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EXCHANGE INTERVENTION EFFECT IN COLOMBIA: 2004-2006

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Summary:

This article measures the effectiveness of the exchange interventions executed exerted by the Colombian Central Bank between 2004-2006 from a relative measure for the size of such interventions and its effects on the mean and variance of the nominal exchange rate in the country in such period. The obtained results by means of a relative index of intervention, a GARCH estimation and an impulse-response function, indicate that such interventions had littie and transitory effects in the level and variance of the exchange rate, presenting several day delays and being rapidly discounted by the market. Likewise, it is shown that such interventions, executed in a moment when a strong appreciation process of the Colombian peso happened, did not generate inflationary pressures and could moderate, but not revert, the peso/dollar revaluation tendency .

Key word: Sterilized interventions, exchange regime, managed floating, exchange market, exchange rate, portfolio model.

Clasificación JEL: E52, E58, F31, G11.

I. INTRODUCTION

In this article we pretend to evaluate the managed floating strategy of the Colombian Central Bank, which has interfered in the exchange market on a high volatility scenario of the nominal exchange rate. Based on a portfolio balance model or budget equilibrium for determining the nominal exchange rate, it is intended to verify the effects of the exchange interventions on the behavior of the exchange rate during the last three years (2003-2006). We look for estimating a GARCH model for the Colombian case which evaluates the effectiveness of the bank interventions on an exchange rate functional volatility scenario. Likewise, using impulse- response exercises it is aimed to measure the temporal impact of the interventions of the Banco de la República.

The aim of this article Is to explain the Colombian exchange course in the last years through the measuring of the relative size of the interventions performed in the period of the peso revaluation, between 2004 and 2006, and calculate

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effect on the exchange rate cycle, and even reacts on the contrary way the same day the discretional intervention is performed (that is to say, a dollar buying makes the exchange cycle decreasing; intervention in small magnitudes only alters three days the cycle responses). At the same time, the impulse-response exercises show transitory effects of the interventions, which are rapidly absorbed by the market.

This article has the following organization. In the second section a theoretical discussion on the posture of the economic literature referring the different exchange regimes and the effectiveness of the interventions is made. The third section discusses the configuration of the exchange policy in Colombia and by means of an analysis of some intervention indicators and simple econometric exercises the size of the intervention is measured. In the fourth section the budget equilibrium model is presented and its variation to be used. In the fifth section the econometric results which assess the pertinence of the discretional intervention and its impact on the cycle and variability, at short and medium term, of the exchange rate in Colombia are shown. Summary and conclusions are in the last section.

II. LITERATURE REVIEW

The "*trilemma*" of the exchange policy demonstrated in the Mundell-Fleming model, on the impossibility of accomplishing at the same time a inflation targeting (or, have monetary autonomy), a previewed pathway for the exchange rate and have free mobility of capital, has been widely accepted in the economic literature[2]. Based on this formulation, and having a scenario of free capital mobility, Bordo (2003) indicates how the economically correct options for the adoption of exchange regimes in the latest times are the called corner solutions: free floating (with monetary autonomy) or fixes exchange rate (declining the inflation control). The intermediate exchange regimes (where there is a target exchange rate or at least a pathway on the time pre established by the central bank) would be completely fragile or defenseless by a monetary policy due to the lack of an enough number of independent instruments.

For instance, IMF (2005b) lists three basic inconveniences for these intermediate systems: i) the central bank delegates part of its power to another country and assumes a lost of the monetary autonomy; ii) the target exchange rate may tie the central bank to speculative attacks and, in an extreme case, force the bank to make a parity change between currencies, which is not necessary in other circumstances; iii) the load of getting a level for the real exchange rate totally falls on the price level, so, when these are sticky, the cost

[2] Concept also referred as the *impossible trinity*.

in terms of product is very high as it must adjust first to the prices. Fischer (2001) also presents good empiric evidence where he showed that during the nineties an important number of countries abandoned the intermediate regimes because they did not accomplished the former target established with the subjacent exchange arrangements[3].

The world standard is basically nowadays to get low inflation rates[4], that is to say, the exchange rate is completely determined by the market. This is the scenario the developed economies joined from the beginning of the nineties (mostly due to the good results in the control of inflation obtained by the Federal Reserve and the Bundesbank, and the everyday more pronounced weakness of the exchange control systems), later the Latin American economies led by Brazil and Chile, and finally the Asian southeast and European east economies which adapted this schema at the end of the century[5].

Nevertheless, Bordo (2003) argues that emergent countries should not adopt any of the extreme regimes for the exchange rate for three reasons: i) for the possible exposition to monetary crisis (in the free floating case) or bank crisis (in the fixed exchange rate case); ii) because of the so called *original sin* (the record of high inflation rates, fiscal laxity and the existence of underdeveloped financial markets typical in these countries which cannot be discharged at short term); and iii) because the variations in the exchange rate can be totally absorbed by the prices, creating inflation pressures. According to the author, these problems would suggest that the intermediate agreements may still have a main role in the emergent countries. He also points out that countries have had less volatility in their currency value and less inflation when there has been a nominal anchor in the management of the exchange rate.

A different approach to the consensus on extreme regimes is in Bofinger and Wollmershäuser (2003a and b): a theory of the managed floating. Generally, central banks look for tuning the trajectories in both: the exchange and inflation

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[3] Bordo (2003), analyzing the evidence in literature on the different exchange arrangements performed by countries, by their real acting (*in facto*) on markets, examines the in force exchange classification in each country, resulting that the free floating of the exchange rate is not associated with high inflation rates (as the IMF official classification establishes), but with larger growths.

[4] Or even zero inflation, as in Japan, besides all the risks linked to the liquidity trap and deflation this phenomena faces.

[5] On this topic Ball (1998) emphasizes how risky a target inflation exclusive policy may be, as it may create great fluctuations in the exchange rate and the product.

rate[6]. *Table 1*, for instance, presents the case of different central banks which in 2004 intervened in the currency market, even though some of them officially declared to maintain a free floating regime[7]. This may serve to demonstrate that nowadays, central banks tend more to active intervention in the exchange market for limiting its volatility, more than any other corner solution when determining the nominal exchange rate[8].

Under this scenario, the central bank simultaneously search for two targets of monetary policy: inflation control and a pathway for the exchange rate, trying to maintain the uncovered interest parity and minimize the social lost function associated with the variations on the price of the currency and the return of the capital flows[9]. The key of this theory is to guarantee that the central bank has access to two independent monetary policy instruments: international reserves and short terms interest rate. To achieve this, an intervention in the exchange market should not have meaningful effects on the monetary base and vice versa. So, an increment on the amount of net foreign assets should attach to a reduction in the net domestic assets, if the intention is to maintain constant the monetary base and avoid changes in the exchange market which may affect the

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[6] Calvo and Reinhart (2000) affirm: "countries that say they allow their exchange rate to float mostly do not-there seems to be an epidemic case or fear of floating."

