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Inflation targeting credibility and reputation: The consequences for the interest rate

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ABSTRACT

The measurement of credibility and reputation is fundamental for the analysis of countries which adopted inflation targeting. Under this perspective, the objective of this article is to illustrate which measures of credibility and reputation are most useful in predicting variations of interest rates. Given a specific inflation target, this relationship is valuable for central bankers as well as for private agents trying to predict the central bank's policies. Due to the fact that Brazil represents a potential laboratory experiment in which the effects of an adoption of inflation targeting after more than a half decade can be observed, an analysis through several indices and its relation with the basic interest rate is made. The findings denote that the credibility indices based on reputation represent an alternative in the cases where the series of inflation expectation are not available. Furthermore, the empirical evidence confirms the hypothesis that higher credibility implies lower variations in the interest rate for controlling inflation.

1. Introduction

During the 1990s the argument that the monetary policy must have as main objective the search for price stability became consolidated around the world. Moreover, the necessity for finding mechanisms which avoid the dynamic inconsistence problem became fundamental in the analysis of credibility in the conduction of the monetary policy. The basic idea is that an increase in central bank credibility contributes to an increase in credibility of the monetary policy, that is, the belief by the public in the probability of a successful execution of the policy (Drazen, 2000).

Since the collapse in the use of the exchange rate as a nominal anchor in the second half of the 1990s, the adoption of inflation targeting emerged as an alternative monetary regime. The main characteristic in the adoption of inflation targeting is the price stabilization as a way for creating an environment which promotes a convergence between inflation expectations and inflation target. Due to the essential role that public expectations have in this framework, reputation and credibility are essential to this monetary regime. Therefore, the measurement of credibility and reputation is fundamental for the analysis of countries which adopted inflation targeting.

With the objective to illustrate which measures of credibility and reputation are most useful in predicting variations of interest rates, the Brazilian case is used. Given a specific inflation target, this relationship is valuable for central bankers as well as for private agents trying to predict the central bank's policies. The justification for the use of Brazil in the analysis is that this country is still building its credibility and it is one of the most important developing countries that have adopted inflation targeting (more than half a decade ago). In particular, the adoption of inflation targeting in Brazil (June 1999) was due to the necessity of finding a new nominal anchor for stabilizing prices after the change in the exchange rate regime in January 1999.

In the last years, taking into consideration the argument presented by Agénor and Taylor (1992, 1993) and Svensson (2000) that series of inflation expectations could be used in the creation of credibility indices, the literature has shown some advances. Under this view, the present article analyzes the Brazilian monetary credibility through several indices and its relation with the basic interest rate (defined by financial market and the target defined by Monetary Policy Committee). This paper is organized as follows: the next section shows the several indices which are used in this study, Section 3 makes an analysis of the indices for the Brazilian economy, Section 4 shows empirical evidence between credibility and inflation taking into account the interest rate, and Section 5 concludes the paper.

2. Credibility indices

The appointment of the monetary authority in each contract with the society is used by the economic agents for planning its strategies. In this sense, a high credibility in the policy adopted by the monetary authority contributes to a stable economic environment which permits the public to plan the future. The objective of this section is to show the credibility indices which are used in this article. Two indices Cecchetti and Krause (2002) and de Mendonça (2007) are

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based on the idea that credibility is defined as negatively related to the distance between the private sector's inflation expectations and the bank's announced inflation target (Faust and Svensson, 2001). Thus, any deviation of inflation in relation to the central target implies a credibility loss. Besides these measures of credibility, an index which takes into consideration departures from interval fluctuation of inflation in relation to the inflation target and another three indices derived from reputation are shown.

Cecchetti and Krause (2002) built an index for measuring credibility (CI_K) which considers the difference between the expected inflation ($E(\pi)$) and the target (π_t). This index assumes values between "0" (without credibility) and "1" (full credibility). When the expected inflation is lower than the target this case represents maximum credibility. While the expected inflation departs from the target, the index decreases in a linear way until it arrives at "0" where the expected inflation crosses 20%.[1] Hence,

$$CI_{CK} = \begin{cases} 1 & \text{if } E(\pi) \le \pi_t \\ 1 - \dfrac{1}{0.2 - \pi_t}[E(\pi) - \pi_t] & \text{if } \pi_t < E(\pi) < 0.2 \\ 0 & \text{if } E(\pi) \ge 0.2 \end{cases}. \tag{1}$$

Taking into account a similar framework to that presented by Cecchetti and Krause (2002), de Mendonça (2007) – CI_M – developed a credibility index which considers the inflation target and the tolerance intervals. The credibility index has a value equal to 1 when the annual expected inflation ($E(\pi)$) is equal to the target inflation and decreases in a linear way while inflationary expectation deviates from the announced target. Therefore, the credibility index shows a value between 0 and 1 strictly if the expected inflation is situated between the maximum and minimum limits (π_t^*) established for each year and assumes a value equal to 0 when the expected inflation exceeds one of these limits. Hence,

$$CI_M = \begin{cases} 1 & \text{if } E(\pi) = \pi_t \\ 1 - \dfrac{1}{\pi_t^* - \pi_t}[E(\pi) - \pi_t] & \text{if } \pi^*_{t\,Min} < E(\pi) < \pi^*_{t\,Max} \\ 0 & \text{if } E(\pi) \ge \pi^*_{t\,Max} \text{ or } E(\pi) \le \pi^*_{t\,Min} \end{cases}. \tag{2}$$

A well-known cause for the failure in the achievement of the inflation target is the imperfect control over inflation by the monetary authority. In an attempt to eliminate this problem, the adoption of tolerance intervals gives more flexibility to the conduction of the monetary policy increasing the transparency and thus avoiding the necessity to justify few deviations of the inflation in relation to the target (Brunilla and Lahdenperä, 1995). Under this perspective, assuming that the public has rational expectations, a loss in credibility due to the deviation of inflation in relation to the target while the inflation is within the tolerance interval is too severe.

Taking into consideration the idea above, a different credibility index is elaborated (CI_A), which assumes a loss in credibility when the public expects that the central bank is not capable of bringing the inflation to the tolerance interval. Therefore, when the inflation expectation is found between upper bound (π^*_{tMax}) and lower bound (π^*_{tMin}) the credibility is full. The justification for this procedure is that the obligation of the monetary authority is the convergence of inflation for the interval and not for a specific value. On the other hand, there is no credibility in two cases: (i) when the inflation expectation is higher than 20%; or (ii) when the inflation expectation is null/negative. Moreover, when the inflation expectation is found between π^*_{tMax} and 20% or between π^*_{tMin} and 0% the credibility index varies between]0, 1[. Therefore, the loss in credibility is due to any deviation of the inflation in relation to the expected interval. That is,

$$CI_A = \begin{cases} 1 & \textit{if } \pi^*_{t\,Min} \le E(\pi) \le \pi^*_{t\,Max} \\ 1 - \dfrac{1}{0.2 - \pi^*_{t\,Max}}\left[E(\pi) - \pi^*_{t\,Max}\right] & \text{if } \pi^*_{t\,Max} < E(\pi) < 0.2 \\ 1 - \dfrac{1}{-\pi^*_{t\,Min}}\left[E(\pi) - \pi^*_{t\,Min}\right] & \text{if } 0\% < E(\pi) < \pi^*_{t\,Min} \\ 0 & \text{if } E(\pi) \ge 0.2 \text{ or } E(\pi) \le 0 \end{cases}. \tag{3}$$

The value of 20% adopted by CI_A as a limit for the loss in credibility is extracted from CI_{CK}. It is important to note that the adoption of an inflation of two digits is not adequate as a limit. A good example is the Brazilian case in 2002. Although the inflation reached 12.53% (much higher than the upper bound which was 5.5%) the Central Bank of Brazil (CBB) was capable of neutralizing the public expectation in respect to the increase in inflation. The value of 0% being considered critical for a loss in credibility is based on the argument that a null or negative inflation implies the risk of reducing output or increasing unemployment (Svensson, 2000).

The combination of fixed critical values with flexibility in the definition of the interval defined by the monetary authority creates an asymmetrical framework which is useful in the measurement of credibility. When the limit of interval is close to the critical point, more sensitivity is associated with the variation of the credibility for values that exceed this limit. In other words, if the central bank defines a tolerance interval where the upper limit is too close to 20%, any variation in the expectation above this limit will be strongly punished with a loss in credibility.

It is important to note that in the economies where credibility is still being built it is synonymous with reputation (de Mendonça, 2007). Besides this, due to the unavailability of the series relative to inflation expectation for some periods and for most countries, there is a difficulty in the application of the above-mentioned indices. Hence, instead of analyzing credibility through expectation, an alternative method which takes into consideration the observed performance, and thus the reputation obtained over time, is proposed. As reputation is essentially backward-looking (depends on past behavior of the monetary authority) while the credibility is forward-looking, the reputation can be fundamental for developing credibility. In short, central banks with little or no reputation would suffer limitations in the conduction of the monetary authority because their policies would not be credible ex-ante.

The next three indices are based on the premises that credibility can be measured by the sum of reputations over time. It is important to note that reputation indices neither are perfect substitutes nor try to emulate the behavior of the credibility indices. In addition, due to the fact that reputation depends on backward-looking behavior, a smooth pattern is expected in these indicators. As a consequence, the divergence between the indices of credibility and those indices derived from reputation is not a puzzle.

