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**TAYLOR PRINCIPLE AND INFLATION
STABILITY IN EMERGING
MARKET COUNTRIES**

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Taylor Principle and Inflation Stability in Emerging Market Countries

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The goal of this paper is to evaluate the validity of the Taylor principle for inflation control in 12 developing countries that use inflation targeting regimes: Brazil, Chile, Colombia, Hungary, Israel, Mexico, Peru, Philippines, Poland, South Africa, Thailand and Turkey. The test is based on a state-space model to determine when each country has followed the principle; then a threshold unit root test is used to verify if the stationarity of the deviation of the expected inflation from its target depends on compliance with the Taylor principle. The results show that such compliance leads to the stationarity of the deviation of the expected inflation from its target in all cases. Furthermore, in most cases, non-compliance with the Taylor principle leads to nonstationary deviation of the expected inflation.

Key Words: Taylor Rule, Emerging Markets, Inflation Stability

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1. INTRODUCTION

Does the Taylor Rule matter? Several works have discussed how efficient it would be to adopt the Taylor principle in order to guarantee economic

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stability. Such discussion has gained strength especially in the United States where there is firm evidence that unemployment and inflation were higher and more volatile between 1965 and 1980 than in the last 20 years. On the one hand, several authors argue that such fact can be explained by an active monetary policy (e.g. Judd and Rudebusch (1998); Clarida, Gali and Gertler (2000); Cogley and Sargent (2001, 2003); Boivin and Giannoni (2003); Lubik and Schorfheide (2004)). On the other hand, others argue that such disparity is due to different exogenous shocks between the periods (e.g. Blanchard and Simon (2001); Stock and Watson (2002); Sims and Zha (2004); Primiceri (2005)).

This paper attempts to test the validity of the Taylor principle for 12 emerging market countries that have adopted inflation targeting regimes: Brazil, Chile, Colombia, Hungary, Israel, Mexico, Peru, Philippines, Poland, South Africa, Thailand and Turkey. The contribution of the paper is twofold. First, it suggests an alternative method to test the validity of Taylor Rules. In contrast to the related literature, in which the relationship between monetary policy and inflation is linear¹, this paper incorporates the nonlinearity of this specific relationship. In particular, an adaptation of the threshold unit root test proposed by Caner and Hanser (2001) is suggested. Compliance with the Taylor principle is defined as a binary variable obtained through a pre-estimated state-space model. Such variable is used to define a threshold where the Taylor principle is respected in one regime but not in another one. Then, the test is conducted in order to verify if the stationarity of the deviation of the expected inflation from its target changes according to the regime. That is, we aim to verify if the deviation of the expected inflation is stationary when the Taylor rule is respected, and if that holds true otherwise.

The second contribution is that the selection of emerging market countries with inflation targeting regimes increases the possibility for further discussion on the validity of the Taylor principle. This occurs because the relationship between inflation stabilization and monetary policies could be different for de-

¹There are other nonlinear tests for the Taylor principle, as in Lubik and Schorfheide (2004), but they do not use the same framework as suggested here

veloped and developing countries (see Gonçalves and Salles, 2006). Therefore, developed countries are not expected to derive important economic gains from their compliance with the Taylor principle since they were not suffering from severe inflation problems or other destabilizing macroeconomic disturbances. In addition, compliance with Taylor rules might be more important for the performance of emerging market economies than for developed countries. Moreover, because these countries have adopted inflation targeting regimes, the rule used by them and also the exact deviation of the expectation from its target can be more accurately determined (Woodford, 2003).

The results can be summarized as follows. In all cases in which the Central Bank (CB) complies with the Taylor principle, the deviation of the expected inflation from its target is stationary, that is, the equilibrium is determined. At the same time, when the CB does not comply with the Taylor principle, the deviation of the expected inflation from its target is nonstationary in, not all, but most of the cases.

2. EMPIRICAL METHODOLOGY

As previously discussed, in the past years, the theoretical discussion on monetary economy has developed from the efficiency point of view about monetary policy rules. According to a significant approach the CB should respond to deviations of the expected inflation from its target and to the output gap through monetary policy rules in order to guarantee equilibrium determination. In this respect, following Woodford (2003), the economy can be represented by two basic equations: one given by the IS intertemporal curve and another by a new-Keynesian Phillips curve.

