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Can inflation targeting mitigate monetary policy time-inconsistency?

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HIGHLIGHTS:

1. The paper evaluates whether inflation targeting is able to mitigate the time-inconsistency problem
2. The paper provides evidence based on cointegration tests for Brazil
3. The findings suggest that the central bank needs to manage the regime better than it has done so far
4. It is recommended that commitment technologies must be improved in emerging countries

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ABSTRACT

Although the adoption of inflation targeting can, on average, bring benefits to developing countries, however, adopting this scheme is not necessarily sufficient to mitigate the time-inconsistency problem of monetary policy. The present paper makes use of two theoretical models in order to analyze for the Brazilian case whether it is possible for the monetary authority to conduct time-inconsistent monetary policies even under inflation targeting. The results obtained for Brazil allow one to conjecture that the traditional argument that the adoption of inflation targeting can avoid the time-inconsistency problem is not necessarily true.

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1.0 Introduction

Despite there are several theoretical arguments for the time-inconsistency problem, empirical evidence is scarce on this subject. Even today, as highlighted by Taylor (2012), one of the most important subjects for analysis in modern macroeconomics is the time-inconsistency problem in monetary policy. However, great difficulties exist in terms of evaluating episodes of time-inconsistency, creating a gap with regard to empirical evidence. There are studies, based on Ireland (1999), that have sought to answer whether the time-inconsistency problem has occurred in some countries – these studies consider a bi-variate time series model for CPI inflation and unemployment (Ruge-Murcia, 2003; Akay and Nargelecekenler, 2007; Pierdzioch and Stadtmann, 2011; Montes, de Mendonça and Bastos, 2014) or a tri-variate time series model for CPI inflation, unemployment and U.S. unemployment (Doyle and Falk, 2008). However, in practice, it is still not possible to ensure if time-inconsistency is/was really a problem.

An important reference with regard to empirical analysis about time-inconsistency problem is the work of Ireland (1999). In order to perform an applied analysis for the U.S. economy, Ireland (1999) modified Barro and Gordon's model by assuming that the natural rate of unemployment is an autoregressive process which holds a unit root and by introducing control errors for inflation. After presenting the theoretical model, Ireland (1999) makes

cointegration tests between inflation and unemployment in order to identify the time-inconsistency problem of monetary policy in the United States.

Despite the unemployment-inflation trade-off represents an important subject in several researches involving the time-inconsistency problem of monetary policy; in the economy, there exist other trade-offs. Researches in macroeconomics also highlight the output-inflation trade-off, and compare the determinants of these trade-offs and the implications for the economy (de Mendonça, 2009). The present paper uses two different approaches to identify the time inconsistency problem – Ireland (1999) and Gupta and Uwilingiye (2010) – and based on these approaches makes an analysis for the Brazilian case, in order to identify if the time-inconsistency problem of monetary policy is verified under inflation targeting. In this sense, the theoretical model of Ireland (1999) is presented and subsequently modified, as did Gupta and Uwilingiye (2010), to turn possible the analysis for the output-inflation trade-off. The empirical study developed for Brazil seeks to answer, for the period from 1999.6 to 2014.1, whether monetary policy is time-inconsistent and therefore whether inflation targeting represents a sufficient commitment technology to mitigate the time-inconsistent problem. In this sense, the following questions arise: Does the time-inconsistency model of monetary policy apply to Brazil even under inflation targeting? The motivation for this analysis simply emanates from the need to evaluate the performance of the Brazilian monetary authority during the inflation targeting period.

This paper is organized as follows: Section 2 presents a review of the literature based on researches that follow Ireland's (1999) model. Section 3 presents Ireland's (1999) time-inconsistency model of monetary policy and Gupta and Uwilingiye's (2010) model. Section 4 develops an empirical analysis for Brazil. Section 5 presents a discussion section, and section 6 offers the concluding remarks.

2.0 Literature review

The seminal papers by Kydland and Prescott (1977) and Barro and Gordon (1983) gave rise to a large theoretical literature that examines the normative and positive implications of the time-inconsistency problem of monetary policy. Although the basic Kydland and Prescott (1977) and Barro and Gordon (1983) frameworks represent well known and influential models in macroeconomics, there has been relatively little empirical testing of that framework, i.e., the empirical analysis of this type of models has been more limited. Furthermore, policy insiders have questioned the relevance of these models, arguing that the time-inconsistency story is a poor representation of policymakers' behavior (Blinder, 1997). Blinder (1997) argues that "*academic economists have been barking loudly up the wrong tree and could learn a great deal from listening to practitioners*". Is it true? Economists remain skeptical about the subject (Taylor, 2012) and have sought answers through empirical work.

