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ABSTRACT

This paper proposes a simple Ordered Probit model to analyse the monetary policy reaction function of the Colombian Central Bank. There is evidence that the reaction function is asymmetric, in the sense that the Bank increases the Bank rate when the gap between observed inflation and the inflation target (lagged once) is positive, but it does not reduce the Bank rate when the gap is negative. This behaviour suggests that the Bank is more interested in fulfilling the announced inflation target rather than in reducing inflation excessively. The forecasting performance of the model, both within and beyond the estimation period, appears to be particularly good.

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1. Introduction

In 1991 a constitutional reform radically modified the structure and functions of the Central Bank in Colombia (Banco de la República) with the aim of creating an institution independent from the Government's executive branch. The new constitution stated that the main objective of the Bank was to control inflation, and that it had to coordinate its policies with the Government's macroeconomic policies related to growth and employment. The Bank also makes decisions on monetary, exchange and credit policies. Since the introduction of Central Bank independence, the monetary policy in Colombia has followed a strategy of inflation targeting, with the Board of Directors of the Bank explicitly setting inflation targets, as defined by the annual variation in the consumer price index. The first target was announced in 1991 at a level of 22%, and it has been gradually reduced to 4% in 2007.

The main instrument used by the Central Bank in Colombia to implement monetary policy is by affecting the interest rate applied to the liquidity given to financial intermediaries. Changes in the interest rate of intervention (which we shall refer to as the Bank rate) are transmitted to the rest of the economy through a variety of channels that ultimately affect aggregate demand and its principal components. Thus, it is understandable that a great deal of expectations are formed by economic agents before the time the Board of Directors of the Bank meets, usually the last Friday of each month, in order to announce whether it has decided to cut, increase or leave the Bank rate unaltered; these changes have historically been discrete, taken on the values 0, ±25, ±50, ±75 and ±100 basis points.[1]

The purpose of this paper is to propose an econometric specification that attempts to model the discrete changes in the interest rate used by the Bank to intervene in the money market.

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[1] Another monetary instrument used by the bank is the Bank Reserve Requirement Ratio, both in average and marginal terms. These requirements seldom change, but when they do their effect is very important.

The chosen specification is known as Ordered Probit, a technique that is most frequently used in cross-sectional studies of ordered dependent variables, i.e. variables that are not continuous but take a natural ordering of alternatives (see e.g. Wooldridge, 2002). Thus, in this paper we postulate a dynamic ordered probit model for a dependent variable that classifies changes in the Bank rate into three categories, depending on whether the rate was cut by at least 25 basis points, not changed, or increased by at least 25 basis points. This modelling approach has been previously applied by Eichengreen, Watson and Grossman (1985), Davutyan and Parke (1995), Choi (1999), Dolado, María-Dolores and Naveira (2005) and Carstensen (2006), among others, to estimate interest rate-setting behaviour by several central banks (Banco de España, Bank of England, Banque de France, Bundesbank, European Central Bank and the U.S. Federal Reserve) over different time periods.

The paper is organised as follows. Section 2 presents a brief review of the structure of central banking in Colombia in recent years. Section 3 presents the results of the estimation of an Ordered Probit model to analyse the Central Bank's interventions in the money market. This also includes an evaluation of the out-of-sample forecasting performance of the model, which involves holding-out sample observations that are not used for the estimation of the parameters of the model. Section 4 offers some concluding remarks.

2. A brief review of the structure of central banking in Colombia in recent years

In 1991 a constitutional reform granted greater political independence to the Central Bank in Colombia. Indeed, the new constitution created the Board of Directors of the Central Bank, which consists of seven members: the Minister of Finance who presides the Board without veto power; five Co-Directors who are appointed by the President and serve for a minimum period of four

years and a maximum of twelve; and the Governor of the Bank who is elected by the Co-Directors for a minimum period of four years and a maximum of twelve. The terms of the Co-Directors are staggered so that no President can appoint the entire Board at any time.[2] The Constitution stated that the main objective of the Bank was to control inflation, and that it had to coordinate its policies with the general macroeconomic policies aimed at generating income and employment growth. The Constitution forbids the Bank from lending to non-financial private agents – Loans to the Government are only permitted after an unanimous vote by the Board, something which has not happened up to now. The Bank provides liquidity to the system using loans to the banks, changes in the Bank Reserve Requirement Ratio and interventions in the foreign exchange and bonds markets.

On the foreign exchange policy front, from November 1991 to September 1999 the Bank followed a crawling band system, a form of currency band (or target zone) in which the band and the central parity within the band are allowed to change in frequent small increments.[3] The crawling band system was subsequently replaced by a policy of dirty floating, with some interventions, theoretically aimed at decreasing the variance of the movements of the exchange rate.

