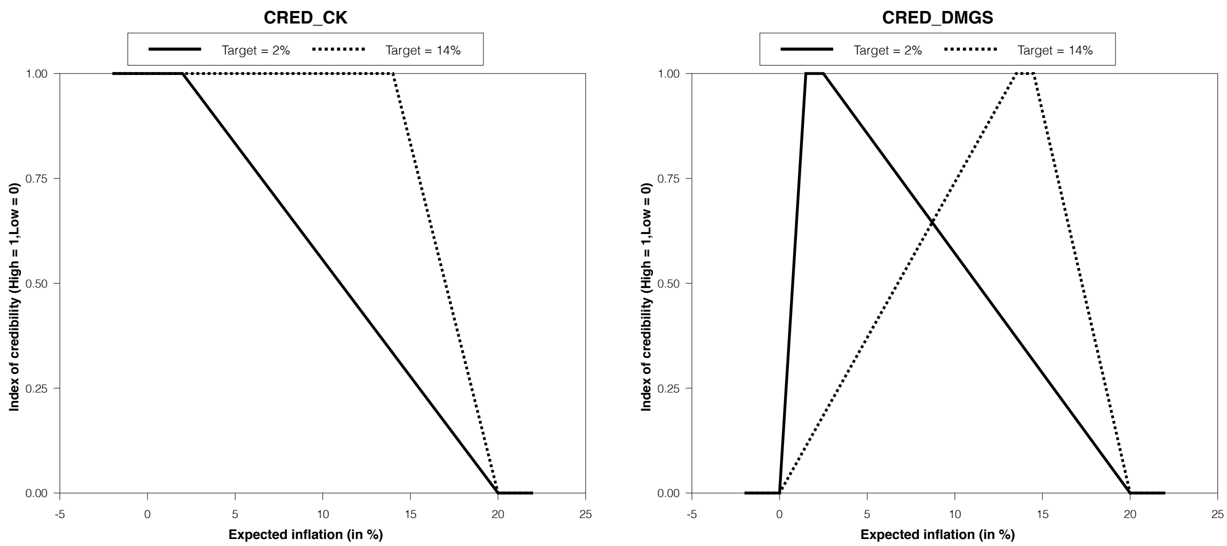

Figure 1: Profile of $CRED_{CK}$ and $CRED_{DMGS}$

As we can see, the profile of these indexes and the marginal loss in credibility largely depends on the level of the inflation target. A positive deviation of inflation expectations from the target is strongly punished in terms of credibility loss if the target is close to the *ad hoc* upper limit of 20%. For example, for a positive deviation of 3 percentage points from the target range, the value of $CRED_{DMGS}$ is then equal to 0.45 in the case of a target equal to 14%, and to 0.83 in the case of a target equal to 2%. The $CRED_{CK}$ index is then equal to 0.50 and 0.83, respectively. Such a framework is inadequate for assessing the current level of credibility of emerging inflation-targeting central banks because most of them now pursue relatively low inflation targets. Indeed, in 2014, none of the emerging inflation-targeting countries pursued an inflation target point higher than 5%. Consequently, we

[5] The $CRED_{DM}$ index is not presented here because, as aforementioned, it is certainly too restrictive in that it assumes that credibility is null when inflation expectations are outside the target range.

propose a new index of central bank credibility, independent of any *ad hoc* upper and/or lower threshold(s). This indicator is described in the next section.

3 A new indicator of central bank credibility

3.1 The rationale for a new indicator

The indicator we suggest is in line with the theoretical considerations of Cukierman & Meltzer (1986), according to which credibility can be viewed as the difference between private inflation expectations and the announced policy target. In this respect, it is an extension of the empirical measures suggested by Cecchetti & Krause (2002), De Mendonça (2007) and De Mendonça & de Guimarães e Souza (2009). However, as we have seen, these measures impose an *ad hoc* and undue upper threshold value (20%) for expected inflation, above which credibility is null.

We consider that an indicator of credibility should fulfill two main properties. First, it should not be based on *ad hoc* upper and/or lower thresholds but should freely converge towards its extreme values. Second, a credibility indicator should not be linear. Indeed, a critical point for developing a credibility index is the following: should negative and positive deviations of expected inflation from the target be considered equivalent in terms of (loss in) credibility? Surely not. The central bank is mandated to maintain control over the growth rate of prices. Positive deviations clearly signal that people do not believe in the ability of the central bank to meet this commitment. Then, the central bank is not entirely credible. Negative deviations also indicate that people believe that actual inflation will not meet the target. However, private agents consider in this case that the monetary authorities can do even better than the announced target in terms of inflation control. This is rarely perceived as a signal that monetary authorities abandon their objective. On the contrary, people consider that "*he who can do more can do less*". As a result, negative deviations are less serious than positive deviations.

Of course, this way of modeling central bank credibility depends on the level of the inflation target. The loss of credibility due to negative deviations from the target is most probably lower for a relatively high inflation target than for a target close to zero. However, one should not forget that in most emerging inflation targeting countries, the inflation targeting framework was adopted with the aim of reinforcing and accelerating the disinflation process. As argued by the IMF (2002), countries such as Poland, Chile, Mexico or the Czech Republic successfully disinflated while missing targets, with no apparent loss in central bank credibility or price stability. The experience of these countries seems to confirm that the private sector reacts differently to positive and negative deviations from the target. This asymmetric loss of credibility may also explain why we observe a strongest monetary policy response against positive deviations from the target rather than negative deviations (see, e.g., Orphanides & Wieland (2000)). Finally, the recent inflationary pressures faced by some emerging economies, such as the Brazil, remind us that deflation fears, and then potential loss in credibility due to negative deviations from the target, concern more industrial countries than emerging countries. Consequently, an indicator of central bank credibility should take this asymmetry into account, with positive deviations being more serious in terms of credibility loss than negative ones.

We suggest an indicator that satisfies this dual challenge based on the asymmetrical LINEX loss function[6] (partly LINear, partly EXPonential). Noting $\tilde{\pi}^e$ the deviation between expected inflation (π^e) and the target ($\bar{\pi}$), a LINEX function with $\tilde{\pi}^e$ as an argument is defined such that:

$$f(\tilde{\pi}^e) = exp\left(\phi\left(\tilde{\pi}^e\right)\right) - \phi\left(\tilde{\pi}^e\right) - 1 \tag{5}$$

For $\phi = 1$, $\tilde{\pi}^e > 0$ will be considered to be more serious than $\tilde{\pi}^e < 0$ (because the exponential part of the function dominates the linear part when the argument is positive). The figure 2 compares the LINEX function with the usual quadratic one for $\bar{\pi} = 2\%$, with the horizontal axis corresponding to π^e.

We will show below that a credibility indicator can be developed on the basis of such a function, with an inverted-U profile between 0 and 1, as is usual in the literature. The indicator will be precisely defined in the next subsections, considering two cases based on whether the target is a single value or a range. Further, in each case, we will successively assume first that negative deviations induce a credibility loss and second that they do not imply any credibility loss.

3.2 The target is a single number

We first considerer that the target is $\bar{\pi}$.

FIRST CASE One considers $\pi^e < \bar{\pi}$ to represent a loss in credibility, even if it is less serious than $\pi^e > \bar{\pi}$. Then, we define a new credibility index as the following inverse *quasi*

[6]See Varian (1974) and Zellner (1986).

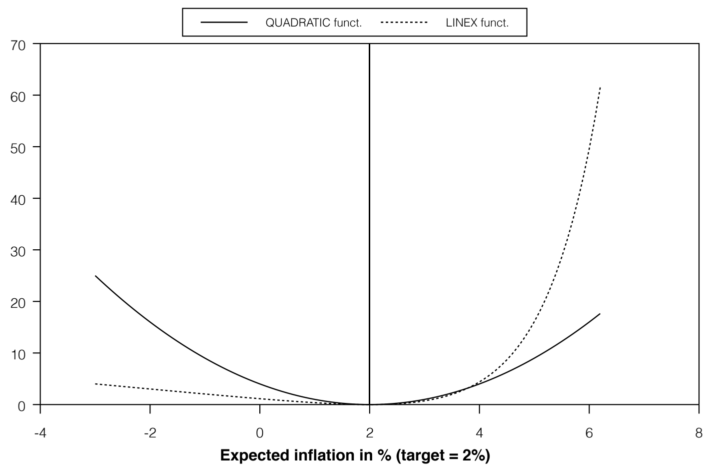

Figure 2: Quadratic *versus* LINEX functions

LINEX function:

$$CRED_{LLR1} = \frac{1}{exp(\tilde{\pi}^e) - \tilde{\pi}^e} \quad \forall\, \pi^e \tag{6}$$

As for the existing indicators in the literature, $0 < CRED_{LLR1} < 1$, with 1 for full credibility. At the extreme opposite, $CRED_{LLR1} = 0$ indicates that the corresponding central bank is not credible at all. With this definition, any reference to a hypothetical upper or lower bound is not required. The upper left panel of the figure 3 gives the profile of this indicator for $\bar{\pi} = 2\%$, with the horizontal axis representing π^e. As expected, the profile is non-linear. Negative deviations do mean that credibility is compromised, but any positive deviation signals a higher loss in credibility than an equivalent negative one. Moreover, the marginal loss in credibility is decreasing with $\tilde{\pi}^e$. This is an important feature of our indicator. The rationale behind is the following. Assume that $\bar{\pi} = 2\%$. An expected inflation rate that grows from 14 to 16% should not coincide with a dramatic loss in credibility, as the latter is already hugely damaged (because of the initial $\pi^e = 14\%$). Quite the opposite, a growing expected inflation rate, say from 2 to 5%, must express a higher marginal loss in credibility. An inverted-U credibility curve, with a higher slope in the neighborhood of the target than at its extremities, is then justified.

SECOND CASE Considers that $\pi^e < \bar{\pi}$ does not mean a loss in credibility. This is an extreme interpretation of the "*he who can do more can do less*" hypothesis. Then, our new indicator simply becomes:

$$CRED_{LLR2} = \begin{cases} 1 & \text{for} \quad \pi^e < \bar{\pi} \\ \dfrac{1}{exp(\tilde{\pi}^e) - \tilde{\pi}^e} & \text{for} \quad \pi^e \geqslant \bar{\pi} \end{cases} \tag{7}$$

The profile of this credibility function is represented at the top right panel of the figure 3.