[7] By the way, taking the textual statement of Frankel (2003) on the country exchange classification: "One reason is that there is a substantial difference between de jure classifications and de facto classifications, between what countries say they do and what they actually do [...] Most of those listed as floating in fact intervene in the foreign exchange market frequently [...] Worryingly, the attempts at de facto classification differ widely, not just from the de jure classification, but from each other as well."

[8] Two well differentiated intervention mechanisms exist. The first kind is preannounce, of public knowledge and is performed systematically with clear signals in the market (options *put* and *call* in Colombian case). The second works on secret, it is not announced by the central bank and no registry is maintained on the moment the bank intervened in the assets market (it is the discretional kind intervention in force in Colombia).

[9] According to this, the central bank chooses a pathway for the exchange rate which is not pre-announced (confront the similarity of this definition with respect to the intervention of the discretional kind carried out by the Banco de la República of Colombia) and by the active intervention in the exchange market (which is not a public intervention), aims to adjust the exchange rate to that predetermined trajectory. When the public expectations are completely compatible with the pathway chosen by the central bank (under a perfect behavior of the exchange market), the exchange rate and the central bank target are identical.

short term interest rate[10]. This procedure is known with the name of monetary sterilization of the interventions in the exchange market.

Table 1. Exchange regimes in selected countries and some intervention characteristics of their Central Banks

Country (currency)	*Exchange regime**	*Intervention characteristics*
Argentina (Peso)	M.F	The Central Bank of Argentina intervenes in the foreign exchange market, but it does not determine an exchange rate level.
Australia (Dollar)	F.F.	The Bank of Reserves of Australia has the power to discretionally intervene in the exchange market.
Brazil (Real)	F.F.	By swaps, the Central Bank of Brazil tried to devaluate its currency between October and December of 2005.
Canada (Dollar)	F.F.	The Central Bank can intervene in the exchange market for promoting ordered market conditions.
Chile (Peso)	F.F.	The Central Bank of Chile can intervene in exceptional circumstances.
Colombia (Peso)	F.F.	The Republic Bank intervenes the exchange market to define international reserves, to control the volatility of the exchange rate and in the search of a determined level of the exchange rate by discretional acting.
Croatia (Kuna)	M.F.	The Croatia National Bank fixes an exchange rate to apply in transactions out of the interbank market to smooth fluctuations.
Czech Republic (Moruna)	M.F.	The Czech National Bank intervenes to smooth the inatraday volatility
Egypt (Pound)	M.F.	The Egyptian Central Bank buys and sells foreign currencies daily with the average exchange rate fixed by the banks the day before.
Guatemala (Quetzal)	M.F.	The Bank of Guatemala buys foreign currencies on behalf of the public sector.
Israel (Sheqel)	F.F.	Authorities have not intervened in the foreign currency market.
Japan (Yen)	F.F.	The Central Bank intervenes to counteract the disorders on market.
Korea (Won)	F.F.	The Central Bank intervenes to counteract the disorders on market.
Mexico (Peso)	F.F.	The Bank of Mexico is been selling dollars daily directly in the foreign currency market for the 50% of the previously accumulated international reserves.
N. Zealand (Dollar)	F.F.	The exchange rate is free determined by the foreign currency market.
Norway (Krone)	F.F.	The monetary policy is anchored on a target inflation frame.
Paraguay (Guarani)	C N.F.	The Central Bank intervenes to smooth the incorrect fluctuations in the price of the foreign currency.
Peru (N. Sol)	M.F.	The Reserve Central Bank discretionally intervenes to moderate the fluctuations and can, extraordinarily, index the bonds to the exchange rate.
Poland (Zloty)	F.F.	The value of its currency is determined by the foreign currency offer and demand forces, there is not any degree of intervention.
Singapore (Dollar)	M.F.	The exchange rate is an intermediate target and dollar fluctuates on a non announced target band.
South Africa (Rand)	F.F.	The South African rand is determined by the forces of the foreign currency market, without any degree of intervention.
Thailand (Thai bath)	M.F.	The Central Bank daily announces a referent for the exchange rate, based on the previous day average, and intervenes only when necessary.
Turkey (N. Lira)	F.F.	The Turkey Central Bank reserves its right to intervene in the foreign currency market in case of daily excessive volatility in any direction.
United Kingdom (Sterling pound)	F.F.	Authorities may discretionally intervene every time they find incorrect fluctuations in the exchange rates.
United States (Dollar)	F.F.	The Federal Reserve may intervene in order to calm down certain disorders in the foreign currency market.
Uruguay (Peso)	F.F.	The Central Bank reserves its right to intervene to ensure the order on market.

* M. F.: Managed floating; F.F.: Free floating.
Source: Personal construction from the IMF (2005). *Annual report on exchange arrangements and exchange restrictions*. Washington.

[10] The domestic bonds are specially represented by TES and REPOS, while the foreign assets are conformed by the international reserves.

Sterilization is the way a central bank gets its two instruments independent. Fischer and Zurlinden (1999) state: "if the central bank key is the sterilized interventions, defined as interventions which leave unchanged the monetary base, it may not have a meaningful influence on the behavior of the exchange rate"[11]. But they warn: "There is not a permanent effect of the interventions on the exchange rate". Nevertheless, Domínguez and Frankel (1993) list three arguments against the effectiveness of the interventions: (i) the relative size of the intervention is small with respect to the ampleness of the market, (ii) a ricardian equivalence which would discount the effects on time may happen, and (iii) the substitutability between the international assets may be high[12]. According to them, only when the domestic and foreign bonds are imperfect substitutes (portfolio channel for determining the exchange rate) or when the central bank public interventions get to alter the expectations on the future of the policy (expectation channel), the sterilized interventions should have effects on the exchange rate level.

Finally, Sarno and Taylor (2001) and Schwartz (2000) offer an interesting compilation on the discussion on the intervention effectiveness. The analyzed bibliography on the first recognizes certain effectiveness to the interventions through the two exchange rate determination channels and a third one is proposed (coordination channel). Quite contrary, the second article concludes that, except the interventions in Japan, no other case offers meaningful effects of the interventions on the exchange rate and signals the impossibility of having two targets at the same time[13].

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[11] The central banks are ready to give signals on market by mean of believable news on the future of the monetary policy to affect the expectations and indirectly influence the exchange rate (referring to the channel of signals or expectations as a way to determine the exchange rate, different to the portfolio channel we will use here). Each sterilized intervention must "modify the preferences of the investors through the net change in the structure and tenancy of their financial assets, which permits to moderate the negative effects of the capital movement" (López y Mesa, 2005).

[12] Dominguez (1998) as well, arrives to the following conclusion: "intervention operations generally increase exchange rate volatility. This is particularly true of secret interventions, which are those undertaken by central banks without notification to the public".

[13] Frankel and Meese (1987) text announces that even when markets function efficiently (a difficult to maintain assumption) arguments against the intervention in the exchange market cannot be stated solely based on how optimum the Arrow-Debreu model is.