Ireland (1999) examines whether the time-inconsistency problem in Barro and Gordon (1983) can explain the behavior of the U.S. inflation rate. Ireland (1999) derives the restrictions imposed by Barro and Gordon's theory of time-consistent monetary policy on a bivariate time series model for inflation and unemployment and tests those restrictions using quarterly U.S. data from 1960 through 1997. Ireland (1999) tests the cointegration constraint shown in the model to see whether the time-inconsistency problem can explain the long-run behavior of inflation and unemployment. The results show that a simple time-inconsistency model of monetary policy, modified to allow for a time-varying NAIRU, can explain long-run trends in U.S. inflation, i.e., that the data are consistent with the implications of the theory for the long-run behavior of the two variables, indicating that the theory can explain the initial rise and subsequent fall of inflation for the period analyzed.

The work of Ruge-Murcia (2003) tests the predictions of the Barro–Gordon model using U.S. data on inflation and unemployment. To that end, it constructs a general game-theoretical model with asymmetric preferences that nests the Barro–Gordon model and a version of Cukierman's (2000) model as special cases. The model is estimated using quarterly U.S. data on inflation and unemployment. In order to assess the robustness of the results and to allow their comparison with those reported by Ireland (1999), two sample periods are considered (1960:1 to 1999:4 and 1970:1 to 1999:4). Likelihood Ratio tests indicate that the restriction imposed by the Barro–Gordon model is rejected by the data but the one imposed by Cukierman's model is not. These results are robust to the forecasting model for unemployment and to the sample period employed. Hence, the behavior of U.S. inflation appears to be better explained by a model where the central banker has asymmetric unemployment preferences around the expected natural rate, than by the standard text book Barro–Gordon model with quadratic preferences and an unemployment target below the natural rate.

Özlale and Özcan (2005) analyze the time-inconsistency problem for monetary policy in Turkey, but their data set consists of monthly observations in a sample period from 1980.1 to 2001.12, between inflation rate and output series. They show that the time inconsistency problem can explain the long-run behavior of inflation and output in the Turkish economy. The results also reveal that the Turkish monetary policymakers have put more emphasis on output stability than price stability in the period analyzed.

The paper of Akay and Nargelecekenler (2007) analyzes the time-inconsistency problem between inflation and unemployment rate series for Turkey. In order to investigate the long-run effects of the time-inconsistency problem, unit root and co-integration tests are applied. The data (taken from the Central Bank of the Republic of Turkey's database) were annually evaluated between 1955 and 2006. The paper used co-integrating tests for analyzing the relationship between unemployment rate and inflation rate series. The findings indicate that both inflation and unemployment series are not cointegrated. In this sense, the results do not support the Barro-Gordon model's implications for the long-run behavior of inflation and unemployment. Furthermore, the results suggest that the time-inconsistency problem for Turkey can be valid in the short-run, but sufficient proof cannot be found to support the Barro-Gordon model's implications for the long-run. This result does not match Özlale and Özcan (2005).

The paper of Doyle and Falk (2008) asks whether time-inconsistency models of monetary policy can explain inflation trends across OECD economies. The authors investigate two important variants of the hypothesis: i) that time-inconsistency was an important component of central bank behavior in earlier decades, but has become less significant in recent years, and ii) that time-inconsistency problems drive U.S. inflation, which affects inflation rates in other countries as a result of central bankers' attempts to manage nominal exchange rate movements vis-à-vis the U.S. dollar. They find that the first hypothesis fits the data no better than the baseline model. Moreover, they also find some support for the international spillovers version of the model, but the behavior of non-U.S. central bankers with respect to domestic unemployment rates, as viewed through the lens of a time-inconsistency account of monetary policy, remains puzzling. Hence, the behavior of non-U.S. central bankers with respect to domestic unemployment rates is not well described by the time-inconsistency mechanism. According to Doyle and Falk (2008), the failure of the time-inconsistency model to fit the data may be due to a failure of the assumption that the model parameters were unchanged over the estimation period. In this sense, in order to allow for this possibility, the authors extend the baseline model to incorporate time varying model parameters, and show that shifts in these parameters imply structural breaks in the cointegrating relationship. Hence, they investigate whether allowing for structural breaks significantly improves the empirical performance of the model using the Gregory-Hansen test for cointegration in the presence of a possible structural break in the cointegrating relationship. The results imply that allowing for time varying model parameters in this way does not overturn the conclusion that the time-inconsistency framework does not fit the data for most OECD countries.

The work of Gupta and Uwilingiye (2010) derives the econometric restrictions imposed by the Barro and Gordon model of dynamic time-inconsistency on a bivariate time series model of consumer price index (CPI) inflation and gross domestic product (GDP), and tests these restrictions based on quarterly data for South Africa. Unlike Ireland (1999), due to the lack of quarterly data on unemployment for South Africa, they model the supply side using a traditional Lucas-type supply curve rather than an expectational Phillips curve. Specifically, Barro and Gordon's (1983) model is modified by allowing the natural rate of output to follow an autoregressive process that contains a unit root and by incorporating control errors for the rate of inflation. While the first extension allows for the real GDP to be nonstationary, the second modification ensures transitory deviations between the actual real GDP and the natural rate of output. The results show that the data are consistent with the long-run implications of the theory of time-consistent monetary policy. Moreover, when the model is used to forecast one-step-ahead inflation over the period of January 2001-February 2008, i.e., the period covering the starting point of the inflation targeting regime until date, they, on average, obtain lower rates of inflation.

