

Empirical Evidence on the Relation between Fiscal Credibility and Central Bank Credibility: The Brazilian case

Gabriel Montes¹

Ana Jordânia de Oliveira²

Rodolfo Nicolay³

Abstract

Since the early 1990s, several countries have adopted inflation targeting (IT). However, IT may not be sufficient to ensure fiscal discipline, and governments can still pursue irresponsible fiscal policies under IT. The adoption of irresponsible policies, which lead to a weak fiscal credibility, could undermine the credibility of the central bank. In the present study, we investigate whether a correlation between fiscal credibility and central bank credibility exists. The study contributes to the literature since it presents evidence on the relation between fiscal credibility and central bank credibility. The empirical analysis uses different econometric techniques (OLS, GMM and TOBIT). The findings suggest a positive relation between fiscal credibility and central bank credibility.

Keywords

Fiscal policy. Monetary policy. Credibility.

Resumo

A partir da década de 1990, vários países adotaram o regime de metas de inflação (RMI). Entretanto, o RMI pode não ser garantia suficiente para a disciplina fiscal, e governos podem continuar adotando políticas fiscais irresponsáveis. A adoção de políticas irresponsáveis, as quais levam à uma fraca credibilidade fiscal, enfraquece a credibilidade do banco central. No presente estudo, investigamos se existe uma correlação entre a credibilidade fiscal e a credibilidade do banco central. O trabalho contribui com a literatura uma vez que apresenta evidências empíricas acerca da relação entre credibilidade fiscal e credibilidade do banco central. A análise empírica emprega diferentes métodos econométricos (OLS, GMM e TOBIT). Os resultados sugerem uma relação positiva entre a credibilidade fiscal e a credibilidade do banco central.

¹ Professor – Universidade Federal Fluminense (UFF) – Endereço: Rua Alexandre Moura, Bloco F, 8 São Domingos – Niterói/RJ – Brasil – CEP: 24210-200 – E-mail: gabrielmontesuff@yahoo.com.br <http://orcid.org/0000-0001-8687-2114>

² Professor – Universidade Candido Mendes – Endereço: Rua da Assembléia, 10 – Sala 319 Rio de Janeiro/RJ – Brasil – CEP: 20119-900 – E-mail: anajordaniaoliveira@gmail.com <https://orcid.org/0000-0002-8668-9245>

³ Professor – Universidade Candido Mendes – Endereço: Rua da Assembléia, 10 – Sala 319 – Rio de Janeiro/RJ – Brasil – CEP: 20119-900 – E-mail: r-nicolay@hotmail.com – <http://orcid.org/0000-0003-1325-5136>
Recebido: 01/08/2016. Aceite: 15/12/2017.



Esta obra está licenciada com uma Licença Creative Commons Atribuição-Não Comercial 4.0 Internacional.

Palavras-Chave

Política fiscal. Política monetária. Credibilidade.

Classificação JEL

E52. E62. H63.

1. Introduction

According to Blinder (2000, 1421), credibility matters in theory, and it is certainly believed to matter in practice. In his study, he argues: Why is credibility so important to central bankers? In addition, how can a central bank create or enhance credibility?

Regarding central bank credibility, Blinder (2000) presents the following definition, which is in accordance with Kydland and Prescott's (1977) argument: a central bank is credible if people believe it will do what it says. Based on this definition, an inflation targeting central bank has credibility when people believe in the announced inflation target; and, credibility is earned when inflation expectations converge to the target rate (Agénor and Taylor, 1992; Svensson, 2000). Based on the idea that series of expected inflation could be applied to derive a credibility index, existing measures of central bank credibility refer to the gap between inflation expectations of economic agents and the central bank inflation target (e.g., Svensson 2000, de Mendonça 2007).

Earning credibility, however, is not a trivial task in emerging economies, particularly in those countries that experienced high inflation rates for several years and, thus, have a history of low credibility. Since the early 1990s, an increasing number of emerging and developed economies have started implementing inflation targeting as the framework to guide monetary policy. However, according to Mishkin (2007), inflation targeting may not be sufficient to ensure fiscal discipline, and governments can still pursue irresponsible fiscal policies with an inflation targeting regime in place. Therefore, the adoption of irresponsible fiscal policies, which lead to a weak fiscal credibility, could undermine the credibility of the central bank.

In this study, based on the arguments presented in the seminal work of Sargent and Wallace (1981), we go further and argue that fiscal discipline and absence of fiscal dominance are key aspects for inflation targeting and for central bank credibility. Hence, we raise the following question: Is there a relationship between fiscal credibility and central bank credibility?

The empirical analysis is based on different econometric techniques (OLS, GMM and TOBIT), and considers the period from December 2001 to February 2016 for the Brazilian economy. As a preliminary analysis, we provide evidence on the temporal precedence between fiscal credibility and central bank credibility through the Granger Causality Test. The test indicates fiscal credibility precedes central bank credibility. Moreover, the main results indicate that fiscal credibility has a positive and significant relation with central bank credibility.

In relation to the literature about the determinants of the central bank credibility, Blinder (2000) highlights the importance of the history of honesty, the history of fighting against inflation and small fiscal debts to construct and maintain credibility. Moreover, Minella *et al.* (2003) indicates that the exchange rate variation is important to the credibility in Brazil. Montes and Nicolay (2016) show the importance of the clarity of the central bank communication to build central bank credibility. This study contributes to the literature since it provides empirical evidence for the relation between fiscal credibility and central bank credibility. To our knowledge, there are no studies empirically addressing the relationship between fiscal credibility and central bank credibility.

Besides this introduction, section 2 presents the literature review about the importance of central bank credibility and fiscal credibility. Section 3 presents the empirical analysis, and section 4 concludes the work.

2. The importance of Credibility

In the 2006 speech to the Annual Washington Policy Conference, the President and CEO of the Federal Reserve Bank of San Francisco, Janet Yellen, argued that, *“credibility is not only virtuous; it is also useful. I will argue that one of its most important benefits is shaping public expectations*

about inflation, and in particular, 'anchoring' those expectations to price stability. As a consequence, credibility enhances the effectiveness of monetary policy" (Yellen 2006).

A credible monetary policy implies less effort by the central bank for the achievement of the inflation target (Blinder 2000). Empirical evidence suggests that a high credibility is associated with a lower volatility of the interest rate for the achievement of the inflation target (de Mendonça and de Guimarães and Souza 2012). This alignment of the central bank's actions with the public's expectations strengthens monetary policy effectiveness.