III. EXCHANGE POLICY EVOLUTION IN COLOMBIA: SIZE AND EFFECTIVENESS OF INTERVENTIONS IN THE EXCHANGE MARKET

The purpose of this section is to analyze the exchange rate behavior in Colombia in force in the period of the free floating regime, emphasizing the role and relative size of the interventions of the Banco de la República in the exchange market in the period 2004-2006. In 1999, the country moved from an exchange rate band to a free floating one in which the Banco de la República committed not to interfere on the determination of the exchange rate market and, later, prioritized its target inflation policy. The Bank would only interfere by mean of foreign currency buying and selling each time the exchange rate volatility level rises (*Put* options for accumulation of international reserves, *Put* and *Call* options for control of volatility and *Call* options for reduction of international reserves). At the beginning of the regime good results were obtained as in the reduction of the dependency on the exchange rate level to the foreign misbalances, getting devaluation tendencies inferior to the ones presented before the end of the band regime (figure 1)[14].

Figure 1. Trajectory of the nominal exchange rate in Colombia, 2000-2006

Source: Representative market exchange rate of the Banco de la República.

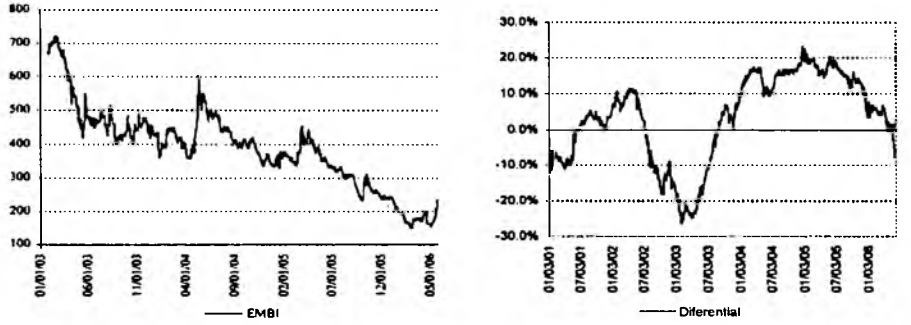
Later, in more recent years, two well defined phases began. Until the late 2003, the exchange rate tendency in Colombia was depreciation or devaluation of the peso, which had a higher dimension since May 2002. The possible causes of this first stage were the fiscal deficit, speculative pressures due to low interest rates, big on force risk premium and the international instability characterized by

[14] By the way, Clavijo (2002) outlines that "the tuning of the monetary and exchange mechanisms happened in Colombia during the years 1999-2002, since the adoption of the exchange flotation and target inflation scheme."

national crisis with great contagious effect[15]. The second stage began once the first ended: appreciation or revaluation of the peso. The positive differential of the interest rates, the massive entrance of speculative capital, the growing immigrants remittances, the weakness of the dollar with respect to all other currencies, (basically due to the twin deficits and negative reports in the macro economic themes had for several trimesters in the Unite States), the bonanza of the external sector and the fell in the Colombian debt spread are signaled as the causes of this phenomena (see *figures 1 and 2*) .

The first stage matched with the creation of a new temporal intervention mechanism of the Bank: the options for reducing the international reserves aiming to stop the possible inflationary pressures derived from peso devaluation. The second, faced a new turn in the management of the monetary policy: the discretional kind intervention in the exchange market. *Table* 2 shows the amounts of this kind of intervention of the Bank. This mechanism receives some critics, mainly for the possible lost of the transparency in the monetary policy in Colombia[16], qualities long time recognized to the Banco de la República under the current free floating regime.

Figure 2. Risk level associated to Colombia and interest rate differential *



*The interest rate differential is defined as $dif = (1+i) - (1+i^*)(1+\Delta S/S)$, being i the internal interest rate (90 day Term Deposit), i^* the external interest rate (Libor in dollars to 90 days) and $\Delta S/S$ the yearly Colombian peso depreciation rate with respect to dollar.
Sources: Term deposit and exchange rates in the Banco de la República; Libor in www.economagic.com; EMBI in www.webstation.com.

[15] For instance, the Venezuelan and Argentinean case in Latin America.

[16] If transparency is assessed by mean of the percentage of credibility of the agents in the inflation target (measured through surveys of inflation expectation) in the last two years, the result would be totally favorable to the bank interests because the credibility levels have been steadily growing.

This way, the evolution of a discretional exchange policy in the 2004-2006 period, represented by the constant interventions of the Banco de la República in the exchange market, limit the possibilities for the existence in Colombia of an exchange rate free floating[17]. According to Wollmershäuser (2003), one way, at least *a priori* for determining if a country has a pure floating or otherwise the central bank is actively interfering in the exchange market, would be to corroborate if the balance of the international reserves stays constant or at least its volatility is small.

Table 2. Interventions of the Banco de la República in the exchange market

	2004	*2005*	*2006 (April)*
Buying	**2904,90**	**4658,40**	**1196,70**
Put Options	1579,60	0,00	0,00
IR accumulation	1399,70	0,00	0,00
For the control of volatility	179,90	0,00	0,00
Discretional intervention.	1325,30	4658,40	1196,70
Buying	**500,00**	**3250,00**	**1168,50**
Call options	0,00	0,00	168,50
For the volatility control	0,00	0,00	168,50
National Government	500,00	3250,00	1000,00
Net buying	2404,90	1408,40	28,20

Source: Banco de la República.

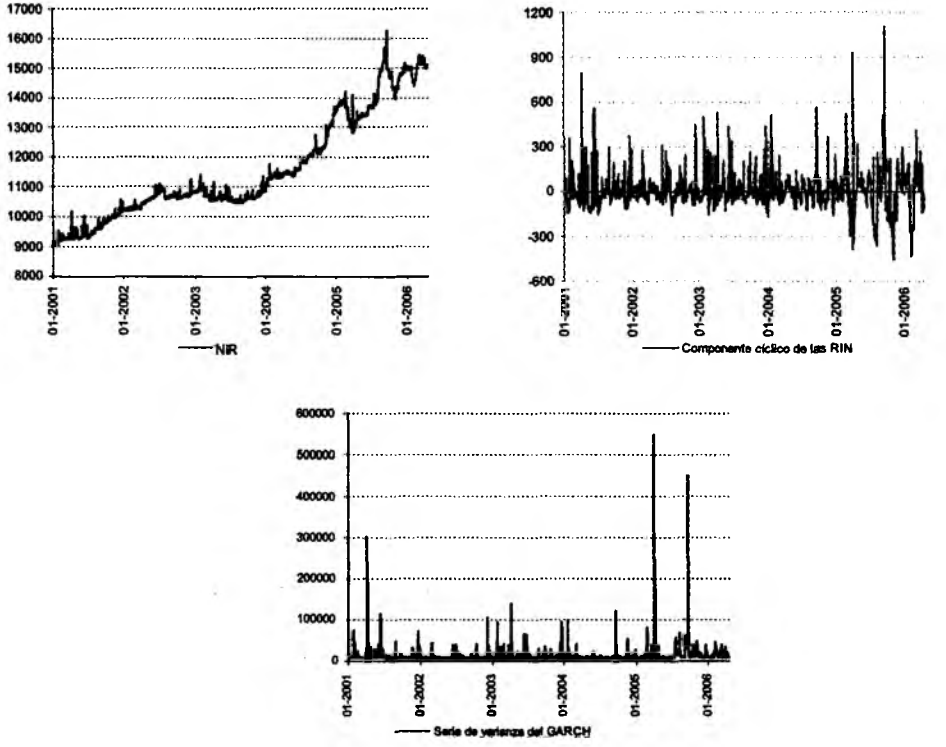
When the exchange policy solely tries to smooth the exchange rate, the behavior of the reserves should follow an identical and independently distributed process. On the other hand, when a target exchange rate is established, the changes in the international reserves present certain degree of persistency. On purpose, figure 3 shows the trajectory of the non adjusted net international reserves –NIR–, of its cyclic component (result of the Hodrick and Prescott filter –HP–) and the variance series of the later (measured through a GARCH modeling) for the Colombian case.