For the calculation of reputation (R) a framework which is similar to that applied for the CI_A is used. The main difference is that the deviations are calculated taking into account the observed inflation and not the expected inflation. It is important to note that credibility is a result of the state of expectation while reputation is given by departures of inflation from the target. Therefore,

$$R = \begin{cases} 1 & \text{if } \pi^*_{t\,Min} \le \pi_{tOBS} \le \pi^*_{t\,Max} \\ 1 - \dfrac{1}{0.2 - \pi^*_{t\,Max}}\left[\pi_{OBS} - \pi^*_{t\,Max}\right] & \text{if } \pi^*_{t\,Max} < \pi_{OBS} < 0.2 \\ 1 - \dfrac{1}{-\pi^*_{t\,Min}}\left[\pi_{OBS} - \pi^*_{t\,Min}\right] & \text{if } 0\% < \pi_{OBS} < \pi^*_{t\,Min} \\ 0 & \text{if } \pi_{OBS} \ge 0.2 \text{ or } \pi_{OBS} \le 0 \end{cases}. \tag{4}$$

[1] The creators of this index believe that an expected inflation higher than 20% implies a loss in the control of inflation by the monetary authority.

Based on the measurement above three new indices of credibility are presented: (i) a credibility index based on average reputation (CI_{AR}); (ii) a credibility index based on weighted reputation (CI_{WR}); and a credibility index based on reputation by movable average (CI_{MAR}).

The CI_{AR} is only the arithmetic average of reputation, that is, the sum of reputation over time on number of reputation (n),[2]

$$CI_{AR} = \left\{ \frac{\sum_{i=1}^{n} R_i}{n} \right\}. \tag{5}$$

For the calculus of CI_{WR}, the weight of reputation is decreasing while the time departs from the current period (t).[3] In other words, the weight (p_i) is given by the ratio between k_i (decreasing in relation to t) and n which in turn implies that the variation of the weight is in interval [0, 1]. Therefore,

$$CI_{WR} = \left\{ \frac{\sum_{i=1}^{n} (R_i \times p_i)}{\sum_{i=1}^{n} p_i} \right\}, \quad \text{where } p_i = \frac{k_i}{n}. \tag{6}$$

The CI_{MAR} calculates the current credibility based on movable average of reputation in the last d (lags) periods,

$$CI_{MAR_t} = \left\{ \frac{R_t + R_{t-1} + \ldots + R_{t-d+1}}{d} \right\}, \text{ or}$$
$$CI_{MAR_t} = \left\{ IC_{RMM_{t-1}} + \frac{R_t - R_{t-d}}{d} \right\}. \tag{7}$$

Credibility can be understood as the level of confidence that the economic agents give in the feasibility of an announced policy to be implemented and to be achieved. In other words, a policy will inspire more credibility if it indicates to the public a small chance of time inconsistency. Thus, for example, if the monetary authority had success in the control of inflation over time (which implies gains in reputation) the public believes that the central bank will have success in the control on future inflation which in turn denotes a high degree of credibility. In short, credibility is the function that transforms past information (R_{t-d}) and current information (R_t) of the reputation for identifying the public expectation relative to the success of an announced policy.

3. Application of indices for the Brazilian case

With the objective of analyzing the behavior of the indices presented in the previous section for the Brazilian economy, the National Consumer Price Index (extended) — IPCA (official price index) was adopted as a measure of inflation. Moreover, taking into consideration the information available by CBB, the annual inflation target and the respective tolerance intervals defined by the Brazilian National Monetary Council (CMN) were used in the analysis.

The strategy planned by the CMN in the launch of the monetary regime assumed a fast disinflation process. However, adverse shocks implied a necessity to revise the original strategy which culminated in changes in inflation targets for 2003, 2004, and 2005 (see Table 1).[4] A good example is the inflation target for 2003 that was changed several times. The inflation target center was increased to 0.75% and also the tolerance interval to 1%. Notwithstanding, the change was not sufficient and in January of 2003 the CBB announced as the new target (adjusted) an inflation of 8.5% without tolerance intervals.

Table 1
Inflation targets and observed inflation.

Year	Inflation target (%)	Tolerance intervals ± (%)	Normative	Observed inflation (%)
1999	8.00	2.0	2615 of June 1999	8.94
2000	6.00	2.0	2615 of June 1999	5.97
2001	4.00	2.0	2615 of June 1999	7.67
2002	3.50	2.0	2744 of June 2000	12.53
2003	3.25	2.0	2842 of June 2001	9.3
	4.00	2.5	2972 of June 2002	
	8.50	0.0	Open letter of January of 2003	
2004	3.75	2.5	2972 of June 2002	7.6
	5.50	0.0	Open letter of January of 2003	
	5.50	2.5	3108 of June 2003	
2005	4.50	2.5	3108 of June 2003	5.69
	5.10	+1.9/−3.1	100th Copom minutes of September 2004*	
2006	4.50	2.0	3210 of June 2004	3.14
2007	4.50	2.0	3.291 of June 2005	3.92**

Notes: Source — Central Bank of Brazil. (*) Copom is the Monetary Policy Committee. (**) Inflation market expectations — October (2007).

Due to the fact that the adjusted target for 2003 represents a break in the framework based on intervals (only in that year), the credibility calculus in 2003 took into consideration the target of 4% and its respective interval in January and the target of 8.5% with a tolerance interval of ±0.5% for the other months. The inclusion of an interval tolerance of ±0.5% is considered reasonable due to the target magnitude.[5]

It is important to note that the CBB has one of the most sophisticated methodologies for monitoring private sector inflation expectations. The survey of market expectations is composed of 104 participants of which 84 are financial institutions, 14 are consulting companies, and 6 are nonfinancial companies and professional entities. "Among the innovations incorporated into the Brazilian survey, the most important were real time information processing through the use of a web-based data collection platform, recognition of the accuracy of participant contributions to the survey by means of reputation-based incentives, and more broad-based access to the results of these surveys." (CBB, 2004, p. 109) Hence, the daily inflation expectations (annual reference) were extracted from the CBB's site. Due to the fact that the frequency adopted in this study is monthly, the monthly average of inflation expectation was calculated (INFEXP). With the intention of calculating the credibility indices based on reputation, the inflation measured by IPCA is considered in the analysis. Moreover, it is important to note that the inflation is annualized for comparison with the annual targets.

It is important to highlight that the inflation annualization takes into consideration the inflation from the beginning of the year until the month when the information is gotten. This procedure is adequate for the calculation of the monthly reputation because it considers the whole inflation during the contract (the annual inflation target). Therefore, the method adopted permits the evaluation of performance in the achievement of the contract over the period under consideration. Thus, in each month the reputation is built based on the current contract. It is assumed that the observed inflation for the months that do not belong to the current year must be related with the inflation target for the correspondent year. Hence, the use of the inflation accumulated in

[2] It is important to note that n depends on the number of observations regarding reputation. In other words, it depends on the time when inflation targeting was adopted. As time advances, an increase in degree of information regarding the monetary authority's reputation is observed.

[3] Just as in the previous case (CI_{AR}) this index depends on the number of observations concerning reputation. Notwithstanding the main difference is that this index uses a weighting system. That is to say more weight is given to recent periods.

[4] The justification for the use of the adjusted targets, instead of inflation targets defined by CMN, is due to the public's behavior, which takes into consideration for its forecasts the target that must be achieved by CBB.

[5] Indeed the distinction between the adoption of tolerance intervals or a single inflation point has a secondary role in the cases where the economic agents have rational expectation and know the central bank limitation for determining inflation (Brunilla and Lahdenperä, 1995).

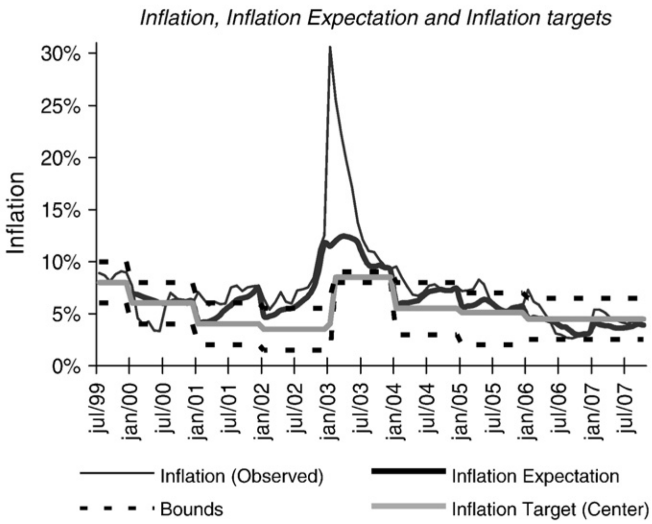

Fig. 1. Inflation, inflation expectation and inflation targets.

the last 12 months would not be adequate because during the disinflation process it is normal that each year (which represents a contract of the monetary authority with the society) there is a different inflation target. Thus, for the Brazilian case, the presence of a structural break and the change in the observed inflation trend each year is expected which in turn makes the uses of this methodology inadvisable.[6]

The behavior of the above-mentioned variables after the adoption of inflation targeting is shown in Fig. 1. It is observed that both inflation expectation and inflation (from the second semester of 2001 until the beginning of 2004) are above the upper bound of the tolerance interval during almost the entire period.

The credibility measured refers to the monetary policy based on the inflation targeting adopted in June 1999. Therefore, the indices based on reputation were calculated since the introduction of the monetary regime. On the other hand, the market expectation for the inflation is available only from January 2000. As a consequence, the indices of credibility based on expectation are calculated starting at 2000.