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 credibility (de Mendonça and de Guimarães and Souza 2012). However, the fulfillment of the inflation target is the main factor to influence inflation expectations.

The inflation targeting regime has played a key role in macroeconomic stabilization in several developed and developing countries since the beginning of the 1990s (Walsh 2009). Inflation targeting in emerging market economies has been a more challenging task than in developed economies due to several vulnerabilities and to low levels of credibility (Minella *et al.* 2003). In fact, one basic task of emerging market central banks has been to build credibility. This requires actions consistent with the inflation targeting framework (such as commitment with price stability, coordination between fiscal and monetary policies as well as fiscal and financial stability) combined with high levels of transparency and communication with the public (Montes 2010).

The success of the inflation targeting regime and the efforts of the central bank in the task of controlling inflation relate, to a large extent, with the earning of credibility (Montes and Bastos 2014, Montes and Curi 2016). Credibility in this context means that private agents believe that the central bank will act consistently within the inflation targeting framework (Minella *et al.* 2003), but also the government will act committed to sound fiscal policies. Sims (2004) argues that the lack of credibility in fiscal policies leads to higher inflation rates. In turn, higher inflation rates undermine monetary policy credibility.

Earning credibility takes time and it depends on both fiscal and monetary policies. Thus, what is the importance of fiscal sustainability and fiscal credibility for inflation targeting emerging countries? Why fiscal sustainability so important, and how does it influence fiscal credibility?

2.1. Importance of Debt Management and Fiscal Sustainability to Fiscal Credibility

According to Sargent and Wallace (1981), fiscal sustainability has an unequivocal impact on price stability and, thus, it represents an important condition to help monetary policy keeping inflation low and stable. As Shirakawa (2012) stresses, when the government loses its credibility with respect to the sustainability of government debt and does not make enough effort to regain it, this ultimately leads to a higher inflation or a default on the debt (or both). Hence, fiscal sustainability itself is an essential precondition for the proper functioning of a central bank, and thus, fiscal credibility represents an essential precondition to build central bank credibility.

Regarding the relation between fiscal sustainability and price stability, high levels of government debt can lead to difficulties in controlling inflation. Sargent and Wallace (1981) consider the situation of a government running deficits, which are financed by issuing government bonds. If these deficits are unsustainable, the government will not be able to finance deficits indefinitely through issuing bonds. Then eventually, the outstanding debt will need to be financed by an increased level of currency, and hence could lead to higher inflation in the future. Sargent and Wallace (1981) also stress that a large public debt implies a difficulty in reducing the interest rate. Moreover, if demand for money depends on expected inflation, then unsustainable deficits could lead to higher inflation in the present period. These arguments present an important relation between fiscal and monetary policy and it justifies fiscal sustainability from the perspective of inflation targeting.

Fiscal stability is a necessary condition for inflation control and for inflation targeting (Mishkin 2007). An important lesson from Sargent and Wallace (1981) is that irresponsible fiscal policy puts pressure on the monetary authorities to monetize the debt, thereby producing rapid money

growth and high inflation. If fiscal imbalances are large enough, monetary policy eventually becomes subservient to fiscal considerations (“fiscal dominance”) and an inflation target would have to be abandoned or modified. Thus, fiscal reforms, which help to keep budget deficits from spinning out of control, are needed to prevent the fiscal imbalances that can lead to a collapse of an inflation targeting regime (Mishkin 2008).

One typical problem of emerging economies that have adopted inflation targeting is that a disinflationary monetary policy can cause a fiscal imbalance. The reason is that under inflation targeting the basic interest rate is the main monetary policy instrument, and in several countries, such as Brazil, public debt is strongly indexed to the interest rate. Therefore, increases in interest rate to achieve the inflation target imply increases in the primary surplus required for stabilizing the public debt/GDP ratio.

The fiscal stability can be achieved by a policy based on a tight fiscal policy (increase in taxes or decrease in government spending) as a way of generating primary surpluses. Another possibility for achieving fiscal stability, such as pointed out by Giavazzi and Missale (2004), is the low cost of government funding. Therefore, public debt management can be an important tool for reducing fiscal vulnerability.

3. Empirical Analysis

In 1999, Brazil adopted inflation targeting. Since then, central bank credibility is fundamentally explained by central bank’s commitment to inflation control. However, since fiscal policy and public debt management also exert influence on inflation, and since the regime of inflation targeting requires coordination between monetary and fiscal policies, the government launched in 1999, the “Fiscal Stability Program” (FSP). This program had the intention to strengthen fiscal discipline, reduce the public deficit and stabilize the debt/GDP ratio. The program introduced targets for the primary surplus, set limits on indebtedness and increased fiscal transparency.

In terms of public debt management, at the end of 1999, in an attempt to improve the composition of government liabilities, efforts were made to increase the share of fixed-rate and price-indexed securities and to

reduce the share of floating rate and exchange rate-indexed debt. Besides, the Brazilian Treasury announced a strategy for extending the maturity of federal securities (de Mendonça and Vivian 2008).¹ The Brazilian Government adopted this strategy in order to improve credibility, based on models of public debt management (Calvo and Guidotti 1990, Giavazzi and Pagano 1990, Barro 2003, Missale, Giavazzi, and Benigno 2002, Giavazzi and Missale 2004).

Thus, it is important to verify whether public debt management policies adopted in Brazil have helped to build fiscal credibility. Furthermore, it is important to analyze whether fiscal credibility helps to improve central bank credibility under inflation targeting.

3.1. Data

The period under analysis runs from December 2001 to February 2016. The database begins in this period due to availability of data on expectations. The series used in this study are presented as follow.