The following is the reasoning: The cyclic component of the NIR show the deviation of the reserves with respect to a tendency component estimated by the HP filter, that is, would show the deviations due to occasional components or short term shock dynamics exerted by the central bank. From this approximation, it is noted that by the end of 2004 a great increment on the series variability level is given, that is, the wave amplitude is greater and greater. This figure evidence on the NIR cycle is confirmed by an estimation GARCH for the variance of the cyclic component, which produces a series of the estimated variance of the NIR

[17] Although it could be set a starting hypotheses the fact that from its constitution in 1999, the floating exchange regime counted with announced intervention mechanisms which somehow have let seen the discretional character of the exchange policy.

cycle. This methodology confirms the greater volatility of the reserves since 2004 (see the inferior panel of *figure* 3).

Figure 3. Net International reserve trajectory –NIR–, its cyclic component and variability.



Source: Original NIR series of the Banco de la República. Millions of dollars. Author's estimation.

This result makes think that there has been a transition in the exchange policy from a free floating exchange rate to a managed floating, without meaning a target exchange rate to the central bank. The noticeable persistency in the trajectory of the NIR and the greater volatility on its cyclic component support this hypothesis. Besides, the bank interventions on the exchange market moved from random events trying to smooth the variability level of the exchange rate to discretional factors which have directly influenced its level, affecting its trajectory on time.

In this order, and as an approach to the intervention activity exerted by the bank and to value its impact, these interventions on the exchange market can be

evaluated according to the relative size with respect to the external sector, that is, relative to the offer (exports) and demand (imports) of foreign currencies derived from the trade balance. A practical (and proxy) way to measure the interventions is by the relative change of the net international reserves, because each operation of the bank determines accumulation or reduction or reserves, then we can build an index dividing the net international reserves by the size of the external sector and taking the first difference in absolute value[18]:

$$I_t = \left| \frac{NIR_t}{\frac{X_t + Q_t}{2}} - \frac{NIR_{t-1}}{\frac{X_{t-1} + Q_{t-1}}{2}} \right| \quad \text{(III.1)}$$

This index measures the relative change in the value of the net international reserves from one period to another, as a proxy of the intervention relative size. Note that there is not difference between one increment or diminution of the reserves (that is to say, between one buy or sell of foreign currency), this is because the interest of this index is not to show the direction of the intervention, but to tell us how the amount of available international reserves, with respect to the needs the size of the external sector states, has evolved on time.

According to this, when the index reports *high* historical values there could be excessive interventions and monetary kind pressures on the inflation control would exert (upward or downward, according to the direction of the intervention). On the other hand, when the index is in the historically *moderated* values, we could say that the intervention was according to the demands the external sector size imposes and this would absorb any monetary kind pressure. *Figure* 4 shows the evolution of this index in Colombia.

On the left panel of the graphic we have represented the monthly trajectory of the index shown in the equation (III.1). Concentrating on the revaluation period, in January, March, and July 2005 this index presented three tops, that is to say, the absolute change in the international reserves with respect to the size of the external sector was meaningful. Nevertheless, excluding these tops, the recent trajectory of the index has even been below the historical average. In fact, the historical average of this index (since 1980) is 0.82, while its average since August 2004 was 0.52, reflecting a minor intensity in the intervention since its

[18] If this index is equal to, let us say, a *c* constant, we can say that the variation in the international reserves in that month was *c* times the monthly size of the external sector, measured as the import and export average value.

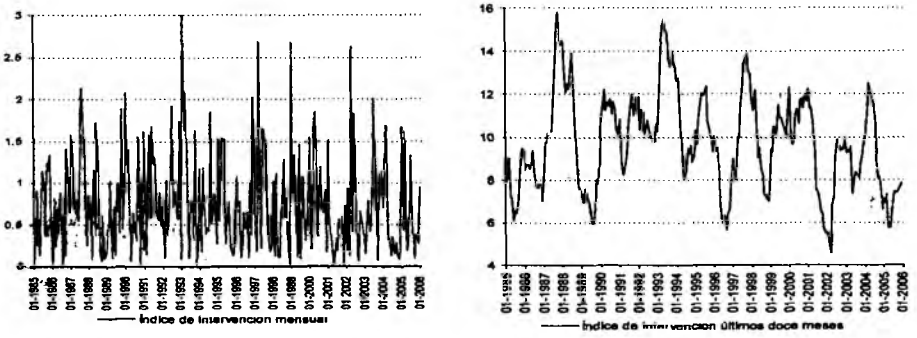
discretional character started, always measured in terms relative to the size of the external sector[19].

Likewise, the right panel of the graphic shows the same twelve month accumulated index, and its annual trajectory[20]:

$$I_t^{12} = \sum_{i=0}^{12} \left| \frac{RIN_{t-i}}{\frac{X_{t-i} + Q_{t-i}}{2}} - \frac{RIN_{t-i-1}}{\frac{X_{t-i-1} + Q_{t-i-1}}{2}} \right| \quad \text{(III.2)}$$

We can see that after it reached its top in March 2004, it began a downward process and during all 2005 it had historical low levels, demonstrating the thesis which says that the bank interventions have not been out of the limits the external sector size imposes. As the bank has had more freedom for buying foreign currencies in the exchange market, and comforted by the growth of the external sector, it has not generated great monetary policy risks against the achievement of the inflation targets.

Figure 4. Monthly and annual intervention index: relative change of the net international reserves, 1985-2006



Source: Original Banco de la República series. Calculations of the authors.

[19] The average of this index in the peso devaluation period registered between 2002 and 2003 was 0.76.

[20] A *k* value of this annual index would suppose that the international reserves had during the last twelve months a variation equivalent to *k* times the size of the external sector in a month.