3.3 The target is a range, such that $\bar{\pi} = \left[\bar{\pi}^{min}, \bar{\pi}^{max}\right]$

Again, two cases are to be considered, depending now on whether $\pi_t^e < \bar{\pi}^{min}$ is synonymous with a loss in credibility or not.

FIRST CASE $\pi_t^e < \bar{\pi}^{min}$ signals loss in credibility. Then,

$$CRED_{LLR1} = \begin{cases} \dfrac{1}{exp(\pi^e - \bar{\pi}^{min}) - (\pi^e - \bar{\pi}^{min})} & \text{for} \quad \pi^e < \bar{\pi}^{min} \\ 1 & \text{for} \quad \pi^e \in \left[\bar{\pi}^{min}, \bar{\pi}^{max}\right] \\ \dfrac{1}{exp(\pi^e - \bar{\pi}^{max}) - (\pi^e - \bar{\pi}^{max})} & \text{for} \quad \pi^e > \bar{\pi}^{max} \end{cases} \tag{8}$$

The bottom left panel of the figure 3 illustrates this case for a range corresponding to $[1.5\% - 2.5\%]$.

SECOND CASE $\pi^e < \bar{\pi}^{min}$ does not imply loss in credibility. Then,

$$CRED_{LLR2} = \begin{cases} 1 & \text{for} \quad \pi^e \leqslant \bar{\pi}^{max} \\ \dfrac{1}{exp(\pi^e - \bar{\pi}^{max}) - (\pi^e - \bar{\pi}^{max})} & \text{otherwise} \end{cases} \tag{9}$$

The corresponding profile is represented in the bottom right panel of the figure 3.

4 Application to emerging inflation-targeting countries

$CRED_{LLR1}$ and $CRED_{LLR2}$ are computed for all emerging economies that adopted an inflation-targeting framework, except for Ghana whose survey data on inflation expectations are not available. This monetary policy strategy is currently led by 18 emerging countries, while Slovakia abandoned inflation targeting in January 2009 to join the euro area. Our sample is then composed of Brazil, Chile, Colombia, the Czech Republic, Guatemala, Hungary, Indonesia, Israel, Mexico, Peru, the Philippines, Poland, Romania, Slovakia, South Africa, South Korea, Thailand and Turkey.

4.1 Data and periods

For each country, the $CRED_{LLR1}$ and $CRED_{LLR2}$ indexes are computed on a monthly basis and cover the period between the effective inflation targeting adoption date (if data on inflation expectations are available) and December 2013. Table 1 provides some details concerning inflation targeting adoption dates and data availability.

Concerning private sector inflation expectations, we use the forecast survey dataset provided by Consensus Economics, which gathers forecasts of professional analysts for a large range of macroeconomic variables. The surveyed forecasters are located in their respective country and are working in the financial sector. Therefore, they have a good idea of how inflation will evolve in the medium-term. Moreover, they are more forward-looking than other categories of the population, such as consumers[7]. Because the forecasts are provided for the current and the next calendar year on a monthly basis, we construct a monthly sample of twelve-month ahead expected inflation by taking the weighted arithmetic average of the mean forecast for the current year and the next year, defined as follows:

$$\pi^e_{t,12m} = \frac{(12-t)\pi_t^{e^{current}} + t\,\pi_t^{e^{next}}}{12} \tag{10}$$

with t representing the month (with 1 (= January) $\leq t \leq$12 (=December)) at the time of the forecast. Thus, by December, the forecast for the current year is already irrelevant and the forecast for the next year receives full weight (t=12). Most of the studies using data from the Consensus Economics adopt this approach for constructing twelve-month ahead forecasts (see, e.g., Beck (2001)). Some emerging countries were surveyed only once every two months at the start of the Consensus Economics survey. For Central and Eastern European countries, surveys have been conducted each month only since May 2007 (see table 1). Linear interpolation can be applied, but cautiously, given the particularity of the data. Indeed, if the missing observation refers to December or January, the interpolated

[7]For example, Lysiak et al. (2007) find that consumers and commercial bank analysts form their inflation expectations in very different ways in Poland. While consumers rely heavily on the current inflation target, commercial bank analysts closely follow the announced inflation target. According to Lysiak et al. (2007), this difference could be explained by the costs of collecting and processing information.

data will overlap two different years. This is a problem when data aims to measure the expected evolution of the consumer price index over a given year. So, we distinguish two cases. On the one hand, if the missing data refer to December, we consider for this month the observation of November of the same year. Similarly, if the missing data refer to January, we consider for this month the observation of February of the same year. On the other hand, if the missing data do not refer to December or January, i.e., if the months before and after the missing observations belong to the same year, a linear interpolation is used.

At this stage, it is important to underline that credibility is often viewed as a medium or long-run concept. However, the countries we consider have rather short run horizon for their objective, as it can be seen in the column "Target Horizon" of table 1. While some of them refer to a quite vague ''medium term" horizon, the latter is very short for most of them. For instance, this horizon is 12-18 months for the Czech Republic, annual for Guatemala, and based on a continuous basis in South Africa and Peru. Moreover, a lot of countries frequently update their target: downward in case of disinflation process, or upward in case of difficulties for reaching their objective. Thus, an indicator based on long-run expectations - even though they were available - would be inadequate for assessing the credibility of the central banks considered in this paper.

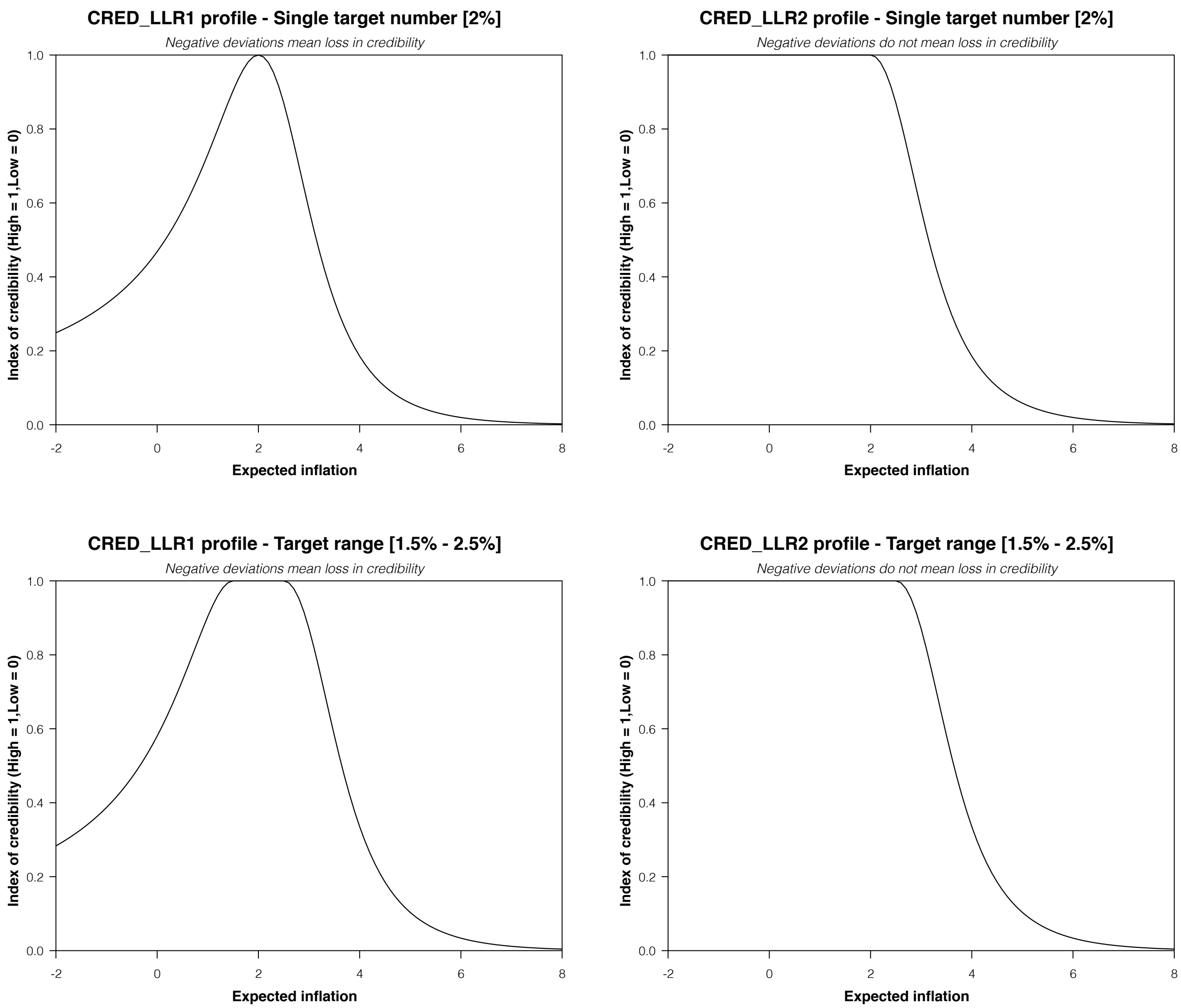

Figure 3: The credibility function as an inverse *quasi* LINEX function ($\bar{\pi} = 2\%$)

Country	Effective IT start	Target measure =Headline Inflation?	Target horizon	Consensus Economics data First obs.	Consensus Economics data Monthly since	Nb. of obs. (in months)
Brazil	1999M6	Yes	Yearly target	1990M2	2001M4	175
Chile	1999M9	Yes	Around two years	1993M3	2001M4	172
Colombia	1999M9	Yes	Medium term	1993M3	2001M4	172
the Czech Rep.	1998M1	Since 01/2002	12-18 months	1995M1	2007M5	192
Guatemala	2005M1	Yes	End of year	2009M1	2009M1	60
Hungary	2001M6	Yes	Medium term	1990M11	2007M5	151
Indonesia	2005M7	Yes	Medium term	1990M11	1990M11	102
Israel	1997M6	Yes	Within two years	1995M1	1995M1	199
Mexico	2001M1	Yes	Medium term	1990M2	2001M4	156
Peru	2002M1	Yes	At all times	1993M3	2001M4	144
the Philippines	2002M1	Yes	Medium term	1994M12	1994M12	144
Poland	1998M10	Yes	Medium term	1990M11	2007M5	183
Romania	2005M8	Yes	Medium term	1995M1	2007M5	101
Slovakia	2005M1	Yes*	$\star$	1995M1	2007M5	48
South Africa	2000M2	Since 01/2009	On a continuous basis	1993M6	1993M6	167
South Korea	2001M1	Since 01/2007	Three years	1990M1	1990M1	156
Thailand	2000M5	Core inflation	Eight quarters	1990M11	1990M11	164
Turkey	2006M1	Yes	Three years	1995M1	2007M5	96

* joined the Eurozone in January 2009.