It is possible to demonstrate that the system of difference equations given by the Phillips and IS curves leads to an undetermined rational expectations equilibrium. That means that an infinite number of possible equilibrium responses of the endogenous variable to real shocks can be obtained - including situations where inflation and output fluctuations are disproportionately larger in relation to changes in the fundamentals.

In order to guarantee the determination of the equilibrium, the CB has to adopt an interest rate feedback rule. In this case, several rules can be adopted. Nevertheless, countries which have adopted inflation targeting regimes should react to the deviations of the expected inflation from its target to ensure the stability of the system consistently with such target (Woodford 2003, chap 4). In other words, the rule should be as follows:

$$\hat{i}_t = \bar{i} + \rho(\hat{i}_{t-1} - \bar{i}) + \phi_\pi(E_t\pi_{t+12} - \bar{\pi}) + \phi_x(x_t) \quad (1)$$

where x is the output gap, \hat{i} is a linearization of the nominal interest rate difference in relation to the equilibrium, π is the inflation, t is time, E is the expectation operator. That is, the nominal interest rate determined by the CB responds to the deviation of the expected inflation from its target in the proportion ϕ_π and to the output gap in the proportion ϕ_x while it follows a smoothing rule.

By using this rule, two conditions are necessary in order for the interest rate rule (1) to guarantee the determination of the equilibrium. The first one is given by:

$$\phi_\pi + \Omega\phi_x > 1 - \rho \quad (2)$$

where $\Omega > 0$ is given by a combination of parameters that reflect the nominal and real levels of economic rigidity. This condition is similar to the Taylor principle, since the reaction of the interest rate to inflation shocks should be more than proportional in order to have the inflation stabilized at the desired level. The second condition is given by:

$$\phi_\pi < 1 + \rho + \Omega(\phi_x + \Lambda(1 + \rho)) \quad (3)$$

This condition suggests that if an excessively rigorous Central Bank shows a disproportionately larger reaction to inflation, the economy is in an undetermined equilibrium. This was explained by Bernanke and Woodford (1997)

and Clarida, Gali and Gertler (2000), who demonstrated that this conduct of monetary policy can lead to an increase in the deviation of the expected inflation from its target due to self-fulfilling expectations.

In short, this paper aims to estimate and calibrate the values included in conditions (2) and (3) above to test whether they are necessary and sufficient to allow the expected inflation to automatically return to its target. The following two subsections describe the procedures used to estimate the model's parameters for each time period and how these estimations are used to test the validity of these conditions.

2.1. Definition of Monetary Policy Rules

The first step to test the validity of the conditions for equilibrium determination is to establish the parameter values. Thus, the economy's fixed parameters were calibrated to $\Omega = 0.1$ and $\Lambda = 1.28$ following Woodford (2003). footnoteTeles and Brundo (2006) calibrated such values to the Brazilian economy and obtained very similar results. By using sensitivity analysis, they also showed that changes in these parameters do not significantly alter the results. Therefore it can be argued that these parameters can be used for all countries included in this paper.. However, the monetary policy reaction parameters are obtained using a state-space model with time-varying parameters to estimate equation (1) with parameters ϕ_π , ϕ_x and ρ varying along time following an autoregressive process, i.e., according to:

$$\hat{i}_t = \bar{i} + \rho_t(\hat{i}_{t-1} - \bar{i}) + \phi_{\pi t}(E_t\pi_{t+12} - \bar{\pi}) + \phi_{xt}(x_t) \quad (4)$$

$$\rho_t = \alpha_i\rho_{t-1} + u_i \quad (5)$$

$$\phi_{\pi t} = \alpha_\pi\phi_{\pi t-1} + u_\pi \quad (6)$$

$$\phi_{xt} = \alpha_x\phi_{xt-1} + u_x \quad (7)$$

where equation (4) is the measurement equation and equations (5) through (7) are the transition equations.