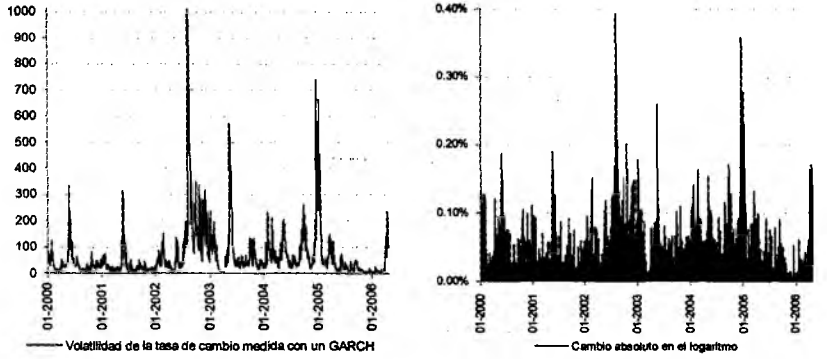
Undoubtedly, the fact that this index is in the *normal* historic limits, or below them, is helping for the growing character of the Colombian foreign trade, which duplicated its size between 2003 and 2005. That is, as hypothesis on the impact of the discretional interventions on the exchange policy targets, the possible financial and inflationary pressures which could have happened during the discretional intervention period have been reduced by the growing size of this sector and the foreign currency absorption the participants of the foreign trade exert.

So, the interventions on the exchange market would result effective as they stopped a devaluation which could have been higher in the case they did not exist, without causing conflicts with the achievement of the inflation target. Speaking of the effectiveness of the discretional intervention in Colombia, Julio and Toro (2005) state: "the interventions obtain the desired effect (a permanent increment in the devaluation rate) only if a credible and not ambiguous signal, accompanied by meaningful intervention amounts is emitted". And later they continue saying that "the discretional intervention in the exchange market has helped moderate the Colombian peso appreciation tendency regarding dollar, though it did not revert it. at the same time, it has introduced a greater volatility to the exchange rate due to the insufficient credibility of the economic agents on the relaxation of the monetary policy and further success of the intervention policy".

Figure 5 shows the volatility of the exchange rate, measured by a GARCH established on a cyclic component of the daily value of the exchange rate (left panel), and by the absolute change of its logarithm (right panel). Accordingly, the exchange rate volatility was huge in the late 2002, mid 2003 and early 2005. In the late 2002, in presence of the revaluation pressure, the government should have intervened on the foreign currency market to avoid the exchange rate levels could affect the inflation compromises for the year. It seemed that one of the possible causes for the greater variability in this period (besides the fluctuations from the financial markets and the fiscal maladjustments in Colombia and the whole world) were the interventions the issuer made for the currency value control[21].

[21] It was specifically about the announced interventions associated with the *Call* options of foreign currency sale (Mesa and Ramos, 2003).

Figure 5. Colombian exchange rate volatility, 2000-2006



Source: Banco de la República original series. Estimations of the authors.

Now, analyzing the possible effects of the discretional intervention exerted by the Banco de la República since the late 2004, this policy could introduce more volatility to the exchange rate until mid 2005, when the interventions (at graphic hypothesis level) could have begun to have a minor impact on the decisions of the market with which they had some general acceptance or were discounted by the agents before its execution.

No doubt, this intervention issue of the bank in the exchange market leads us again to confirm that the current Colombian exchange regime is far from being free floating and that the performance of this through time is being determined by the intromission of the central bank. It is then necessary to evaluate if the bank labor has been successful in the exchange rate control. This evaluation will be done in the fifth part, now we will study some theoretical aspect on the exchange rate determination.

IV. THE PORTFOLIO BALANCE CHANNEL: AN EXCHANGE RATE DETERMINATION THEORY

The aim of this section is to evaluate the determinant of the nominal exchange rate in Colombia from a variant of the portfolio balance model. The portfolio balance channel (or model) (PBC) tries to explain the motives by which the investor diversify their portfolio between domestic and foreign assets (the government domestic bonds are in national legal currency and the foreign ones in foreign legal currency) due to their expectations on the returns in each country[22]. It is a dynamic model (dynamic because there changes on time in the

[22] The explanation to this model is based on Bofinger and Wollmershäuser (2003a and b), Domínguez and Frankel (1993), Sarno and Taylor (2001) and Wollmershäuser (2003).

agents decision on the place for investing their richness) for determining the exchange rate by interacting among the international asset markets[23]. The misbalances in the current account define the net accumulation or reduction level of international assets of a country, its return and the perceived risk level.

Four markets are considered by these models: two monetary markets (national and foreign) and two bond ones (national and foreign), determining the exchange rate by the interaction of these four markets and the restriction of the financial richness. A depreciation increases the value of richness when incrementing the value of the foreign bonds maintained by national agents. For this motive, every time there is an increment in the exchange rate value a parallel increase in the interest rate must happen to maintain the equilibrium in the money market. The equilibrium value of the exchange rate is that the owners of the financial wealth agree to preserve the totality of the asset levels offered in the country.

The expected return rate depends on the interest rate of both countries, the expectations of the agents on changes on the exchange rate and the risk level associated to each country. Then, for a given asset supply, in equilibrium, the exchange rate differential ($i_t - i_t^f$) must be equal to the expected depreciation ($E_t s_{t+1} - s_t$, being s the logarithm of the nominal exchange rate) plus a risk premium (rp_t) ,that is to say, the uncovered interest parity must be accomplished:

$$i_t - i_t^f = E_t s_{t+1} - s_t + rp_t \quad \text{(IV.1)}$$

The risk premium is explained due to the existence of the imperfect substitutability in the domestic and foreign assets and because it is supposed agents do not like risks. That is to say, when a country has positive levels of risk, must offer an extra return for the agents to be ready to acquire the existing bonds offer as the owners of the richness maximize their earnings including both the national bond risk level and the foreign bond risk one.

An equation which explains exchange rate determination, supposing the four participating markets in this channel are in equilibrium after the decisions of replacing the assets subject to changes in profit perceived by agents, would be:

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[23] Different to the PBC, the monetary focus of the exchange rate supposes that only the amount of money in a country as well as its balance of trade will define the exchange rate level.

$$E_t \Delta s_{t+1} = i_t - i_t^f - rp_t \text{ (IV.1.1)}$$

Being $E_t \Delta s_{t+1} = E_t s_{t+1} - s_t$

This channel is relevant as it explains the effects (and evaluates the effectiveness) of central banks interventions in the exchange market, emphasizing its net effects on domestic asset relative supply and demand. After the authorities have intervened in the exchange market and have sterilized, intervention may have very little, or not effects, on the domestic interest rate, as the monetary supply did not change. Nevertheless, the asset owners are not indifferent to the currency they are valuing their portfolios and have an exchange rate variation associated risk level. As a consequence, what is altered is the agent portfolio composition, as the central banks have bought and sold assets in their sterilization operations and investors have rebalanced their portfolios according to the new supply.

So, the spot value for the exchange rate and the risk premium (given the interest rate differential and the expectations of the exchange rate) should change in order to affect the domestic value of the foreign bonds and their expected return: this is the transmission channel in which interventions affect the exchange rate level by mean of the PBC. Also note that from the perspective of the PBC sterilized interventions imply that a central bank can define (or at least influence in part) the country risk.

