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A NOTE ON OPENNESS AND INFLATION TARGETING: IMPLICATIONS FOR THE UNPLEASANT FISCAL ARITHMETIC

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Emerging economies that have adopted inflation targeting and that combine low credibility, high public debt, and a high interest rate suffer from a typical problem. Increases in the interest rate to reduce departures of inflation from the target imply that a higher primary surplus is required for stabilizing public debt/GDP ratio. This tricky situation is known as "unpleasant fiscal arithmetic" (UFA). This article develops a theoretical model showing how increased financial openness and capital account liberalization can mitigate UFA. Furthermore, empirical evidence from the Brazilian case through OLS, GMM, and GMM system methods is offered. The findings show that increases in capital mobility and financial openness work as a commitment technology, which contributes to the success of the inflation targeting and thus reduces the risk of UFA.

Keywords: Inflation Targeting, Financial Openness, Unpleasant Fiscal Arithmetic, Credibility

1. INTRODUCTION

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 an inflation-targeting regime, interest rate is the main instrument available to the central bank for managing the monetary policy. Moreover, in countries such as Brazil, public debt is strongly indexed to the interest rate. Therefore, increases in interest rate to reach the inflation target imply increases in the primary surplus required for stabilizing the public debt/GDP ratio. This tricky situation is known as "unpleasant fiscal arithmetic" (UFA) and it is necessary to find frameworks capable of mitigating it.

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In the search for mechanisms capable of avoiding the inflation bias of discretionary monetary policy, financial openness and capital account liberalization are pointed to as a solution.[1] The main idea is that greater freedom for capital flow reduces the time-inconsistency problem in monetary policy. Therefore, it is possible to consider openness as a strategy for avoiding UFA. This article makes a contribution in this direction. A theoretical model is developed showing how an increase in openness contributes to the convergence between inflation and its target and thus to decreasing the primary surplus. Furthermore, empirical evidence concerning UFA from the Brazilian case is offered.

The remainder of this paper is organized as follows. The next section presents a small survey of the relation between capital mobility and its effects on the inflation rate. Section 3 develops a theoretical model that considers how an increase in financial openness can mitigate UFA. Section 4 provides empirical evidence, through an econometric analysis, for the Brazilian case. The last section presents the conclusion.

2. CAPITAL MOBILITY AND LOW INFLATION

Rogoff (2003) shows that market globalization has a double role: it implies a decrease in the price of goods and contributes to the settlement of lower inflation targets. Furthermore, the increase in competitiveness increases price flexibility and thus weakens the impact of monetary policy on the economy.

As observed by Obstfeld and Taylor (1998), when capital controls are eliminated, the monetary authority needs to choose between adopting a fixed exchange rate or an independent monetary policy. The reason is that the combination of these elements is not feasible. According to Dornbusch (1998), independent of the exchange rate regime, the capital account liberalization is a constraint on monetary policy. In short, an increase in openness implies an increase in the central bank's commitment to low and stable inflation.

As highlighted by Frankel (1999), a combination of an administered exchange rate and an independent monetary policy is feasible through an intermediate capital control. Although this is possible, a lack of central bank credibility implies a fear of floating the exchange rate [Calvo and Reinhart (2002)]. This observation is important because in the case of low credibility the impact of fluctuations of the exchange rate on inflation and on the financial system is not negligible.

Focusing on inflation, one of the main channels for the effect of capital account liberalization is money demand elasticity. One possibility due to an increase in liberalization is that people will make the substitution of domestic currency for foreign currency in the case of a lack of confidence. Therefore, greater capital mobility can penalize the central bank when it adopts an inflationary monetary policy. As observed by Romer (1993), countries with greater trade openness have lower inflation. The main reason is that a nonexpected inflationary policy causes currency devaluation, and thus the pass-through is greater in economies that are more open. Furthermore, an increase in openness implies an increase in the cost

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of an inflationary policy because of the greater competition among the countries, which in turn implies a higher risk of financial capital loss [Wagner (2001); Cooke (2010)].

Gruben and McLeod (2001) provide empirical evidence that an increase in capital mobility is associated with a lower inflation. These authors, considering a cross section of 100 countries, found a strong negative relation between inflation and capital account liberalization. These results are also observed in Gupta (2008) through the use of a dynamic panel data model based on 163 countries for the period from 1980 to 2003.

3. OPENNESS AND THE CONVERGENCE OF INFLATION TO THE TARGET

The main objective of this section is to present a theoretical model where openness (financial and capital account liberalization) works as a commitment technology that contributes to the convergence between inflation expectations and the inflation target.[2] According to the literature on capital account liberalization, this strategy would be desirable because it avoids the problem of time inconsistency in the management of monetary policy.[3]

Openness creates a punishment for the monetary authority in the case of an inflationary policy. The punishment occurs through the substitution of currencies, implying a fall in the central bank's reserves (in the case of fixed exchange rate) or an increase in inflation due to a currency devaluation (in the case of flexible exchange rate). Because the private capital flows depend on the inflation expectation, this channel implies that openness reduces the central bank's inflationary bias.

The success of inflation targeting depends on the public believing that the target will be reached. In the search for this objective, the main instrument for the central bank is the interest rate [Freedman and Ötker-Robe (2010)]. However, the settlement of the interest rate may consider the impact on the dynamics of the public debt and the future performance of the economy. The use of a high interest rate (tight monetary policy) in an attempt to reach the inflation target demands a large primary surplus as a way to impede an explosive path for the public debt.[4]

This model considers an inflation-targeting environment. Hence, the main objective of the central bank is to reach the inflation target (π^*). Furthermore, the relation between households and firms is observed through the labor market. The households decide the labor supply based on the real wage. Therefore, inflation expectations (π_t^e) have a crucial role in this process. Moreover, the real wage is a determinant of labor demand by firms. Hence, when the inflation (π_t) is different from the inflation expectations, the consequence is a change in the output (y_t). Specifically, when the inflation is greater than the inflation expectation ($\pi_t - \pi_t^e > 0$), the result is an output greater than that which corresponds to flexible prices ($\bar{y}$). Consequently, the output (in logs) is given by

$$y_t = \bar{y} + (\pi_t - \pi_t^e) - z_t, \quad z_t \sim N(0, \sigma^2), \tag{1}$$

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where z_t is a random supply shock. The monetary authority defines the policy to be adopted in the period t after the public's inflation expectations in $t-1$ and to observe the occurrence of any supply shock.