Once the values of the Central Bank's reaction parameters are obtained for each point in time, the parameters are applied to conditions (2) and (3) along with the economy's calibrated values in order to verify the periods in which the Central Bank complied with these conditions and when it did not. Therefore, the following binary variable is defined:

$$\lambda_t = \begin{cases} 0, & \text{if } CB \text{ do not respect conditions (2) and (3)} \\ 1, & \text{if } CB \text{ respect conditions (2) and (3)} \end{cases} \quad (8)$$

Thus, variable λ defines two monetary policy regimes. Such variable provides the basis for testing whether the deviation of the expected inflation from its target converges automatically to the target when conditions (2) and (3) are, or are not, met. At the same time, it tests whether the non-observation of these conditions leads to an undetermined equilibrium behavior. In fact, condition (3) was observed in all cases for all countries; therefore the variable λ simply defines if the Central Bank has complied with the Taylor principle.

2.2. Testing the Taylor Principle

To test the efficiency of monetary rules, it is necessary to use a test that contemplates the nonlinear nature laid down by the theory. However, the tests commonly used in the literature to assess the validity of the Taylor principle do not specify this nonlinear behavior. This paper seeks to contribute to this literature by using the threshold autoregressive model (TAR). We propose to verify if the deviation of the expected inflation from its target presents different processes when the conditions for equilibrium determination are, or are not, observed. So, the test can be described by the following equation:

$$\Delta(E_t\pi_{t+12} - \bar{\pi})_t = \theta_1\lambda_t Z_{t-1} + \theta_2(1 - \lambda_t)Z_{t-1} + \epsilon \quad (9)$$

where $Z_{t-1} = ((E_t\pi_{t+12} - \bar{\pi})_{t-1}, \Delta(E_t\pi_{t+12} - \bar{\pi})_{t-1}, \dots, \Delta(E_t\pi_{t+12} - \bar{\pi})_{t-k})$. That is, when the Central Bank respects the conditions for equilibrium deter-

minacy $\lambda_t = 1$ and the model is given by $\Delta(E_t\pi_{t+12} - \bar{\pi})_t = \theta_1 Z_{t-1} + \epsilon$. On the other hand, when the conditions are not respected $\lambda_t = 0$ and the model is given by $\Delta(E_t\pi_{t+12} - \bar{\pi})_t = \theta_2 Z_{t-1} + \epsilon$. Thus, whether the conditions for equilibrium determinacy suggested by the theory are valid $\theta_1 \neq \theta_2$. As a result, the deviation of the expected inflation is different for periods in which the Central Bank complies with the rule. Therefore, the null hypothesis for the first test is $H_0 : \theta_1 = \theta_2$.

The most interesting case concerning this test is that the deviation of the expected inflation is possibly stationary when $\lambda_t = 1$, containing a unit root otherwise. Such circumstance is clearly a nonstationary situation; however, it is not a classic unit root process. From a monetary theory standpoint, this means that the inflation expectation naturally converges to the target if, and only if, $\lambda_t = 1$. Consequently, in this case the unit root test with threshold is very useful to verify the validity of the theory.

The test distribution was exhaustively studied by Caner and Hansen (2001). The Wald test is indicated to verify the existence of a threshold. However, the traditional critical values of the Wald test are not valid in the presence of a unit root. At the same time, as documented by Pippenger and Goering (1993), in the case of the unit root test the presence of a threshold significantly decreases the power of the traditional ADF test. Therefore, critical values should be obtained adequately for each test.

Caner and Hansen (2001) found the asymptotic distribution of the test, but they showed that, in the case of small samples, the critical values can not be tabulated in a standard fashion. Thus, the best alternative is to estimate the critical values through bootstrap simulations for each case. As a result, we obtained the critical values for the unit root test by assuming that the true process is stationary (null hypothesis) through bootstrap simulations. In this paper, 10,000 bootstrap simulations were conducted to obtain the critical values for the tests.

Consequently, the application of the threshold and the unit root tests for the regime with $\lambda_t = 0$ indicates the validity of the Taylor principle and

of the conditions for equilibrium determination with rational expectations anticipated by the theory.