Discretional interventions can also have a direct effect on the cyclic or tendency behavior of the exchange rate. For this motivation, to collect the direct effects of these policy strategies we offer to consideration the following variation of the PBC:

$$E_t \Delta s_{t+1} = \alpha Int_t + \beta\left(i_t - i_t^f\right) - \delta rp_t \text{ (IV.2)}$$

Being *Int* a measure for the bank interventions and the parameters $\alpha, \beta, \delta > 0$ mean the relative answer of the exchange rate to variations in each one of the explicit variables. Note that the equation (IV.1.1) has identity properties, but this new equation (IV.2) provides a direct importance to interventions menacing to change the relative effect of the interest differential and risk premium.

V. ESTIMATIONS AND EMPIRIC RESULTS

A. Using the portfolio balance channel in the cyclic component of the exchange rate

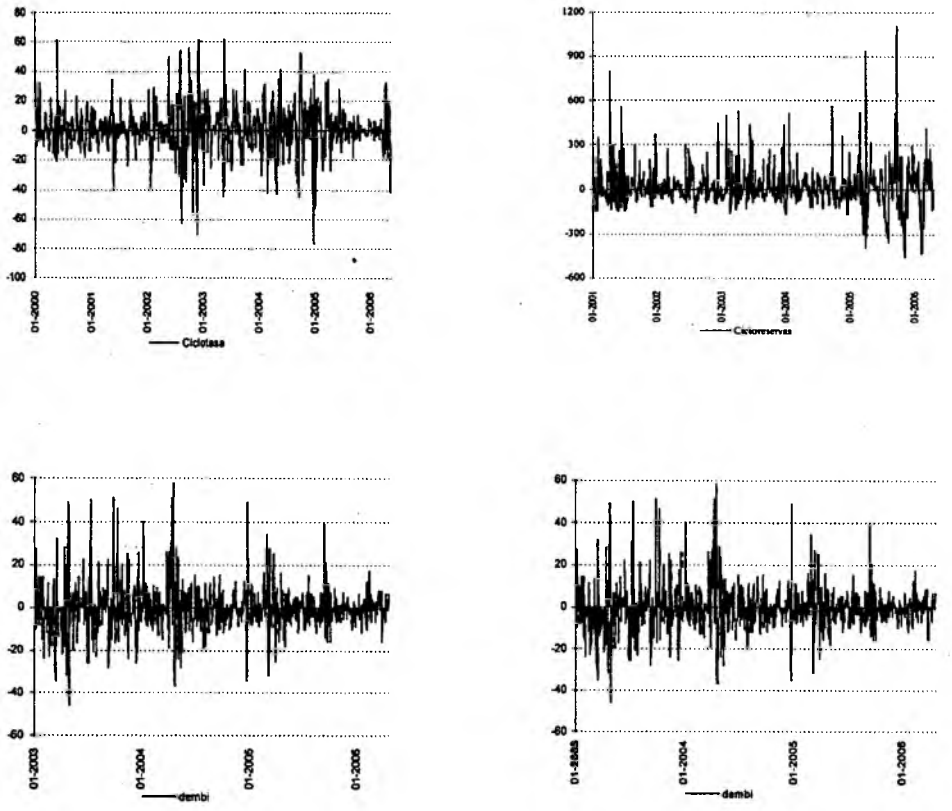
By the described approximation in section IV, in which the Portfolio Balance Channel –PBC– was exposed and the possibly existing relationship between the exchange rate, interventions, interest rate differential and risk level was identified –summarized in the equation (IV.2)–, we try to measure the determinants which explain the exchange rate expected values and, specifically, the intervention impact in the exchange market (exerted by the Banco de la República). *A priori* we expect the following causality relationships to happen:

$$\textit{Exchange rate expected variation} = f\left(\underset{+}{interventions}, \underset{-}{differential}, \underset{+}{risk} \right) \quad \text{(V.1)}$$

Nevertheless, there are four difficulties in the series considered which demand transformations on the variables and the use of *proxy* variables in some cases, or special problematic behavior modeling in others. Firstly, all the considered series are the financial kind (exchange rate, interventions, ¿EMBI measured country risk? and interest rate differential) and these series often present stochastic tendencies in their trajectory (they would be one order integrated: unitary roots, *table 3).*

Secondly, the intervention variable, in the new discretional intervention frame adopted by the bank, is secret. For this motive, we need a *proxy* variable which allows us measure somehow the bank activity. As it was done in the second section to measure the intensity of the interventions, here we also use the net international reserves to see (only in part if you wish) the movement made by the central bank in the exchange market. The use of this variable has been supported by Bofinger and Wollmershäuser (2003) and Wollmershäuser (2003) studies. It makes sense the reserve cycle is the variable which necessarily reacts when the central bank buys or sells in the exchange market.

Figure 6. Exchange rate and international reserve cyclic component and first differences of the EMBI and the interest differential



Source: HP filter cycle estimation. For the sources of the original series, see previous figures

Thirdly, all financial market interdependent characteristic, market collective determination possibilities, its dynamic responses to past (recent) and contemporary phenomena and the influence of the market participant expectations on the values each period financial assets take, make crashes from model endogenous variables and other not observed exogenous ones be very persistent, short term at least. Finally, as shown in *figure 2,* the exchange rate variability is too high and seems to present its own functionality.

Table 3. Results on the tests of unitary roots: Phillips-Perron–PP– and Kwiatkowski-Phillips-Schmidt-Shin–KPSS– January 2003 and May 2006 period

Variable	*Statistic PP (without intercept or tendency)**	*P-values of test PP*	*Statistical KPSS (with intercept)***	*Stationary PP y KPSS*
Lntasa	-2.0192	0.0417	3.5769	Yes and no
Ciclotasa	-9.8193	0.0000	0.0257	Yes and yes
Lncierre	-1.7822	0.0711	3.5729	No and no
Lnreservas	1.6083	0.9741	3.5657	No and no
Ciclreser	-17.8023	0.0000	0.0123	Yes and yes
Lnembi	-1.7568	0.0750	2.8871	No and no
Dlnembi	-27.6334	0.0000	0.0634	Yes and yes
Diferencial	-1.7766	0.0719	1.7846	No and no
Ddif	-25.5962	0.0000	0.0359	Yes and yes

Definitions: Daily data for Colombia (five day weeks) being *lntasa*: representative market exchange rate natural logarithm, *ciclotasa*: cyclic component of the representative market exchange rate resulting from HP filter. *lncierre:* every day exchange rate close value natural logarithm. *Lnreservas:* net international reserve level natural logarithm. *Ciclreser*: net international reserve cycle component *Lnembi:* EMBI level natural logartihm. *dlnembi*: first lnembi difference. *diferencial:* see explanatory note of figure 2. *ddif:* first interest differential difference.

* The nuil hypothesis of the PP test is the existence of a unitary root. This hypothesis is rejected at 5% for statistic values above (-1.9412). ** The null hypothesis of the KPSS test is the existence of stationary series. This hypothesis is rejected for statistic values above 0.463.

Source: For the exchange rate close value, www.corfinsura.com and for the other series see previous figures.