The central bank credibility index (CBCI) is based on the idea of Agénor and Taylor (1992) that series of expected inflation could be applied to derive a credibility index. As Svensson (2000) proposed, the credibility can be measured by the difference between expected inflation and the target. In this sense, the credibility index is the index proposed by de Mendonça (2007). The central bank credibility index has a value equal to 1 when the annual expected inflation ($E[\pi]$) is equal to the target (π^T) 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^*) established for each year and assumes a value equal to zero when the expected inflation exceeds one of these limits. The index uses the series of inflation expectations of professional forecasters obtained from the Central Bank of Brazil (CBB), the inflation target defined by the monetary authority and the tolerance bands. Hence,

¹ See de Mendonça and Machado (2013), Gomes, Pires and Terra (2014) and de Mendonça and Pessanha (2014) for more details regarding public debt management in Brazil.

$$CBCI = \begin{cases} 1 & \text{if } E[\pi] = \pi_t^T \\ 1 - \frac{1}{\pi_t^* - \pi_t^T} [E[\pi] - \pi_t^T] & \text{if } \pi_{tMIN}^* < E[\pi] < \pi_{tMAX}^* \\ 0 & \text{if } E[\pi] \geq \pi_{tMAX}^* \text{ or } E[\pi] \leq \pi_{tMIN}^* \end{cases} \quad (1)$$

Since credibility is not something to be achieved quickly, indeed, central banks take time to earn credibility; we decide to work with the smoothed series (trend) of the credibility index obtained from the Hodrick-Prescott filter. Figure 1 shows the graph of the index and its trend.

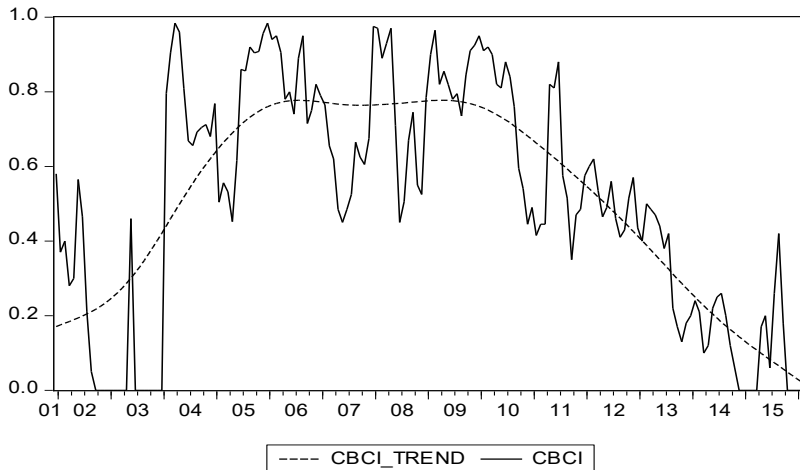


Figure 1 – Central bank credibility index

Source: author's elaboration

In terms of control variables that affect monetary policy credibility, we follow Blinder (2000). Thus, the history of honesty is an important aspect of credibility. In this sense, the success in keeping inflation under control is an important factor. We check this effect through the inflation deviation from the target (**INFD**).² We expect a negative relation between INFD and credibility. Moreover, the fight against inflation is also important to

² This series is constructed by the deviation of the inflation rate accumulated in a year (IPCA “Consumer Price Index” – series 13522 obtained from the CBB) from the inflation target.

credibility. When central bank raises the basic interest rate (**IR**),³ it represents the effort to control inflation, and therefore it is expected to increase credibility.

Since the literature recognizes the pass-through effect from exchange rate to inflation (de Mendonça and Tostes 2015, Minella *et al.* 2003), we also check the influence of the exchange rate variation (**D_ER**) on inflation.⁴ We also include in the analysis the GDP⁵ growth rate (**ΔGDP**). This variable indicates the general optimism in the economy.

The main goal of this paper is to show the relation between fiscal credibility and central bank credibility. The fiscal credibility index (FCI)⁶ is calculated based on the indicator proposed by de Mendonça and Machado (2013). Since credibility represents the belief by the public in the probability of a successful execution of the policy (Drazen 2000), and taking into account IMF's recommendation and Maastricht limits to public debt, the fiscal credibility index seeks to capture the government's commitment to public debt sustainability and, thus, the public's expectations regarding fiscal solvency. The benchmarks assumed in the fiscal credibility index are in line with the IMF's (2002) calculations. Thus, the lower limit is a public debt to GDP ratio of 40% (debt^{Min}) because it is a long-term target that should not be breached by emerging economies. The upper limit is a public debt to GDP ratio of 60% (debt^{Max}), because this debt to GDP ratio target is part of the Maastricht treaty, and thus it is a useful reference for developed countries. Since credibility is a forward-looking variable, the credibility index takes into account the information (monthly frequency) available by the CBB on market expectations regarding public debt to GDP ratio.

Therefore, based on these benchmarks, the credibility index considers the following possibilities: (i) market's expectations on the public debt for the next 12 months are lower than the lower limit (40%) - in this case the risk of fiscal imbalance is null and thus the credibility index is 1 (full credibility); (ii) market's expectations for the next 12 months are greater than the upper limit (60%) - in this case there exists a high probability that a fiscal

³ The interest rate is the nominal basic interest rate in Brazil (SELIC - series 4189 obtained from the CBB).

⁴ The exchange rate series is the nominal exchange rate (purchase, "end of period")

⁵ The GDP growth rate is the nominal GDP deflated by the general price index (IGP-DI) and seasonally adjusted. We calculated the percentage variation in 12 months.

⁶ Following de Mendonça and Machado (2013), in order to build this index we use expert's expectations for the debt/GDP ratio. The data are obtained from surveys (interviews) conducted with experts (forecasters) about their expectations for the debt/GDP ratio. The series is provided by the CBB.

imbalance occurs and thus the credibility index is 0 (null credibility); and (iii) market's expectations for the next 12 months are between the above-mentioned limits - in this case the risk of fiscal imbalance is decreasing as it approaches the lower limit and it is increasing as it approaches the upper limit, thus the range of the credibility index is from 0 to 1 (strictly) (de Mendonça and Machado, 2013). The credibility index is a result of:

$$FCI = \begin{cases} 1 & \text{if, } E_t(debt_{t+12}) \leq debt^{Min} \\ 1 - \frac{1}{debt_t^{Max} - debt_t^{Min}} [E_t(debt_{t+12}) - debt^{Min}] & \text{if, } \pi_{tMin}^* < E_t(debt_{t+12}) < debt^{Max} \\ 0 & \text{if, } E_t(debt_{t+12}) \geq debt^{Max} \end{cases} \quad (2)$$

Such as for the monetary policy credibility index, we apply the Hodrick-Prescott filter to obtain the trend of the series.