Source: Roger (2009), Hammond (2012, Table A p.9) and Central Banks' website.

Table 1: IT adoption dates, target measures and data coverage

4.2 Overview of the new credibility indicators

Figures 4 to 7 in appendix represent $CRED_{LLR1}$ and $CRED_{LLR2}$ for each country, as well as expected and actual inflation and inflation targets. We first observe that negative deviations are very rare. $CRED_{LLR2}$ is then very close to $CRED_{LLR1}$. Moreover, we can see a high correlation between actual and expected inflation. The latter rarely overshoots the former. This means that the monetary authorities in the countries we investigate are generally credible. However, episodes of important loss in credibility are possible.

Before comparing our new indicators with the existing ones, table 2 summarizes the country-by-country evolution of the $CRED_{LLR1}$ index over different sub-periods[8]. In particular, we consider the first 12 and 24 months following the adoption of inflation targeting to assess the initial credibility of the central bank. We also focus on the period between June 2007 and December 2008, which is characterized by a surge in food and energy prices and then by a subsequent increase of inflation in most emerging economies[9]. Three main conclusions can be drawn.

First, most emerging inflation-targeting countries display a relatively high level of central bank credibility over the full period we consider (IT start–2013M12). Indeed, the average value of the $CRED_{LLR1}$ index is equal to 0.89, while the average probability that $CRED_{LLR1}$ exceeds 0.95 is equal to 0.67. South Korea exhibits the highest level of credibility, with an index equal to 0.99 on average. Furthermore, as suggested by the fourth column of table 2 (IT start – 2009M12), these good results are not driven by the recent low inflation environment in the wave of the Great Recession. Our results are consistent with previous empirical studies showing that the adoption of an inflation-targeting framework in emerging economies has helped to better anchor private-sector inflation expectations (see, e.g., IMF (2008), Davis (2014)) and to reduce their dispersion (Capistrán & Ramos-Francia (2010)).

Second, focusing on the one year and the two years following the adoption of inflation targeting (columns 1 and 2 of table 2), it appears that the introduction of this new monetary framework was initially perceived as not very credible (Romania, Turkey), if not non-credible (the Czech Republic, Indonesia) by the private sector. Such an initial lack of credibility could be explained by the fact that these countries did not fully satisfy

[8] As $CRED_{LLR1}$ and $CRED_{LLR2}$ are very close to each other, we only present the characteristics of the former and we will only focus on $CRED_{LLR1}$ in the following sections.

[9] According to Habermeier, Ötker-Robe, Jacome, Giustiniani, Ishi, Vavra, Kişinbay & Vazquez (2009), this inflationary episode was the first significant test for the credibility of the inflation targeting regimes in emerging countries.

the macroeconomic and institutional preconditions for adopting inflation targeting, such as central bank independence and transparency, fiscal discipline, or exchange rate flexibility. More importantly, the Turkish experience shows that the initial lack of central bank credibility has led to a loss in inflation control and a self-sustaining loss in credibility. To stop this vicious cycle and to reduce the risk of future overshooting, Turkey decided in June 2008 to revise its target upward. However, as we can see in figure 8, this revision was insufficient to restore the medium-run credibility of the central bank. The private sector considered this revision to be a renouncement of the authorities' commitment to price stability (Habermeier et al. (2009)).

Finally, it appears that the food and energy price shocks in the second half of 2007 and 2008 did not abruptly destroy the monetary policy credibility of the emerging inflation-targeting countries. Indeed, while figures 4 to 8 in appendix show that most countries overshot their targets during this period, the third column of the table 2 (2007 M6-2008 M12) does not highlight a sharp decrease of the $CRED_{LLR1}$ index, except for Hungary. Of course, the size of the increase in inflation expectations and the evolution of the credibility index depend on the severity of the inflation shocks. Nonetheless, some countries (Chile, Israel, Mexico, South Africa, and South Korea) succeeded in containing inflation expectations notwithstanding a subsequent increase in actual inflation to above the target. This demonstrates how important well-established past credibility is to addressing adverse supply shocks and to limiting second round effects on output. The lower the credibility is, the stronger the tightening of monetary policy should be (Alichi & Al. (2009), Neuenkirch & Tillmann (2014)).

	First 12 months	First 24 months	Mean (07M6-08M12)	Mean (IT start - 09M12)	Mean (overall period)	St. Dev. (overall period)	$Prob[LLR1 > 0.95]$ (overall period)	$Prob[LLR1 < 0.5]$ (overall period)	Rank (overall period)
Brazil	1.00	1.00	1.00	0.91	0.94	0.05	0.87	0.06	9
Chile	1.00	1.00	0.83	0.97	0.98	0.01	0.91	0.01	2
Colombia	0.76	0.88	0.90	0.96	0.98	0.01	0.88	0.00	4
the Czech Rep.	0.21	0.59	0.78	0.88	0.92	0.04	0.71	0.05	11
Guatemala	-	-	-	-	0.98	0.00	0.82	0.00	-
Hungary	1.00	0.99	0.25	0.66	0.64	0.09	0.19	0.32	17
Indonesia	0.41	0.69	0.55	0.68	0.80	0.09	0.52	0.17	13
Israel	1.00	0.87	1.00	0.97	0.97	0.01	0.87	0.00	5
Mexico	0.91	0.96	0.97	0.98	0.98	0.00	0.85	0.00	3
Peru	1.00	1.00	0.76	0.95	0.97	0.01	0.88	0.03	6
the Philippines	0.92	0.89	0.69	0.75	0.83	0.06	0.50	0.16	12
Poland	0.99	0.82	0.97	0.95	0.96	0.01	0.81	0.00	7
Romania	0.75	0.87	0.60	0.76	0.77	0.05	0.32	0.13	14
Slovakia	0.99	0.87	0.47	0.71	0.71	0.06	0.15	0.19	16
South Africa	1.00	1.00	0.66	0.90	0.93	0.03	0.73	0.04	10
South Korea	1.00	1.00	0.97	0.99	0.99	0.00	0.93	0.00	1
Thailand	1.00	1.00	0.81	0.95	0.95	0.01	0.68	0.02	8
Turkey	0.66	0.56	0.38	0.59	0.72	0.10	0.46	0.27	15
Mean	0.86	0.88	0.74	0.86	0.89	0.03	0.67	0.08	
Median	0.99	0.89	0.78	0.91	0.94	0.02	0.77	0.04	

Note: Guatemala is excluded from the ranking because of the short available time span.

Table 2: Some characteristics of the $CRED_{LLR1}$ index

4.3 Comparison with the existing indicators

Figures 4 to 7 in the appendix allow for comparing $CRED_{LLR1}$ and $CRED_{LLR2}$ to the two existing credibility indicators that constitute a reference so far, namely $CRED_{KM}$ and $CRED_{DMGS}$. Immediately, it appears that the variation amplitudes of $CRED_{LLR1}$ and $CRED_{LLR2}$ are higher than those of the existing indicators inside of the [0-1] interval. This is justifiable. Consider for instance the case of Brazil in 2003-2004, when the monetary authorities entirely lost their credibility according to $CRED_{LLR1}$ and $CRED_{LLR2}$. In 2003, the agents unequivocally (and rightly) expected that the central bank would not meet its commitment. The deviations were important: the expected (actual) inflation rate reached 11% (17%), while the target ceiling was 6.5%. Such a situation encourages agents to ignore the target when negotiating their salary or updating their prices, all the more because of a need to catch up wages and prices, as the initial surge in prices was not covered in the previous contracts. Thus, the context of Brazil in 2003-2004, by definition and given the size of the deviations, can reasonably be considered to be a complete loss in credibility. On the contrary, $CRED_{KM}$ and $CRED_{DMGS}$ did not fall below 0.52 and 0.60, respectively. Given the [0,1] range, the plausibility of their message in terms of credibility is questionable.

The Romanian case also supports our indicators. Indeed, while the monetary authorities failed most of the time to meet the target, and consequently private expectations were often above the target ceiling, $CRED_{KM}$ and $CRED_{DMGS}$ always remained higher than 0.8. However, $CRED_{LLR1}$ and $CRED_{LLR2}$ appropriately address the deviations, falling for instance to 0.40 in 2006, 0.22 in 2008, 0.40 in 2011 and 0.45 in 2013. They plausibly suggest that the Romanian central bank had suffered from loss in credibility.

Turkey also offers an interesting comparison. From 2006 to 2008, the actual and expected inflation rates always exceeded the target ceiling by up to 4 and 6.5 percentage points, respectively. In these conditions, it is very hard to believe that the Turkish central bank was credible over this period. However, $CRED_{KM}$ and $CRED_{DMGS}$ remained close to 0.75 on average. Once again, to the contrary, $CRED_{LLR1}$ and $CRED_{LLR2}$ duly signal a significant loss in credibility, with values considerably lower than 0.5. Interestingly, while our indicators highlight a full loss in credibility at the end of 2008, Turkey decided to raise the target range, a gambit to restore credibility (see, e.g., Habermeier et al. (2009)).

Similarly, the existing indicators do not appropriately address the (sometimes huge) deviations of inflation expectations from the target that typically occurred in South Africa, Indonesia, the Philippines and Hungary, contrary to $CRED_{LLR1}$ and $CRED_{LLR2}$.