The nonstationary variables included in the original model would be solved in two different ways. For the exchange rate and international reserve case (this late proxy of interventions), looking for short term results and to establish a cyclic relationship between these two variables, the cyclic component from Hodrick and Prescott–HP–will be used as their transformation. On the other hand, for the EMBI and the differential of interest rates the first difference series will be taken (*figure 6a* and table *3*). Likewise, for evaluating model delay response, dependent variable lags will be included (AR part), none observed exogenous crash lags (MA part) and explanatory variables with their significant lags (altogether it would be a Autorregresive distributed lag relationship). Finally, the variance will be model by ARCH-GARCH methodology.

The regression results are in *table 4*. The estimation was made for maximum likelihood to allow variance modeling. The used period is between January 23, 2003 and May 12, 2006, with daily data from Monday through Friday (for the holy days the last working day data was used) with a total of 862 data (before the corresponding adjustments due to used differences and lags). The need for an ARCH type modeling (variance equation) was corroborated because the square residual correlogram concluded, when only the modeling with the distributed lags was included, these were not stationary; as a consequence, there would be functional problems to be modeled in the variance. To control the heteroscedasticity the Bollerslev-Wooldrige robust standard errors & covariance was used. When the two previous correction mechanisms where included (the

variance equation and the solution to the heteroscedasticity) the ARCH test (table 4 inferior extreme) confirmed the stationariness of the residuals.

Table 4. Estimation of maximum likelihood with variance modeling for the cyclic component of the exchange rate

Dependent Variable: CICLOTASA
Method: ML - ARCH (Marquardt) - Normal distribution
Sample (adjusted): 1/30/2003 5/10/2006
Included observations: 855 after adjustments
Bollerslev-Wooldrige robust standard errors & covariance

Variable		*Coefficient*	*standard Errors*
CICLORESERVAS		-0.003901*	0.001488
CICLORESERVAS(-1)		-0.003242*	0.001635
CICLORESERVAS(-3)		0.003205*	0.001411
DDIF		-498.9270*	37.86709
DDIF (-1)		-365.0851*	45.26939
DDIF (-2)		-274.5937*	47.71574
DDIF (-3)		-121.3013*	42.20914
D(EMBI(-1))		0.029262*	0.013366
AR(1)		0.711053*	0.035844
MA(1)		0.338502*	0.043621
Variance Equation			
C		0.883234*	0.381908
RESID(-1)^2		0.200327*	0.035932
GARCH(-1)		0.807646*	0.026420
R-squared	0.742278	Log likelihood	-2793.377
Adjusted R-squared	0.738605	Inverted AR Roots	0.71
S.E. of regression	7.485448	Inverted MA Roots	-0.34
ARCH Test:			
F-statistic	0.081367	Prob. F(1.852)	0.775523
Obs*R-squared	0.081550	Prob. Chi-Square(1)	0.775207

*Significant at 5%.
Source: See previous figures.

The variables part of the regression are all meaningful at 5%. The roots of the terms AR and MA are inside the unitary circle and the determination coefficients seem to indicate that a good part of the dependent variable variance could be explained. According to the results, the exchange rate cyclic component reacts negatively the same day and the next one a foreign currency buy intervention (reserve accumulation) of the central bank, which alter the reserve cycle, happens.

Only the third day there is a devaluation effect on the exchange rate, that is, the objective of the bank only consolidates after the intervention is totally known in the market and when the expectations of the agents accommodate to a non announced news and make decisions on this new scenario (remember that most

of the time interventions had a discretional character). Nevertheless, from the obtained result we can say the impact is very low and with little power to change the orientation of the exchange rate, at least on its cyclic component.

Anyway, we must emphasize that the variable used in this study (net international reserves) is determined by other capital flows which do not belong to the precise intervention labor, but do define the daily accumulation level of the reserves. Nevertheless, we can expect the cyclic component here used to collect most of the shock activity of the Banco de la República.

The interest rate differential of the interest rate has a negative effect on the short term exchange rate, due to its very strong answer to the return changes among countries (which the portfolio balance model predicts). The interest differential has been the most determinant on the short term exchange rate level, according to the magnitude of the other coefficients. Finally, the country risk would also be considered in the exchange market, but a period later. It seems the agents decisions are based on the country risk variations the day before negotiations[24].

The other coefficients only demonstrate that deviations on the interest rate, compared with their previous day tendency, affect today's value and that also the exogenous shocks on the mean of the cyclic component would only have one day effect. Likewise, the variance levels and the shocks on it would determine the exchange rate variability level only next day.

B. Impulse-response analysis on the portfolio balance model

We saw that in short term the possibilities of interfering in the exchange rate cycle were greater but little at the third day of operating in the exchange market. But we have not answered yet how long lasting those effects may be. The persistency degree on each variable effects, especially those interventions of the central bank on the currency value, must be established looking for an *a priori* and proxy approximation of the short term trajectory. To answer this doubt, we estimated the variable relationships with a VAR and then calculated the impulse-response functions derived of this estimation.

For applying the VAR we placed all the variables in first differences (as the previous literal modeling corresponded to the explanation of the exchange rate cycle), as our target is still to analyze the relative changes caused on each

[24] A detail to consider is that for the estimation reference period, a strong country risk fall happened, partly because of the effect of devaluation on the country borrowing capacity.

variable from a determined point, more than explaining the level itself. So, by now we do not pretend to present hypothesis on the long term variable common trajectory. The oniy objective up to here is to obtain the size and duration of the bank intervention effect by a change in the international reserve level caused by a shock on the perturbation term associated to this variable[25].

The first step is to see the length of the lag which is suggested by the different associated tests. All of them conclude that the optimal lag which guarantees white noise residual is two (*table 5*). As our objective is not to get the VAR, we will concentrate on the results of impulse response graphics. The figure *7* shows us the corresponding results. The exchange rate response to a shock on the perturbation term, called innovation, associated to the interventions variable is analyzed.

Table 5. Lag length test and VAR autocorreiation

VAR Lag Order Selection Criteria
Endogenous variables: D(LNCIERRE) D(LNDIF) D(LNEMBI) D(LNRESERVAS)
Exogenous variables: C
Sample: 1/23/2003 5/12/2006
Included observations: 851

Lag	LR	FPE	AIC	SC	HQ
0	NA	0	-26,3	-26,3	-26,3
1	305	0	-26,6	-26,5	-26,6
2	149,8*	0*	-26,8*	-26,5*	-26,7 *

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

VAR Residual Portmanteau Tests for Autocorrelations
H0: no residual autocorrelations up to lag h
Sample: 1/23/2003 5/12/2006
Included observations: 857

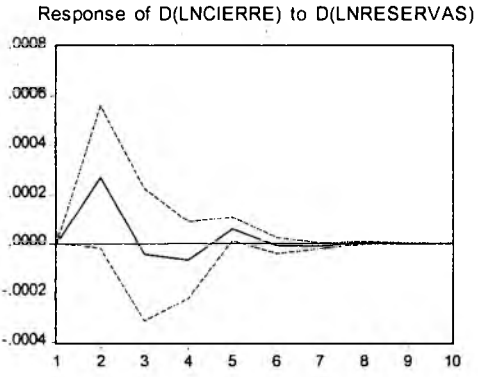
Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	1,15	NA*	1,15	NA*	NA*
2	3,80	NA*	3,81	NA*	NA*
3	19,04	0,27	19,10	0,26	16
4	28,13	0,66	28,23	0,66	32
5	45,40	0,58	45,60	0,57	48
6	64,73	0,45	65,07	0,44	64

*The test is valid only for lags larger than the VAR iag order.
df is degrees of freedom for (approximate) chi-square distribution.