The CI_{CK} reveals a high credibility (greater than 0.90 in average) for almost the whole period with a value under this level only between 2002 and 2003 (see Fig. 2). It is important to note that this index does not punish the credibility if the expectation is under the inflation target (center). Moreover, the framework of this index with a large interval between the center of the inflation target and the critical point for the credibility loss (20%) is a justification for the high average credibility in the period (0.92).

Contrary to the observed for CI_{CK}, the CI_M shows an unsatisfactory performance for credibility over the period under analysis. Null values are present for a long period (from the second quarter 2001 to the end of 2003), and the remainder of the period exhibits a high volatility (see Fig. 3). The punishment with whole loss credibility when the inflation crosses the bounds of the tolerance interval justifies the low average credibility in the period ($CI_M = 0.47$).

Due to the fact that CI_A indicates full credibility when the inflation expectation is within the tolerance interval, the years 2000, 2004, 2005, 2006 and 2007 are marked by a stability in the maximum level ($CI_A = 1$). On the other hand, a credibility under the maximum level (inflation expectation out of the tolerance interval) is observed in large part for the years 2001, 2002, and 2003 (see Fig. 4). The fact that the credibility index reveals a loss in credibility only in extreme conditions, the average credibility in the period corresponds to 0.96.

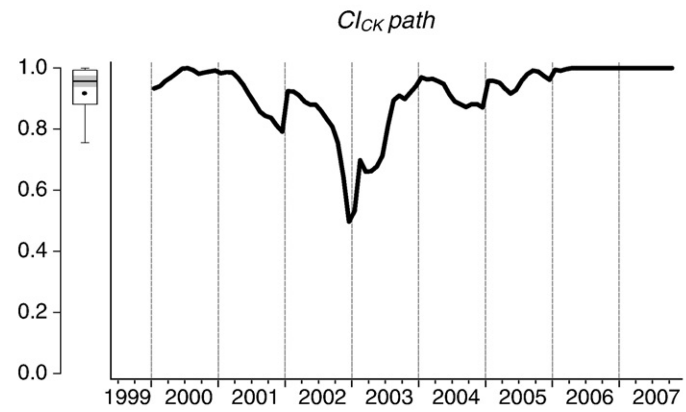

Fig. 2. CI_{CK} path.

In each period of new contract for inflation target (one year in the Brazilian case) the inflation expectation and thus the above-mentioned credibility indices represents a break in the standard of the previous year. Therefore, in the beginning of each year the inflation expectation is adjusted to the target taking into consideration the performance of the monetary authority based on the past contract which in turn strengthens the idea that the past is relevant.

The indices CI_{AR}, CI_{WR}, CI_{MAR} are variants of a same function with the objective of measuring credibility. The basic difference among the above-mentioned indices is the sensitivity in relation to the past information and current information. The CI_{AR} does not consider the distance of the reputation in relation to the current period (t). The CI_{WR} is more sensitive to the recent reputation while the CI_{MAR} assumes that

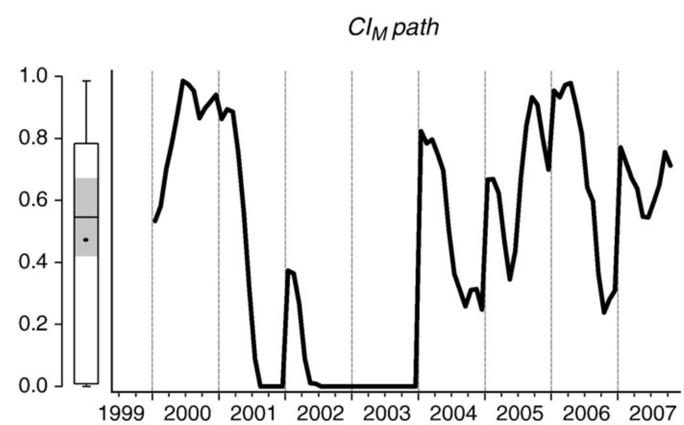

Fig. 3. CI_M path.

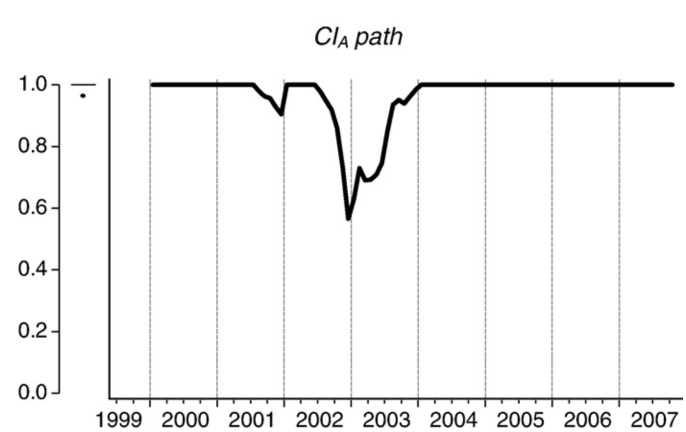

Fig. 4. CI_A path.

[6] Fig. 1 reveals that the main oscillation in the series under consideration occurs in the changes each year, that is, the transactions of contracts between the CBB and the society.

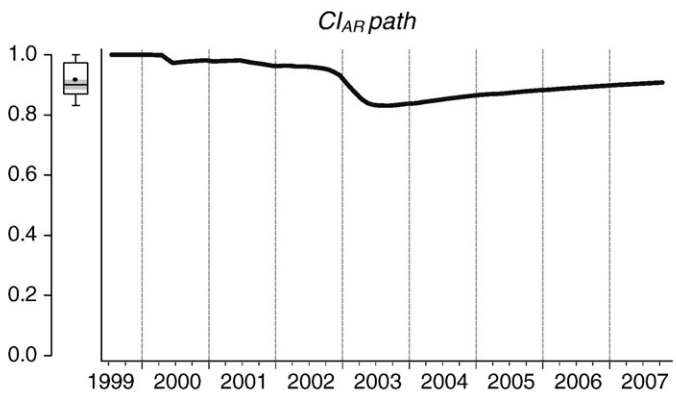

Fig. 5. CI_{AR} path.

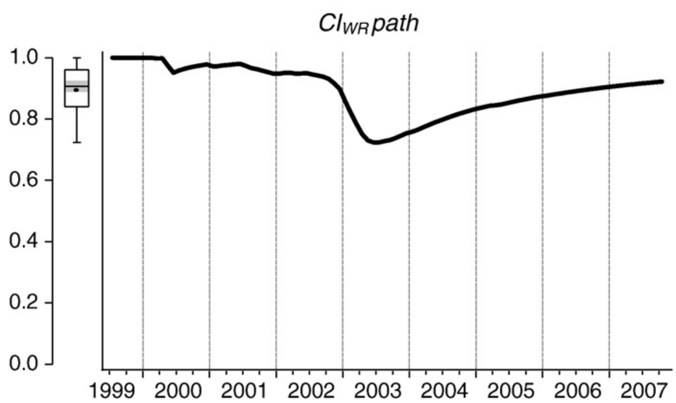

Fig. 6. CI_{WR} path.

the economic agents have short memory and thus, for the evaluation of credibility, take into consideration only the recent period.

The credibility indices calculated through reputation (see Figs. 5–7) exhibit a behavior less unstable than the previous indices. Due to the standard that recognizes the past and current reputation for calculating credibility, these indices take more time to reveal the loss and gain of credibility. It is observed that the paths are smoothed specially for CI_{AR} and CI_{WR}. This effect is more visible for CI_{AR} because this index considers the same weight for all reputations. In other words, lagged reputation has the same influence in the credibility as well as current reputation. The CI_{WR} weights differently each reputation taking into consideration the premises that past information is less relevant than current information. The average credibility measured by both indices has little difference. While CI_{AR} corresponds to 0.92 the CI_{WR} is 0.89.

For the calculation of CI_{MAR}, the last 6 months were adopted, that is, only the last six reputations (monthly) are considered in the measurement of current credibility.[7] The behavior of this index (more volatility) is close to those indices that adopt expectation due to the framework with weights. The CI_{MAR} had an average credibility which corresponds to 0.91. However, the CI_{MAR} between 2002 and 2003 revealed a significant fall in credibility due to the weak performance of the monetary policy in the control of inflation.

In short, all indices revealed a non-negligible fall in credibility for 2001, 2002, and 2003. The year of 2001 was marked by the announcement of electrical energy rationing, the expected crisis in Argentina, and the fall of economic activity in the world. In 2002 the adverse environment was not different because the loss of US$ 27.8 billion due to a strong increase in risk aversion in the international

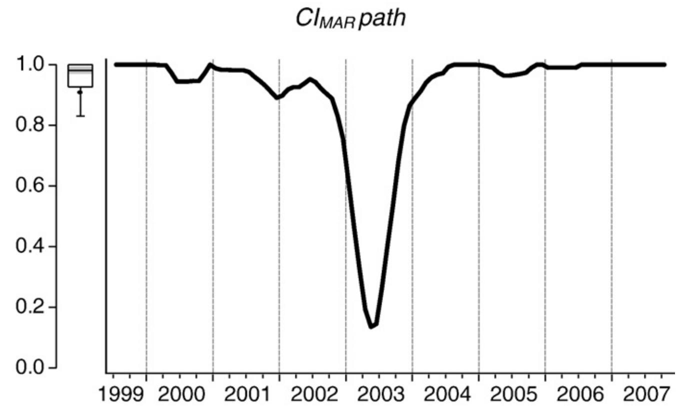

Fig. 7. CI_{MAR} path.

markets, the difficulty in the management of the public debt, and the uncertainty in relation to the continuity of the current macroeconomic policy damaged the economic performance. In relation to 2003 the bad performance is focused on the first quarter reflecting the adversities of the previous year.