The paper of Pierdzioch and Stadtmann (2011) applied Ireland's (1999) time-inconsistency model to study whether the European Central Bank (ECB) has had a time-inconsistency problem. The data cover the sample period from January 1999 to December 2009. However, because the credibility of the ECB may have changed since it resumed responsibility for monetary policy in European Monetary Union (EMU), the authors analyzed subsample periods and used rolling tests for cointegration between the inflation rate and the unemployment rate. Based on the assumption that the inflation rate and the unemployment rate are nonstationary, the authors used the approach developed by Johansen (1991) to analyze whether the inflation rate and the unemployment rate are cointegrated and analyzed the sign of the estimated coefficient of the cointegration vector. The test results provide no strong evidence of cointegration between the inflation rate and the unemployment rate. Furthermore, the estimated coefficient of the cointegration vector has a negative sign, i.e., the sign of the estimated cointegration coefficient is not in line with a sign restriction imposed by the time-inconsistency model. According to Pierdzioch and Stadtmann (2011), violation of the sign restriction implies that, even if one assumes cointegration between the inflation rate and the unemployment rate, it is unlikely that a potential time-inconsistency problem, at least insofar as it is described by Ireland (1999), was the main driving force of cointegration.

Due to the fact that cointegration is a long-run concept, and because Pierdzioch and Stadtmann (2011) were obliged to study a relatively short sample period, it is quite relevant to ask whether it is reasonable to expect that tests for cointegration can detect economically interesting cointegration patterns in the data that can be interpreted in terms

of a time-inconsistency problem. In order to answer this question, Pierdzioch and Stadtmann (2011) collected data for the pre-EMU period (1993.1–1998.12) for three member countries of EMU: France, Germany, and the Netherlands. The authors found evidence of cointegration between the inflation rate and the unemployment rate for France, but they did not find evidence of cointegration in the cases of Germany and the Netherlands. Besides, the authors found that the sign of the coefficient of cointegration estimated for France is in line with Ireland's (1999) time-inconsistency model.

The paper of Montes, de Mendonça and Bastos (2014) makes an empirical analysis concerning time-inconsistency problem (TIP) based on a sample of 12 countries for the period from 1993 to 2011 and it sheds light on four important issues: (1) Has the change in the mindset of monetary policy management from the 1990s eliminated TIP? (2) Is TIP a sickness only for developing countries? (3) Is inflation targeting associated with TIP? (4) Has the TIP increased around the world due to the subprime crisis? The findings indicate that the large majority of countries in the sample have policies that are consistent with long-term goals. Furthermore it is possible to conjecture that the traditional argument that developing countries have weak institutions and thus present a fertile ground for TIP or that the adoption of IT can avoid TIP is not necessarily true.

In this sense, further analysis in relation to an important developing country that operates with inflation targeting (as is the case of Brazil) is required.

3.0 The theoretical models

This section presents Ireland's (1999) model and Gupta and Uwilingiye's (2010) model. The main difference between the models is that the paper of Gupta and Uwilingiye (2010) models the supply side using a traditional Lucas-type supply curve while the work of Ireland (1999) models the supply side using an expectational Phillips curve.

3.01 The model considering the unemployment-inflation trade-off

The inflation rate, π_t, and the unemployment rate, u_t, are linked via an expectations-augmented Phillips curve:

$$u_t = \bar{u}_t - \alpha(\pi_t - \pi_t^e), \quad \alpha > 0, \qquad (1)$$

Where, $\bar{u}_t$ is the natural rate of unemployment and π_t^e is the expected inflation rate. In Ireland's (1999) model, a difference-stationary data-generating process describes the dynamics of $\bar{u}_t$:

$$\bar{u}_t = \bar{u}_{t-1} + \lambda(\bar{u}_{t-1} - \bar{u}_{t-2}) + \varepsilon_t, \qquad -1 < \lambda < 1, \qquad (2)$$

Where, ε_t is a serially uncorrelated mean-zero shock. The central bank does not observe ε_t when deciding on the planned inflation rate, π_t^P. The actual inflation rate, π_t, differs from the planned inflation rate, π_t^P, by a serially uncorrelated mean-zero control error, η_t, such that $\pi_t = \pi_t^P + \eta_t$. Rational expectations imply $\pi_t^e = \pi_t^P$.