The bank interventions permit an immediate rise on the exchange rate variation (contrary to what happened on the previous apart, when only three days later there was influence on its cyclic level). This effect becomes negative after the third day (second moment) and has presents another positive effect the sixth and seventh day (third movement). We imagine these two last effects are due to the market reaction to the intervention.

[25] To avoid contradictions on the unitary root test, we will use the daily exchange rate close value in first differences in this part, not the RMR we used before.

Figure 7. Impulse response function for the exchange rate on a portfolio balance model



In the second moment agents strongly react to the operation of the market on the opposite way, for instance, if the bank is buying dollars and these have already increased price, they will use some reserves they have for taking profits, making the intervention an explanation to the exchange rate variation lows. Then, on a third moment, the pressure reverts due to the lack of enough funds to continue the foreign currency supply on market and variation becomes positive again. After these seven days, the central bank intervention seems to have no effects on the economy devaluation rate and this goes back the levels previous to the shock.

VI. CONCLUSIONS

Managed floating has become one of the main challenges to current monetary policy, mainly in emerging countries. As signaled, the impossible trinity of the monetary policy which used corner solutions for the management of the exchange rate is being rebated from different angles. From the theory, the models summarizing the managed floating are more and more popular, increasing the number of economists supporting the idea of the active participation of central banks in the exchange market, intending to get a pre set pathway for the currency value. These have more and more echo in economic literature. In practice, likewise, sterilized interventions have become a tool by which banks assume an active role in the exchange rate value without causing big (or none) inflationary pressures.

In Colombia, under the characteristic pressures of the free floating regime, where market and its shocks make the currency value present great variability and long tendencies, managed floating became the internal monetary policy design. The growing variability in the international reserves and the discretional interventions exerted by the bank are laudable examples of this case and the active role of the central bank on the path of the exchange rate. Nevertheless, the exchange intervention index, measured by the change in the net international reserves, show that interventions in the 2004-2006 period have not generated great risks of monetary policy against the achievement of the inflation goals, as the index has been into the historically normal levels or bellow them.

The effectiveness of this kind of intervention in the exchange market was evaluated under the exchange rate determination frame by mean of portfolio balance channel or budget equilibrium. According to the results, interventions have not affected the exchange rate tendency on market, this from the answer of its cyclic component. That is, the international reserve change affects the short term exchange rate in little proportions and opposite way at first. On the other hand, we saw that the exchange rate cycle is mainly determined by the interest differential, while the country risk hardly exerts a little pressure on the currency value cyclic level (or short term). Likewise, we realized the central bank interventions do not have a long term character, that is, each activity effects rapidly fade on market and do not affect the tendency level, or the currency value long term growth rate.

This study verified then that exchange interventions did not have a meaningful effect on the exchange rate tendency. Nevertheless, during the analyzed period, interventions did not generate monetary disorders which would compromise the Banco de la República projected inflation target.

REFERENCES

Ball, Lawrence (1998), "Policy rules for open economies", *NBER,* Working paper 6760, octubre.

Bofinger, Peter y Timo Wollmershäuser (2003a), "Managed floating as a monetary policy strategy", *Economics of Planning*, Vol. 36, No. 2, June, pp. 81-109.

— (2003b), "Managed floating: theory, practice and ERM II", *Managed floating: an alternative to the two corner solutions?*, seminario in Kronberg, Germany, 30-31, enero.

— (2001), "Managed floating: understanding the new international monetary order", *CEPR*, Discussion Paper No. 3064, noviembre.

Bordo, Michael (2003), "Exchange rate regime choice in historical perspective", *NBER*, Working paper 9654, abril.

Calvo, Guillermo y Carmen Reinhart (2000), "Fear of floating", *NBER*, Working paper 7993, noviembre.

Clavijo, Segio (2002), "Política monetaria y cambiaria en Colombia: Progresos y desafíos (1991-2002)", *Ensayos sobre Política Económica,* No. 42, junio, pp. 87-142.

Dominguez, Kathryn (1998), "Central bank intervention and exchange rate volatility", *Journal of International Money and Finance*, No. 17, pp. 161-190.

Dominguez, Kathryn y Jeffrey Frankel (1993), "Does foreign-exchange intervention matter? The portfolio effect", *The American economic Review*, Vol. 83, No. 5, diciembre, pp. 1356-1369.

Fischer, Andreas y Mathias Zurlinden (1999), "Exchange rate effects of central bank interventions: an analysis of transaction prices", *The Economic Journal,* No. 109, octubre, pp. 662-676.

Fischer, Stanley (2001), "Exchange rate regimes: is the bipolar view correct?, *Journal of Economic Perspectives*, Vol 50, No. 2, spring, pp. 3-24.

FMI (2005a), *Annual report on exchange arrangements and exchange restrictions*, Washington.

— (2005b), *World Economic Outlook*, Washington.

Frankel, Jeffrey (2003), "Experience of and lessons from exchange rate Regimes in emerging economies", *NBER,* Working Paper 10032, octubre.

Frankel, Jeffrey y Richard Meese (1987), "Are exchange rates excessively variable?", *NBER,* Working Paper 2249, mayo.

Gómez Pineda, Javier (2006), "La política monetaria en Colombia," *Borradores de Economía,* No. 394, Abril.

Toro, Jorge Hernán y Julio, Juan Manuel (2005), "Efectividad de la intervención discrecional del Banco de la República en el mercado cambiario", *Borradores de Economía,* No. 336, junio.

López, Mauricio y Ramón Javier Mesa (2005), "Coyuntura y política económica colombiana 2005-2006: análisis y perspectivas", *Perfil de Coyuntura Económica*, No. 6, diciembre, pp. 5-32.

Mesa, Ramón Javier y Elizeth Ramos (2003), "Sector externo y política cambiaria en Colombia 1999-2002: del desequilibrio externo al equilibrio precario", *Perfil de Coyuntura Económica,* No. 2, octubre, pp. 64-83.

Sarno, Lucio y Mark Taylor (2001), "Official intervention in the foreign exchange market: Is it effective and, if so, how does it work?", *Journal of Economic Literature,* Vol. 39, No. 3, septiembre, pp. 839-868.

Schwartz, Anna (2000), "The rise and fall of foreign exchange market intervention", *NBER,* Working paper 7751, junio.

Wollmershäuser, Timo (2003), *A theory of managed floating*, Universität Würzburg.