The central bank's loss function,

$$L_{\mathrm{CB}_t} = (y_t - y^*)^2 + \chi(\pi_t - \pi^*)^2, \tag{2}$$

where χ is a positive constant and gives the relative weight that the central bank attributes to the inflation stabilization, follows the standard in the literature; that is, it considers the departures of inflation from the target and of output from the socially optimal level (y^*).

As a manner of considering the time inconsistency problem due to the presence of an inflationary bias in the model, the socially optimal output is greater than for full employment. According to Kydland and Prescott (1977) and Barro and Gordon (1983), this assumption is a consequence of, for example, positive marginal taxation (the households do not receive all advantages from additional work) or imperfect competition (firms do not receive all advantages from additional output). Hence, $y^* - \bar{y} = k > 0$, where k is the central bank's inflationary bias. Making the substitution of equation (1) into equation (2),

$$L_{\mathrm{CB}_t} = \left(\pi_t - \pi_t^e - k - z_t\right)^2 + \chi(\pi_t - \pi^*)^2. \tag{3}$$

Assuming that the public has rational expectations and knows the central bank's loss function, the monetary authority's problem is to reach the inflation capable of minimizing its losses. Therefore, based on (3),

$$\pi_t = \frac{\pi_t^e + k + z_t + \chi\pi^*}{1+\chi}. \tag{4}$$

Therefore, the monetary authority's optimal inflation is a function of the expected inflation rate. Because that uncertainty is not considered in the model, the public anticipates the inflation rate that will be implemented by the central bank. As a consequence, the inflation expectations built up in the period $t-1$ correspond to

$$\pi_t^e = E_{t-1}(\pi_t) = E_{t-1}\left(\frac{\pi_t^e + k + z_t + \chi\pi^*}{1+\chi}\right). \tag{5}$$

When $E_{t-1}(z_t) = 0$, expected inflation is

$$\pi_t^e = \pi^* + k/\chi. \tag{6}$$

Hence, an increase in the gap between the socially optimal output and the equilibrium with flexible prices (k) implies an increase in the expected inflation rate. Because of the possibility of the central bank settling the interest rate after observing the public's inflation expectations, the ex post optimal result is different from the ex ante, and thus a dynamic inconsistency problem is created. In other words, if the central bank states an inflation target π^* and the public believes that

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this target will be reached, then $\pi_t^e = \pi^*$. However, after the public's expectations are known, the monetary authority has an incentive to implement greater inflation to achieve the optimal social output ($\pi > \pi^*$). Therefore, assuming rational expectations, the public's expectations become $\pi_t^e > \pi^*$.

In the model, a greater the relative weight given by the monetary authority for price stability over a greater output, the lower is the inflation expectation. In other words, as highlighted by Rogoff (1985), when the public knows that the monetary policy is managed by a conservative central banker, the result is a lower inflation expectation. In brief, as private capital flows are associated with inflation expectations, it is expected that an increase in the capital account liberalization decreases the central bank's inflation bias.

Taking into account the effect of capital mobility on the central bank's loss function, equation (3) can be rewritten as

$$L_{\mathrm{CB}_t} = \left[\mu\left(\pi_t - \pi_t^e\right) - k - z_t\right]^2 + \chi(\pi_t - \pi^*)^2, \tag{7}$$

where μ is a positive constant and refers to the level of control on the capital account. The main idea is that the adoption of capital controls implies an increase in the asymmetric information between the central bank and the public. Hence, a market failure is created and the consequence is an increase in the central bank's inflationary bias. Therefore, the monetary authority's problem is

$$\min_{\pi_t} L_{\mathrm{CB}_t} = \left[\mu\left(\pi_t - \pi_t^e\right) - k - z_t\right]^2 + \chi(\pi_t - \pi^*)^2, \tag{8}$$

and thus

$$\pi_t = \frac{\mu^2\pi_t^e + \mu k + \mu z_t + \chi\pi^*}{\mu^2 + \chi}. \tag{9}$$

The inflation expectations built in the period $t-1$ are given by

$$\pi_t^e = E_{t-1}(\pi_t) = E_{t-1}\left(\frac{\mu^2\pi_t^e + \mu k + \mu z_t + \chi\pi^*}{\mu^2 + \chi}\right), \tag{10}$$

and thus expected inflation is

$$\pi_t^e = \pi^* + \frac{\mu k}{\chi}. \tag{11}$$

This equation shows an important implication. As a decrease in capital controls leads to a lower μ, there is an increase in the central bank's commitment to achieve the inflation target, thus contributing to a convergence between inflation expectation and the target. This result is in consonance with the idea that a greater capital flow promotes a decrease in the inflation rate, even if the central bank is not fully committed to a low inflation policy ($k/\chi > 0$).

In recent years several emerging economies have used the tripod of flexible exchange rate, inflation targeting, and fiscal balance as a rule of thumb. In a

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general way, these economies search for a high level of credibility and are subject to UFA. In other words, when it is necessary to decrease inflation and there is not sufficient credibility, the consequence is an increase in the interest rate, which in turn creates an increase in the public debt/GDP ratio. Hence, the lack of credibility implies a cost, which is the primary surplus necessary to ensure fiscal balance [King (1995)].

Based on the previous model and arguments presented in King (1995) and Rogoff (2003), it is possible to see that the openness can avoid UFA because it works as a commitment technology that ensures the convergence of inflation expectations to the target. Hence, assuming that the seigniorage is negligible and the public deficit is financed by issue of public bonds, the dynamic of public debt is

$$\dot{D} = -\mathrm{PS}_t + r_t^{\mathrm{N}} D_t, \tag{12}$$

where D is the public debt, PS is the primary surplus, and r^{N} is the nominal interest rate.

When both D and PS are divided by the nominal GDP, to give d and ps, respectively, equation (12) can be rewritten as

$$\dot{d} = d_t \left(r_t^{\mathrm{N}} - g_t - \pi_t\right) - \mathrm{ps}_t, \tag{13}$$

where g is the economic growth rate; π is the inflation rate; and $(r_t^{\mathrm{N}} - g_t - \pi_t)$ gives the increase in the public debt due to the interest rate discounting the economic growth and the inflation rate.

Because the real interest rate is $r_t = r_t^{\mathrm{N}} - \pi_t^e$, equation (13) corresponds to

$$\dot{d} = d_t \left[(r_t - g_t) + \left(\pi_t^e - \pi_t\right)\right] - \mathrm{ps}_t. \tag{14}$$

With the objective of observing the adoption of inflation targeting, this model considers an environment without full central bank credibility and where the inflation target (π^*) is lower than the current inflation (π_0). As a consequence, the convergence of inflation to the target takes place in a sluggish manner. The main idea is that low central bank credibility impedes the inflation targeting working as a guide for inflation expectations. Therefore, low convergence between inflation and the target is expected in this case. On the other hand, while the target is achieved over time, the credibility (α_t) improves and thus the inflation expectations are near the target; thus

$$\pi_t^e = \pi^* - (\pi^* - \pi_0)e^{-\alpha_t}. \tag{15}$$

In regard to the fiscal balance, the primary surplus necessary to maintain the public debt/GDP ratio stable at its original level (d_0) is

$$\mathrm{ps}_t = (r_t - g_t)d_0 + (\pi_0 - \pi^*)d_0 e^{-\alpha_t}, \tag{16}$$

where the first part of the right-hand side of the equation shows the effect caused by a real interest rate higher than the economic growth rate on the public debt. The second part apprehends the effect of credibility on the public debt.

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A lower credibility implies a greater impact of the deviations in inflation from its target,

$$\lim_{\alpha_t \to 0} (\pi_0 - \pi^*) d_0 e^{-\alpha_t} = (\pi_0 - \pi^*) d_0. \tag{17}$$

Therefore the increase in the primary surplus necessary to hold the public debt/GDP ratio constant in an environment without full credibility is

$$\Delta \mathrm{ps}_t = (\pi_0 - \pi^*) d_0 e^{-\alpha_t}. \tag{18}$$

Based on Rogoff (2003) and King (1995), capital mobility can work as an increase in the required credibility for avoiding UFA. Hence, departures of inflation expectations from the target, taking into account the relevance of the openness, corresponds to

$$\pi_t^e = \pi^* - \frac{\mu k}{\chi}(\pi^* - \pi_t) \text{ or } \pi_t^e = \pi^* - \frac{(\pi^* - \pi_t)}{\chi/\mu k}, \quad \text{where } \pi_t = \pi_0. \tag{19}$$

The intuition behind equation (19) is similar to that in equation (11); that is, openness contributes to the convergence between the inflation expectations and the inflation target. With the objective of observing the direct effect of capital controls (μ) on the public's inflation expectations and assuming the central bank's preference for inflation stabilization and inflation bias are constant ($\chi = 1$ and $k = 1$), equation (19) is simplified to

$$\pi_t^e = \pi^* - \frac{(\pi^* - \pi_t)}{1/\mu}. \tag{20}$$

Such As presented in equation (15), an increase in openness (β) over time provokes a quick adjustment of the inflation expectations to the target, and thus

$$\pi_t^e = \pi^* - (\pi^* - \pi_t) e^{-\beta_t}, \tag{21}$$

where $\beta_t = 1/\mu_t$. Hence, the primary surplus needed to maintain the stability of the public debt, considering the effect of capital account liberalization, is

$$\mathrm{ps}_t = (r_t - g_t) d_0 + (\pi_t - \pi^*) d_0 e^{-\beta_t}. \tag{22}$$

The second part of the right-hand side of this equation indicates that an increase in openness contributes to a lower primary surplus because of the divergence between inflation and the target. Hence, in the case of perfect capital mobility,

$$\lim_{\beta_t \to 0} (\pi_t - \pi^*) d_0 e^{-\beta_t} = 0. \tag{23}$$

Contrary to this, when the capital account liberalization is near zero, deviation of the inflation from the target provokes an increase in primary surplus; thus,

$$\lim_{\beta_t \to 0} (\pi_t - \pi^*) d_0 e^{-\beta_t} = (\pi_t - \pi^*) d_0. \tag{24}$$

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Therefore, in an environment with imperfect capital mobility, the increase in primary surplus that is necessary to maintain stable public debt/GDP is

$$\Delta \text{ps}_t = (\pi_t - \pi^*) d_0 e^{-\beta_t}. \quad (25)$$

Therefore, greater capital mobility attenuates fiscal effort because it contributes to the convergence of the public's inflation expectations to the target. In brief, greater openness strengthens the central bank's commitment to achieve the inflation target and thus reduces UFA.

4. EMPIRICAL ANALYSIS

According to Sargent and Wallace (1981), a combination of two factors puts control over inflation at risk. The use of high interest rates, in an attempt to avoid inflationary pressure, implies a negative impact on consumption and investment, which in turn decreases economic growth. Another concern is that high interest rates produce fiscal imbalances because of the increase in public debt. These factors are crucial for the analysis of UFA, because it assumes an environment where the central bank does not have full credibility, high interest rates are practiced after the adoption of inflation targeting, and the public debt is strongly indexed to the interest rate.

Brazil possesses these features and, thus, an empirical analysis of its economy may observe if the openness attenuates the problem, as indicated by the theoretical model [see de Mendonça and Silva (2009)]. Over the period from 1999 to 2010 the real interest rate was greater than the economic growth rate a large part of the time (see Figure 1). This observation suggests an environment of low central bank credibility (high interest rates for controlling inflation) with the necessity of primary surpluses for avoiding an increase in the public debt. Furthermore, the path of the primary surplus is another element that suggests that Brazil has an environment propitious for analyzing UFA. An increase in primary surplus (negative values) is observed, especially after 2002. The change in the trend observed at the end of 2008 and during 2009 (shaded area in the graph) is justified by the expansionist fiscal policy adopted in response to the fall in economic growth caused by the subprime crisis.

4.1. Openness under Inflation Targeting

Taking as reference the theoretical model, openness can work as a tool for mitigating UFA. The Brazilian case is a good fit for an empirical analysis. In January of 1999, the adoption of the flexible exchange rate regime, combined with a decrease in restrictions on foreign capital and the opening of new foreign investment channels, stimulated the process of capital account liberalization in the country. Since 2000 the process has continued through measures for reducing bureaucracy in the capital market.

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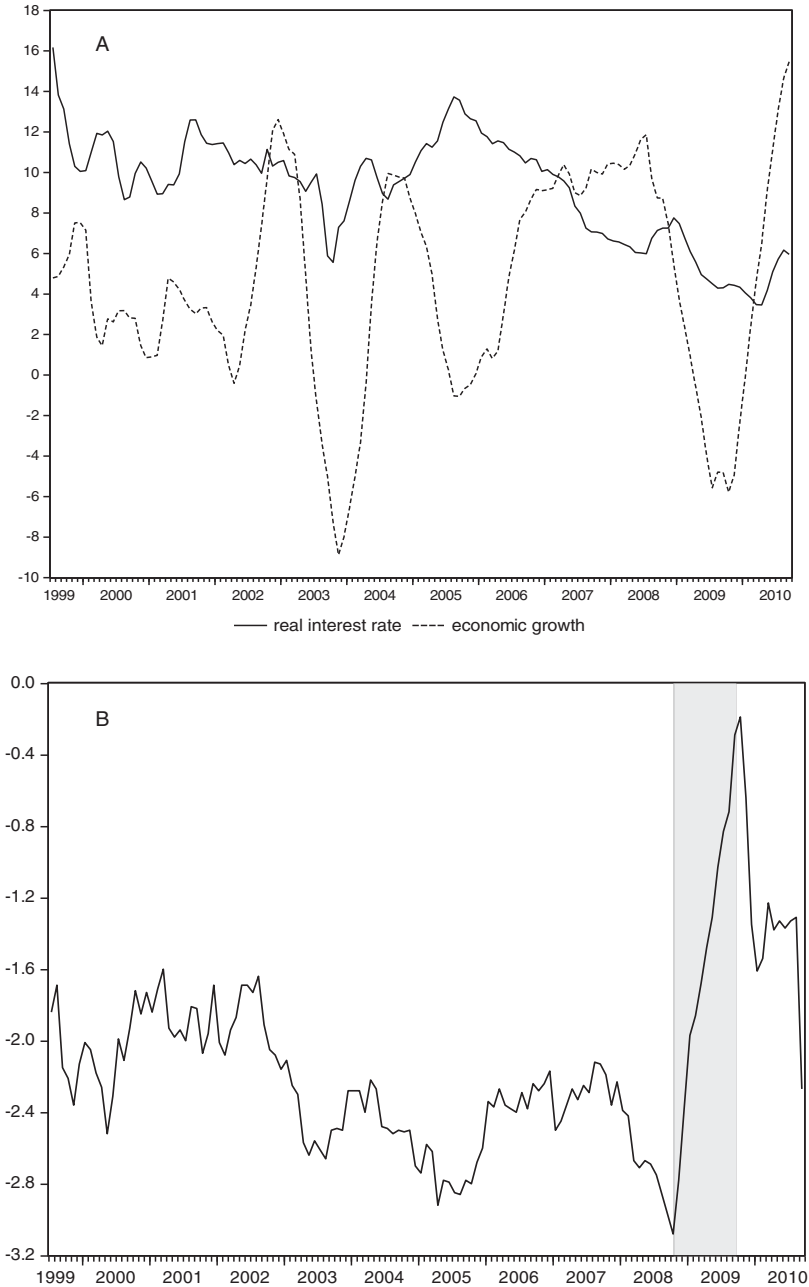


FIGURE 1. (A) Real interest rate and economic growth rate (1999–2010). (B) Primary surplus/GDP % (1999–2010).

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In this study, two indices of capital account mobility are considered. The first is the Financial Openness Index (FOI), which corresponds to a measurement of the capital flow movement month to month in the Brazilian economy over the period under analysis (July of 1999 to September of 2010). Hence,

$$\text{FOI} = \sum (\text{inflow} - \text{outflow}) \Big/ \text{GDP}. \tag{26}$$

For building the index, data regarding the financial and capital accounts of the Brazilian balance of payments made available by the Central Bank of Brazil (CBB) are used. Figure 2 shows the evolution of the FOI accumulated and indicates that the periods from 2000 to 2003 and after 2006 are marked by a trend of liberalization. In contrast, the period from 2004 to 2006 shows stagnation in its movement (shaded area in the graph).

The second index considered in this analysis is a capital control index (CCI) based on monthly decrees (legislation of portfolio flow in the short run) for the period from July of 1999 to September of 2010.[5] The information on decrees is made available by CBB and the Brazilian Finance Ministry. Each decree is classified as "+1" if it indicates liberalization; "−1" if it constrains the capital flow; and "0" if it only standardizes or communicates a fact without changes in the capital flow. The evolution of the accumulated CCI indicates that during the periods from 1999 to 2002 and after the subprime crisis the capital controls were reduced considerably, whereas between 2006 and 2008 there was relative stagnation (shaded area in the graph).

4.2. Data

The indicators (monthly frequency), made available by the CBB, used in this analysis for the period from July 1999 to September 2010, are as follows:[6]

(i) Primary surplus (PS) is the public borrowing requirements without devaluation (%GDP)—flows accumulated in 12 months—primary result (federal government and CBB). Primary surplus is the dependent variable in the model.

(ii) Deviation in inflation from the target $(\pi_t - \pi^*) - \pi^*$ is the weighted average of the target for the current year and the preceding year;[7] and π_t is the Broad National Consumer Price Index (IPCA) accumulated in 12 months (official price index). It is expected that the lack of accomplishment of the inflation target implies an increase in the interest rate and thus, with some lag, an increase in the primary surplus for stabilizing the public debt/GDP ratio.

(iii) Difference between real interest rate and the growth economic rate is $(R - G)$, where the real interest rate is the Selic accumulated in the month in annual terms deflated by IPCA, and the economic growth rate in the last 12 months is based on GDP accumulated in the last 12 months (at constant prices and seasonally adjusted). When the real interest rate is greater than the economic growth rate, there is a negative impact on consumption and investment. Moreover, a high interest rate provokes a rise in the public debt. Hence, it increases the risk of fiscal imbalance, and thus a primary surplus is necessary for stabilization.

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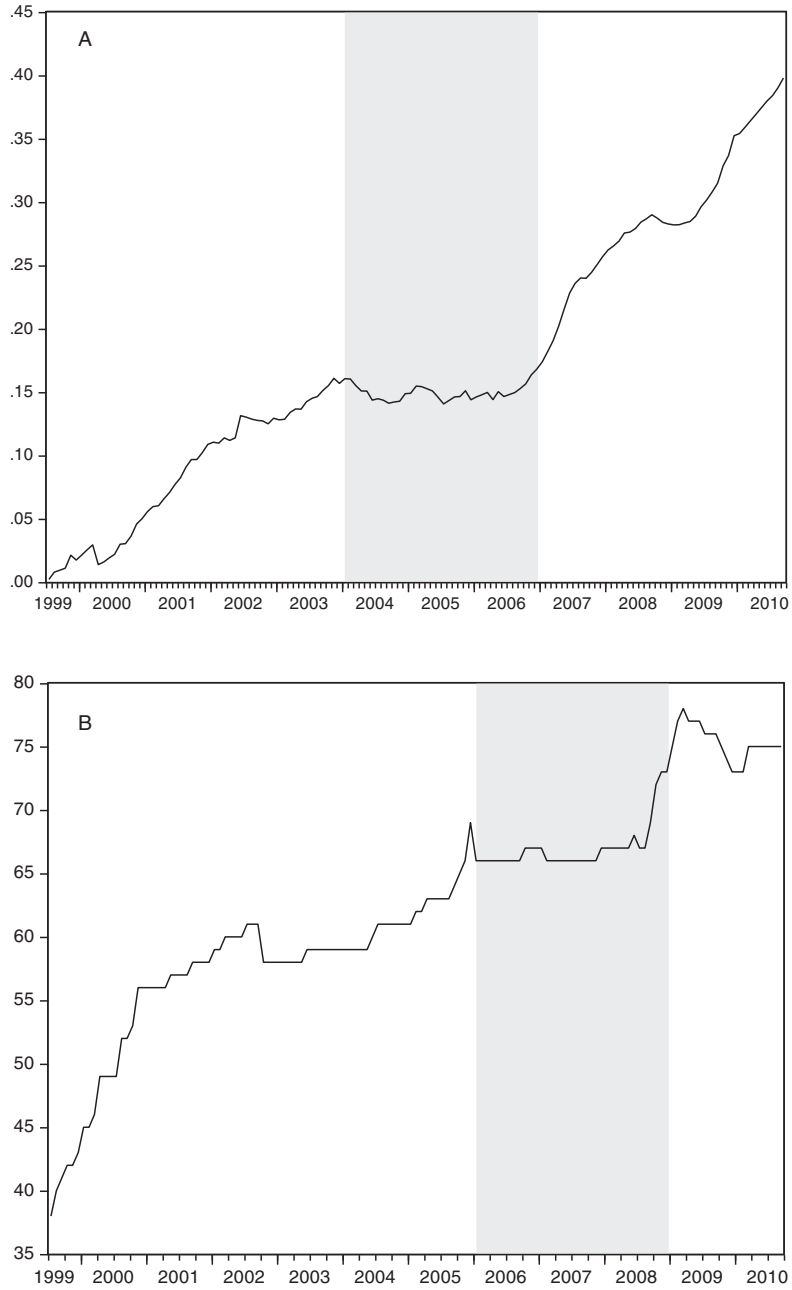


FIGURE 2. (A) Financial openness index (1999–2010). (B) Capital control index (1999–2010).

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TABLE 1. Descriptive statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.
PS	−2.1344	−2.2500	−0.1900	−3.0800	0.5242
$(\pi - \pi^*)$	1.5060	0.6800	12.1950	−3.4300	3.1083
$(R - G)$	4.7415	5.4633	16.1677	−9.5087	5.8930
D	30.5170	30.5000	41.2000	23.5000	3.0225
IR	15.9488	16.3200	26.3200	8.6500	4.2902
EX	22.9126	21.7290	38.0590	15.9140	5.1379
FOI	0.1702	0.1488	0.3980	0.0022	0.0998
CCI	62.4370	62.0000	78.0000	38.0000	8.6288

(iv) Public debt/GDP ratio (D) is the net public debt (% GDP federal government and CBB). An increase in the public debt can be a result of an expansionist fiscal policy, and thus creates a pressure of demand, which, in turn, implies a departure of inflation from the target.

(v) Interest rate (IR) is the Selic accumulated monthly in annual terms. It is the main instrument for the central bank to reach the inflation target. Because of the relevance of the interest rate in the indexation of the Brazilian public debt, a rise in the interest rate for decreasing demand inflation increases the primary surplus for avoiding the risk of an unsustainable public debt path. Therefore, it is expected that an increase in the interest rate contributes to the convergence between inflation and the target.

(vi) Exchange rate (EX) is the United States dollar (sale) period average. An increase in the exchange rate causes an increase in the price of imported inputs and thus causes a rise in the inflation rate, which, in turn, deviates from the target. Furthermore, it is important to highlight that in the period from January of 2000 to December of 2002 the relevance of the exchange rate in the indexation of the public debt was around 25%.

(vii) Financial openness index (FOI) it is a result of equation (26). The main idea is that an increase in this index is associated with a decrease in the primary surplus for ensuring stability in the public debt/GDP ratio. A greater capital flow implies an increase in the central bank's commitment to achieve the inflation target. As a consequence, a decrease in the interest rate is possible and thus a fall in the primary surplus for assuring a constant public debt/GDP ratio.

(viii) The capital control index (CCI) series is made based on the methodology presented in the preceding section. The idea is similar to the case of the FOI. A decrease in capital control works as a commitment technology for the CBB to reach the inflation target.

See Table 1 for descriptive statistics for these indicators.

4.3. Empirical Evidence

The empirical analysis for observing UFA in the Brazilian economy is divided into three steps. A first step is the analysis of the effect of the deviation of inflation from the target on primary surplus. A second step presents evidence regarding the

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effect of financial openness (FOI) and capital controls (CCI) on the convergence between inflation and the target. A third step provides robustness to the found results by estimation of the system of equations used in the previous steps.