The focus of this paper is on the interest rate at which the Central Bank gives liquidity to financial intermediaries.

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[2] However, it is worth mentioning that on 27th December 2004, the Colombian Congress, through Legislative Act 02, approved the presidential re-election for up to one period, starting in 2006-2010. President Uribe (whose administration had started in 2002) was allowed to participate in the presidential election and defeated the other candidates. Clearly, this opened the possibility that in 2009 all five Co-Directors would have been appointed by President Uribe, which could compromise the political independence of the Bank.

[3] See Williamson (1996) for an account of how the crawling band performed in Colombia during the first half of the nineties.

3. Empirical modelling exercise

We consider a dynamic Ordered Probit model where the outcome of interest is whether at a particular moment in time, the Central Bank of Colombia modified the interest rate at which it is willing to provide liquidity to the money market. As a result, the dependent variable takes on three discrete values, namely –1, 0 and 1, depending on whether the Bank rate was cut by at least 25 basis points, not changed, or increased by at least 25 basis points.[4] The choice of variables to be considered in the discrete monetary policy reaction function is guided by the type of variables typically considered in the tradition of the so-called "Taylor rules" (see Taylor, 1993), also including variables that might be relevant in the context of a small open economy such as Colombia. Thus, we assume that the Central Bank in Colombia acts according to the function:

$$\Delta BR_t = f\left(\left(\Delta p_{t-1} - \Delta p_{t-1}^*\right), u_{t-1}, \Delta e_{t-1}, \Delta i_{t-1}^{US}, \left(BR_{t-1} - i_{t-1}\right), \Delta\left(BR - i\right)_{t-1}\right), \qquad (1)$$

where ΔBR_t is the change in the Bank rate, $\left(\Delta p_{t-1} - \Delta p_{t-1}^*\right)$ is the gap between observed inflation and the Central Bank's inflation target, u_{t-1} is the unemployment rate, Δe_{t-1} is the annual variation in the peso-U.S. dollar nominal exchange rate, Δi_{t-1}^{US} is the annual variation in the foreign interest rate as measured by the effective federal funds rate set by the Federal Reserve, $\left(BR_{t-1} - i_{t-1}\right)$ is the spread between the Bank rate and the market rate, the latter being measured by the interbank interest rate, and $\Delta\left(BR - i\right)_{t-1}$ is the first difference in this spread. In the terminology of Svensson (1999), the reaction function (1) is of an explicit type because the Bank rate depends upon lagged variables, as opposed to an implicit reaction function which includes unknown future values of

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[4] We also tried to estimate an ordered probit model using a dependent variable defined over a finer grid of alternatives, taking the values of –100, –75, –50, –25, 0, 25, 50, 75 and 100 depending on the magnitude of the Bank rate change (measured in basis points). The results indicate that although the estimated coefficients are qualitatively the same, confidence intervals of the estimated threshold parameters overlap, suggesting the need to reduce the number of categories.

the variables. It is also important to notice that having lagged independent variables does not to contravene the spirit of a real-time forecasting exercise, which uses only information available at the time the forecasts are made.

Equation (1) assumes that the Bank reacts symmetrically to changes in $\left(\Delta p_{t-1} - \Delta p_{t-1}^{*} \right)$. However, it may well be the case that the Bank adjusts the Bank rate asymmetrically, depending on whether lagged inflation is above or below its target. This behaviour is of particular interest in an environment in which the Central Bank is more interested in fulfilling the announced inflation target rather than in reducing inflation excessively. To allow for the possibility of asymmetric adjustment, we partition the term $\left(\Delta p_{t-1} - \Delta p_{t-1}^{*} \right)$ into $\left(\Delta p_{t-1} - \Delta p_{t-1}^{*} \right)^{+}$ and $\left(\Delta p_{t-1} - \Delta p_{t-1}^{*} \right)^{-}$. Thus, equation (1) becomes:

$$\Delta BR_{t} = f\left(\left(\Delta p_{t-1} - \Delta p_{t-1}^{*} \right)^{+}, \left(\Delta p_{t-1} - \Delta p_{t-1}^{*} \right)^{-}, u_{t-1}, \Delta e_{t-1}, \Delta i_{t-1}^{US}, \left(BR_{t-1} - i_{t-1} \right), \Delta\left(BR - i \right)_{t-1} \right). \quad (2)$$