5 The impact of credibility on the volatility of monetary policy instrument

5.1 Baseline estimates

We now investigate the extent to which central bank credibility, as measured by our new indicator, influences the volatility of the key instrument of monetary policy, namely the short-term interest rate. This is an important issue, as a credible central bank is more likely to anchor inflation expectations to its target. In such a case, the central banker does not have to move his key instrument too much to influence the yield curve in the desired direction. At the extreme, speeches are enough. On the contrary, non-credibility is penalizing in that it implies more volatility of the interest rate, while the variance of the interest rate theoretically enters the micro-founded welfare-based loss function of central banks[10]. Furthermore, the volatility of the monetary policy instrument increases macroeconomic uncertainty and (financial) instability. Thus, we want to test the following hypothesis: a higher (lower) credibility contributes to a lower (higher) volatility of the interest rate.

A similar issue has been addressed by De Mendonça & de Guimarães e Souza (2009) in the case of Brazil. However, they do not explicitly assess the relationship between credibility and interest rate volatility, as they regress the first-difference of the interest rate on the variation of their credibility index by using Ordinary Least Squares (OLS) estimates. We consider a General Auto-Regressive Conditional Heteroscedastic (GARCH) approach to be more adequate for analyzing the volatility of any variable. We will use such a model to test whether our index of credibility significantly influences the conditional variance of interest rates.

As usual, the mean equation of our GARCH model aims to deliver white noise residuals, whose conditional variance is investigated in a second step. For this purpose, we assume that the interest rate follows an AR(p) process. $p = 2$ is found to be enough for obtaining white noise residuals (except for Columbia and Poland, for which $p = 3$, see *infra*), in the baseline model, such as:

$$i_t = c + \rho_1 i_{t-1} + \rho_2 i_{t-2} + \varepsilon_t \tag{11}$$

ε_t represents the innovations of the short-term interest rate at time t with a zero mean and time-varying variance h_t. More precisely, we suppose that $\varepsilon_t = z_t \sqrt{h_t}$, with z_t representing

[10]See the demonstration of Woodford (2003, Chap. 6).

a standardized white noise residual.

The time-varying conditional variance of the interest rate is supposed to follow an Exponential General Auto-Regressive Conditional Heteroscedastic (EGARCH) process, augmented with the lagged $CRED\_LLR1$ indicator as an additional determinant. Its general representation is given by:

$$log\,(h_t) = \alpha_0 + \sum_{i=1}^{q} \alpha_i g(z_{t-i}) + \sum_{i=1}^{p} \beta_i log(h_{t-i}) + \omega CRED\_LLR1_{t-1} \qquad (12)$$

with $g\,(z_{t-i}) = \theta z_{t-i} + \gamma\,(|z_{t-i}| - E|z_{t-i}|)$, where $E|z_{t-i}|$ is conditional to a given density function. While a GARCH(p,q) model requires the parameters α_i and β_i to be positive, the EGARCH(p,q) model is expressed in terms of the log of h_t. Thus the conditional variance will always be positive whatever the sign of the parameters (Nelson (1991)). This is important in our specific case because $CRED\_LLR1$ is expected to have a negative influence on the conditional variance of the interest rate (namely, ω is expected to be negative).

The first column of table 7 in appendix reports the results of excess kurtosis tests for the interest rate data series. The null hypothesis of normality is only rejected for Colombia, the Czech Republic and Mexico. For these three countries, a Student's t distribution with a degree of freedom v (to be estimated) is then preferred to a normal one, as is usual in the case of leptokurtic distribution. Table 7 in appendix also reports the results of no ARCH effect tests. Such a test requires serially uncorrelated ε_t. However, the usual Q tests of no serial correlation rely on an assumption of conditional homoscedasticity. So we used the robust Q test suggested by West & Cho (1995). As indicated in the fourth column, the null hypothesis of an absence of serial correlation is not rejected at the usual risk levels for every country, even if we have some doubt about Peru. Finally, the hypothesis of no ARCH effect (for lags = 2, 4 and 6 months) is clearly rejected for most of the countries, except for Hungary, Israel, Slovakia, Thailand and Turkey. For the other countries, the interest rate data series exhibit types of large residual clustering that is consistent with a GARCH specification.

The results of the estimation of the baseline EGARCH(1,1)-X models[11] are reported in tables 5 and 6. Focusing on the variance equation, the nullity of α_1 and β_1 is rejected for every country, except for the nullity of α_1 for the Czech Republic and South Korea.

[11]Hungary, Israel, Slovakia, Thailand and Turkey are excluded because of the absence of ARCH effects, while Guatemala is not considered because of the lack of short-term interest rate data series.

	Brazil	Chile	Colombia	the Czech R.	Indonesia	Mexico
MEAN EQUATION						
constant	0.076*	0.128***	0.019	0.005	0.319***	0.008
	(0.039)	(0.025)	(0.029)	(0.004)	(0.041)	(0.020)
i_{t-1}	1.799***	1.627***	1.461***	1.390***	1.235***	1.367***
	(0.004)	(0.009)	(0.006)	(0.006)	(0.044)	(0.516)
i_{t-2}	-0.806***	-0.653***	-0.374***	-0.393***	-0.303***	-0.379***
	(0.005)	(0.008)	(0.099)	(0.005)	(0.044)	(0.067)
i_{t-3}			-0.088			
			(0.056)			
VARIANCE EQUATION						
constant	-0.917***	0.058***	1.455**	-0.248**	-0.985***	-1.167**
	(0.316)	(0.005)	(0.618)	(0.104)	(0.252)	(0.516)
$g(z_{t-1})$	0.619***	0.681***	2.035***	1.722**	0.884***	0.474
	(0.143)	(0.059)	(0.212)	(0.786)	(0.210)	(0.324)
h_{t-1}	0.577***	0.945***	0.961***	0.903***	0.961***	0.985***
	(0.012)	(0.011)	(0.003)	(0.041)	(0.035)	(0.015)
$CRED1\_LLR_{t-1}$	-0.709**	-0.762***	-1.578***	-0.416***	0.240	0.864
	(0.307)	(0.007)	(0.605)	(0.148)	(0.230)	(0.550)
Degrees of freedom (a)	-	-	2.05	2.09	-	2.21
GARCH LB test (b)	0.074	0.631	0.399	0.624	0.873	0.999
GARCH McLL test (c)	0.971	0.708	0.717	0.408	0.986	0.999
Number of observations	173	167	170	163	100	108

Notes: Std. errors are in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.
(a) Estimation of the number of degrees of freedom v (in case of Student-t distribution).
(b) P-Value of the Ljung-Box no serial correlation test on the standardized residuals $\varepsilon_t/\sqrt{(h_t)}$.
(c) P-Value of the McLeod-Li no serial correlation test on the squared standardized residuals ε_t^2/h_t.

Table 3: EGARCH-X baseline estimates (1/2)

	Peru	the Philippines	Poland	Romania	South Africa	South Korea
MEAN EQUATION						
constant	0.167***	-0.035	0.162***	0.151	0.029***	0.032
	(0.001)	(0.143)	(0.043)	(0.141)	(0.004)	(0.029)
i_{t-1}	0.850***	1.294***	0.921***	1.325***	1.630***	1.502***
	(0.001)	(0.108)	(0.036)	(0.077)	(0.004)	(0.054)
i_{t-2}	0.124***	-0.289***	0.193***	-0.343***	-0.636***	-0.509***
	(0.001)	(0.103)	(0.071)	(0.083)	(0.004)	(0.055)
i_{t-3}			-0.158**			
			(0.073)			
VARIANCE EQUATION						
constant	1.240***	-0.252	-0.112*	-0.261	-0.329	7.827***
	(0.001)	(0.370)	(0.060)	(0.383)	(0.349)	(2.028)
$g\left(z_{t-1}\right)$	-0.322***	0.379	0.466***	1.085***	0.494***	-0.011
	(0.002)	(0.260)	(0.141)	(0.240)	(0.100)	(0.118)
h_{t-1}	0.917***	0.863***	0.942***	0.584***	0.739***	0.743***
	(0.001)	(0.088)	(0.019)	(0.134)	(0.105)	(0.071)
$CRED1\_LLR_{t-1}$	-1.316***	-0.618**	-0.377***	-1.141**	-0.970***	-9.154***
	(0.001)	(0.317)	(0.076)	(0.553)	(0.340)	(2.283)
Degrees of freedom (a)	-	-	-	-	-	-
GARCH LB test (b)	0.127	0.500	0.114	0.777	0.383	0.701
GARCH McLL test (c)	0.145	0.467	0.264	0.989	0.238	0.471
Number of observations	131	142	181	99	165	154

Notes: Std. errors are in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.
(a) Estimation of the number of degrees of freedom v (in case of Student-t distribution).
(b) P-Value of the Ljung-Box no serial correlation test on the standardized residuals $\varepsilon_t/\sqrt{(h_t)}$.
(c) P-Value of the McLeod-Li no serial correlation test on the squared standardized residuals ε_t^2/h_t.

Table 4: EGARCH-X baseline estimates (2/2)

So, the current conditional variance of the interest rate is significantly explained by past innovations contained both in $g(.)$ and in the conditional variance h_{t-1}. This confirms the existence of ARCH effects and supports our econometric approach. Moreover, according to the test suggested by McLeod & Li (1983), the null hypothesis of no serial correlation for the squared standardized residuals is never rejected at the usual risk levels. This suggests that the variance equation is correctly specified with the orders $q = 1$ and $p = 1$ chosen for the EGARCH. In the same way, a second-order autoregressive process is found to be appropriate for the mean equation (third-order for Colombia and Poland). Indeed, according to the usual Ljung & Box test, the null hypothesis of no serial correlation test for the standardized residuals is never rejected at the usual risk levels. Finally, the fact that the estimated degrees of freedom are low (close to but higher than 2) for Colombia, the Czech Republic and Mexico validates *ex post* the choice of a Student's t distribution.