2.3. Database

For each country, the estimation of the system (4)-(7) was based on monthly data from the adoption of an inflation targeting regime to July 2007. For the output, data from the manufacturing industry were used. An HP (Hodrick-Prescott) filter was used to create a potential output series in the output log series. The output gap was calculated by the difference between the log of the original series of the deseasonalized output and the potential output obtained by the HP filter.

Through a linear interpolation, the target, which is usually annual, had to be modified to an annualized monthly target. All the data were obtained from official governmental websites and the expected inflations were obtained from information provided by the Central Banks of the countries. The information about interest rates, which was obtained from the International Financial Statistics (IFS) of IMF.

3. RESULTS

The analysis was simulated for 12 emerging market countries that use inflation targeting regimes: Brazil, Chile, Colombia, Hungary, Israel, Mexico, Peru, Philippines, Poland, South Africa, Thailand and Turkey. The initial analysis for determination of periods in both regimes resulted in different cases for each country. Brazil, Poland and Turkey presented periods in which the Taylor principle was respected and others in which it was not. On the other hand, South Africa, Colombia, and the Philippines have never complied with the Taylor principle. Finally, Chile, Hungary, Israel, Mexico, Peru and Thailand stuck to the principle in all of the periods analyzed.

For countries in which both regimes were identified, a threshold analysis was performed. For the other countries, we assumed that there was no threshold and a simple augmented Dickey-Fuller (ADF) unit root test was run, which

TABLE 1.
Taylor Principle Tests

Single-Regime Cases (ADF Test)			
Regime 1			
	Statistic	p-value	
Mexico	-3.28	0.03	
Chile	-2.51	0.01	
Thailand	-1.98	0.04	
Israel	-3.63	0.00	
Peru	-1.72	0.08	
Hungary	-3.03	0.00	
Regime 2			
	Statistic	p-value	
South Africa	-1.82	0.37	
Colombia	-3.34	0.02	
Philippines	-1.35	0.60	
Two-Regime Cases (Threshold Test)			
	Threshold Test	t1	t2
Brazil	176.50*	3.57*	-7.60
Poland	9.47	17.74*	0.43
Turkey	0.17	14.37*	5.68*
OBS: (*) null hypothesis rejected at 5% of significance			

is equivalent to a case without threshold. The results are presented in Table 1.

The results show that the unit root can be rejected in all the relevant cases when determinacy conditions are observed (regime 1), that is, Chile, Hungary, Israel, Mexico, Peru and Thailand throughout the period, and Brazil, Poland and Turkey during regime 1 (test statistic in t1 column). These results provide evidence that the observation of the Taylor principle was a sufficient condition for equilibrium determination.

However, the results do not indicate that this is a necessary condition. Some cases, like Colombia (during the entire period) and Turkey (during

regime 2) showed that inflation expectation converged to the target even when determinacy conditions were not satisfied.

Notwithstanding, there is evidence from South Africa and the Philippines (during the entire period) and from Brazil and Poland (during regime 2) that the non-observation of Taylor principle leads to the nonstationarity of the deviation of the expected inflation from its target.

4. CONCLUSION

The paper evaluates whether the Taylor principle is applicable to 12 emerging market countries that have adopted inflation targeting regimes: Brazil, Chile, Colombia, Hungary, Israel, Mexico, Peru, Philippines, Poland, South Africa, Thailand and Turkey.

To do that, we suggest an alternative method to test the validity of the Taylor Rule based on an adaptation of the threshold unit root test proposed by Caner and Hansen (2001). The compliance with the Taylor principle is defined as a binary variable obtained through a pre-estimated state-space model. Such variable is used to define a threshold where the Taylor principle is respected in one regime but not in another one. Then, the test is conducted in order to verify if the stationarity of the deviation of the expected inflation from its target changes according to the regime.

The results undisputedly show that when the Central Bank complies with the Taylor principle the deviation of the expected inflation from its target is stationary, but when the opposite holds true, such deviation is nonstationary in most of the cases.

The results provide a clear prescription of the Taylor principle. That is, if a Central Bank wants to stabilize inflation around the target, it should closely follow a long-term more than proportional reaction rule in relation to the expected inflation deviations.

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