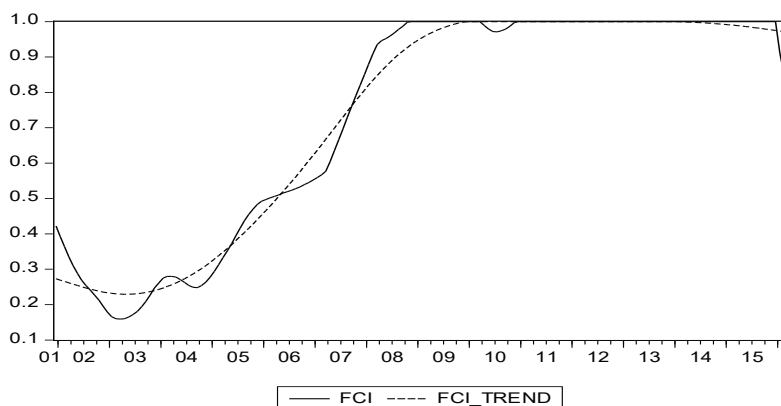


Figure 2 – Fiscal credibility index

Source: author's elaboration

In order to explain fiscal credibility, we choose a set of variables important to debt sustainability. As a consequence, fiscal credibility is undermined if public debt presents an unsustainable path. Hence, we use the primary surplus (PSBR)⁷ since it helps the stabilization of the debt/GDP ratio. We expect a negative relationship between PSBR and FCI. The debt indexa-

⁷ We use the public sector borrowing requirement, primary result, as percentage of the GDP. Series provided by the CBB (code 17244).

tion profile and the maturity of the public debt are also important to fiscal credibility (Montes and Acar 2015). The average maturity of the public debt (**AMD**)⁸ is connected to the refinancing risk. A more extended period of maturity represents a factor that reduces the amount of bonds that need to be rolled over in a period of crisis (Giavazzi and Pagano 1990). The series is used following the ideas of Giavazzi and Pagano (1990), Calvo and Guidotti (1990) and Missale, Giavazzi and Benigno (2002). It is expected a positive relation between AMD and FCI.

Regarding the debt indexation profile, following Montes and Acar (2015), we create an index to simplify the interpretation. The index is created based on the idea of Giavazzi and Missale (2004) that most of the Brazilian public debt should consist of fixed-rate bonds and price indexed bonds, and that the proportion of exchange-rate indexed bonds and interest-rate indexed bonds should be reduced in order to improve the composition of public debt and, thus, the efficiency in the management of public debt. Hence, increases in fixed rate bonds (**FIX_B**) and inflation-linked bonds (**INF_B**) represent improvements in public debt profile, whereas increases in bonds indexed to the interest rate (**INT_B**) and indexed to the BRL/dollar exchange rate (**EX_B**) indicate a deterioration of the public debt profile. Therefore, the index is calculated as:

$$INDEX = (FIX_B + INF_B) - (INT_B + EX_B) \quad (3)$$

The interpretation of the **INDEX**⁹ is straightforward. When the **INDEX** is positive, it denotes a good quality of the indexation profile. On the other hand, when the **INDEX** is negative, it represents a bad quality in the public debt profile. The expected relation between **INDEX** and FCI is positive. Figure 3 shows in the second semester of 2006 the **INDEX** became positive and there is a trend toward improvement.

⁸ Series provided by the CBB: "Dívida mobiliária federal - Títulos do Tesouro Nacional - Emitidos - Prazo médio - Total" (code 10618).

⁹ Series provided by the CBB (series code 4178 for the proportion of fixed-rate bonds, series code 12001 for the proportion of bonds indexed to the IPCA, series code 4175 for the proportion of bonds indexed to the IGP-M and series code 4176 for the proportion of bonds indexed to the IGP-DI, series code 4173 for the proportion of exchange-rate indexed bonds and series 4177 for the proportion of interest-rate (over/SELIC) indexed bonds).

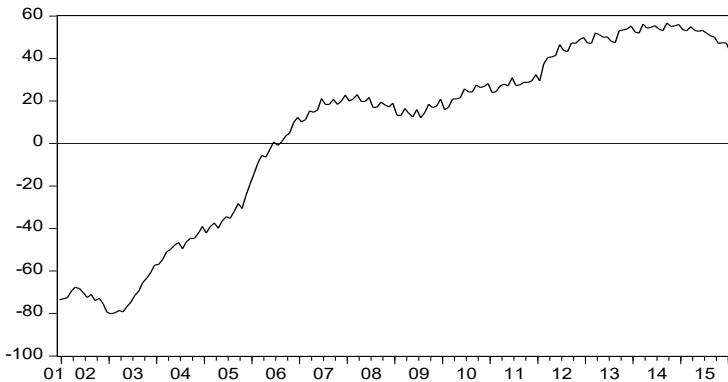


Figure 3 – Indexation profile index

Source: author's elaboration

A first condition to be analyzed, before applying the estimations, is to check if the series have unit root. Therefore, the following tests Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) were made (Table A.1, Appendix). Based on the tests, one can observe that all series are stationary.

The empirical analysis is conducted in two stages. First, the equation for fiscal credibility (FCI) is estimated, and then the equation for central bank credibility (CBCI) is estimated.

3.2. Methodology and Preliminary Analysis

The estimations make use of ordinary least squares (OLS), generalized method of moments (GMM), TOBIT and GMM system. One reason for using GMM is due to endogeneity problems. Besides, this method provides consistent estimators for the regressions (Hansen 1982). As pointed out by Wooldridge (2001, 95), “to obtain a more efficient estimator than two-stage least squares (or ordinary least squares), one must have overriding restrictions”. The weighting matrix in the equation was chosen to enable the GMM estimates to be robust, considering the possible presence of heteroskedasticity and autocorrelation of unknown form.

Overidentification analysis has an important role in the selection of instrumental variables to improve the efficiency of the estimators (Cragg 1983). We performed a standard J-test with the objective of testing this property for the validity of the overidentifying restrictions (Hansen 1982). We follow Johnston (1984) in the selection of the instruments. The chosen instruments were dated to the period $t-1$ or earlier to help predict the contemporaneous variables, which are unavailable at time t . This methodology provides instruments that correlate with the variables in the model and are orthogonal to the error term. Moreover, macroeconomic variables have a strong autoregressive component. Hence, the instruments are highly correlated with the variables in the model. We also present the Durbin–Wu–Hausman test of the endogeneity of regressors (Durbin 1954, Wu 1973, Hausman 1978).