Following Eichengreen et. al. (1985) and Davutyan and Parke (1995), let us consider an unobserved target Bank rate, BR_{t}^{*}, whose changes are governed by:

$$\Delta BR_{t}^{*} = \mathbf{X}_{t}\beta + \varepsilon_{t}, \qquad \varepsilon_{t} \sim N\left(0, \sigma_{\varepsilon}^{2} \right) \quad (3)$$

where $\mathbf{X}_{t}$ denotes the set of explanatory variables in equation (2). Next, the observed Bank rate is assumed to change based on the following rule:

$$
\begin{aligned}
\Delta BR_{t} &= -1 && \text{if} && BR_{t}^{*} < BR_{t-1} - \alpha_{1}, \\
\Delta BR_{t} &= 0 && \text{if} && BR_{t-1} - \alpha_{1} < BR_{t}^{*} < BR_{t-1} - \alpha_{2}, \\
\Delta BR_{t} &= 1 && \text{if} && BR_{t}^{*} > BR_{t-1} + \alpha_{2}.
\end{aligned} \quad (4)
$$

For instance, the first (third) equation in (4) indicates that the observed rate will decrease (increase) whenever the target rate is appreciably below (above) last month's observed Bank rate. The model involves the unknown threshold parameters α_{1} and α_{2} as well as the parameter vector

β, all of which can be estimated by maximum likelihood.

For the purpose of our empirical modelling exercise, we have at our disposal 85 monthly observations running from January 2001 to January 2008. During this sample period, the number of times the Bank rate was cut, not changed, or increased was 16, 55 and 14 respectively.[5]

Model 1 in Table 1 reports the maximum likelihood estimation results over the period January 2001 to December 2007. As can be seen, several of the estimated coefficients turn out to be statistically significant. For example, the finding that $\left(\Delta p_t - \Delta p_t^*\right)^+$ is statistically significant, but $\left(\Delta p_t - \Delta p_t^*\right)^-$ is not, can be viewed as an indication that, at least during the period of estimation, the Central Bank has been more interested in fulfilling the announced inflation target rather than in achieving an inflation rate lower than the target. Neither $\left(BR_{t-1} - i_{t-1}\right)$ nor $\Delta\left(BR_{t-1} - i_{t-1}\right)$ was found to be statistically significant in the implementation of monetary policy. Model 2 in Table 1 reports the parsimonious version of the model, after excluding irrelevant regressors. The McFadden pseudo-R2 of the estimated Ordered Probit model is 0.235, while the likelihood ratio test statistic for the significance of the four included variables is 35.327 (p-value = 0.000), and the overall percentage correctly predicted within the sample period is about 69%.

Figure 1 plots the estimated probabilities that the Central Bank would cut, not change, or increase the interest rate used to intervene in the money market, as a function of $\left(\Delta p_t - \Delta p_t^*\right)^+$ (the other explanatory variables are set equal to their corresponding sample averages). The figure shows that as the gap between observed inflation and the Central Bank's inflation target gets larger, the

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[5] The selection of the sample period is dictated by the availability of data; in particular, the unemployment data are available on a monthly basis starting in January 2001. The Colombian data series have been taken from Departamento Administrativo Nacional de Estadistica (DANE) as well Banco de la República, while the U.S. effective federal funds rate has been taken from the Federal Reserve Economic Database (FRED).

probability that the Bank would increase the intervention rate goes up, while the probability of leaving the intervention rate constant goes down. It is also interesting to notice that the negative sign on the estimated unemployment coefficient suggests that when unemployment goes up the probability of increasing the interest rate goes down. This finding suggests that, at least during the sample period, the Central Bank has been concerned not only with controlling inflation, but also with the potential recessionary effects of its policies. The estimated coefficients on Δe_t and Δr_t^{US} are found to be positive, which indicates that external factors are also taken into account when implementing monetary policy.

Finally, we present an out-of-sample forecasting exercise in which our preferred specification of the Ordered Probit model, which we referred to as Model 2 in Table 1, is kept fixed out-of-sample, but each time a forecast is made the model is re-estimated using the observed data that would have been available at the time. In other words, we start off by using data up to June 2007 to forecast July 2007, and then the sample is extended by one month, up to December 2007 to forecast January 2008. As can be seen from Table 2, the out-of-sample model forecasts practically ruled out any possibility of a cut in the Bank rate, that is $\Pr\left(\Delta BR_t = -1\right)$ is very low. Furthermore, the forecasting performance of the model outside the estimation period appears to be particularly good, as the model correctly predicts the observed outcomes in five out of seven occasions.