Making use of the variables listed in the preceding section, estimations of the primary surplus [based on equation (22)] and of the convergence between inflation and its target [based on equation (25)], consider three empirical models:[8]

$$\begin{aligned} \mathrm{PS}_t &= \delta_0 + \delta_1(R-G)_{t-1} + \delta_2(\pi_t - \pi^*)_{t-3} + \delta_3 D_t \\ &\quad + \delta_4 \mathrm{dummy1} + \varepsilon_t, \varepsilon_\tau \sim N(0,\sigma^2), \end{aligned} \tag{27}$$

$$\begin{aligned} (\pi_t - \pi^*)_t &= \phi_0 + \phi_1 \mathrm{IR}_{t-9} + \phi_2 \mathrm{EX}_{t-3} + \phi_3 D_{t-6} + \phi_4 \mathrm{FOI}_{t-1} \\ &\quad + \phi_5 \mathrm{dummy1} + \phi_6 \mathrm{dummy2} + \varepsilon_t, \end{aligned} \tag{28}$$

$$\begin{aligned} (\pi_t - \pi^*)_t &= \tau_0 + \tau_1 \mathrm{IR}_{t-9} + \tau_2 \mathrm{EX}_{t-3} + \tau_3 D_{t-6} + \tau_4 \mathrm{CCI}_{t-1} \\ &\quad + \tau_5 \mathrm{dummy1} + \tau_6 \mathrm{dummy2} + \varepsilon_t, \end{aligned} \tag{29}$$

where dummy1 is the effect caused by the subprime crisis (assumes value "1" for the period from October of 2008 to September of 2009, and "0" otherwise) and dummy2 is the confidence crisis in the Brazilian economy due to the presidential election in 2002 (assumes value "1" for the period from July of 2002 to June of 2003, and "0" otherwise).

Estimations of the preceding equations are made through ordinary least squares (OLS) and generalized method of moments (GMM). The reason for the application of the GMM is that it presents consistent estimators for the regressions even when problems such as serial autocorrelation, heteroskedasticity, or nonlinearity, which are typical in macroeconomic time series, are observed [Hansen (1982)]. As a condition to predict the contemporaneous variables which are unavailable at time t, the use of instruments needs to be dated to the period $t-1$ or earlier [Wooldridge (2001)]. In this sense, besides constant and lag of regressors, lag of output gap was considered as an instrument.[9]

With the objective of checking the presence or not of a unit root in the series, the Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit-root tests were executed. The result denotes that the series are $I(1)$ and thus the use of the first difference of the series in the estimation of the equations is correct in order to avoid spurious regression (see Table A.1). Nevertheless, long-term information contained in levels of time series will be lost after differencing [Chiarella and Gao (2002)]. Therefore, it is necessary to check if a linear combination among series is stationary even if individually series are nonstationary. Hence, cointegration tests were performed taking into account the three equations in the empirical model and the results indicate that the series are cointegrated in each model (see Table A.2). As a consequence, there is a long-term equilibrium relationship among the variables under analysis and thus the equations can be estimated with the series in level without the problem of spuriousness.

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TABLE 2. Primary surplus (PS_t): OLS and GMM estimates

Variable	OLS	GMM
Constant	−3.3904***	−2.4225***
	(0.9422)	(0.8119)
	[−3.5983]	[−2.9837]
$(R - G)_{t-1}$	0.0109	0.0166
	(0.0152)	(0.0102)
	[0.7132]	[1.6329]
$(\pi - \pi^*)_{t-3}$	−0.0442**	−0.0288*
	(0.0197)	(0.0157)
	[−2.2475]	[−1.8393]
D_t	0.0381	0.0050
	(0.0290)	(0.0262)
	[1.3109]	[0.1905]
dummy1	0.9118***	0.7383**
	(0.3421)	(0.3457)
	[2.6654]	[2.1356]
Adj. R^2	0.27	0.24
F-stat	12.94	
$P(F$-stat)	(0.00)	
J-stat		13.47
$P(J$-stat)		(0.20)
S.E. reg.	0.45	0.47

Note: Standard errors in parentheses and t-statistics in brackets. Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.10.

Table 2 presents estimates based on OLS and GMM methods for equation (27). It is observed that the statistical significance and the sign of the coefficients are in agreement in both methods. Although the coefficient on the difference between real interest rate and the growth economic rate has a positive sign, it is not statistically significant. In the same manner, the coefficient on the public debt/GDP ratio is positive without statistical significance. It is important to note that this observation is consistent with the theoretical model, where the public debt is a constant and thus does not have a crucial role in the explanation of the primary surplus.

As expected, the departure of inflation from the target matters in the behavior of the primary surplus. The coefficient on the primary surplus is negative and statistically significant. One interpretation for this result is that there is no full central bank credibility over this period, which, in turn, forces the CBB to increase the interest rate in order to reach the inflation target. The consequence of the higher interest rate is an increase in the public debt service and a fall in the economic activity. Hence, for avoiding the possibility of a fiscal imbalance,

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TABLE 3. Deviation in inflation from the target $(\pi - \pi^*)_t$: OLS and GMM estimates

Variable	OLS	OLS	GMM	GMM
Constant	−7.4202	4.3166	−4.6654	8.9473
	(6.0640)	(3.1533)	(4.4835)	(6.5654)
	[−1.2237]	[1.3689]	[−1.0406]	[1.3628]
IR_{t-9}	−0.3493**	−0.3395***	−0.4996***	−0.3963***
	(0.1413)	(0.0610)	(0.1300)	(0.1028)
	[−2.4722]	[−5.5614]	[−3.8433]	[−3.8551]
EX_{t-3}	0.1803**	0.2223***	0.1876**	0.2185**
	(0.0831)	(0.0540)	(0.0917)	(0.0981)
	[2.1705]	[4.1144]	[2.0457]	[2.2271]
D_{t-6}	0.4025**	0.3035***	0.4139**	0.2720**
	(0.1873)	(0.0897)	(0.1802)	(0.1332)
	[2.1492]	[3.3824]	[2.2967]	[2.0419]
FOI_{t-1}	−13.0851***		−17.984***	
	(4.3823)		(4.6102)	
	[−2.9859]		[−3.9010]	
CCI_{t-1}		−0.1919***		−0.2353***
		(0.0358)		(0.0593)
		[−5.3582]		[−3.9673]
dummy1	4.1057***	3.9679***	3.9915*	5.1403**
	(1.4938)	(0.6708)	(2.2256)	(2.0419)
	[2.7485]	[5.9149]	[1.7931]	[2.5175]
dummy2	1.8367**	2.2843***	2.2296*	3.1231**
	(0.7675)	(0.6848)	(1.2439)	(1.5322)
	[2.3932]	[3.3358]	[1.7925]	[2.0384]
Adj. R^2	0.68	0.70	0.66	0.68
F-Stat	45.39	49.95		
$P(F$-Stat$)$	(0.00)	(0.00)		
J-Stat			3.97	7.79
$P(J$-Stat$)$			(0.86)	(0.45)
Instrument rank			15	15

Note: Standard errors in parentheses and t-statistics in brackets. Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.10.

higher primary surplus is needed. Therefore, the findings are consonant with the theoretical view and thus strengthen the idea that it is necessary to find mechanisms that make the convergence of the inflation to the target a way of mitigating UFA.

Table 3 shows the estimates for equations (28) and (29) using OLS and GMM methods. The results in the two methods are in agreement. As expected from the theoretical view, the coefficient on the interest rate is negative and has statistical

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significance. Hence, an increase in the interest rate provokes convergence between inflation and its target. In regard to the coefficient on the exchange rate, it is also compatible with theoretical predictions. The fact that it is positive and statistically significant indicates that the exchange rate channel is not negligible. The relevance of the fiscal balance for the success of the inflation targeting is observed with the coefficient on the public debt. The positive sign of the coefficient and its statistical significance make it clear that increases in the public debt/GDP ratio wreck the monetary system.

One important result from the estimates is that the coefficients on both indices, FOI and CCI, are negative and statistically significant. Therefore, the theoretical argument that decreases in capital controls and increases in capital flow work as a commitment technology for the central bank focusing on the inflation target is relevant. In other words, an increase in the openness contributes to reducing the divergence between inflation and an inflation target. As a consequence, the possibility of UFA under this environment decreases.

A manner of validating the equations and coefficients previously achieved is the estimation through system of equations [see Hallsten (1999)]. For treating possible problems of endogeneity (in particular, in the relation between primary surplus and deviation in inflation from the target), the use of the system of equations that applies GMM is adequate for estimating nonbiased coefficients. Therefore, based on equations (27) to (29), two systems of equations are considered:

System 1:

$$\begin{cases} \mathrm{PS}_t = a_0 + a_1(R-G)_{t-1} + a_2(\pi_t - \pi^*)_{t-3} + a_3 D_t + a_4 \mathrm{dummy1} + \varepsilon_t \\ (\pi_t - \pi^*)_t = b_0 + b_1 \mathrm{IR}_{t-9} + b_2 \mathrm{EX}_{t-3} + b_3 D_{t-6} + b_4 \mathrm{FOI}_{t-1} \\ \quad + b_5 \mathrm{dummy1} + b_6 \mathrm{dummy2} + \varepsilon_t \end{cases} \tag{30}$$

System 2:

$$\begin{cases} \mathrm{PS}_t = a_5 + a_6(R-G)_{t-1} + a_7(\pi_t - \pi^*)_{t-3} + a_8 D_t + a_9 \mathrm{dummy1} + \varepsilon_t \\ (\pi_t - \pi^*)_t = b_7 + b_8 \mathrm{IR}_{t-9} + b_9 \mathrm{EX}_{t-3} + b_{10} D_{t-6} + b_{11} \mathrm{CCI}_{t-1} \\ \quad + b_{12} \mathrm{dummy1} + b_{13} \mathrm{dummy2} + \varepsilon_t. \end{cases} \tag{31}$$

Table 4 shows the estimates for both of the preceding systems.[10] The results indicate that all coefficients are in accordance with the theoretical view and, with the exception of the coefficient on public debt in the case where the primary surplus is the dependent variable, are statistically significant. Furthermore, the coefficients in the systems are close to those observed in the individual estimates. In addition, the fact that the estimation through the systems considerably increased the accuracy of the coefficients in the models (the standard errors are smaller) cannot be neglected. Therefore, once again empirical evidence shows that the openness is a useful tool for increasing the convergence between inflation and its target and thus reduces the risk of UFA occurring.

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TABLE 4. PS and $(\pi - \pi^*)$: GMM system

System 1				System 2			
Variable	PS_t	Variable	$(\pi - \pi^*)_t$	Variable	PS_t	Variable	$(\pi - \pi^*)_t$
Constant	−2.4557***	Constant	−10.2533***	Constant	−2.7681***	Constant	7.8431*
	(0.7677)		(3.2466)		(0.7345)		(4.6836)
	[−3.1987]		[−3.1582]		[−3.7686]		[1.6746]
$(R - G)_{t-1}$	0.0171**	IR_{t-9}	−0.5343***	$(R - G)_{t-1}$	0.0179**	IR_{t-9}	−0.3267***
	(0.0080)		(0.1150)		(0.0082)		(0.0798)
	[2.1243]		[−4.6480]		[2.1850]		[−4.0937]
$(\pi - \pi^*)_{t-3}$	−0.0309**	EX_{t-3}	0.1883**	$(\pi - \pi^*)_{t-3}$	−0.0391***	EX_{t-3}	0.1332*
	(0.0144)		(0.0798)		(0.0142)		(0.0760)
	[−2.1485]		[2.3604]		[−2.7532]		[1.7516]
D_t	0.0065	D_{t-6}	0.6357***	D_t	0.0180	D_{t-6}	0.3830***
	(0.0246)		(0.1440)		(0.0235)		(0.1071)
	[0.2644]		[4.4147]		[0.7658]		[3.5766]
dummy1	0.7228**	FOI_{t-1}	−21.3835***	dummy1	0.8179**	CCI_{t-1}	−0.2611***
	(0.3311)		(3.6956)		(0.3148)		(0.0479)
	[2.1833]		[−5.7863]		[2.5976]		[−5.4503]
		dummy1	2.1437			dummy1	5.6652***
			(1.9410)				(1.6766)
			[1.1045]				[3.3790]
		dummy2	3.5419***			dummy2	4.4721***
			(1.0799)				(1.2455)
			[3.2797]				[3.5907]
Adj. R^2	0.25	Adj. R^2	0.64	Adj. R^2	0.25	Adj. R^2	0.66
J-statistic			0.14	*J*-statistic			0.15
			$p > .50$				$p > .40$

Note: Standard errors in parentheses and *t*-statistics in brackets. Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, (*) denotes 0.1.

5. CONCLUDING REMARKS

The theoretical model developed in this article shows that greater capital mobility attenuates the fiscal strength to assure that the central bank will reach the inflation target. Greater openness implies greater public confidence regarding central bank accountability because it decreases the risk of an expansionist monetary policy without punishment. The transmission channel for decreasing the possibility of UFA in the economy is through the convergence between inflation and its target caused by an increase in the openness, and thus reduces the necessity of increasing primary surplus.

The results observed from the empirical analysis for the Brazilian case are in consonance with predictions of the theoretical model. It is important to highlight that both indices used in the analysis as proxies for openness are relevant for reducing the deviation in inflation from the target. Moreover, the failure of the CBB in the achievement of the inflation target matters for explaining increases in primary surplus. Therefore, there exists evidence that increases in openness work

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as a commitment technology that contributes to the success of inflation targeting and thus reduces the risk that UFA occurs.

NOTES

1. See Bartolini and Drazen (1997); Gruben and McLeod (2001); Gupta (2008); Badinger (2009); and Spiegel (2009).
2. The model framework is inspired by King (1995) and Rogoff (2003).
3. See Bartolini and Drazen (1997), Gruben and McLeod (2001), de Mendonça and Pires (2007), and Gupta (2008).
4. This environment is more probable in emerging economies with a history of high inflation, where the fear of a monetization is greater than in the case of developed countries.
5. A similar index was built by Cardoso and Goldfajn (1998) and de Mendonça and Pires (2007).
6. See Table 1 with descriptive statistics of the series.
7. For example, the target in June of 2002 is a result of ($6 \times$ target 2002 $+ 6 \times$ target 2001).
8. The number of lags on each variable in the empirical models is in agreement with the time that is necessary, through its transmission channels, for the variables used as regressors to cause an effect on the dependent variable.
9. The output gap is the difference between GDP accumulated in the last 12 months (made available by the CBB with monthly frequency) and potential GDP (obtained by the Hodrick–Prescott filter).
10. Instruments and lags are the same as those applied in the estimation of the individual equations.

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APPENDIX

TABLE A.1. Unit root tests (ADF, PP, and KPSS)

	ADF			PP			KPSS			
Series	Lag	Test	cv - 1%	Band	Test	cv - 1%	Band	Test	cv = 10%	Order
OS	1	−2.7323	−4.0285	2	−2.4443	−4.0280	33.5	0.1411	0.1190	$I(1)$
ΔPS	0	−8.4775	−4.0285	4	−8.3957	−4.0285	3.11	0.0487	0.1190	$I(0)$
$(\pi - \pi^*)$	1	−3.3202	−4.0285	7	−2.8197	−4.0280	48.7	0.1286	0.1190	$I(1)$
$\Delta(\pi - \pi^*)$	0	−4.6976	−4.0285	1	−4.8891	−4.0285	12	0.0661	0.1190	$I(0)$
$(R - G)$	3	−4.0918	−4.0296	7	−2.8254	−4.0280	55.8	0.1729	0.1190	$I(1)$
$\Delta(R - G)$	1	−5.3839	−4.0290	4	−4.9120	−4.0285	11.4	0.0411	0.1190	$I(0)$
D	0	−1.9824	−4.0279	4	−2.0875	−4.0280	40.5	0.1340	0.1190	$I(1)$
ΔD	0	−12.4400	−4.0285	3	−12.4087	−4.0285	1.89	0.0621	0.1190	$I(0)$
IR	1	−4.0118	−4.0285	8	−2.4358	−4.0280	74.2	0.2043	0.1190	$I(1)$
ΔIR	0	−3.9852	−4.0285	3	−4.3565	−4.0285	15.7	0.0615	0.1190	$I(0)$
EX	1	−1.9621	−4.0285	6	−2.0373	−4.0280	59.2	0.1566	0.1190	$I(1)$
ΔEX	0	−8.1878	−4.0285	4	−8.3167	−4.0285	4.68	0.0607	0.1190	$I(0)$
FOI	2	−0.6696	−4.0290	7	−0.6231	−4.0280	188	0.6984	0.1190	$I(1)$
ΔFOI	1	−5.2062	−4.0290	7	−9.2920	−4.0285	4.27	0.1797	0.1190	$I(0)$
CCI	0	−3.7063	−4.0279	6	−3.6790	−4.0280	28.1	0.0941	0.1190	$I(1)$
ΔCCI	0	−10.4085	−4.0285	6	−10.5132	−4.0285	2.04	0.1657	0.1190	$I(0)$

Notes: "cv" is the critical value. Constant and linear trend were used for series. ADF—the final choice of lag was made based on Schwarz criterion. PP—spectral estimation method is Bartlett kernel and Newey–West bandwidth is used. KPSS—spectral estimation method is Bartlett kernel and Andrews bandwidth is used.

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TABLE A.2. Number of cointegrating relations by model

			Data trend and test type				
			None	None	Linear	Linear	Quadratic
			No intercept No trend	Intercept No trend	Intercept No trend	Intercept Trend	Intercept Trend
PS, $(R - G)$,	Trace		1	1	1	1	1
$(\pi - \pi^*)$, D	Rank or	0	6.3598*	6.3598*	6.5039	6.5039	6.6299
	N. of	1	6.4255	6.3921	6.4999	6.5284	6.6192
	CEs	2	6.6280	6.6105	6.6817	6.7186	6.7729
		3	6.8773	6.8768	6.9112	6.9701	6.9973
		4	7.1683	7.1991	7.1991	7.2705	7.2705
$(\pi - \pi^*)$, IR,	Trace		2	2	2	1	1
EX, D, FOI	Rank or	0	−0.0768*	−0.0768*	−0.0465	−0.0465	0.0938
	N. of	1	−0.0647	−0.0647	−0.0007	0.0194	0.1265
	CEs	2	0.0525	0.0677	0.1312	0.1698	0.2466
		3	0.3612	0.3449	0.3891	0.4620	0.5034
		4	0.6896	0.7094	0.7191	0.8178	0.8430
		5	1.0545	1.0762	1.0762	1.1971	1.1971
$(\pi - \pi^*)$, IR,	Trace		1	1	1	3	5
EX, D, CCI	Rank or	0	10.3062*	10.3062*	10.4134	10.4134	10.5635
	N. of	1	10.3554	10.3699	10.4627	10.4429	10.5600
	CEs	2	10.5179	10.5446	10.6489	10.6543	10.7351
		3	10.8152	10.8538	10.9219	10.8877	10.9521
		4	11.1720	11.1879	11.2199	11.1987	11.2270
		5	11.5393	11.5854	11.5854	11.5396	11.5396

Notes: Schwarz criteria by rank (rows) and model (columns). Lag specification for differenced endogenous is based on Schwarz and Hanna–Quinn criteria in a VAR model. *Model selection criteria: Schwarz by rank (rows) and model (columns).

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