Furthermore, we use the TOBIT method (Tobin 1958), which is an adequate method because the credibility indexes are continuous variables that assume different values between 0 and 1. It is worth noting that the values of the dependent variable (CBCI and FCI) are not concentrated in censored values. In fact, as one can see through Figure 1, the values for MCI are not concentrated at all, and the Figure 2 shows FCI concentrate less than 30% of the observations. The TOBIT model uses all of the information, including information about the censoring data, and provides consistent estimates of the parameters (Long 1997).¹⁰

We applied one lag in all variables due to the availability of information at the moment economic agents define their expectations. Expectations are affected only when the information is released. Hence, lagged variables are more suitable to explain the credibility index.

Moreover, to assure the relation we propose in this work is in the correct direction, we present in Table 1 the Granger Causality Test for the two main variables of our analysis, CBCI and FCI. Following Granger (1969), in order to address the causality between two variables one need to observe if the current value of one variable can be explained by past values of the other variable. The test measures precedence and information content. To perform the Granger Causality Test we choose the lag order based on three information criteria (Akaike, Schwarz and Hannan-Quinn), presented in the Table A.2 in the appendix. The results of the Granger Causality

¹⁰ We run TOBIT model with robust Huber-White covariance approach.

Test indicate the CBCI does not cause FCI, but the FCI is able to influence the CBCI. In this sense, FCI has time precedence over CBCI.

Table 1 – Granger Causality Teste

Null Hypothesis:	Obs	F-Statistic	Prob.
CBCI does not Granger Cause FCI	166	1.13	0.35
FCI does not Granger Cause CBCI		4.46	0.00

Source: author's elaboration

3.3. Estimations Related to Fiscal Credibility

In order to observe the behavior of the fiscal credibility, we estimated Equation 4. Following the ideas of Giavazzi and Pagano (1990), Calvo and Guidotti (1990), Missale, Giavazzi and Benigno (2002) and Giavazzi and Missale (2004), the debt indexation profile and average maturity are included in the equation. Moreover, the primary surplus is also included as a measure of the fiscal effort. Since the interest rate affects the public debt, it is expected to influence public debt expectations and therefore fiscal credibility. The GDP growth reflects general optimism and thus it is also included. Hence, the estimated equation is:

$$FCI_t = \alpha_1 + \alpha_2 PSBR_{t-1} + \alpha_3 AMD_{t-1} + \alpha_4 INDEX_{t-1} + \alpha_5 IR_{t-1} + \alpha_6 \Delta GDP_{t-1} + \varepsilon_t \quad (4)$$

Table 2 presents the estimations for Equation 4. The reported t-statistics in the OLS estimates are based on the estimator of Newey and West (1987), which is consistent with the presence of both heteroskedasticity and autocorrelation of unknown form. Regarding GMM estimations,¹¹ the J-statistic indicates that we cannot reject the hypothesis of orthogonality. In order to detect endogenous regressors, we perform the Durbin-Wu-Hausman test. The result of the Durbin-Wu-Hausman test validates the estimates.

¹¹ Instrumental variables: FCI(-1 to -3), PSBR(-2 to -4), AMD(-2 to -4), INDEX(-2 to -4), IR(-2 to -4), ΔGDP (-2 to -4).

All estimated coefficients present the expected signals. The negative signal for the PSBR suggests that higher primary deficits reduce fiscal credibility. The PSBR coefficients present statistical significance through GMM and TOBIT estimates. In turn, both AMD and INDEX variables present positive and significant coefficients through all methods. In this sense, an increase in the average maturity helps to reduce the risk of refinancing the public debt and then improve fiscal credibility. The result for the indexation profile implies fiscal authority can benefit from a proper public debt management compatible with the inflation targeting regime. Hence, when the INDEX increases, it also increases the fiscal credibility. This result corroborates the findings obtained by Montes and Acar (2015). Moreover, the basic interest rate (IR) presents a negative coefficient. When the central bank raises the basic interest rate, it increases the cost of the public debt, reducing the fiscal credibility. Moreover, the GDP growth rate presented negative coefficients, but statistical significance is not found.

In this sense, the evidence shows that the actions adopted by the National Treasury regarding the composition of public debt and lengthening the period of maturity of public debt contributed to increase fiscal credibility. Thus, our estimates reinforce the arguments and recommendations of Calvo and Guidotti (1990), Giavazzi and Pagano (1990) and Giavazzi and Missale (2004), and corroborates some findings presented by the literature (e.g., Montes and Acar 2015).

Table 2 – OLS, GMM and TOBIT estimates (dependent variable: FCI)

	OLS	GMM	TOBIT
CONSTANT	0.435 (0.301) [1.447]	0.173 (0.234) [0.741]	0.356* (0.190) [1.871]
PSBR (-1)	-0.032 (0.020) [-1.581]	-0.051*** (0.016) [-3.081]	-0.058*** (0.011) [-5.354]
AMD (-1)	0.011** (0.005) [2.287]	0.013*** (0.003) [3.780]	0.016*** (0.003) [5.165]
INDEX (-1)	0.004*** (0.001) [3.303]	0.005*** (0.001) [4.320]	0.003*** (0.001) [5.354]
IR (-1)	-0.017** (0.008) [-1.987]	-0.009 (0.007) [-1.260]	-0.029*** (0.005) [-6.114]
ΔGDP (-1)	-0.067 (0.394) [-0.169]	-0.259 (0.291) [-0.889]	-0.305 (0.254) [-1.204]
R ²	0.915	0.899	
R ² Adjusted	0.913	0.895	
F-Statistic (p-value)	0.000		
Left Censored Obs			0
Right Censored Obs			49
Uncensored Obs			110

Residual and Stability Diagnostics

Ramsey-RESET(1) (p-value)	0.000
Jarque-Bera (p-value)	0.005
ARCH(1) (p-value)	0.000
ARCH(2) (p-value)	0.000
LM(1) (p-value)	0.000
LM(2) (p-value)	0.000
Durbin-Wu-Hausman (p-value)	0.998
J-Statistic (p-value)	0.101
Instrument Rank	19

Source: author's elaboration Notes: Marginal Significance Levels: *** denotes 0.01, ** denotes 0.05 and * denotes 0.1. Coefficients in bold, standard errors in parentheses and *t*-statistics in square brackets. Regarding OLS estimates, due to the problems of autocorrelation and heteroscedasticity, the reported *t*-statistics in the OLS estimates are based on the estimator of Newey and West (1987).