Despite the very important informational content of the past conditional variance h_{t-1}, we find that the coefficient associated with $CRED_{LLR1}$ is always statistically significant, except for Indonesia and Mexico, and negative. This confirms that central bank credibility decreases the volatility of the key instrument of monetary policy. In that sense, credibility improves the efficiency of monetary policy, notably through the expectations channel.

5.2 Robustness checks

First, one can argue that central bank credibility evolves according to a gradual process, as it can rarely be suddenly increased or annihilated (see, e.g., Blinder (2000)). In this respect, we have replaced the one-lagged value of $CRED_{LLR1}$ by its 6-month and 12-month moving average in the variance equation of the EGARCH models. The corresponding results are reported in tables 8 and 9 in the appendix. The significance of credibility is found to be very robust to this alternative specification. The results are qualitatively the same as for the baseline estimates (just the MA(6) measure of credibility is insignificant for Peru).

Second, the innovations from the mean equation (11) are supposed to be free of inflationary shocks. To be sure that ε_t represent the intentional efforts of the central banker to reach its final objective, beyond such exogenous shocks, we explicitly consider the latter through the inclusion of the inflation rate in the mean equation:

$$i_t = c + \rho_1 i_{t-1} + \rho_2 i_{t-2} + \phi \pi_t + \varepsilon_t \tag{13}$$

It should be noted that, as such, the mean equation looks like the original Taylor rule with gradual adjustment. The corresponding results are in table 5 and table 6 below. We can observe that the results hold to the inclusion of the inflation rate (which is significant in most cases) in the mean equation. The significance of the credibility index $CRED_{LLR1}$ is the same as for the baseline estimates. Finally, in line with Clarida, Gali & Gertler (1998), we consider the case in which π_t in (13) is replaced by $E_t[\pi_{t+12}]$. The corresponding results are presented in table 10 and table 11 in appendix[12]. The expected inflation is less often found significant compared to the current inflation, though always with a positive sign. More importantly, the significance of the credibility index $CRED_{LLR1}$ is the same as in the baseline estimates.

Thus, as summarized in table 12 in appendix, our results are clearly robust to alternative measures of credibility and different econometric specifications.

[12]Certainly, central bankers conduct their policy according to their own forecasts, while we consider the Consensus Economics' forecasts here. However, the former are unknown for most of the countries we consider. Moreover, we can hope that there is no large and systematic differences between the two forecast sources.

	Brazil	Chile	Colombia	the Czech R.	Indonesia	Mexico
MEAN EQUATION						
constant	0.063	0.107***	0.017***	-0.022*	0.324***	-0.037
	(0.067)	(0.025)	(0.006)	(0.012)	(0.012)	(0.029)
i_{t-1}	1.802***	1.559***	1.414***	1.267***	0.896***	1.300***
	(0.016)	(0.067)	(0.001)	(0.064)	(0.019)	(0.088)
i_{t-2}	-0.815***	-0.589***	-0.427***	-0.286***	-0.069***	-0.338***
	(0.018)	(0.005)	(0.001)	(0.062)	(0.017)	(0.088)
π_t	0.019**	0.017***	0.009***	0.028***	0.097***	0.013
	(0.009)	(0.005)	(0.001)	(0.006)	(0.003)	(0.006)
VARIANCE EQUATION						
constant	-0.632**	0.354	0.770***	0.028	-2.304***	-1.436**
	(0.278)	(0.396)	(0.001)	(0.432)	(0.264)	(0.639)
$g(z_{t-1})$	0.497***	0.661***	-0.291***	2.061	2.287***	0.776
	(0.114)	(0.104)	(0.001)	(1.394)	(0.203)	(0.584)
h_{t-1}	0.643***	0.949***	0.942***	0.897***	0.865***	0.955***
	(0.013)	(0.015)	(0.001)	(0.039)	(0.050)	(0.023)
$CRED\_LLR1_{t-1}$	-0.729***	-1.043***	-0.788***	-0.564*	0.262	0.968
	(0.260)	(0.385)	(0.001)	(0.313)	(0.375)	(0.694)
Degrees of freedom (a)	-	-	2.92	2.04	-	2.16
GARCH LB test (b)	0.078	0.586	0.035	0.213	0.526	0.999
GARCH McLL test (c)	0.994	0.774	0.750	0.643	0.318	0.999
Number of observations	173	167	170	163	100	108

Notes: Std. errors are in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.
(a) Estimation of the number of degrees of freedom v (in case of Student-t distribution).
(b) P-Value of the Ljung-Box no serial correlation test on the standardized residuals $\varepsilon_t/\sqrt{(h_t)}$.
(c) P-Value of the McLeod-Li no serial correlation test on the squared standardized residuals ε_t^2/h_t.

Table 5: EGARCH-X with inflation in the mean equation (1/2)

	Peru	the Philippines	Poland	Romania	South Africa	South Korea
MEAN EQUATION						
constant	0.286***	-0.044	-0.069	0.077	0.014***	0.032
	(0.003)	(0.030)	(0.059)	(0.148)	(0.001)	(0.028)
i_{t-1}	1.727***	1.305***	0.845***	1.326***	1.573***	1.542***
	(0.001)	(0.001)	(0.009)	(0.072)	(0.001)	(0.004)
i_{t-2}	-0.783***	-0.303***	0.116***	-0.345***	-0.584***	-0.549***
	(0.001)	(0.002)	(0.015)	(0.081)	(0.001)	(0.010)
π_t	-0.019***	0.004	0.077***	0.017	0.013***	-0.001
	(0.001)	(0.007)	(0.007)	(0.019)	(0.001)	(0.006)
VARIANCE EQUATION						
constant	-2.253***	-0.242	-0.097*	-0.255	-0.274	7.659***
	(0.077)	(0.173)	(0.051)	(0.381)	(0.285)	(1.752)
$g\left(z_{t-1}\right)$	1.517***	0.373***	0.328***	1.062***	0.546***	-0.003
	(0.074)	(0.101)	(0.106)	(0.213)	(0.109)	(0.097)
h_{t-1}	0.538***	0.866***	0.959***	0.567***	0.767***	0.735***
	(0.019)	(0.051)	(0.016)	(0.123)	(0.080)	(0.063)
$CRED1\_LLR_{t-1}$	-0.508***	-0.617***	-0.262***	-1.142**	-0.985***	-9.032***
	(0.078)	(0.202)	(0.049)	(0.573)	(0.302)	(1.997)
Degrees of freedom (a)	-	-	-	-	-	-
GARCH LB test (b)	0.227	0.501	0.119	0.783	0.491	0.688
GARCH McLL test (c)	0.996	0.321	0.682	0.982	0.184	0.557
Number of observations	131	142	181	99	165	154

Notes: Std. errors are in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.
(a) Estimation of the number of degrees of freedom v (in case of Student-t distribution).
(b) P-Value of the Ljung-Box no serial correlation test on the standardized residuals $\varepsilon_t/\sqrt(h_t)$.
(c) P-Value of the McLeod-Li no serial correlation test on the squared standardized residuals ε_t^2/h_t.

Table 6: EGARCH-X with inflation in the mean equation (2/2)

6 Concluding remarks

The aim of this article was to provide a simple time-varying metric of central bank credibility. To this end, we suggest a measure of credibility based on the gap between private sector inflation expectations and the inflation target. In contrast to the existing measures, our index introduces two major innovations. First, it is an asymmetric measure of credibility that is based on a linear-exponential (LINEX) function. Indeed, one can expect that, in practice, negative deviations of inflation expectations from the target are less likely to indicate a loss in credibility than positive deviations. Second, contrary to the main contributions to date, our measure does not impose any *ad hoc* threshold above which credibility is considered to be null.

We then compute our index for all emerging inflation-targeting countries and compare it to the existing indicators. Our findings suggest a relatively high level of central bank credibility in these countries over the inflation targeting period. Nonetheless, we observe that monetary policy was not necessarily perceived to be very credible in the immediate wake of inflation targeting adoption, in particular in the Czech Republic, Indonesia, Romania, and Turkey. More importantly, we show that our measure is more suited to assess the monetary experiences of these economies than the existing ones. In particular, our index is better able to discriminate between the periods of low *versus* high credibility in a context of rather low inflation targets.

Finally, we empirically investigate the linkage between central bank credibility (measured by our index) and short-term interest rate volatility. An EGARCH model is used to this end. Our results confirm that the level of credibility negatively impacts the variance of the interest rate in a large number of countries. This conclusion is highly robust. Therefore it confirms first that our indicator actually measures credibility; otherwise, there would be no alternative reason why a gap between expected inflation and the inflation target would have an impact on the volatility of the main monetary policy instrument. Next, the results suggest that a credible central bank does not need to frequently change its key instrument to reach the inflation target. Credibility is then expected to improve the efficiency of monetary policy transmission, particularly through the expectations channel. In terms of policy implications, it implies that candidates for an inflation-targeting framework need to previously make institutional reforms that will ensure an initial high level of credibility. Otherwise, an initial weak credibility could lead to higher and self-sustaining volatility in interest rates, which in turn would trigger higher macroeconomic instability.

Against this background, an interesting extension would consist in investigating the economic and institutional factors ensuring a minimum level of credibility. The literature on the preconditions for adopting inflation targeting would be a relevant benchmark to this end, as it highlights some determinants that are likely to play a role: the degree of independence of the central bank, the fiscal context, the exchange rate regime, the quality of institutions, *etc.* It would be interesting to combine our credibility index with this literature. Revealing the deep factors that establish initial credibility is actually very important for those emerging countries that are candidates for the inflation-targeting framework.

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Appendix

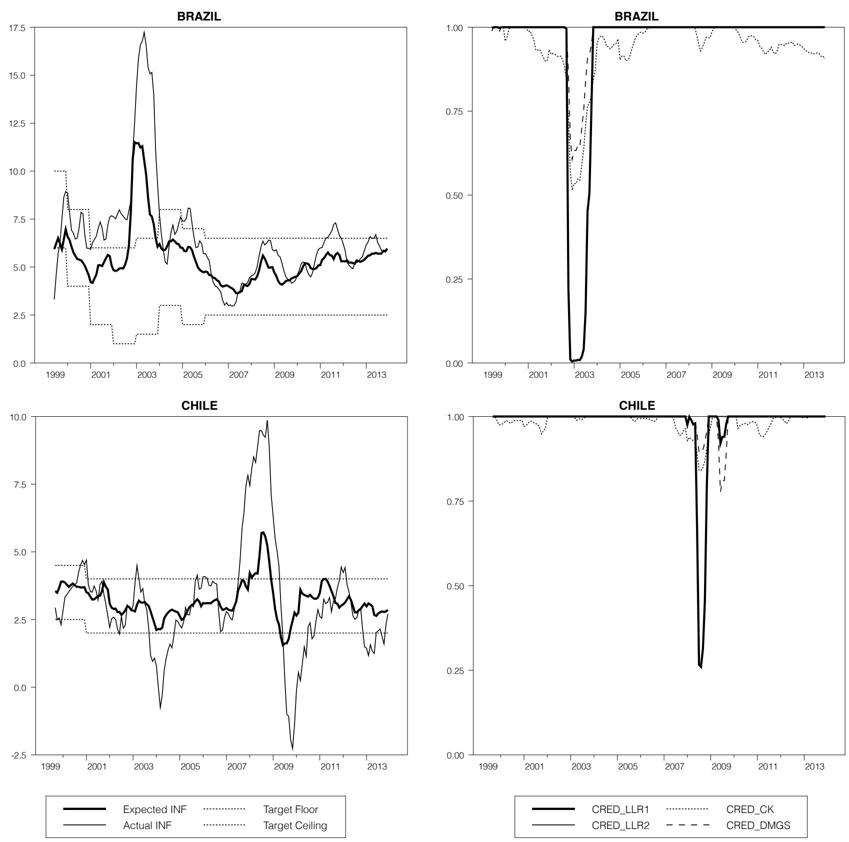

Figure 4: Target range, expected inflation and credibility indicators (1/5)

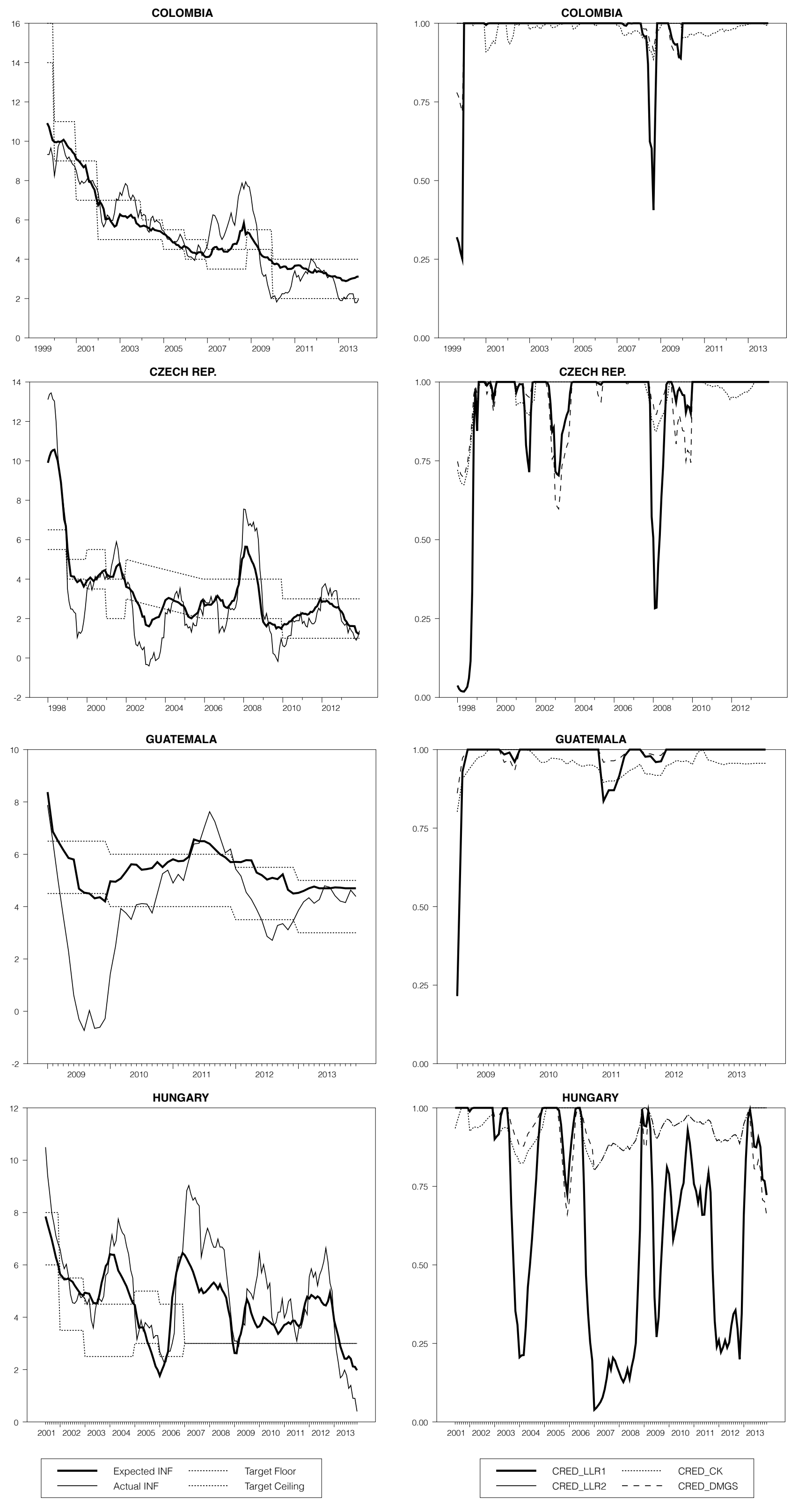

Figure 5: Target range, expected inflation and credibility indicators (2/5)

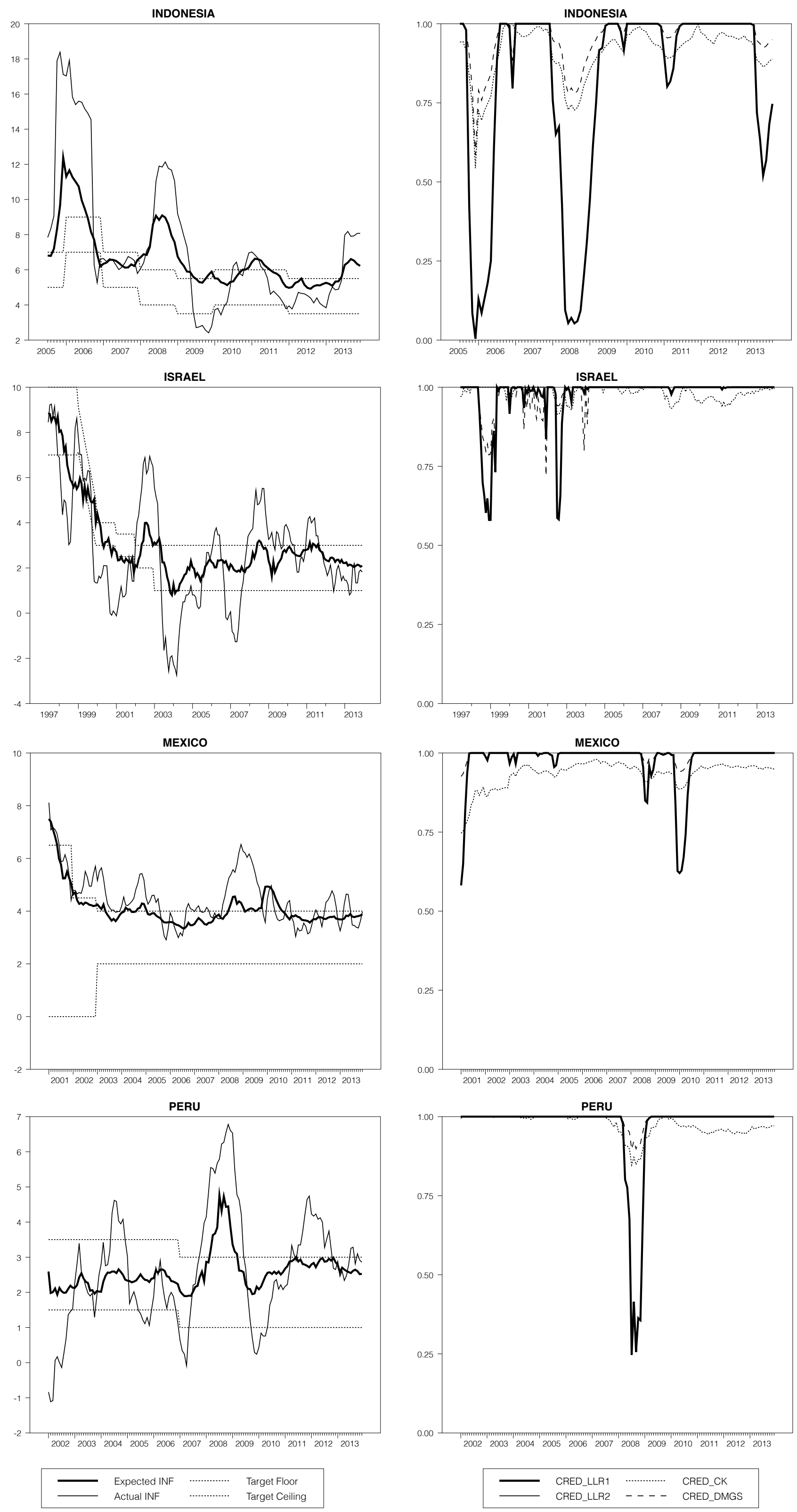

Figure 6: Target range, expected inflation and credibility indicators (3/5)

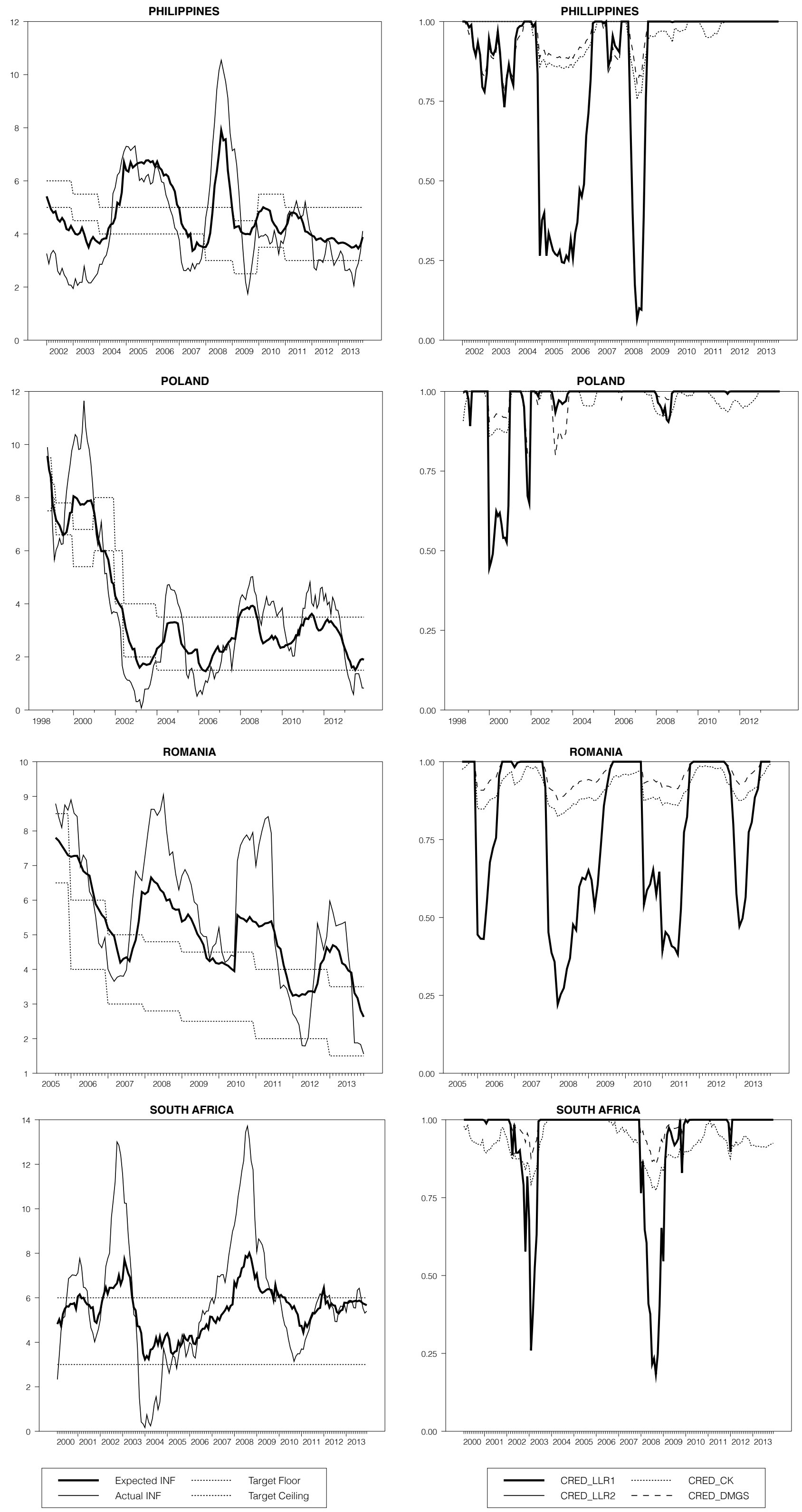

Figure 7: Target range, expected inflation and credibility indicators (4/5)

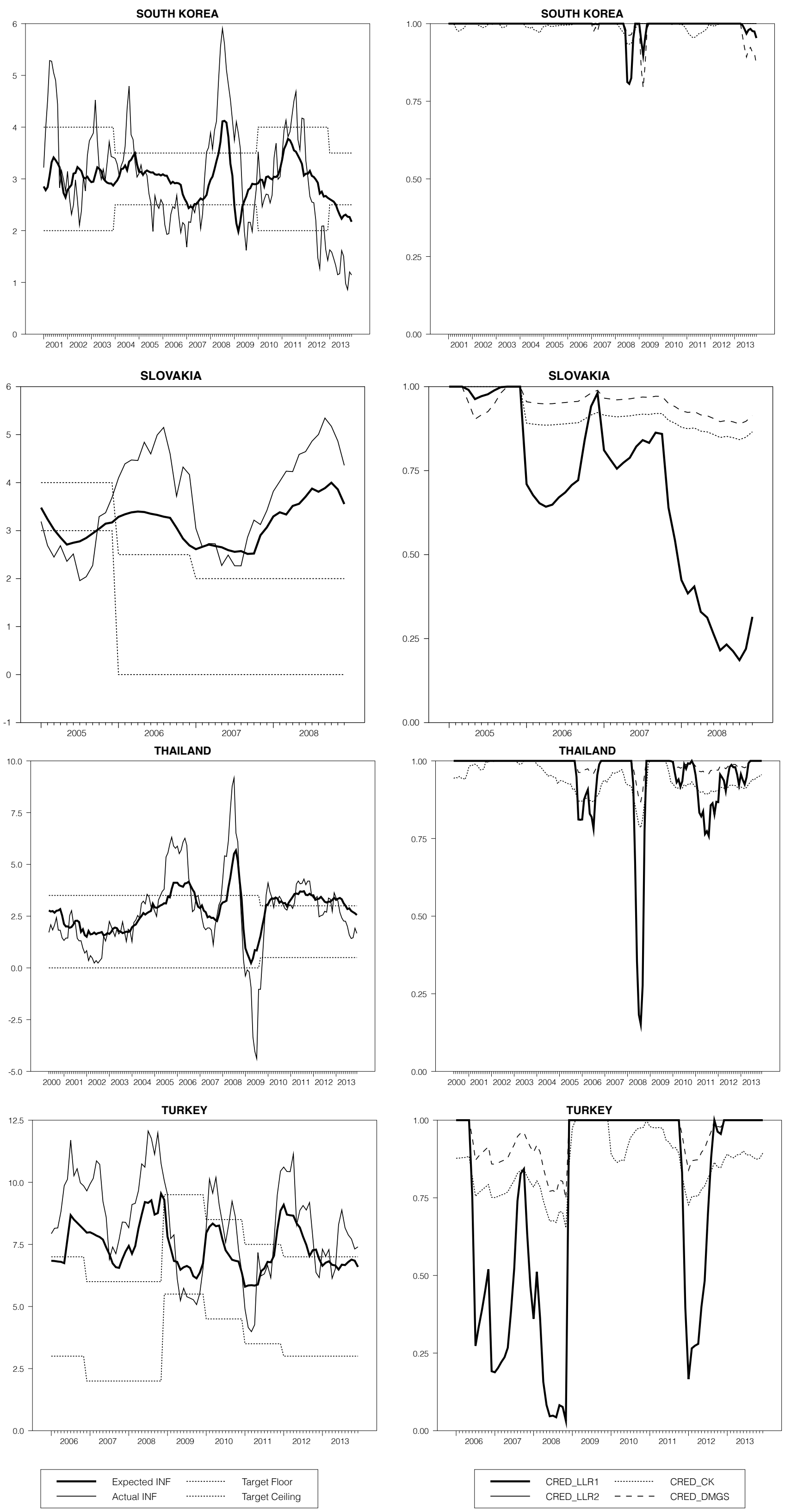

Figure 8: Target range, expected inflation and credibility indicators (5/5)

Country	Kurtosis excess on interest rate data series (a)	No serial correlation test on residuals ε_t (b)	No ARCH Effect test on residuals ε_t (c)		
			lags = 2	lags = 4	lags = 6
Brazil	-0.52	0.764	0.022	0.023	0.056
Chile	0.42	0.591	0.000	0.000	0.000
Colombia	0.88*	0.035	0.000	0.017	0.000
the Czech Rep.	5.51*	0.918	0.000	0.000	0.000
Hungary	-0.34	0.168	0.951	0.982	0.000
Indonesia	-0.47	0.708	0.000	0.000	0.000
Israel	-0.56	0.846	0.137	0.403	0.096
Mexico	4.32*	0.605	0.006	0.000	0.000
Peru	-0.05	0.001	0.001	0.008	0.035
the Philippines	-0.89	0.547	0.056	0.001	0.004
Poland	0.13	0.563	0.000	0.000	0.000
Romania	0.33	0.938	0.025	0.039	0.127
Slovakia	-0.96	0.101	0.233	0.248	0.398
South Africa	-0.95	0.672	0.111	0.002	0.014
South Korea	-1.01	0.965	0.005	0.005	0.021
Thailand	-0.32	0.100	0.115	0.256	0.052
Turkey	-1.60	0.176	0.305	0.596	0.912

(a) * means rejection of the Normality hypothesis at the 5% level (leptokurtic distribution).
(b) P-value of the West & Cho (1995) test on the residuals ε_t of the mean equation.
(c) P-value of the ARCH test consisting in regressing the square residuals series on its own lags.
Under the null, the corresponding R^2 is equal to zero.