4. Concluding remarks

In this paper we have estimated a simple Ordered Probit model, in order to analyse the monetary policy reaction function of the Central Bank in Colombia. Our findings provide evidence of an asymmetric reaction function, in the sense that the Central Bank increases the Bank rate when the gap between observed inflation and the inflation target (lagged once) is positive, but it does not

reduce the Bank rate when the gap is negative. This result can be viewed as evidence that the Central Bank has been more interested in fulfilling the announced inflation target rather than in reducing inflation excessively. Other variables such as economic activity (as measured by the unemployment rate) as well as the evolution of external variables (as measured by variations in the peso-U.S. dollar nominal exchange rate and in the effective federal funds rate set by the FED) have also been taken into account when setting the interest rate of intervention. The forecasting performance of the model beyond the estimation period appears particularly good, as the model correctly predicts the observed outcomes in five out of seven occasions.

Table 1. Ordered Probit estimates of monetary policy reaction function
Sample period 2001(m1) to 2007(m12)

Explanatory variables	Model 1		Model 2	
	Coeff.	St. error	Coeff.	St. error
u_{t-1}	-0.442	(0.099)	-0.437	(0.099)
$\left(\Delta p_{t-1} - \Delta p^*_{t-1}\right)^{+}$	0.540	(0.226)	0.561	(0.201)
$\left(\Delta p_{t-1} - \Delta p^*_{t-1}\right)^{-}$	0.252	(1.433)		
Δe_{t-1}	0.038	(0.014)	0.039	(0.015)
Δr^{US}_{t-1}	1.364	(0.554)	1.415	(0.598)
$\left(BR_{t-1} - i_{t-1}\right)$	-0.125	(0.638)		
$\Delta\left(BR_{t-1} - i_{t-1}\right)$	-0.902	(0.872)		
Threshold parameters:				
α_1	-6.768	1.478	-6.688	(1.401)
α_2	-4.283	1.366	-4.192	(1.255)
Observations	82		83	
LR statistic	37.007	[0.000]	35.327	[0.000]
Pseudo-R2	0.248		0.235	

The standard errors are Huber/White standard errors. Probability
values appear in [ ].

Table 2. One-step-ahead forecast of the probabilities of change in the Bank rate

Month	$\Pr\left(\Delta BR_t = -1\right)$	$\Pr\left(\Delta BR_t = 0\right)$	$\Pr\left(\Delta BR_t = 1\right)$	Observed change
2007(m7)	0.025	0.676	0.299	Increase
2007(m8)	0.014	0.593	0.393	No change
2007(m9)	0.021	0.650	0.329	No change
2007(m10)	0.072	0.778	0.150	No change
2007(m11)	0.005	0.479	0.515	Increase
2007(m12)	0.001	0.238	0.762	No change
2008(m1)	0.261	0.708	0.032	No change

Figure 1. Probability of changing the Bank rate as a function of the gap between observed inflation and inflation target
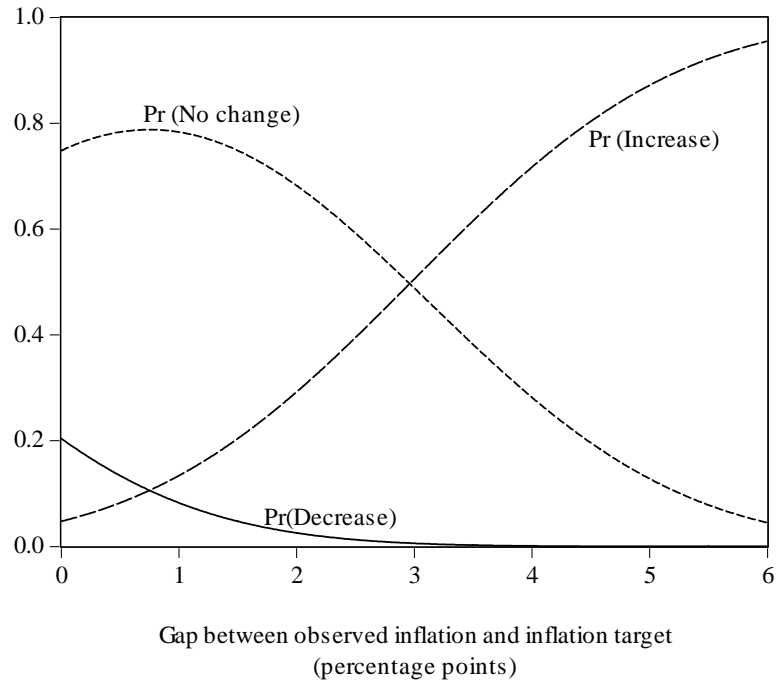
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