The loss function of the central bank is given by $L = \frac{1}{2}(u_t - k\bar{u}_t)^2 + \frac{b}{2}\pi_t^2$, where $b > 0$, and $0 < k < 1$ gives rise to the usual inflation bias. The central bank chooses π_t^P to minimize the expected value of the loss function. Under commitment, the central bank chooses $\pi_t^P = 0$, and under discretion

$$\pi_t^P = \alpha\frac{1-k}{b}E_{t-1}\bar{u}_t, \qquad (3)$$

Where, E denotes the expectation operator. The planned inflation rate depends on the expected unemployment rate, and it is equal to the expected inflation rate ($\pi_t^e = \pi_t^P$). Equations (1) and (3), in conjunction with $\pi_t = \pi_t^P + \eta_t$, yield $u_t = \bar{u}_t - \alpha\eta_t$. Upon using this result together with equation (2), one obtains

$$u_t = \bar{u}_{t-1} + \lambda(\bar{u}_{t-1} - \bar{u}_{t-2}) + \varepsilon_t - \alpha\eta_t, \qquad (4)$$

Because equation (2) implies $E_{t-1}\bar{u}_t = \bar{u}_{t-1} + \lambda(\bar{u}_{t-1} - \bar{u}_{t-2})$, and because of $\pi_t^P = \pi_t - \eta_t$, it follows that

$$\pi_t = \alpha\frac{1-k}{b}\bar{u}_{t-1} + \lambda\alpha\frac{1-k}{b}(\bar{u}_{t-1} - \bar{u}_{t-2}) + \eta_t, \qquad (5)$$

Taken together, equations (4) and (5) imply that, in the case of discretionary policy, π_t and u_t should be co-integrated:

$$\pi_t - \alpha\frac{1-k}{b}u_t = -\alpha\frac{1-k}{b}\varepsilon_t + (1+\alpha^2\frac{1-k}{b})\eta_t. \quad (6)$$

Equation (6) yields the sign restriction that, because $-\alpha\frac{1-k}{b} < 0$, the coefficient of cointegration in the cointegration vector, $\pi_t = \alpha\frac{1-k}{b}u_t$, should have a positive sign.

3.02 The model considering the output-inflation trade-off

The economy is characterized by the Lucas Supply curve (equation 7):

$$y_t = \bar{y}_t + \beta(\pi_t - \pi_t^e), \quad (7)$$

where, π_t is the actual inflation rate, π_t^e is the expected inflation rate, y is the actual output, $\bar{y}$ is the output at its flexible-price level (natural level) and $\beta > 0$.

The output at its flexible-price level, in turn, fluctuates over time in response to a real shock ξ_t according to the autoregressive process:

$$\bar{y}_t - \bar{y}_{t-1} = \psi(\bar{y}_{t-1} - \bar{y}_{t-2}) + \xi_t, \quad (8)$$

where, $1 > \psi >$ -1 and ξ is serially uncorrelated and normally distributed with mean zero and standard deviation σ_ξ.

The loss function of the central bank is given by:

$$L = \left(\tfrac{1}{2}\right)(y_t - y^*)^2 + \left(\tfrac{c}{2}\right)(\pi_t)^2 \quad (9)$$

where, y^* is the *socially optimum* level of *output* and $c >$0 denotes the relative weight that the policymaker puts on the price stability. Due to imperfections, it is assumed that $y^* > \bar{y}$. Thus, the policymaker has an incentive to push the output above its flexible price level.

Due to $y^* > \bar{y}$, thus, it is possible to consider that $y^* = \theta\bar{y}$, where, $\theta >$1. Hence,

$$L = \left(\tfrac{1}{2}\right)(y_t - \theta\bar{y}_t)^2 + \left(\tfrac{c}{2}\right)(\pi_t)^2, \quad (9')$$

Similar to Ireland (1999), it is assumed that the monetary authority cannot commit to a policy rule. Instead, at the beginning of each period t = 0,1,2,..., after private agents have formed their expectation π_t^e, but before the realization of the real shock ξ_t, the policymaker chooses a planned rate of inflation π_t^p. Actual inflation for the period is then determined as the sum of π_t^p and a control error υ_t so that

$$\pi_t = \pi_t^p + \upsilon_t, \quad (10)$$

where, υ_t is serially uncorrelated and normally distributed with mean zero, standard deviation σ_υ, and covariance $\sigma_{\xi\upsilon}$ with ξ_t.

Substituting (7) and (10) into (9'), the loss function to be minimized is:

$$\mathrm{E}_{t\text{-}1}\left\{\left(\tfrac{1}{2}\right)\left[(1\text{-}\theta)\bar{y}_t + \beta\left(\pi_t^p + \upsilon_t\text{-}\pi_t^e\right)\right]^2 + \left(\tfrac{c}{2}\right)\left(\pi_t^p + \upsilon_t\right)^2\right\}, \quad (11)$$

where E_{t-1} denotes the expectation at the beginning of period t or, equivalently, the end of period t-1. Solving for (π_t^p), the first-order condition is:

$$\beta E_{t-1}\left[(1-\theta)\bar{y}_t + \beta\left(\pi_t^p + \upsilon_t - \pi_t^e\right)\right] = -cE_{t-1}\left(\pi_t^p + \upsilon_t\right), \quad (12)$$

Private agents know the structure of the economy and understand the policymaker's time-consistency problem. Thus, in equilibrium, they correctly anticipate the policymaker's actions, so that $\pi_t^e = \pi_t^p$. Using this condition, along with the fact that $E_{t-1}\upsilon_t = 0$, equation (12) simplifies to

$$\pi_t^e = \pi_t^p = -\beta\left[\frac{1-\theta}{c}\right]E_{t-1}\bar{y}_t, \quad (13)$$

It is possible to observe that when the policymaker acts with discretion, the resulting inflation will be nonzero. The inflationary bias resulting from the policymaker's inability to commit depends positively on $E_{t-1}\bar{y}$. Thus, the equilibrium inflation rate moves together with the output at its flexible-price level.