3.4. Estimations Related to Monetary Policy Credibility

Aiming to verify the relation between fiscal credibility and central bank credibility, we estimate Equation 5. Equation 5 includes control variables based on the contribution of Blinder (2000) and Minella *et al.* (2003). Blinder (2000) addresses the topic through a survey applied to policymakers and academics. The results highlight the importance of the history of honesty, the history of fighting against inflation and small fiscal debts to construct and maintain credibility. Montes and Nicolay (2016) addresses the issue empirically, and relate the history of honesty to the inflation deviation, and the behavior to fight against inflation to the interest rate. Besides, we follow the idea of Minella *et al.* (2003) that the exchange rate variation is important to the credibility in Brazil. Hence, the estimated equation is:

$$CBCI_t = \beta_1 + \beta_2 INFD_{t-1} + \beta_3 IR_{t-1} + \beta_4 D_ER_{t-1} + \beta_5 \Delta GDP_{t-1} + \beta_6 FCI_{t-1} + \nu_t \quad (5)$$

Table 3 presents the estimates. The reported t-statistics in the OLS estimates are based on the estimator of Newey and West (1987). In terms of GMM estimation,¹² the J-statistic indicates that we cannot reject the hypothesis that the instrument selection is correctly specified. The result of the Durbin-Wu-Hausman test validates the estimates.

The estimates present the expected coefficients. The positive and significant signal for the coefficient of IR and the negative and significant signal for INFD corroborate the arguments of Blinder (2000). The inflation deviation has a negative influence over central bank credibility. When the inflation deviates from the target it captures the lack of commitment of the central bank with the goal of price stability, and as a consequence, it reduces central bank credibility. In turn, the results suggest that an increase in the basic interest rate (IR) indicate the commitment of the central bank to keeping inflation under control and thus increases central bank credibility. The estimated coefficients for D_ER indicate a negative and significant relation between exchange rate variations and monetary policy credibility. This result corroborates the idea of Minella *et al.* (2003) that the pass-through effect is relevant to the central bank credibility in an emerging economy.

¹² Instrumental variables: CBCI(-1 to -3) INFD(-2 to -4) IR(-2 to -4) D_ER(-2 to -4) ΔGDP(-2 to -4) FCI(-2 to -4)

Moreover, the GDP growth rate (ΔGDP) presents a positive and significant coefficient in all estimates. Hence, when the GDP grows, it improves the optimism in the economy and presents a positive influence over central bank credibility.

Regarding fiscal credibility, the estimated coefficients for the FCI variable present positive signals, suggesting fiscal credibility has a positive relation with central bank credibility. Since fiscal credibility is related to the expected capacity of the fiscal authority to honor its debts and to provide public debt sustainability, the positive signal of the estimated coefficient indicates when the fiscal authority is committed to a sound fiscal policy it helps to increase monetary policy credibility. This result reinforces the argument of King (1995) that fiscal discipline enhances monetary policy credibility.

Thus, the results indicate that when there is a commitment of the monetary authority and the government to their goals, an increase in central bank credibility is verified.

Table 3 – OLS, GMM and TOBIT estimates (dependent variable: CBCI)

	OLS	GMM	TOBIT
CONSTANT	0.014 (0.257) [0.055]	-0.024 (0.157) [-0.154]	0.014 (0.135) [0.105]
INFD (-1)	-0.033* (0.017) [-1.931]	-0.055*** (0.009) [-6.204]	-0.033*** (0.009) [-3.516]
IR (-1)	0.027** (0.012) [2.275]	0.033*** (0.007) [4.451]	0.027*** (0.006) [4.228]
D_ER (-1)	-0.620*** (0.191) [-3.248]	-1.822*** (0.311) [-5.861]	-0.621*** (0.1558) [-3.983]
FCI(-1)	0.152 (0.176) [0.866]	0.259** (0.103) [2.520]	0.152* (0.090) [1.684]
Δ GDP (-1)	2.556*** (0.660) [3.874]	1.454*** (0.401) [3.629]	2.556*** (0.374) [6.838]
R ²	0.484	0.274	
R ² Adjusted	0.468	0.251	
F-Statistic (p-value)	0.000		
Left Censored Obs			0
Right Censored Obs			0
Uncensored Obs			169

Residual and Stability Diagnostics

Ramsey-RESET(1) (p-value)	0.069	
Jarque-Bera (p-value)	0.167	
ARCH(1) (p-value)	0.000	
ARCH(2) (p-value)	0.000	
LM(1) (p-value)	0.000	
LM(2) (p-value)	0.000	
Durbin-Wu-Hausman (p-value)		0.859
J-Statistic (p-value)		0.321
Instrument Rank		19

Source: author's elaboration Notes: Marginal Significance Levels: *** denotes 0.01, ** denotes 0.05 and * denotes 0.1. Coefficients in bold, standard errors in parentheses and *t*-statistics in square brackets. Regarding OLS estimates, due to the problems of autocorrelation and heteroscedasticity, the reported *t*-statistics in the OLS estimates are based on the estimator of Newey and West (1987).

3.5. *Systems of Simultaneous Equations*

A way of testing the validity of the equations and coefficients previously achieved is through estimates based on system of equations. For treating possible problems of endogeneity, the use of a system of equations, which applies GMM, is adequate for estimating non-biased coefficients. Thus, in order to give robustness for the results presented in the previous sections, the following system of equations presented below is estimated.¹³ One can observe that the system of equations is formed by both Equations (4) and (5).

$$\text{System} = \begin{cases} FCI_t = \alpha_1 + \alpha_2 PSBR_{t-1} + \alpha_3 AMD_{t-1} + \alpha_4 INDEX_{t-1} + \alpha_5 IR_{t-1} + \alpha_6 \Delta GDP_{t-1} + \varepsilon_t \\ CBCI_t = \beta_1 + \beta_2 INFD_{t-1} + \beta_3 IR_{t-1} + \beta_4 D_ER_{t-1} + \beta_5 \Delta GDP_{t-1} + \beta_6 FCI_{t-1} + \nu_t \end{cases}$$

The results presented in Table 4 corroborate the previous findings for the relation between fiscal credibility and monetary policy credibility. All coefficients present the same signals and statistical significance, except ΔGDP in the FCI equation. The J-test indicates the instruments respect the orthogonality restriction. Hence, the evidences based on the GMM system provide robustness to previous results.