Table 7: Properties of the interest rate data series and tests on the mean equation residuals

	Brazil	Chile	Colombia	the Czech R.	Indonesia	Mexico
VARIANCE EQUATION						
constant	-0.815	0.292	0.844***	-0.386***	-1.028***	-1.240**
	(1.029)	(0.409)	(0.129)	(0.048)	(0.300)	(0.549)
$g(z_{t-1})$	0.883**	0.676***	2.161***	0.648***	0.966***	1.092***
	(0.414)	(0.095)	(0.115)	(0.077)	(0.243)	(0.152)
h_{t-1}	0.166*	0.942***	0.953***	0.879***	0.947***	0.983***
	(0.095)	(0.017)	(0.034)	(0.012)	(0.047)	(0.022)
$CRED\_LLR1\_MA(6)$	-2.270***	-1.006**	-0.949***	-0.561***	0.175	0.867
	(0.854)	0.411	(0.110)	(0.052)	(0.288)	(0.592)
Degrees of freedom (a)	-	-	2.06	3.27	-	2.07
GARCH LB test (b)	0.072	0.608	0.467	0.587	0.960	0.999
GARCH McLL test (c)	0.716	0.825	0.874	0.359	0.957	0.999

	Peru	Philippines	Poland	Romania	South Africa	South Korea
VARIANCE EQUATION						
constant	-0.723*	-0.315	-0.050	-0.053	-0.142	-0.866***
	(0.444)	(0.245)	(0.078)	(0.094)	(0.269)	(0.287)
$g(z_{t-1})$	0.603***	0.395***	0.359**	1.092***	0.436***	0.502***
	(0.128)	(0.135)	(0.161)	(0.129)	(0.133)	(0.134)
h_{t-1}	0.935***	0.817***	0.951***	0.545***	0.600***	0.565***
	(0.024)	(0.096)	(0.018)	(0.092)	(0.133)	(0.101)
$CRED\_LLR1\_MA(6)$	0.039	-0.752***	-0.347***	-1.458***	-1.633***	-1.571***
	(0.426)	(0.271)	(0.077)	(0.147)	(0.508)	(0.239)
Degrees of freedom (a)	-	-	-	-	-	-
GARCH LB test (b)	0.199	0.425	0.057	0.727	0.332	0.750
GARCH McLL test (c)	0.995	0.282	0.135	0.948	0.229	0.824

Notes: Std. errors are in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.
(a) Estimation of the number of degrees of freedom v (in case of Student-t distribution).
(b) P-Value of the Ljung-Box no serial correlation test on the standardized residuals $\varepsilon_t/\sqrt{(h_t)}$.
(c) P-Value of the McLeod-Li no serial correlation test on the squared standardized residuals ε_t^2/h_t.

Table 8: EGARCH-X estimates with the 6-month moving average of $CRED_{LLR1}$

	Brazil	Chile	Colombia	the Czech R.	Indonesia	Mexico
VARIANCE EQUATION						
constant	-0.946	0.164	1.535***	2.295	-0.928***	-1.375**
	(0.728)	(0.535)	(0.375)	(1.518)	0.274	(0.704)
$g(z_{t-1})$	0.947***	0.677***	1.959***	0.142	0.914***	0.539
	(0.197)	(0.115)	(0.235)	(0.233)	(0.227)	(0.361)
h_{t-1}	0.103	0.921***	0.919***	-0.788**	0.944***	0.992***
	(0.187)	(0.022)	(0.046)	(0.312)	(0.036)	(0.017)
$CRED\_LLR1\_MA(12)$	-2.317***	-0.924*	-1.710***	-9.984***	0.081	1.063
	(0.862)	(0.557)	0.363	(1.968)	(0.295)	(0.739)
Degrees of freedom (a)	-	-	2.31	3.87	-	2.19
GARCH LB test (b)	0.053	0.429	0.304	0.310	0.926	0.993
GARCH McLL test (c)	0.776	0.766	0.721	0.810	0.933	0.999

	Peru	Philippines	Poland	Romania	South Africa	South Korea
VARIANCE EQUATION						
constant	-0.880***	-0.348	-0.300***	1.250	0.262	-1.130***
	(0.082)	(0.338)	(0.013)	(0.952)	(0.407)	(0.360)
$g(z_{t-1})$	0.798***	0.335**	0.372***	1.037***	0.304***	0.581***
	(0.173)	(0.172)	(0.034)	(0.319)	(0.116)	(0.145)
h_{t-1}	0.116***	0.717***	0.944***	0.255	0.561***	0.482***
	(0.019)	(0.185)	(0.014)	(0.208)	(0.020)	(0.138)
$CRED\_LLR1\_MA(12)$	-3.269***	-1.091**	-0.124***	-3.338**	-2.107***	-1.756***
	(0.083)	(0.575)	(0.026)	(1.402)	(0.422)	(0.355)
Degrees of freedom (a)	-	-	-		-	-
GARCH LB test (b)	0.408	0.316	0.037	0.769	0.214	0.713
GARCH McLL test (c)	0.999	0.218	0.101	0.921	0.053	0.780

Notes: Std. errors are in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.
(a) Estimation of the number of degrees of freedom v (in case of Student-t distribution).
(b) P-Value of the Ljung-Box no serial correlation test on the standardized residuals $\varepsilon_t/\sqrt{(h_t)}$.
(c) P-Value of the McLeod-Li no serial correlation test on the squared standardized residuals ε_t^2/h_t.

Table 9: EGARCH-X estimates with the 12-month moving average of $CRED_{LLR1}$

	Brazil	Chile	Colombia	the Czech R.	Indonesia	Mexico
MEAN EQUATION						
constant	-0.091	-0.177***	0.072	-0.107***	-0.521***	-0.009
	(0.294)	(0.051)	(0.045)	(0.032)	(0.070)	(0.064)
i_{t-1}	1.769***	1.477***	1.500***	1.231***	0.656***	1.355***
	(0.055)	(0.032)	(0.051)	(0.086)	(0.045)	(0.067)
i_{t-2}	-0.779***	-0.513***	-0.497***	-0.272***	0.184***	-0.365***
	(0.058)	(0.032)	(0.051)	(0.080)	(0.050)	(0.067)
$E_t[\pi_{t+12}]$	0.044	0.116***	-0.018	0.073***	0.230***	0.003
	(0.055)	(0.017)	(0.013)	(0.020)	(0.016)	(0.016)
VARIANCE EQUATION						
constant	-0.616	0.578*	1.259**	-0.408*	-0.941***	-1.372**
	(0.398)	(0.338)	(0.580)	(0.242)	(0.180)	(0.639)
$g(z_{t-1})$	0.495***	0.599***	0.717***	0.600***	0.886***	0.656
	(0.128)	(0.084)	(0.154)	(0.189)	(0.202)	(0.448)
h_{t-1}	0.624***	0.955***	0.953***	0.884***	0.941***	0.956***
	(0.022)	(0.013)	(0.019)	(0.043)	(0.032)	(0.448)
$CRED1\_LLR_{t-1}$	-0.802**	-1.222***	-1.406***	-0.494*	0.144	0.942
	(0.416)	(0.326)	(0.533)	(0.307)	(0.209)	(0.693)
Degrees of freedom (a)	-	-	2.03	3.37	-	2.19
GARCH LB test (b)	0.081	0.384	0.219	0.538	0.482	0.998
GARCH McLL test (c)	0.982	0.919	0.940	0.565	0.993	0.999

Notes: Std. errors are in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.
(a) Estimation of the number of degrees of freedom v (in case of Student-t distribution).
(b) P-Value of the Ljung-Box no serial correlation test on the standardized residuals $\varepsilon_t/\sqrt{(h_t)}$.
(c) P-Value of the McLeod-Li no serial correlation test on the squared standardized residuals ε_t^2/h_t.

Table 10: EGARCH-X with expected inflation in the mean equation (1/2)

	Peru	Philippines	Poland	Romania	South Africa	South Korea
MEAN EQUATION						
constant	-0.442***	-0.122***	-0.263***	0.079	-0.002	0.008
	(0.046)	(0.042)	(0.015)	(0.150)	(0.065)	(0.060)
i_{t-1}	0.609***	1.251***	0.788***	1.325***	1.625***	1.495***
	(0.096)	(0.013)	(0.002)	(0.079)	(0.062)	(0.069)
i_{t-2}	0.335***	-0.253***	0.158***	-0.348***	-0.629***	-0.504***
	(0.096)	(0.016)	(0.002)	(0.080)	(0.062)	(0.069)
$E_t[\pi_{t+12}]$	0.240***	0.026**	0.177***	0.023	0.005	0.008
	(0.026)	(0.013)	(0.004)	(0.015)	(0.012)	(0.017)
VARIANCE EQUATION						
constant	-0.898**	-0.227	-0.328***	-0.253	-0.384	7.781***
	(0.459)	(0.171)	(0.025)	(0.355)	(0.347)	(2.015)
$g\,(z_{t-1})$	1.700***	0.346***	0.617***	1.049***	0.488***	-0.009
	(0.178)	(0.091)	(0.035)	(0.228)	(0.140)	(0.112)
h_{t-1}	0.836***	0.863***	0.917***	0.577***	0.690***	0.746***
	(0.041)	(0.056)	(0.012)	(0.139)	(0.108)	(0.064)
$CRED1\_LLR_{t-1}$	-0.791*	-0.624***	-0.341***	-1.118**	-1.073***	-9.095***
	(0.481)	(0.163)	(0.026)	(0.515)	(0.378)	(2.257)
Degrees of freedom (a)	-	-	-	-	-	-
GARCH LB test (b)	0.212	0.519	0.555	0.751	0.451	0.700
GARCH McLL test (c)	0.999	0.190	0.636	0.990	0.253	0.433

Notes: Std. errors are in parentheses. *, **, and *** denote significance at the 10%, 5% and 1% level, respectively.
(a) Estimation of the number of degrees of freedom v (in case of Student-t distribution).
(b) P-Value of the Ljung-Box no serial correlation test on the standardized residuals $\varepsilon_t/\sqrt{(h_t)}$.
(c) P-Value of the McLeod-Li no serial correlation test on the squared standardized residuals ε_t^2/h_t.

Table 11: EGARCH-X with expected inflation in the mean equation (2/2)

	Baseline	LLR1 MA(6)	LLR1 MA(12)	with π_t	with $E_t[\pi_{t+12}]$
Brazil	5%	1%	1%	1%	5%
Chile	1%	1%	10%	1%	1%
Columbia	1%	1%	1%	1%	1%
Czech Rep	1%	1%	1%	10%	1%
Indonesia	NS	NS	NS	NS	NS
Mexico	NS	NS	NS	NS	NS
Peru	1%	NS	1%	1%	10%
The Philippines	5%	1%	5%	1%	1%
Poland	1%	1%	1%	1%	1%
Romania	5%	1%	5%	5%	5%
South Africa	1%	1%	1%	1%	1%
South Korea	1%	1%	1%	1%	1%

Note: 'NS' means "not significantly different from zero"

Table 12: Summary: Significance level of the credibility indicators