Equations (7), (10) and (13) imply that:

$$y_t = \bar{y}_t + \beta\upsilon_t, \quad (14)$$

Which shows how the control error for inflation (υ_t) allows the output to fluctuate, in equilibrium, around the output at its flexible-price level. Combining equation (14) with (8) yields

$$y_t = \bar{y}_{t-1} + \psi\Delta\bar{y}_{t-1} + \xi_t + \beta\upsilon_t, \quad (15)$$

Where ($\Delta\bar{y}_{t-1} = \bar{y}_{t-1} - \bar{y}_{t-2}$) denotes the change in the output at its flexible-price level during period t–1. Substituting (13) into (10) and combining with equation (8), and considering that $E_{t-1}\bar{y} = \bar{y}_t$, and ξ_t is a white noise, gives

$$\pi_t = -\beta\left[\frac{1-\theta}{c}\right]\bar{y}_{t-1} - \beta\left[\frac{1-\theta}{c}\right]\psi\Delta\bar{y}_{t-1} + \upsilon_t, \quad (16)$$

It is important to note that, separately, equations (15) and (16) indicate that both inflation and output are non-stationary, inheriting unit roots from the underlying process for the equilibrium output. Together, however, they imply that

$$\pi_t + \beta\left[\frac{1-\theta}{c}\right]y_t = \beta\left[\frac{1-\theta}{c}\right]\xi_t + \left\{1 + \beta^2\left[\frac{1-\theta}{c}\right]\right\}\upsilon_t, \quad (17)$$

which shows that a linear combination of inflation and output is stationary.

Equation (17), therefore, summarizes the constraint imposed on the long-run behavior of inflation and output; according to the model, these variables should be non-stationary but cointegrated. Equation (17) yields the sign restriction, $\beta[(1-\theta)/c] < 0$, that the coefficient of cointegration in the cointegration vector should have. Thus, it is possible to test whether these conditions are met, and as a consequence, affirm whether the time-inconsistency model describes well the behavior of inflation and output for the period.

4.0 Empirical analysis

Brazil adopted an inflation targeting framework in June 1999. This framework included all the features of a full-fledged inflation targeting regime, including: 1) the announcement of multi-year inflation targets; 2) assigning the National Monetary Council the responsibility for setting the inflation targets and tolerance ranges based on a proposal by the Minister of Finance; 3) giving to the Central Bank of Brazil (CBB) full responsibility to implement the policies needed to attain the inflation targets; 4) establishing procedures to increase the central bank's accountability (specifically, if the target range is breached, the central bank president would have to issue an open letter to the Minister of Finance explaining the causes of the deviation, the measures that will be taken to eliminate it, and the time it will take to get inflation back inside the tolerance range) and, 5) taking actions to improve the transparency of monetary policy.

The independence of Brazil's central bank and the commitment to price stability, however, were not clear cut. Both were based on a presidential decree and confidence in a reliable central bank president, but not on a more formal commitment based on legislation. Despite the initial success, the weakness of some aspects of the institutional framework for fiscal and monetary policy did come back to haunt the inflation targeting regime in Brazil. In the run-up to the presidential election in October 2002, the market had concerns that the front-runner, Luiz Inácio "Lula" da Silva, would weaken fiscal and monetary institutions. Lula had made statements that seemed to indicate that once in office he would encourage fiscal policy to be highly expansionary and would not take steps to prevent a possible default on Brazil's foreign debt. He also indicated that he would not reappoint the highly respected president of the central bank, Arminio Fraga. Moreover, Lula's commitment to the independence of the central bank, price stability and the inflation targeting regime was far from clear. Not surprisingly, the lack of market confidence in Lula, who was then elected President led to a sharp depreciation of the Brazilian Real and a sharp upward spike to inflation to

12.5%, which substantially overshot the inflation target of 3.5% for 2002 (Table 1). The impact of the Brazilian election on the inflation targeting regime illustrate that weak fiscal and monetary institutions are likely to create severe problems for an inflation targeting regime.

Since the premise of the time-inconsistency model is the inability of the monetary authority to commit to an announced goal, the analysis focuses on the period after the adoption of inflation targeting in Brazil (from 1999.6 to 2014.1). Moreover, following Montes, de Mendonça and Bastos (2014), the analysis considers two sub-samples, one corresponding to the period before the subprime crisis (from 1999.6 to 2008.10) and another corresponding to the period that also considers the crisis (from 1999.6 to 2014.1). The idea of separating the period in before and after the financial crisis is to identify a possible change in the behavior of the monetary authority.

Table 01: Inflation, inflation target and tolerance limits

Period	Observed Inflation	Inferior Limit	Superior Limit	Inflation Target
1999	8.9	6.0	10.0	8.0
2000	6.0	4.0	8.0	6.0
2001	7.7	2.0	6.0	4.0
2002	12.5	1.5	5.5	3.5
2003	9.3	1.5	6.5	4.0 / 8.5*
2004	7.6	3.0	8.0	5.5
2005	5.7	2.0	7.0	4.5
2006	3.1	2.5	6.5	4.5
2007	4.5	2.5	6.5	4.5
2008	5.9	2.5	6.5	4.5
2009	4.3	2.5	6.5	4.5
2010	5.9	2.5	6.5	4.5
2011	6.5	2.5	6.5	4.5
2012	5.8	2.5	6.5	4.5
2013	5.9	2.5	6.5	4.5

Source: Central Bank of Brazil. * denotes adjusted inflation target.

Based on the empirical literature (e.g., Ireland (1999) and Pierdzioch and Stadtmann (2011)), after analyzing the results of the cointegration tests and the signs of the estimated coefficients of the cointegration vectors, the following results are possible taking into account the time-inconsistency problem in the Ireland sense:

- *Inflation and unemployment/output are not cointegrated*: this outcome does not support the Kydland and Prescott (1977) and Barro and Gordon (1983) framework's implications for the long-term behavior of inflation and unemployment/output, and does not match with Ireland's (1999) model.
- *Inflation and unemployment/output are cointegrated and the estimated coefficient of the cointegration vector is negative*: this outcome indicates that much of the comovement of the inflation rate with the unemployment/output appears to be business-cycle related. It follows that it is unlikely that a potential time-inconsistency problem of the monetary authority was the main driving force of cointegration between the inflation rate and unemployment/output.
- *Inflation and unemployment are cointegrated and the estimated coefficient of the cointegration vector is positive*: this outcome indicates the monetary authority's inability to commit to a monetary policy that reduces its temptation to exploit the trade-offs present in the Phillips curve and in the Lucas Supply curve. In other words, when the cointegration vector presents a positive coefficient it means that this estimated coefficient is in line with the predictions of the models, and thus the time-inconsistency problem of the monetary authority is the main driving force of cointegration between the inflation rate and the unemployment rate.

4.01 Econometric methodology

In the seminal article of Ireland (1999), the time-inconsistency problem is studied by testing the existence of cointegration between inflation and unemployment rate series. In the present paper, cointegration tests are made considering inflation[1] and unemployment[2] series as well as inflation and output[3] series. In the present paper the standard Engle and Granger (1987) residual-based and Johansen (1991) approaches are compared with Gregory

[1] Inflation is measured by National Consumer Price Index – IPCA – in 12 months – %. The data code for the inflation rate is 13522 (Central Bank of Brazil). Due to the fact that Brazil presents very high inflation in the period, this study follows Montes, de Mendonça and Bastos (2014) and considers inflation "D" for this country, as suggested by Cukierman, Webb, and Neyapti. (1992), instead of percentage change in price level ($D=\pi/(1+\pi)$, where π is the inflation rate).

[2] Unemployment rate is based on the metropolitan region of São Paulo (SEADE-SP Foundation). Available through IPEADATA.

[3] The output is GDP accumulated in the last 12 months - evaluated by the IGP-DI in the month (R$ million) – R$ (million). The data code for the output is 4190 (Central Bank of Brazil).

and Hansen[4] (1996) sequential breaking test procedure. Besides the coefficient obtained from Johansen cointegration test, the coefficient of cointegration in the cointegration vector is estimated using three different methods: Fully-modified OLS (FMOLS), Dynamic OLS (DOLS) and Canonical cointegrating regression (CCR).

A necessary condition for testing for a long-run relationship between two variables is that these variables are I(1), i.e., stationary in first differences. Therefore, the classical unit root test, namely, the Augmented Dickey-Fuller (ADF) test was used. Table 2 below presents the results for the ADF test considering both periods.

Table 02: Augmented Dickey-Fuller (ADF) test

period: 1999.06 to 2013.01				period: 1999.06 to 2008.10			
Variable	Lag	ADF test statistic	Summary	Variable	Lag	ADF test statistic	Summary
u	1	-2.469	I(1)	u	1	-1.233	I(1)
d(u)	0	-10.912		d(u)	0	-8.762	
y	1	-1.770	I(1)	y	1	-1.067	I(1)
d(y)	0	-5.109		d(y)	0	-4.663	
infl	1	-3.497	I(1)	infl	1	-2.949	I(1)
d(inf)	0	-5.403		d(inf)	0	-4.429	
Lag length based on Schwarz information criteria; ADF: constant and linear trend; critical value ADF: 1% = -4.01				Lag length based on Schwarz information criteria; ADF: constant and linear trend; critical value ADF: 1% = -4.01			

Once it is established that the series representing measures of inflation, unemployment and output are I(1), it is possible to proceed to test for a long-run relationship between the series. If such a relationship exists and the signs of the coefficients are positive, it is possible that the time-inconsistency problem is occurring. Before undertaking cointegration tests, it was necessary to specify the relevant order of lags of the vector autoregression (VAR) model. Table 3 presents the results for each case.

Table 03: Order of lags of the vector autoregression (VAR) model

Period	unemployment-inflation	output-inflation
1999.06 to 2013.01	2	2
1999.06 to 2008.10	2	2

Lag order selected by the Schwarz information criterion

The results of the cointegration tests are presented in Table 4. The upper part of Table 4 considers the subprime crisis period. The lower part of Table 4 shows the results for the period before the subprime crisis.

Table 04 (a): Cointegration tests and signs of coefficients

inflation-unemployment				period: 1999.6 to 2013.01		
cointegration test	z	τ		λ_{max}	λ_{trace}	coint. coef.
Engle-Granger	-29.543**	-3.873**	Johansen	18.651**	20.569**	0.559
Gregory-Hansen	ADF* (t-stat)			Method	coint. coef.	
Cointegration with Regime Shift	-5.007**		Cointegrat. Regression	FMOLS	1.183	
				DOLS	1.207	
				CCR	1.182	

Regarding the results for the relation between inflation and unemployment, the findings suggest (for both periods) that inflation and unemployment are cointegrated; besides, positive coefficients were found. In this sense, considering the monetary authority's possibility to exploit the unemployment-inflation trade-off, it seems that, even under inflation targeting, the findings support the Barro-Gordon model's implications for the long-run, and thus the time-inconsistency problem of monetary policy cannot be neglected.

Table 04(b): Cointegration tests and signs of coefficients

inflation-output	period: 1999.6 to 2013.01

[4] The Gregory-Hansen (1996) test is developed within the framework of the Engle-Granger (1987) residual-based cointegration analysis and can be viewed as a multivariate extension of the endogenous break univariate tests of Zivot and Andrews (1992). The null hypothesis of no-cointegration is tested against the alternative of cointegration with a break in the cointegrating relationship. Three models to take account of different types of structural changes in the cointegrating relationships are considered: 1) the "C" level shift model; 2) the "C/T" level shift with trend model; 3) the "C/S" regime shift model which allows the cointegrating vector parameters to shift. The Gregory-Hansen test statistic is the smallest values of ADF across all possible break points. The approximate critical values for the break cointegration tests in presence of structural break, obtained through simulation methods, are reported in Gregory and Hansen (1996, Table 1).

cointegration test	z	τ		λ_{max}	λ_{trace}	coint. coef.
Engle-Granger	-24.305**	-3.479**	Johansen	11.965**	13.74**	-0.000002
Gregory-Hansen	ADF* (t-stat)			Method	coint. coef.	
Cointegration with Regime Shift	-4.524**		Cointegrat. Regression	FMOLS	-0.000009	
				DOLS	-0.000007	
				CCR	-0.000009	

Table 04(c): Cointegration tests and signs of coefficients

inflation-unemployment				period: 1999.6 to 2008.10		
cointegration test	z	τ		λ_{max}	λ_{trace}	coint. coef.
Engle-Granger	-42.588**	-4.127**	Johansen	16.260**	17.46**	-0.879
Gregory-Hansen	ADF* (t-stat)			Method	coint. coef.	
Cointegration with Regime Shift	-4.312**		Cointegrat. Regression	FMOLS	2.058	
				DOLS	2.161	
				CCR	2.056	

Table 04(d): Cointegration tests and signs of coefficients

inflation-output				period: 1999.6 to 2008.10		
cointegration test	z	τ		λ_{max}	λ_{trace}	coint. coef.
Engle-Granger	-17.898**	-2.999**	Johansen	8.980**	12.97**	0.0000006
Gregory-Hansen	ADF* (t-stat)			Method	coint. coef.	
Cointegration with Regime Shift	-3.901**		Cointegrat. Regression	FMOLS	0.0000001	
				DOLS	-0.0000001	
				CCR	-0.0000002	

Engle-Granger and Johansen cointegration tests based on the null hypothesis of no cointegration. (***) denotes rejection of the null hypothesis at the 0.01 level, and (**) denotes rejection of the null hypothesis at the 0.05 level.
Gregory-Hansen Test: the asymptotic critical values are obtained from Gregory and Hansen (1996, Table 1, $m = 1$). The null hypothesis of no cointegration with structural breaks is tested against the alternative of cointegration by Gregory and Hansen approach.

Regarding the findings for the relation between inflation and output, the results do not support the model's implications for the long-run and thus monetary policy is not inconsistent when considered the output-inflation trade-off. For the period 1999.06 to 2013.01, the estimated coefficient of the cointegration vector is negative. In this sense, it is unlikely that a potential time-inconsistency problem of the monetary authority was the main driving force of cointegration between the inflation rate and the output. In turn, for the period 1999.06 to 2008.10, inflation and output are not cointegrated. In general, for both periods, there is no strong evidence of time-inconsistency problem of the monetary policy when considered the relation between the inflation rate and the output.

5.0 Result discussion, policy implication and recommendation

Since the early 1990s, inflation targeting has been adopted by several central banks as a strategy for the implementation of monetary policy. This regime has as its main feature the official announcement of ranges for inflation fluctuations and the explicit recognition that the main objective of monetary policy is to assure a low and stable inflation rate. Inflation targeting works as a guide for inflation expectations and it is associated with an increase in central bank transparency, which, in turn, increases accountability in the implementation of monetary policy and thus improves the central banks' credibility.

An important step in controlling inflation is to guide inflationary expectations, thus one main task of a central bank is to build credibility through the commitment to price stability. According to de Mendonça and de Guimarães e Souza (2012), the effectiveness of this framework for inflation control fuels a controversial debate between policymakers and academics. As a consequence, two key questions are raised: (i) How successful is inflation targeting in reducing and stabilizing the inflation rate? (ii) Are effects caused by inflation targeting sufficiently homogeneous when both developing and industrialized countries are taken into consideration?

Gonçalves and Salles (2008) reproduced Ball and Sheridan's (2005) analysis using data for 36 developing economies, 13 of which have implemented the inflation targeting framework. Their findings suggest that the choice of the inflation targeting regime proved beneficial for emerging economies. In particular, they found that the greater fall in inflation experienced by emerging market targeters can, to some extent, be attributed to the regime itself and

not only to mean reversion. Moreover, the often heard claim that inflation targeting regimes hinder economic growth is clearly not sustained by the empirical evidence. In sum, the data so far suggests that the adoption of inflation targeting by emerging economies did contribute towards the attainment of superior outcomes in terms of economic performance.

Considering a sample of 180 countries for the period from 1990 to 2007, de Mendonça and de Guimarães e Souza (2012) analyzed whether the adoption of inflation targeting can reduce inflation and inflation volatility. The sample of 180 countries was split into two sets of countries (advanced and developing). The findings suggest that the adoption of inflation targeting represents a good strategy for developing economies and, in addition to reducing inflation volatility, can drive inflation down to internationally acceptable levels. The empirical literature suggests that inflation targeting may bring benefits to developing countries. Nevertheless, another key question is raised: does inflation targeting represent a framework capable of mitigating the time-inconsistency problem of monetary policy in an important developing country?

Based on the findings of the empirical literature on inflation targeting and on the findings of the present paper, it is suggested that although the adoption of inflation targeting can, on average, bring benefits to developing countries, not necessarily adopting this scheme is sufficient to mitigate the time-inconsistency problem of monetary policy. Then, what kind of strategies should be followed in order to reduce the inflationary bias and mitigate the time-inconsistency problem of the monetary policy? Following Walsh (1995), incentive contracts can be designed to bind the actions of the central bank. Besides, central bank independence can be improved: a lower turnover rate of central bank governors and longer terms of office may improve the reputation of the policymakers. Last but not least, transparency about both objectives and operations of central banks as well as accountability, which is a key element of the inflation targeting regimes, should be increased in order to remove the uncertainties during the policymaking process.

6.0 Conclusion

The results allow one to conjecture that the traditional argument that the adoption of inflation targeting can avoid the time-inconsistency problem is not necessarily true. It is important to note that the findings are different from those presented by Montes, Bastos and de Mendonça (2014) for the specific case of Brazil. Particularly, developing countries present a fertile ground for the occurrence of the time-inconsistency problem due to the history of weak institutions and lack of commitment on the part of policymakers. Inflation targeting seems to not have improved the time-consistency of monetary policy expected out of such a regime. The results, thus, point to the fact that the CBB needs to manage monetary policy under inflation targeting better than it has done so far. In this regard, as Gupta and Uwilingiye (2010) concluded for the South African Reserve Bank, a lower inflation target and possibly also a narrower target band could be of immense help in improving the central bank's credibility and causing inflation expectations to converge to a focal point, and hence, bring down the rate of inflation. Moreover, commitment technologies must be taken seriously if the regime still has the intention to serve as a guide for the formation of expectations and safeguard the stability achieved with the Real Plan.

Recent data on the behavior of inflation and inflation expectations in Brazil point to the loss of reputation of the monetary authority and the weakening of credibility. Based on the findings, the paper provides interesting policy implications: 1) the inflation targeting framework currently operating in Brazil is not enough to mitigate discretionary actions of the monetary authority and therefore is not able to eliminate the time-inconsistency problem; 2) since the management of expectations is a key task for the monetary authority under inflation targeting, the commitment to a low and stable inflation target cannot be abandoned, otherwise once the public knows that policymakers have the incentive to pursue expansionary policies, they will not expect a low and stable inflation; 3)the framework of inflation targeting in Brazil should be redefined in order to increase the commitment of the monetary authority with its main long-term goal; 4) incentive contracts can be designed to bind the actions of the central bank, central bank independence can be improved and, a lower inflation target and a narrower target band could be adopted.

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