¹³ The system of simultaneous equations estimated through GMM applied the same instrumental variables of the individual equations estimated through GMM

Table 4 – GMM system estimates

	Equation 1		Equation 2
	Dependent Variable: FCI		Dependent Variable: CBCI
CONSTANT	0.141 (0.211) [0.665]	CONSTANT	0.025 (0.136) [0.181]
NFSP (-1)	-0.048*** (0.013) [-3.638]	INFD (-1)	-0.057*** (0.007) [-8.004]
AMD (-1)	0.016*** (0.003) [4.754]	IR (-1)	0.030*** (0.006) [4.890]
INDEX (-1)	0.004*** (0.001) [4.552]	D_ER (-1)	-2.046*** (0.321) [-6.369]
IR (-1)	-0.013* (0.007) [-1.916]	FCI(-1)	0.225** (0.087) [2.568]
Δ GDP (-1)	0.091 (0.255) [0.355]	Δ GDP (-1)	1.339*** (0.368) [3.641]
R ²	0.907		0.182
R ² Adjusted	0.904		0.156
J-Statistic		0.171	
Prob (J-Statistic)			

Source: author's elaboration Notes: Marginal Significance Levels: *** denotes 0.01, ** denotes 0.05 and * denotes 0.1. Coefficients in bold, standard errors in parentheses and *t*-statistics in square brackets.

The estimates show the importance of public debt management and government commitment to fiscal targets for building fiscal credibility. In other words, the improvement in the composition of public debt, a more extended period of maturity of public debt and the commitment to the fiscal targets contributed to the increase of fiscal credibility. Regarding the determinants of central bank credibility, the findings corroborate those already found and, in particular, the estimates of the system reveal, as well as in the individual estimates, the influence of fiscal credibility on central bank credibility.

4. Conclusion

This study investigates the relation between fiscal credibility and central bank credibility in Brazil. A relevant finding obtained through the empirical analysis is the influence of fiscal credibility on central bank credibility, i.e., fiscal credibility has a positive relation with central bank credibility. In other words, when agents form expectations that public debt is under control, these expectations end up influencing inflation expectations.

Moreover, since 2002, the National Treasury has promoted improvements in public debt management that were important to fiscal credibility: the improvement in the indexation profile and the lengthening of the country's average debt maturity. The analysis showed the commitment to an appropriate debt management and responsible fiscal policies are important to fiscal credibility.

Regarding central bank credibility, the analysis showed that inflation deviations from the target and currency devaluations have a negative effect on central bank credibility. In turn, increases in the basic interest rate show the public the commitment of the central bank to a specified inflation.

References

- Agénor, P., Taylor, M. P. 1992. "Testing for credibility effects". *IMF Staff Papers*, 39, September, 545–71.
- Barro, R. J. 2003. "Optimal management of indexed and nominal debt". *Annals of Economics and Finance, Society for AEF*, 4 (1), 1-15.
- Blinder, A. S. 2000. "Central-Bank credibility: why do we care? How do we built it?" *The American Economic Review*, 90 (5), 1421-1431.
- Calvo, G., Guidotti, P. 1990. "Indexation and maturity of government bonds: an exploratory model." In: R. Dornbusch and M. Draghi, *Public Debt Management: Theory and History*, Cambridge, Cambridge University Press.
- Cragg, J. G. 1983. "More efficient estimation in the presence of heteroscedasticity of unknown form." *Econometrica*, 51 (3), 751-763.
- de Mendonça, H. F. 2007. "Towards credibility from inflation targeting: the Brazilian experience." *Applied Economics*, 39 (20), 2599–2615.
- de Mendonça, H. F., Vivian, V. S. 2008. "Public-debt management: the Brazilian experience." *CEPAL Review*, 94, 145-162.
- de Mendonça, H. F., de Guimarães e Souza, G. J. 2012. "Is inflation targeting a good remedy to control inflation?" *Journal of Development Economics*, 98 (2), 178–191.

- de Mendonça, H. F., Machado, M. R. 2013. "Public Debt Management and Credibility: Evidence from an emerging economy." *Economic Modelling*, 30 (1), 10-21.
- de Mendonça, H. F., Pessanha, K. M. 2014. "Fiscal insurance and public debt management: Evidence for a large emerging economy." *Economia*, 15 (2), 162-173.
- de Mendonça H. F., Tostes F. S. 2015. "The effect of monetary and fiscal credibility on exchange rate pass-through in an emerging economy." *Open Economies Review*, 26 (4), 787-816.
- Drazen, A., 2000. "Political Economy in Macroeconomics." Princeton University Press, New Jersey.
- Durbin, J. 1954. "Errors in variables." *Review of the International Statistical Institute*, 22, 23-32.
- Giavazzi, F., Pagano M. 1990. "Confidence crises and public debt management." In R. Dornbusch and M. Draghi, "Public Debt Management: Theory and History", Cambridge, Cambridge University Press.
- Giavazzi, F., Missale, A., 2004. Public Debt Management in Brazil. NBER Working Paper n. 10394.
- Gomes, C., Pires, M. C. C., Terra, F. H. B. 2014. "The effects of public debt management on macroeconomic equilibrium: An analysis of the Brazilian economy." *Economia*, 15 (2), 174-188.
- Granger, C. W. J. 1969. "Investigating Causal Relations by Econometric Models and Cross-spectral Methods." *Econometrica*, 37 (3), 424-438.
- Hansen, L. P. 1982. "Large sample properties of generalized method of moments estimators." *Econometrica*, 50 (4), 1029-1054.
- Hausman, J. 1978. "Specification tests in econometrics." *Econometrica*, 46 (6), 1251-1271.
- Hendry, D. F. 2001. "Achievements and challenges in econometric methodology." *Journal of Econometrics*, 100 (1), 7 - 10.
- IMF - International Monetary Fund, 2002. "Assessing sustainability." Prepared by the Policy Development and Review Department. In consultation with the Fiscal Affairs, International Capital Markets, Monetary and Exchange Affairs, and Research Departments, May 28.
- Johnston, J. 1984. "Econometric Methods", McGraw-Hill.
- Kydland, F. E., Prescott, E. C. 1977. "Rules rather than discretion: the inconsistency of optimal plans." *Journal of Political Economy*, 85 (3), 473-492.
- King, M. 1995. "Commentary: Monetary policy implications of greater fiscal discipline." In: Budget deficits and debt: issues and options. Federal Reserve Bank of Kansas City, 171-182.
- Koop, G., Pesaran, M. H., Potter, S. M., 1996. Impulse response analysis in non-linear multivariate models. *Journal of Econometrics*, 74 (1), 119-147.
- Long, J. S. 1997. "Regression models for categorical and limited dependent variables." SAGE Publications. London.
- MacKinnon, J. G., Haug, A. A., Michelis, L. 1999. "Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration." *Journal of Applied Econometrics*, 14 (5), 563-577.
- Minella, A. Springer, P. F., Goldfajn I., Muinhos M. K. 2003. "Inflation targeting in Brazil constructing credibility under exchange rate volatility." *Journal of International Money and Finance*, 22 (7), 1015-1040.
- Mishkin, F. S. 2007. *Monetary Policy Strategy*, The MIT Press.
- Mishkin, F. S., 2008. Can inflation targeting work in emerging market countries? In: Carmen M. Reinhart, Carlos A. Vegh, and Andres Velasco, "Money, Crises, and Transition: Essays in Honor of Guillermo A. Calvo", MIT Pres.
- Missale, A., Giavazzi, F., Benigno, P., 2002. How is debt managed? Learning from fiscal stabilization. *The Scandinavian Journal of Economics*, 104 (3), 443-469.
- Montes, G. C. 2010. "Uncertainties, monetary policy and financial stability: challenges on inflation targeting." *Revista de Economia Política*, 30 (1), 60-85.
- Montes, G. C. 2013. "Credibility and monetary transmission channels under inflation targeting: an econometric analysis from a developing country." *Economic Modelling*, 30, 670-684.