The difficulties and the fall in credibility observed between 2001 and 2003 implied a bad performance of the inflation targeting (see Fig. 1). Taking into consideration all indices of credibility, the average during 2002 and 2003 is the lowest in comparison with the other years in the sample (see Table 2). Hence, the years that exhibit the highest fall in credibility correspond to that where the inflation target were not achieved.

4. Empirical analysis

The main instrument to the disposition of the CBB for the convergence of inflation to the target is the basic interest rate (over/Selic rate). A credible monetary policy implies less effort by the CBB for the achievement of the inflation target due to the increased capacity of affecting the public expectation. Therefore, it is expected that a high credibility, *ceteris paribus*, is associated with a lower volatility of the interest rate for the achievement of the inflation target. Hence, this section shows empirical evidence between credibility and inflation taking into consideration the interest rate. In other words, the relations among each credibility index and the basic interest rate are analyzed. For the basic interest rate two concepts are used: the target announced by Copom (IR_T) and the interest rate practiced in the market (IR_M) both with monthly frequency and annualized.

The models of multiple regressions estimated through the OLS method show the following variations:

$$\Delta IR_{T_i} = \alpha + \beta\Delta[E(\pi) - \pi_t]_i - \Delta CI_i + \varepsilon_i, \tag{8}$$

$$\Delta IR_{M_i} = \alpha + \beta\Delta IR_{M_{(t-1)_i}} - \Delta CI_i + \varepsilon_i. \tag{9}$$

For avoiding the deviation of the inflation in relation to the target, the CBB uses as its main mechanism the variation in the basic interest

Table 2
Credibility indices — annual average.[a]

Indices	1999	2000	2001	2002	2003	2004	2005	2006	2007
CI_{CK}	–	0.98	**0.90**	**0.82**	**0.78**	0.92	0.96	1.00	1.00
CI_M	–	0.83	**0.36**	**0.09**	**0.00**	0.51	0.67	0.67	0.66
CI_A	–	1.00	**0.98**	**0.92**	**0.82**	1.00	1.00	1.00	1.00
CI_{AR}	1.00	0.99	0.97	0.96	**0.85**	**0.85**	**0.87**	0.89	0.90
CI_{WR}	1.00	0.98	0.97	0.94	**0.76**	**0.80**	**0.85**	0.89	0.91
CI_{MAR}	1.00	0.97	**0.96**	**0.90**	**0.45**	0.97	0.98	0.99	1.00
Average	1.00	0.96	0.86	**0.77**	**0.61**	**0.84**	0.89	0.91	0.91

[a]The values in bold indicate the lowest three average for each index in the period.

[7] The number of lags between 3 and 12 was tested but the final results did not imply significant changes.

Table 3
Unit root tests and stationary test.[a]

Series	Level			
	ADF	PP	DF-GLS	KPSS
CI_{CK}	Unit root	Unit root	Unit root	Unit root
CI_M	Unit root	Unit root	Unit root	Unit root
CI_A	Stationary	Unit root	Unit root	Unit root
CI_{AR}	Unit root	Unit root	Unit root	Unit root
CI_{WR}	Unit root	Unit root	Unit root	Unit root
CI_{MAR}	Unit root	Unit root	Unit root	Stationary
IR_T	Stationary	Unit root	Stationary	Unit root
IR_M	Stationary	Unit root	Stationary	Unit root
$E(\pi)-\pi_t$	Stationary	Stationary	Unit root	Unit root
First difference (D)				
$D(CI_{CK})$	Stationary	Stationary	Stationary	Stationary
$D(CI_M)$	Stationary	Stationary	Stationary	Stationary
$D(CI_A)$	Stationary	Stationary	Stationary	Stationary
$D(CI_{AR})$	Stationary	Stationary	Stationary	Stationary
$D(CI_{WR})$	Stationary	Stationary	Stationary	Stationary
$D(CI_{MAR})$	Stationary	Stationary	Stationary	Stationary
$D(IR_T)$	Stationary	Stationary	Stationary	Stationary
$D(IR_M)$	Stationary	Stationary	Stationary	Stationary
$D[E(\pi)-\pi_t]$	Stationary	Stationary	Stationary	Stationary

[a]Level of significance used is 10%.

rate. Due to the lag for the effect of the monetary policy on inflation, deviations in the inflation expectation in relation to the target imply changes in the basic interest rate. However, this change in basic interest rate occurs in an indirect way. It is important to note that the Copom defines the target for the basic interest rate and it is the responsibility of the CBB to maintain this rate close to the target. The Eq. (8) evaluates the relation between credibility and the inflation target and controlling the effect of the average variation in the basic interest rate target through deviations of expectations due to the inflation target.

It is expected that a monetary authority that has reputation and conducts the monetary policy in a credible manner will be capable of achieving its objectives implying a lower social loss (considering unemployment and output). Thus, it is assumed that a high credibility implies a low cost in the control of inflation (represented by an increase in the interest rate). Consequently, the credibility affects the definition of the basic interest rate by Copom as well as the interest rate in the market. The Eq. (9) estimates the variation of the basic interest rate average in the market through the variation in the credibility assuming as constant the effect caused by its own interest rate lagged one period.

For the empirical analysis, a first step is the examination of behavior of the stochastic process of the series over time, that is, the integration order of the series. The justification is that with this procedure spuriousness in the results can be avoided. Besides the visual analysis of the series through correlograms of series, the following unit root tests were performed: Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and the DF-GLS. Based on Maddala (2001) the Kwiatkowski–Phillips–Schmidt–Shin's stationary test (KPSS) to confirmatory analysis was used. The number of lags for each series was defined according to the Schwarz criterion and the Newey–West Bandwidth (see Table 3).[8]

It is important to note that in the cases where the results are not clear (IR_T, IR_M, $[E(\pi)-\pi_t]$), a graphical analysis of the correlograms from the original values of the series based on the idea that non-stationary series have strong autocorrelation is made (Vandaele, 1983). It is observed that in all cases the autocorrelation decreases slowly and gradually while lags increase. In other words, it can be seen that the present values depend on past values suggesting a presence of unit root in the series. Therefore, all series in this analysis are I(1).

[8] The results of each model are in the appendix (Table A.1).

The hypotheses adopted by models suggest that the $E(\pi)-\pi_t$ must precede the IR_T and this precedes IR_M. In other words, departures of inflation expectations from inflation target imply a variation of basic interest rate target which in turn changes the interest rate practiced in the market.

With the objective of verifying the assertions above, pairwise Granger causality tests were made (see Table A.2 — appendix). Although the variables $D(IR_T)$ and $D(IR_M)$ show a bilateral causality, the probability of rejecting the hypothesis that $D(IR_T)$ does not Granger cause $D(IR_M)$ is lower than the opposite. The analysis for the relation between $D[E(\pi)-\pi_t]$ and $D(IR_T)$ confirms the hypothesis that departures of inflation expectations from inflation target must precede the interest rate target defined by the central bank.

In relation to the credibility indices, the hypothesis that changes in credibility imply (in the Granger sense) variation in interest rate ($D(IR_T)$ and $D(IR_M)$) is tested. The results denote that the $D(CI_A)$ and $D(CI_{MAR})$ precede $D(IR_T)$ and $D(IR_M)$ (both cases show statistical significance at 1% level). The $D(CI_{CK})$ reveals that the causality on $D(IR_T)$ and $D(IR_M)$ is statistically significant at 5%. The credibility indices $D(CI_{AR})$ and $D(CI_{WR})$ reveal precedence on $D(IR_M)$ taking into consideration a statistical significance at 5% level. In relation to remain credibility indices there is no evidence.

Due to the objective of verifying the relation between the credibility (measured by the presented indices) and the central bank's effort (measured by variation in the interest rate) to achieve the main objective (control on inflation), the empirical relation between credibility and the interest rate target announced by Copom and the relation between credibility and the interest rate practiced in the market are analyzed (see Tables 4 and 5). The models have the following frameworks[9]:

$$IR_T = f(E(\pi)-\pi_t, CI), \tag{10}$$

$$IR_M = F\left(IR_{M_{(-1)}}, CI\right), \tag{11}$$

where $\partial f/\partial[E(\pi)-\pi_t]>0$, $\partial f/\partial CI<0$; and $\partial F/\partial IR_{M_{-1}}>0$, $\partial F/\partial CI<0$.

The role of the control variables $E(\pi)-\pi_t$ and $IR_{M_{(-1)}}$ is to show the statistical significance and the sign of coefficients. Therefore, controlling a variable which changes the interest rate (IR_T or IR_M), the expected relation between credibility and interest rate (negative sign and statistical significant for the coefficient of credibility) is tested. A priori, positive (negative) variations in credibility would reduce (increase) the variations in the basic interest rate for controlling inflation.

The process for the choice of the models is based on the analysis of autocorrelations and partial autocorrelations, cross-correlograms, residues, principle of parsimony, taking into account the basic presupposition in a multiple linear regression model, and the economic coherence.[10] The lags were defined based on Schwarz criterion. Table 4 shows the estimated regressions for each credibility index taking into account the distributed lag model (Eq. (8)) while Table 5 exhibits the estimation for each index based on an autoregressive framework (Eq. (9)).

Due to the fact that the regressions in Table 4 were estimated with the same basic specification ($D[E(\pi)-\pi_t]$ lagged one period as a control explanatory variable) but with a different quantity of parameters, it is possible to compare the degree of explanation of $D(IR_T)$ of each model taking into account the adjusted R^2. Under this perspective, the credibility indices with the best explanation of the average variation in $D(IR_T)$ are: CI_A (53.2%), CI_{CK} (44.34%), and CI_{MAR} (38.73%). The power of explanation of other indices (CI_M, CI_{AR}, and CI_{WR}) is lower than 18%.

[9] It is important to note that the Johansen and Engle-Granger cointegration tests were performed and the results indicate that the series are not cointegrated.
[10] The main statistical tests used in the analysis are in Table A.3 (appendix).

Table 4
Estimations for $D(IRT)$.

Dependent variable — $D(IR_T)$						
Credib. index	Estimated coefficients (Newey–West t-statistics)	N	F-stat.	Adj. R^2 (%)	AIC	SIC
Basic specification	$\underset{(-0.7152)}{-0.0008} + \underset{(1.6424)^{*}}{0.3859}D[E(\pi)-\pi_t]_{t-1}$	92	12.29***	11.03	−7.07	−7.01
CI_{CK}	$\underset{(-0.9274)}{-0.0007} + \underset{(4.0663)^{***}}{0.2567}D[E(\pi)-\pi_t]_{t-1} - \underset{(-3.1951)^{***}}{0.0791}D(CI_{CK})_t - \underset{(-4.0537)^{***}}{0.0673}D(CI_{CK})_{t-2} - \underset{(-3.2156)^{***}}{0.0375}D(CI_{CK})_{t-3} - \underset{(-2.8418)^{***}}{0.0404}D(CI_{CK})_{t-4}$	89	15.02***	44.34	−7.46	−7.30
CI_M	$\underset{(-0.7132)}{-0.0008} + \underset{(1.6218)^{*}}{0.3821}D[E(\pi)-\pi_t]_{t-1} - \underset{(-1.5441)^{*}}{0.0036}D(CI_M)_{t-2}$	91	6.29***	10.53	−7.04	−6.96
CI_A	$\underset{(-1.1746)}{-0.0008} + + \underset{(1.8555)^{***}}{0.1469}D[E(\pi)-\pi_t]_{t-1} - \underset{(-6.4070)^{***}}{0.1120}D(CI_A)_t - \underset{(-7.5392)^{***}}{0.1025}D(CI_A)_{t-2} - \underset{(-4.4571)^{***}}{0.0541}D(CI_A)_{t-4}$	89	26.01***	53.20	−7.65	−7.51
CI_{AR}	$\underset{(-1.1112)}{-0.0011} + \underset{(2.022)^{***}}{0.3868}D[E(\pi)-\pi_t]_{t-1} - \underset{(-2.3015)^{***}}{0.3341}D(CI_{AR})_t$	92	9.51***	15.76	−7.11	−7.03
CI_{WR}	$\underset{(-0.9588)}{-0.0010} + \underset{(2.0905)^{**}}{0.3785}D[E(\pi)-\pi_t]_{t-1} - \underset{(-2.7194)^{***}}{0.2046}D(CI_{WR})_t$	92	10.76***	17.67	−7,14	−7.05
CI_{MAR}	$\underset{(-1.0428)}{-0.0008} + \underset{(3.0767)^{***}}{0.3119}D[E(\pi)-\pi_t]_{t-1} - \underset{(-5.8788)^{***}}{0.0860}D(CI_{MAR})_t$	92	29.77***	38.73	−7.43	−7.35

Note: t-statistics between parentheses. Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1.

Table 5
Estimations for $D(IR_M)$.

Dependent variable — $D(IR_M)$						
Credib. index	Estimated coefficients (Newey–West t-statistics)	N	F-stat.	Adj. R^2 (%)	SIC	AIC
Basic specification	$\underset{(-0.2033)}{-0.0001} + \underset{(13.2787)^{***}}{0.7922}D(IR_M)_{t-1}$	98	176.32***	64.38	−8.25	−8.20
CI_{CK}	$\underset{(-0.5608)}{-0.0002} + \underset{(11.6721)^{***}}{0.7099}D(IR_M)_{t-1} - \underset{(-5.0826)^{***}}{0.0496}D(CI_{CK})_t - \underset{(-2.7487)^{***}}{0.0299}D(CI_{CK})_{t-2}$	91	89.40***	74.66	−8.50	−8.39
CI_A	$\underset{(-0.6969)}{-0.0002} + \underset{(12.4034)^{***}}{0.7047}D(IR_M)_{t-1} - \underset{(-2.9452)}{0.0342}D(CI_A)_t - \underset{(-3.5008)^{***}}{0.0432}D(CI_A)_{t-1}$	98	92.66***	75.13	−8.53	−8.42
CI_{AR}	$\underset{(-0.0261)}{-0.0001} + \underset{(11.8684)^{***}}{0.7834}D(IR_M)_{t-1} - \underset{(-2.6646)^{***}}{0.3973}D(CI_{AR})_t + \underset{(-3.5761)^{***}}{0.4973}D(CI_A)_{t-1}$	98	69.86***	68.05	−8.34	−8.23
CI_{WR}	$\underset{(-0.1456)}{-0.0001} + \underset{(11.5115)^{***}}{0.7798}D(IR_M)_{t-1} - \underset{(-2.8361)^{***}}{0.2209}D(CI_{WR})_t + \underset{(-3.6294)^{***}}{0.2618}D(CI_{WR})_{t-1}$	98	70.02***	68.10	−8.34	−8.23
CI_{MAR}	$\underset{(-0.5965)}{-0.0002} + \underset{(7.7024)^{***}}{0.6366}D(IR_M)_{t-1} - \underset{(-2.6368)^{***}}{0.0323}D(CI_{MAR})_t$	98	97.11***	66.46	−8.30	−8.22

Note: t-statistics between parentheses. Marginal significance levels: (***) denotes 0.01.

Furthermore, it is observed that with the inclusion of any credibility index (except CI_M) the adjusted coefficient of determination is increased. When using the model selection criteria of Akaike and Schwarz, the results above are confirmed. The most parsimonious model and with the best ability to explain the data is given by CI_A while the worst is given by CI_M.

The regressions show significant F-statistics at 0.01 level for all indices tested. Moreover the partial coefficients of credibility indices have a coherent sign with the theory and have statistical significance. Taking into consideration the Newey–West matrix due to the presence of autocorrelation in residuals the t-statistics were calculated. Furthermore, it is important to note that the best specification for models regarding indices based on reputation suggests the use of the credibility index without lags. This observation confirms the idea that these indices contain past information and thus the use of lagged terms is not necessary in its specification.

The regressions regarding basic interest rate defined by the financial market (see Table 5) also have a common basic specification $D(IR_M)$ lagged one period as a control variable and a different quantity of parameters which in turn allows making a comparison through the adjusted R^2. Once again, the best specifications are given by the inclusion of CI_A (75.13%) and CI_{CK} (74.66%) as a measurement of credibility. It is important to highlight that the CI_M did not reveal any significant relation in this model.[11] In relation to the indices based on reputation, the performances were similar: CI_{AR} (68.05%), CI_{WR} (68.10%), and CI_{MAR} (66.46%). However, CI_{AR} and CI_{WR} exhibit signals contrary to the expected for the terms lagged one period which in turn strengthen the idea that these indices contain past information. Moreover, the model selection criteria of Akaike and Schwarz are in accordance with the results of adjusted R^2.

The model without credibility index had a high degree of adjustment (64.38) due to the fact large part of the average variation of $D(IR_M)$ is explained by itself (lagged). Notwithstanding the inclusion of the credibility index improved the explanation of $D(IR_M)$ for all indices. Such as in the previous case the F-statistics are significant at 0.01 level. Moreover the inclusion of lagged dependent variable avoids the autocorrelation in residuals and allowed the estimation of t-statistics in a traditional way. The indices with the best general performance were the CI_A and the CI_{CK}. The CI_A has the best performance in the Granger causality tests as far as in the models with dependent variables $D(IR_T)$ and $D(IR_M)$ are concerned. Therefore, a proposed change in the CI_{CK} which generates CI_A, besides presenting theoretical coherence, allowed finding the best performance among the indices in this analysis.

5. Conclusion

This study reveals that the credibility index (CI_A) is that which has the best incremental contribution to the explanation of variations of basic interest rate (defined by financial market and the target defined by Monetary Policy Committee). The indices based on reputation have a worse performance in comparison with the CI_A. However, these indices did have a performance close to the other indices. Among indices based on reputation, CI_{MAR} presented the best performance. This result is important because it is the index (based on reputation) with the highest volatility and is more sensitive to the current events. Therefore, the result suggests a short memory of economic agents in the process of building credibility in Brazil. It is important to note that

[11] The main reason for this result is that the CI_M punishes with full loss any deviation regarding expectations out of a predetermined interval of the inflation target.

alternative specifications regarding lags in reputation or even other measurements different from those adopted in this analysis can improve the indices. The credibility indices based on reputation represent an alternative in the cases where the series of inflation expectation are not available. A last important point is that the empirical evidence confirms the hypothesis that a higher credibility implies lower variations in the interest rate for controlling inflation in Brazil.

Appendix A

Table A.1
Unit root tests (ADF, PP, DF-GLS) and stationary test (KPSS).

Series	ADF				PP				DF-GLS				KPSS			
	Lag	Test	CV 5%	CV 10%	Lag	Test	CV 5%	CV 10%	Lag	Test	CV 5%	CV 10%	Lag	Test	CV 5%	CV 10%
CI_{CK}	1	−2.2656	−2.8932	−2.5837	1	−1.8482	−2.8929	−2.5836	1	−2.3847	−3.0556	−2.7640	7	0.1874	0.1460	0.1190
$D(CI_{CK})$	0	−7.0581	−1.9444	−1.6144	6	−6.9426	−1.9444	−1.6144	0	−7.0340	−3.0556	−2.7640	0	0.1027	0.4630	0.3470
CI_M	0	−1.9354	−2.8929	−2.5836	1	−2.1219	−2.8929	−2.5836	0	−1.9818	−3.0524	−2.7610	7	0.1926	0.1460	0.1190
$D(CI_M)$	0	−8.0374	−1.9444	−1.6144	2	−8.0556	−1.9444	−1.6144	0	−7.9187	−3.0556	−2.7640	0	0.0750	0.4630	0.3470
CI_A	3	−1.9444	−2.8940	−2.5841	3	−2.1690	−2.8929	−2.5836	3	−2.6549	−3.0620	−2.7700	7	0.1324	0.1460	0.1190
$D(CI_A)$	1	−6.8857	−1.9444	−1.6144	5	−6.1784	−1.9444	−1.6144	1	−6.8948	−3.0588	−2.7670	2	0.0669	0.4630	0.3470
CI_{AR}	2	−1.8457	−2.8916	−2.5828	6	−1.5414	−2.8909	−2.5825	1	−1.9913	−3.0364	−2.7460	8	0.2303	0.1460	0.1190
$D(CI_{AR})$	1	−3.1472	−1.9442	−1.6146	3	−2.9875	−1.9441	−1.6146	1	−3.2725	−3.0396	−2.7490	6	0.1015	0.1460	0.1190
CI_{WR}	1	−2.2473	−2.8912	−2.5827	6	−1.5593	−2.8909	−2.5825	1	−2.0738	−3.0364	−2.7460	8	0.2336	0.1460	0.1190
$D(CI_{WR})$	1	−3.2731	−1.9442	−1.6146	3	−3.1119	−1.9441	−1.6146	1	−3.3635	−3.0396	−2.7490	6	0.0857	0.1460	0.1190
CI_{MAR}	8	−2.2057	−2.8936	−2.5839	6	−0.4680	−1.9441	−1.6146	8	−2.1015	−3.0588	−2.7670	8	0.1607	0.4630	0.3470
$D(CI_{MAR})$	7	−3.4280	−1.9444	−1.6144	5	−3.3509	−1.9441	−1.6146	7	−3.4506	−3.0588	−2.7670	6	0.0608	0.4630	0.3470
IR_T	2	−3.3607	−3.4568	−3.1543	6	−1.9316	−3.4558	−3.1537	2	−3.4321	−3.0396	−2.7490	8	0.1660	0.1460	0.1190
$D(IR_T)$	2	−3.6850	−1.9442	−1.6145	3	−5.4085	−1.9441	−1.6146	2	−2.8713	−3.0428	−2.7520	6	0.0545	0.1460	0.1190
IR_M	1	−3.2703	−3.4563	−3.1540	6	−1.9118	−3.4558	−3.1537	1	−3.3814	−3.0364	−2.7460	8	0.1640	0.1460	0.1190
$D(IR_M)$	0	−3.5081	−1.9441	−1.6146	4	−3.8337	−1.9441	−1.6146	0	−2.0778	−1.9441	−1.6146	6	0.0536	0.1460	0.1190
$E(\pi)-\pi_t$	1	−2.0355	−1.9444	−1.6144	3	−1.7291	−1.9443	−1.6145	1	−2.5622	−3.0556	−2.7640	7	0.2022	0.1460	0.1190
$D[E(\pi)-\pi_t]$	1	−7.5747	−1.9444	−1.6144	10	−7.3154	−1.9444	−1.6144	1	−7.5573	−3.0588	−2.7670	5	0.0465	0.1460	0.1190

Notes: ADF — the final choice of lag was made based on Schwarz criterion. For all indices in level, a constant was applied. Constant and linear trend For IR_M and IR_T was used. For other series, no-constant specification or time trend was used.
PP — the final choice of lag was made based on Newey–West. For all indices in level, a constant was applied. Constant and linear trend for IR_M and IR_T was used. For other series no-constant specification or time trend was used.
DF-GLS — the final choice of lag was made based on Schwarz criterion. Constant and linear trend for other series were applied.
KPSS — the final choice of lag was made based on Newey–West. For the series: $D(CI_{CK})$, $D(CI_M)$, $D(CI_A)$, CI_{MAR}, and $D(CI_{MAR})$ constant was applied. Constant and linear trend for other series were applied.

Table A.2
Granger causality test.

	Null hypothesis	Obs.	*F*-statistics	*P*-value
	$D(IR_M)$ does not Granger Cause $D(IR_T)$	87	2.0282	0.0363
	$D(IR_T)$ does not Granger Cause $D(IR_M)$		6.9207	0.0000
	$D[E(\pi)-\pi_t]$ does not Granger Cause $D(IR_T)$	81	2.3141	0.0176
	$D(IR_T)$ does not Granger Cause $D[E(\pi)-\pi_t]$		2.0058	0.0408
Basic interest rate — defined by CBB ($D(IR_T)$)	$D(CI_{CK})$ does not Granger Cause $D(IR_T)$	81	2.02315	0.0389
	$D(IR_T)$ does not Granger Cause $D(CI_{CK})$		1.82029	0.0668
	$D(CI_M)$ does not Granger Cause $D(IR_T)$	81	0.6355	0.8030
	$D(IR_T)$ does not Granger Cause $D(CI_M)$		1.8967	0.0546
	$D(CI_A)$ does not Granger Cause $D(IR_T)$	81	4.0520	0.0002
	$D(IR_T)$ does not Granger Cause $D(CI_A)$		1.4883	0.1562
	$D(CI_{AR})$ does not Granger Cause $D(IR_T)$	87	1.2339	0.2813
	$D(IR_T)$ does not Granger Cause $D(CI_{AR})$		7.2417	0.0000
	$D(CI_{WR})$ does not Granger Cause $D(IR_T)$	87	1.2242	0.2875
	$D(IR_T$ does not Granger Cause DCI_{WR}		7.3391	0.0000
	$D(CI_{MAR})$ does not Granger Cause $D(IR_T)$	87	7.2527	0.0000
	$D(IR_T$ does not Granger Cause $D(CI_{MAR})$		1.3160	0.2328
Basic interest rate — defined by market ($D(IR_M)$)	$D(CI_{CK})$ does not Granger Cause $D(IR_M)$	81	2.0390	0.0373
	$D(IR_M)$ does not Granger Cause $D(CI_{CK})$		1.0157	0.4476
	$D(CI_M)$ does not Granger Cause $D(IR_M)$	81	0.7020	0.7428
	$D(IR_M)$ does not Granger Cause $D(CI_M)$		2.2649	0.0201
	$D(CI_A)$ does not Granger Cause $D(IR_M)$	81	4.0633	0.0002
	$D(IR_M)$ does not Granger Cause $D(CI_A)$		1.3891	0.1986
	$D(CI_{AR})$ does not Granger Cause $D(IR_M)$	87	2.1403	0.0265
	$D(IR_M)$ does not Granger Cause $D(CI_{AR})$		4.9758	0.0000
	$D(CI_{WR})$ does not Granger Cause $D(IR_M)$	87	2.1207	0.0280
	$D(IR_M)$ does not Granger Cause $D(CI_{WR})$		4.9922	0.0000
	$D(CI_{MAR})$ does not Granger Cause $D(IR_M)$	87	4.0548	0.0001
	$D(IR_M)$ does not Granger Cause $D(CI_{MAR})$		2.1435	0.0263

Note: 12 lags were applied.

Table A.3
Model selection.

Dependent variable: $D(IR_T)$
Sample (adjusted): 2000:03 2007:10
Included observations: 92 after adjustments
Newey–West HAC Standard Errors & Covariance (lag truncation = 3)

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
$D[E(\pi)-\pi_t](-1)$	0.3859	0.2350	1.6424	0.1002
C	−0.0008	0.0011	−0.7153	0.4763
R-squared	0.1201	Mean dependent var		−0.0008
Adjusted *R*-squared	0.1103	S.D. dependent var		0.0074
S.E. of regression	0.0070	Akaike info criterion		−7.0685
Sum squared resid	0.0044	Schwarz criterion		−7.0137
Durbin–Watson stat	1.0825	*F*-statistic***		12.2867

Tests	Test statistic	Value
White heteroskedasticity:	*F*-statistic**	4.3219
	Obs. *R*-squared**	8.1442
Breusch–Godfrey LM:	*F*-statistic***	20.5178
	Obs. *R*-squared***	29.2576
ARCH:	*F*-statistic	1.5601
	Obs. *R*-squared	1.5677
Jarque–Bera:	J–B statistic***	80.4093
Ramsey RESET:	*F*-statistic***	11.3771
	Log likelihood ratio***	11.0674
Chow Breakpoint: 2003:01	*F*-statistic***	7.4248
	Log likelihood ratio***	14.3457

Dependent variable: $D(IR_T)$
Sample (adjusted): 2000:06 2007:10
Included observations: 89 after adjustments
Newey–West HAC Standard Errors & Covariance (lag truncation = 3)

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
$D[E(\pi)-\pi_t](-1)$	0.2567	0.0631	4.0663	0.0001
DCI_{CK}	−0.0791	0.0248	−3.1951	0.0020
$DCI_{CK}(-2)$	−0.0673	0.0166	−4.0537	0.0001
$DCI_{CK}(-3)$	−0.0375	0.0117	−3.2156	0.0019
$DCI_{CK}(-4)$	−0.0404	0.0142	−2.8418	0.0056
C	−0.0007	0.0007	−0.9274	0.3564
R-squared	0.4751	Mean dependent var		−0.0008
Adjusted *R*-squared	0.4434	S.D. dependent var		0.0075
S.E. of regression	0.0056	Akaike info criterion		−7.4643
Sum squared resid	0.0026	Schwarz criterion		−7.2965
Durbin–Watson stat	1.5544	*F*-statistic***		15.0225

Tests	*df*	Test statistic	Value
Wald	(1.83)/1	*F*-stat./Chi-square***	30.4613
White heteroskedasticity		*F*-statistic	0.7032
		Obs. *R*-squared	7.3599
Breusch–Godfrey LM		*F*-statistic**	4.7810
		Obs. *R*-squared*	9.3971
ARCH		*F*-statistic	0.0792
		Obs. *R*-squared	0.0810
Jarque–Bera		J–B statistic***	35.9052
Ramsey RESET		*F*-statistic	0.0460
		Log likelihood ratio	0.0500
Chow Breakpoint: 2003:01		*F*-statistic	0.7644
		Log likelihood ratio	5.1495

Dependent variable: $D(IR_T)$
Sample (adjusted): 2000:04 2007:10
Included observations: 91 after adjustments
Newey–West HAC Standard Errors & Covariance (lag truncation = 3)

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
$D[E(\pi)-\pi_t](-1)$	0.3821	0.2356	1.6218	0.1008
$DCI_{M}(-2)$	−0.0036	0.0013	−1.8440	0.0928
C	−0.0008	0.0011	−0.7132	0.4776
R-squared	0.1251	Mean dependent var		−0.0009
Adjusted *R*-squared	0.1053	S.D. dependent var		0.0074
S.E. of regression	0.0070	Akaike info criterion		−7.0410
Sum squared resid	0.0044	Schwarz criterion		−6.9582
Durbin–Watson stat	1.0750	*F*-statistic***		6.2934

Note: Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1.

Table A.3 (*continued*)

Tests	Test statistic	Value
White heteroskedasticity	*F*-statistic*	2.2568
	Obs. *R*-squared*	8.6445
Breusch–Godfrey LM	*F*-statistic***	20.2657
	Obs. *R*-squared***	29.1498
ARCH	*F*-statistic	1.5315
	Obs. *R*-squared	1.5395
Jarque–Bera	J–B statistic***	85.4098
Ramsey RESET	*F*-statistic***	11.0145
	Log likelihood ratio***	10.8479
Chow Breakpoint: 2003:01	*F*-statistic***	4.6595
	Log likelihood ratio***	13.8549

Dependent variable: $D(IR_T)$
Sample (adjusted): 2000:06 2007:10
Included observations: 89 after adjustments
Newey–West HAC Standard Errors & Covariance (lag truncation = 3)

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
$D[E(\pi)-\pi_t](-1)$	0.1469	0.0792	1.8555	0.0670
DCI_{A}	−0.1120	0.0175	−6.4070	0.0000
$DCI_{A}(-2)$	−0.1025	0.0136	−7.5391	0.0000
$DCI_{A}(-4)$	−0.0541	0.0121	−4.4571	0.0000
C	−0.0008	0.0007	−1.1746	0.2435
R-squared	0.5533	Mean dependent var		−0.0008
Adjusted *R*-squared	0.5320	S.D. dependent var		0.0075
S.E. of regression	0.0051	Akaike info criterion		−7.6481
Sum squared resid	0.0022	Schwarz criterion		−7.5083
Durbin–Watson stat	1.5603	*F*-statistic***		26.0091

Tests		Test statistic	Value
Wald	(1. 84) / 1	*F*-stat. / Chi-square***	82.8126
White heteroskedasticity		*F*-statistic	0.3531
		Obs. *R*-squared	3.0357
Breusch–Godfrey LM		*F*-statistic**	3.6205
		Obs. *R*-squared**	7.2215
ARCH		*F*-statistic	2.4405
		Obs. *R*-squared	2.4283
Jarque–Bera		J–B statistic***	31.2069
Ramsey RESET		*F*-statistic	0.4556
		Log likelihood ratio	0.4872
Chow Breakpoint: 2003:01		*F*-statistic	1.5146
		Log likelihood ratio	8.1472

Dependent variable: $D(IR_T)$
Sample (adjusted): 2000:03 2007:10
Included observations: 92 after adjustments
Newey–West HAC Standard Errors & Covariance (lag truncation = 3)

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
$D[E(\pi)-\pi_t](-1)$	0.3868	0.1913	2.0220	0.0462
DCI_{AR}	−0.3341	0.1452	−2.3015	0.0237
C	−0.0011	0.0010	−1.1118	0.2692
R-squared	0.1761	Mean dependent var		−0.0008
Adjusted *R*-squared	0.1576	S.D. dependent var		0.0074
S.E. of regression	0.0068	Akaike info criterion		−7.1125
Sum squared resid	0.0041	Schwarz criterion		−7.0303
Durbin–Watson stat	1.2198	*F*-statistic***		9.5108

Tests	Test statistic	Value
White heteroskedasticity	*F*-statistic**	2.6930
	Obs. *R*-squared**	10.1361
Breusch–Godfrey LM	*F*-statistic***	18.2399
	Obs. *R*-squared***	27.1797
ARCH	*F*-statistic	1.8788
	Obs. *R*-squared	1.8813
Jarque–Bera	J–B statistic***	59.4904
Ramsey RESET	*F*-statistic	0.0619
	Log likelihood ratio	0.0647
Chow Breakpoint: 2003:01	*F*-statistic**	3.7896
	Log likelihood ratio***	11.4226

Table A.3 (*continued*)

Dependent variable: $D(IR_T)$
Sample (adjusted): 2000:03 2007:10
Included observations: 92 after adjustments
Newey–West HAC Standard Errors & Covariance (lag truncation = 3)

Variable	Coefficient	Std. error	t-Statistic	Prob.
$D[E(\pi)-\pi_t](-1)$	0.3785	0.1810	2.0905	0.0394
DCI_{WR}	−0.2046	0.0752	−2.7194	0.0079
C	−0.0010	0.0010	−0.9588	0.3403
R-squared	0.1948	Mean dependent var		−0.0008
Adjusted R-squared	0.1767	S.D. dependent var		0.0074
S.E. of regression	0.0067	Akaike info criterion		−7.1354
Sum squared resid	0.0040	Schwarz criterion		−7.0532
Durbin–Watson stat	1.2537	F-statistic***		10.7629

Tests	Test statistic	Value
White heteroskedasticity	F-statistic	1.7171
	Obs. R-squared	6.7316
Breusch–Godfrey LM	F-statistic***	16.9601
	Obs. R-squared***	25.8076
ARCH	F-statistic	1.8788
	Obs. R-squared	1.8813
Jarque–Bera	J–B statistic***	58.0239
Ramsey RESET	F-statistic	0.0619
	Log likelihood ratio	0.0647
Chow Breakpoint: 2003:01	F-statistic**	3.7896
	Log likelihood ratio***	11.4226

Dependent variable: $D(IR_T)$
Sample (adjusted): 2000:03 2007:10
Included observations: 92 after adjustments
Newey–West HAC Standard Errors & Covariance (lag truncation = 3)

Variable	Coefficient	Std. error	t-Statistic	Prob.
$D[E(\pi)-\pi_t](-1)$	0.3119	0.1014	3.0767	0.0028
DCI_{MAR}	−0.0860	0.0146	−5.8789	0.0000
C	−0.0008	0.0008	−1.0429	0.2998
R-squared	0.4008	Mean dependent var		−0.0008
Adjusted R-squared	0.3873	S.D. dependent var		0.0074
S.E. of regression	0.0058	Akaike info criterion		−7.4310
Sum squared resid	0.0030	Schwarz criterion		−7.3488
Durbin–Watson stat	1.6352	F-statistic***		29.7669

Tests	Test statistic	Value
White heteroskedasticity	F-statistic**	3.0890
	Obs. R-squared**	11.4412
Breusch–Godfrey LM	F-statistic***	6.2681
	Obs. R-squared***	11.5871
ARCH	F-statistic	0.1258
	Obs. R-squared	0.1284
Jarque–Bera	J–B statistic***	189.5571
Ramsey RESET	F-statistic	4.8042
	Log likelihood ratio	4.8902
Chow Breakpoint: 2003:01	F-statistic	4.0434
	Log likelihood ratio	12.1391

Dependent variable: $D(IR_M)$
Sample (adjusted): 1999:09 2007:10
Included observations: 98 after adjustments

Variable	Coefficient	Std. error	t-Statistic	Prob.
$DIR_M(-1)$	0.7922	0.0597	13.2787	0.0000
C	−0.0001	0.0004	−0.2033	0.8393
R-squared	0.6475	Mean dependent var		−0.0009
Adjusted R-squared	0.6438	S.D. dependent var		0.0065
S.E. of regression	0.0039	Akaike info criterion		−8.2489
Sum squared resid	0.0014	Schwarz criterion		−8.1961
		F-statistic***		176.3236

Tests	Test statistic	Value
White heteroskedasticity	F-statistic**	4.0056
	Obs. R-squared**	7.6215
Breusch–Godfrey LM	F-statistic	1.3671
	Obs. R-squared	2.7699
ARCH	F-statistic*	3.8731
	Obs. R-squared*	3.7997
Jarque–Bera	J–B statistic***	80.4093
Ramsey RESET	F-statistic	0.1098
	Log likelihood ratio	0.1132
Chow Breakpoint: 2003:01	F-statistic	1.8417
	Log likelihood ratio	3.7668

Dependent variable: $D(IR_M)$
Sample (adjusted): 2000:04 2007:10
Included observations: 91 after adjustments

Variable	Coefficient	Std. error	t-Statistic	Prob.
$DIR_M(-1)$	0.7099	0.0608	11.6721	0.0000
DCI_{CK}	−0.0496	0.0098	−5.0826	0.0000
$DCI_{CK}(-2)$	−0.0299	0.0109	−2.7488	0.0073
C	−0.0002	0.0004	−0.5609	0.5763
R-squared	0.7551	Mean dependent var		−0.0008
Adjusted R-squared	0.7466	S.D. dependent var		0.0067
S.E. of regression	0.0034	Akaike info criterion		−8.4964
Sum squared resid	0.0010	Schwarz criterion		−8.3860
		F-statistic***		89.4026

Tests	df	Test statistic	Value
Wald	(1. 87)/1	F-stat./Chi-square***	25.1571
White heteroskedasticity		F-statistic	0.9025
		Obs. R-squared	5.5110
Breusch–Godfrey LM		F-statistic	2.2824
		Obs. R-squared	4.6379
ARCH		F-statistic	0.5646
		Obs. R-squared	0.5737
Jarque–Bera		J–B statistic***	24.6637
Ramsey RESET		F-statistic	0,2456
		Log likelihood ratio	0.2595
Chow Breakpoint: 2003:01		F-statistic	1.2019
		Log likelihood ratio	5.1240

Dependent variable: $D(IR_M)$
Sample (adjusted): 2000:02 2007:10
Included observations: 93 after adjustments

Variable	Coefficient	Std. error	t-Statistic	Prob.
$DIR_M(-1)$	0.8247	0.0610	13.5102	0.0000
DCI_M	0.0014	0.0028	0.4835	0.6299
C	−0.0001	0.0004	−0.3683	0.7135
R-squared	0.6732	Mean dependent var		−0.0008
Adjusted R-squared	0.6660	S.D. dependent var		0.0067
S.E. of regression	0.0038	Akaike info criterion		−8.2531
Sum squared resid	0.0013	Schwarz criterion		−8.1714
		F-statistic***		92.7067

Tests	Test statistic	Value
White heteroskedasticity	F-statistic	1.8023
	Obs. R-squared	7.0417
Breusch–Godfrey LM	F-statistic	1.4643
	Obs. R-squared	2.9953
ARCH	F-statistic	2.8641
	Obs. R-squared	2.8375
Jarque–Bera	J–B statistic***	74.2854
Ramsey RESET	F-statistic	0.0000
	Log likelihood ratio	0.0000
Chow Breakpoint: 2003:01	F-statistic	1.5599
	Log likelihood ratio	4.8725

Dependent variable: $D(IR_M)$
Sample (adjusted): 2000:03 2007:10
Included observations: 92 after adjustments

Variable	Coefficient	Std. error	t-Statistic	Prob.
$DIR_M(-1)$	0.7047	0.0568	12.4034	0.0000
DCI_A	−0.0342	0.0116	−2.9452	0.0041
$DCI_A(-1)$	−0.0432	0.0123	−3.5008	0.0007
C	−0.0002	0.0004	−0.6969	0.4877
R-squared	0.7595	Mean dependent var		−0.0008
Adjusted R-squared	0.7513	S.D. dependent var		0.0067
S.E. of regression	0.0033	Akaike info criterion		−8.5266
Sum squared resid	0.0010	Schwarz criterion		−8.4170
		F-statistic***		92.6570

(*continued on next page*)

Table A.3 (*continued*)

Tests	df	Test statistic	Value
Wald	(1.88)/1	*F*-stat./Chi-square***	31.8943
White heteroskedasticity		*F*-statistic	1.1586
		Obs. *R*-squared	6.9552
Breusch–Godfrey LM		*F*-statistic	1.6631
		Obs. *R*-squared	4.3654
ARCH		*F*-statistic	0.5277
		Obs. *R*-squared	0.5363
Jarque–Bera		J–B statistic***	30.5185
Ramsey RESET		*F*-statistic	2.6871
		Log likelihood ratio	2.7986
Chow Breakpoint: 2003:01		*F*-statistic	1.7325
		Log likelihood ratio	7.2931

Dependent variable: $D(IR_{\mathrm{M}})$
Sample (adjusted): 1999:09 2007:10
Included observations: 98 after adjustments

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
$DIR_{\mathrm{M}}(-1)$	0.7834	0.0660	11.8684	0.0000
DCI_{AR}	−0.3973	0.1491	−2.6646	0.0091
$DCI_{\mathrm{AR}}(-1)$	0.4973	0.1391	3.5761	0.0006
C	0.0000	0.0004	0.0261	0.9793
R-squared	0.6904	Mean dependent var		−0.0009
Adjusted *R*-squared	0.6805	S.D. dependent var		0.0065
S.E. of regression	0.0037	Akaike info criterion		−8.3377
Sum squared resid	0.0013	Schwarz criterion		−8.2322
		F-statistic***		69.8568

Tests	df	Test statistic	Value
Wald	(1.94)/1	*F*-stat./Chi-square	1.3302
White heteroskedasticity		*F*-statistic**	2.2957
		Obs. *R*-squared**	12.8837
Breusch–Godfrey LM		*F*-statistic	1.0106
		Obs. *R*-squared	2.1067
ARCH		*F*-statistic	2.1070
		Obs. *R*-squared	2.1047
Jarque–Bera		J–B statistic***	80.0103
Ramsey RESET		*F*-statistic	0.4780
		Log likelihood ratio	0.5024
Chow Breakpoint: 2003:01		*F*-statistic	1.1609
		Log likelihood ratio	4.9300

Dependent variable: $D(IR_{\mathrm{M}})$
Sample (adjusted): 1999:09 2007:10
Included observations: 98 after adjustments

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
$DIR_{\mathrm{M}}(-1)$	0.7798	0.0677	11.5115	0.0000
DCI_{WR}	−0.2209	0.0779	−2.8361	0.0056
$DCI_{\mathrm{WR}}(-1)$	0.2618	0.0721	3.6294	0.0005
C	−0.0001	0.0004	−0.1456	0.8846
R-squared	0.6909	Mean dependent var		−0.0009
Adjusted *R*-squared	0.6810	S.D. dependent var		0.0065
S.E. of regression	0.0037	Akaike info criterion		−8.3394
Sum squared resid	0.0013	Schwarz criterion		−8.2338
	–	*F*-statistic***		70.0205

Tests	df	Test statistic	Value
Wald	(1.94)/1	*F*-stat./Chi-square	0.7430
White heteroskedasticity		*F*-statistic	1.8247
		Obs. *R*-squared	10.5244
Breusch–Godfrey LM		*F*-statistic	1.0612
		Obs. *R*-squared	2.2099
ARCH		*F*-statistic	2.2635
		Obs. *R*-squared	2.2574
Jarque–Bera		J–B statistic***	82.4173
Ramsey RESET		*F*-statistic	0.2927
		Log likelihood ratio	0.3080

Table A.3 (*continued*)

Tests	df	Test statistic	Value
Chow Breakpoint: 2003:01		*F*-statistic	1.1586
		Log likelihood ratio	4.9207

Dependent variable: $D(IR_{\mathrm{M}})$
Sample (adjusted): 1999:09 2007:10
Included observations: 98 after adjustments

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
$DIR_{\mathrm{M}}(-1)$	0.6366	0.0827	7.7024	0.0000
DCI_{MAR}	−0.0323	0.0122	−2.6369	0.0098
C	−0.0002	0.0004	−0.5966	0.5522
R-squared	0.6715	Mean dependent var		−0.0009
Adjusted *R*-squared	0.6646	S.D. dependent var		0.0065
S.E. of regression	0.0038	Akaike info criterion		−8.2991
Sum squared resid	0.0013	Schwarz criterion		−8.2200
		F-statistic***		97.1053

Tests	Test statistic	Value
White heteroskedasticity	*F*-statistic	2.1898
	Obs. *R*-squared	8.8231
Breusch–Godfrey LM	*F*-statistic	3.7560
	Obs. *R*-squared	7.3242
ARCH	*F*-statistic	0.9082
	Obs. *R*-squared	0.9186
Jarque–Bera	J–B statistic***	189.5571
Ramsey RESET	*F*-statistic	0.1851
	Log likelihood ratio	0.1928
Chow Breakpoint: 2003:01	*F*-statistic	1.5394
	Log likelihood ratio	4.7999

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