- Montes, G. C., Acar, T. 2015. "Determinants of Fiscal Credibility and Country Risk in Brazil: An Empirical Analysis." *The Empirical Economics Letters*, 14, 409-420.
- Montes, G. C., Bastos, J. C. A. 2014. "Effects of reputation and credibility on monetary policy: theory and evidence for Brazil." *Journal of Economic Studies*, 41 (3), 387-404.
- Montes, G. C., Nicolay, R. T. F. 2016. "Does clarity of central bank communication affect credibility? Evidences considering governor-specific effects." *Applied Economics*.
- Montes, G. C., Curi, A., 2016. "The importance of credibility for the conduct of monetary policy and inflation control: theoretical model and empirical analysis for Brazil under inflation targeting." *Planejamento e Políticas Públicas*, 46, 13-37.
- Newey, W., West, K. 1987. "A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix." *Econometrica*, 55 (3), 703-708.
- Pesaran, M. H., Shin, Y. 1998. "Generalized impulse response analysis in linear multivariate models." *Economic Letters*, 58 (1), 17-29.
- Sargent, T. J., Wallace, N. 1981. "Some unpleasant monetarist arithmetic." *Quarterly Review Federal Reserve Bank of Minneapolis*, 5 (3), 1-17.
- Shirakawa, M. 2012. "The Importance of Fiscal Sustainability: Preconditions for Stability in the Financial System and in Prices." Remarks at the Banque de France Financial Stability Review Launch Event in Washington D.C., April.
- Sims, C. 1980. "Macroeconomics and reality". *Econometrica*, 48 (1), 1-48.
- Sims, C. 2004. "Limits to inflation targeting." In: Bernanke B. and Woodford, M. (eds.), *The inflation targeting debate*, The University of Chicago Press, pp. 283- 308
- Svensson, L. E. O. 2000. "How should monetary policy be conducted in an era of price stability?" NBER Working Paper, N. 7516.
- Tobin, J. 1958. "Estimation of relationships for limited dependent variables". *Econometrica*, 26 (1), 24-36.
- Walsh, C. E. 2009. "Inflation targeting: what have we learned?" *International Finance*, 12 (2), 195-233.
- Wooldridge, J. M. 2001. "Applications of generalized method of moments estimation." *Journal of Economic Perspectives*, 15 (4), 87-100.
- Wu, D. M. 1973. "Alternative tests of independence between stochastic regressors and disturbances". *Econometrica*, 41 (4), 733-750.
- Yellen, J. 2006. "Enhancing FED credibility." Luncheon Keynote Speech to the Annual Washington Policy Conference Sponsored by the National Association for Business Economics (NABE), Washington (D.C.).

Appendix

Table A.1 – Unit Root Tests

Series	Leg Length	ADF			PP			KPSS				
		Forma	Teste	10%	Bandwidth	Forma	Teste	10%	Forma	Bandwidth	Teste	1%
AMD	22	I/T	-3.43	-3.14	3.08	I/T	-3.36	-3.14	I/T	44.7	0.14	0.22
D_EXCH	10	I/T	-5.49	-3.14	0.661	N	-9.18	-1.62	I/T	4.88	0.14	0.22
PSBR	9	I	-3.59	-2.58	2.61	N	-1.36	-1.62	I/T	47.1	0.15	0.22
ΔGDP	13	I	-3.16	-2.58	8	N	-1.95	-1.62	I	10	0.26	0.74
INDEX	12	I	-3.38	-2.58	0.429	N	-1.62	-1.62	I	141	0.42	0.74
INF_DEV	13	I/T	-1.60	-3.14	7.33	N	-2.25	-1.62	I	60.7	0.15	0.74
SELIC	13	I	-3.55	-2.58	20	N	-0.90	-1.62	I	129	0.38	0.74

Source: author's elaboration Notes: "I" denotes intercept; "I/T" denotes intercept and trend; and "N" denotes none. The final lag selection in the ADF tests was made based on the Akaike information criteria. PP and KPSS spectral estimation method is Bartlett kernel and the Andrews Bandwidth is used.

Table A.2 – Lag order selection - Granger Causality Test

Lag	AIC	SC	HQ
0	0.468	0.506	0.483
1	-16.691	-16.577	-16.644
2	-27.377	-27.188	-27.300
3	-33.000	-32.734	-32.892
4	-35.149	-34.808	-35.011
5	-35.803*	-35.385*	-35.633*
6	-35.7780	-35.284	-35.578
7	-35.7584	-35.189	-35.527
8	-35.7281	-35.083	-35.466

* indicates lag order selected by the criterion

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion