Monetary policy and the exchange rate in Colombia

Hernando Vargas H[1]

1. Introduction

The monetary policy framework in Colombia is based on an extended inflation targeting strategy that aims at maintaining a low and stable inflation rate, stabilising output around its natural level and contributing to the preservation of financial stability. The latter objective is shared with other state agencies and implies a close monitoring of and occasional policy responses to the movements of financial variables. Since there is no explicit or implicit target for the nominal or real exchange rate, and the implementation of monetary policy relies mostly on changes in the short-term interest rate, a substantial degree of exchange rate flexibility is required and allowed. "Impossible trinity" considerations in an economy with a relatively open capital account make any other setting unfeasible over the medium and long run.

In this context, the exchange rate embodies one of the most relevant channels of transmission of monetary policy in an open economy such as Colombia's. It is also a key asset price that is closely related to other local asset prices and one that influences private agents' decisions on the currency composition of their balance sheets. As such, the exchange rate greatly influences the implementation and the impact of monetary policy. This note describes the role of the exchange rate and the exchange rate regime in the monetary policy decision-making process and in the response of the economy and the central bank to external shocks.

Even under its extended inflation targeting framework with a flexible exchange rate regime, the Bank of the Republic, the central bank, has made significant interventions in the FX market. This note also explains the rationale for such interventions and describes the experience of Colombia in this regard. Special attention is given to the seemingly varying effectiveness of different types of intervention and to the challenges posed by the sterilisation of foreign currency purchases.

2. The exchange rate in the implementation of monetary policy

The inflation targeting strategy posits that the path of monetary policy instruments must be determined by the forecast trends of macro variables such as inflation or output. To build such forecasts for an open economy, it is crucial to have an idea about the future behaviour of the exchange rate. This in turn needs an assumption or model about the long-run equilibrium exchange rate and its determinants. Usually models incorporate a version of the uncovered interest rate parity (UIP) condition, which relates the nominal exchange rate to current and future domestic and foreign monetary policy stances *and to a long-run equilibrium level of the exchange rate*. Hence, the very functioning of the inflation targeting strategy in an open economy is based on a notion of an equilibrium real exchange rate. Different assumptions (or models) in this respect could imply different paths for the policy interest rate.

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[1] Comments and suggestions by Juan Pablo Zárate are gratefully acknowledged and included.

In practice, the central bank bases its models and its thinking in this regard on medium- and long-term balance of payments forecasts that capture the main fundamental factors behind the trends of the real exchange rate and the current account balance (terms of trade, external demand, FDI and other capital flows etc). In the DSGE model, the evolution of net foreign assets determines sovereign risk premium and affects the real exchange rate.

As previously mentioned, the exchange rate represents one of the most important channels for monetary policy transmission in an open economy. As such, the central bank's models, diagnostics and forecasts emphasise the effect of shocks and policy responses on the exchange rate and, through it, on inflation and output. Considerable effort is devoted to understanding the behaviour of the FX market in order to extract information on the size and duration of shocks. This is routinely integrated into the inflation forecast rounds to generate scenarios and derive the monetary policy implications.

3. Exchange rate volatility, FX regulation and the policy response to shocks

A key issue regarding the exchange rate in the monetary policy framework in Colombia is the set of conditions that allow the exchange rate to work as a shock absorber. As in other open emerging economies, in Colombia the bulk of shocks are real, not nominal. Thus, a flexible exchange rate regime is appropriate as a means of stabilising the economy in the face of those shocks, especially in the context of rigid formal labour markets. Importantly, a flexible exchange rate regime is necessary for a countercyclical monetary policy response to the shocks. It is therefore crucial to preserve the conditions for a flexible exchange rate.

Among those conditions, two deserve special attention. One is the absence of sizable currency and FX liquidity mismatches. This is important because it implies that large exchange rate adjustments are possible without the risk of bankruptcies, pronounced drops in aggregate demand or strong pressures on the currency and the international reserves. Otherwise, a shock to, say, the sovereign risk premium would require a pro-cyclical monetary policy response (an increase in local interest rates) to prevent a sharp depreciation. The economy's financial fragility is therefore exacerbated by currency mismatches and this not only increases the risk of financial instability, but also constrains the set of policy options available to deal with the shock.

The second condition is the absence of a large pass-through from the exchange rate to domestic prices. This is important because it allows a large adjustment of the exchange rate after an external shock without the risk of a substantial spike in inflation. Hence, it also avoids a procyclical monetary policy response.

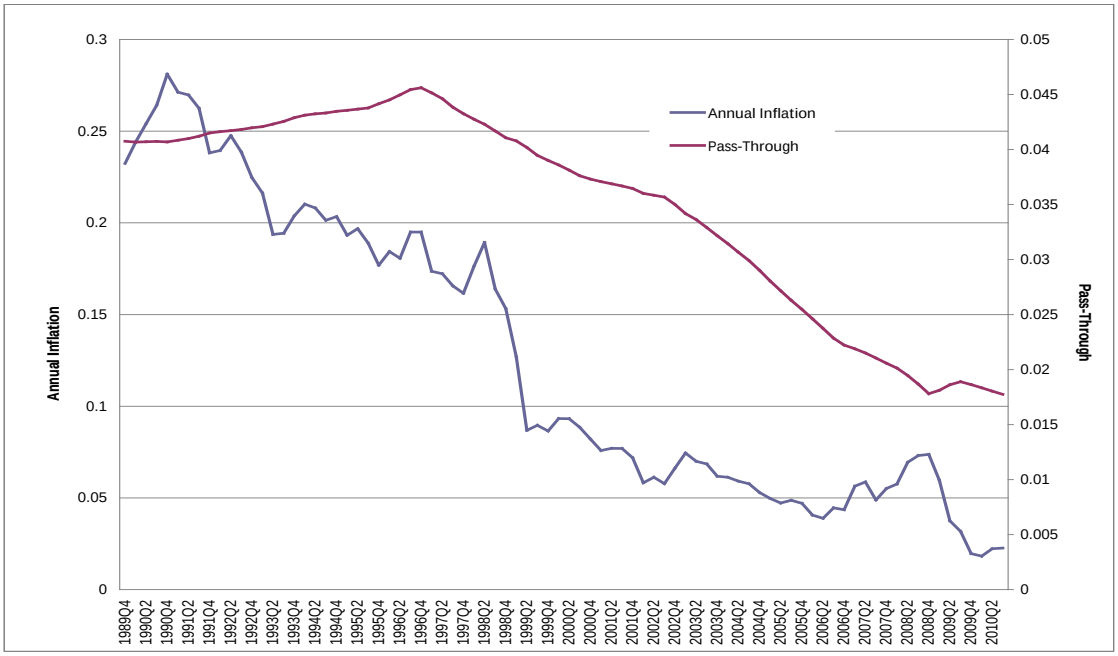
In contrast to the past and particularly to the 1990s, the abovementioned conditions were maintained in Colombia throughout the last decade, allowing for a countercyclical monetary policy and a less disruptive adjustment of the economy after the global financial crisis. At the root of this achievement lie three factors. First, the permanent reduction of inflation after 1999 and the fulfilment of low and declining inflation targets since then prompted a fall in the pass-through coefficient (Graph 1).[2] According to Taylor (2000), in a high inflation regime, movements of the nominal exchange rate signal permanent nominal shifts that influence future marginal costs expected by firms that have market power and are subject to price rigidities. In this environment, the transmission of exchange rate movements to domestic prices is large. On the other hand, when inflation is low and credible, the response of local

[2] See Appendix 1 for a description of the variables.

prices to the exchange rate is more subdued, because the changes to the latter do not signal significant effects on expected future marginal costs.

Graph 1

Inflation and pass-through



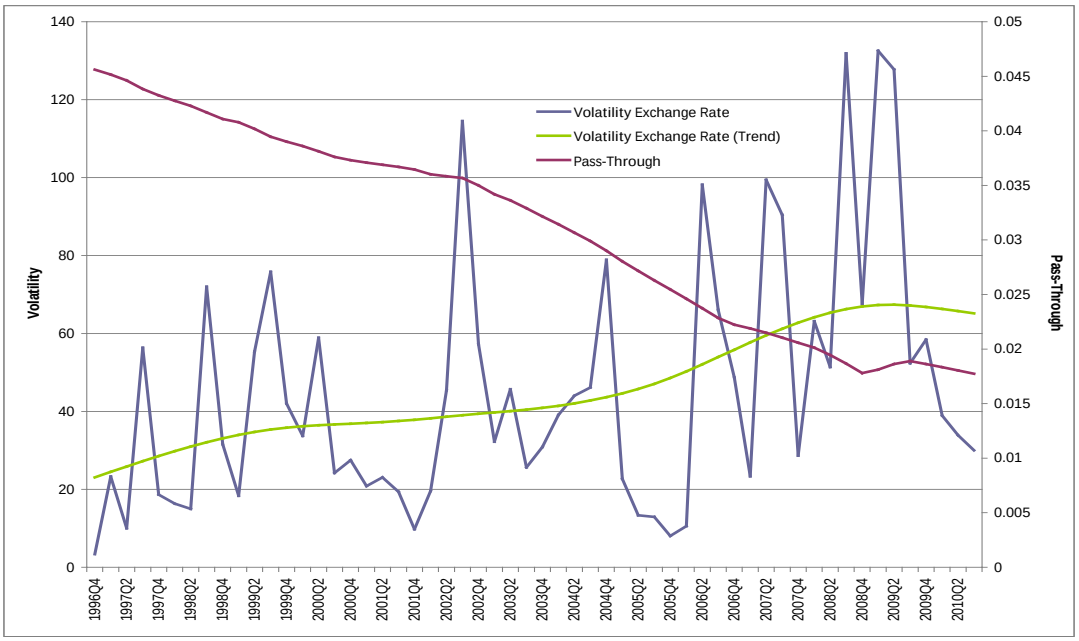
A second factor behind the emergence of favourable conditions for a floating exchange rate and countercyclical monetary policy is the increased volatility of the exchange rate after the abandonment of the target zone in 1999. This has also reduced the pass-through from the exchange rate to local prices, as movements in the exchange rate are often temporary and do not signal persistent changes in future marginal costs (Graph 2).[3] Similarly, the response of net exports to shifts in the real exchange rate may be more muted under higher exchange rate volatility, since movements in the value of the currency rarely signal persistent variations in external competitiveness (Graph 3).[4] This means lower demand pressures on domestic inflation stemming from a real depreciation of the currency.

[3] See Appendix 1 for a description of the variables.

[4] See Appendix 1 for a description of the variables.

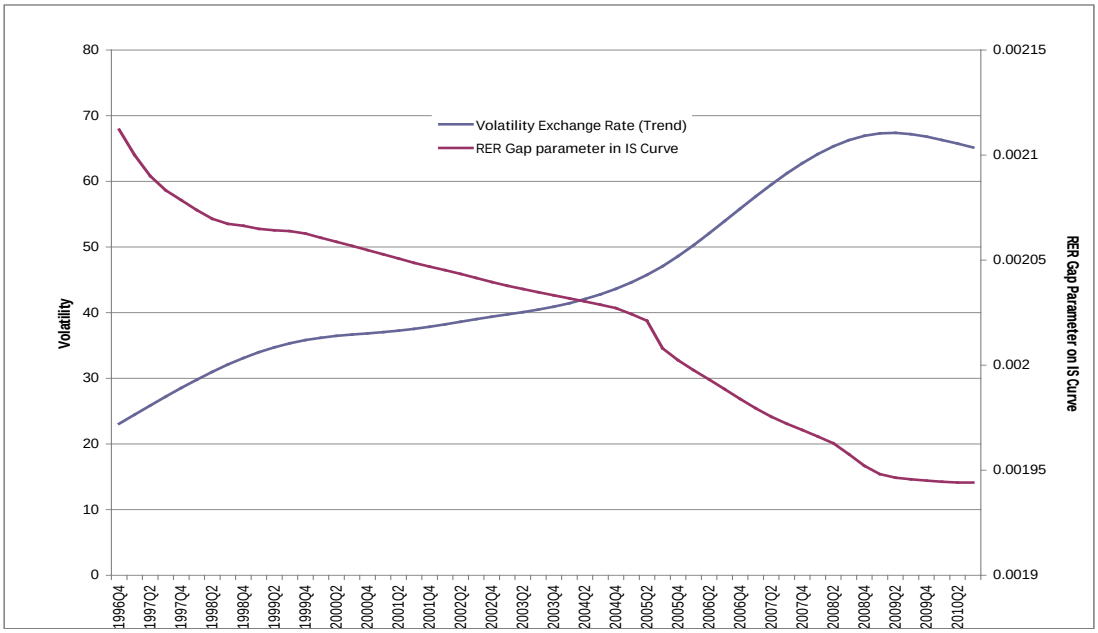
Graph 2

Exchange rate volatility and pass-through



Graph 3

Exchange rate volatility and the response of output to the real exchange rate



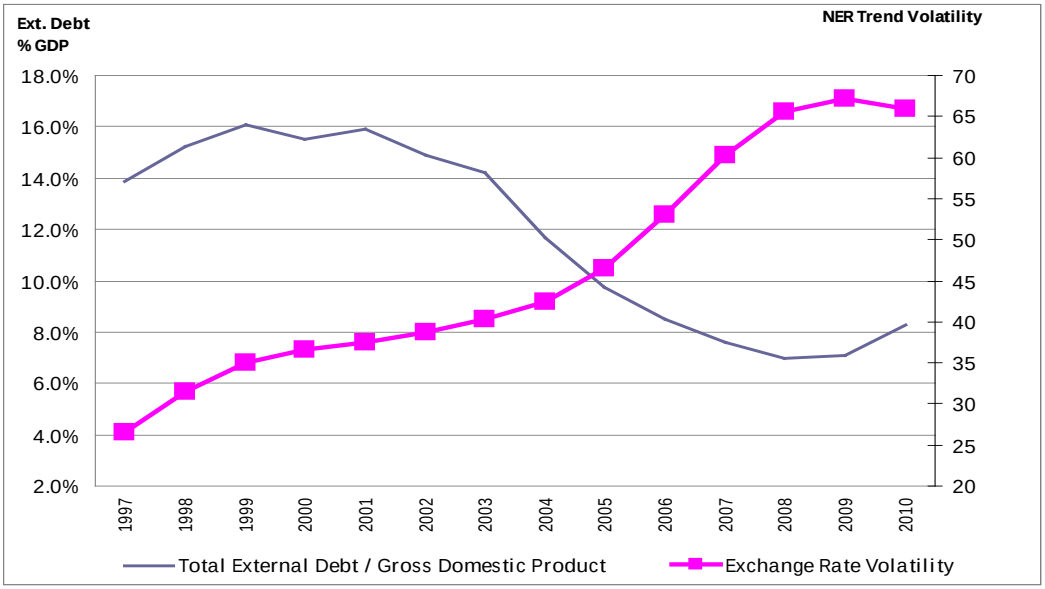
Moreover, greater exchange rate volatility forces residents to internalise currency risk in their financing decisions and may have contributed to a decrease in currency mismatches (Graph 4).[5] Also, it has encouraged the development of markets for hedging instruments, such

[5] Ize and Levy-Yeyati (2003) show that the financial dollarisation of an economy depends on the relation between the volatility of inflation and the volatility of the real exchange rate. When inflation is volatile relative to

as Columbia's FX forward market (Graph 5). Overall, exchange rate volatility has strengthened financial stability and has allowed a substantial degree of exchange rate flexibility.

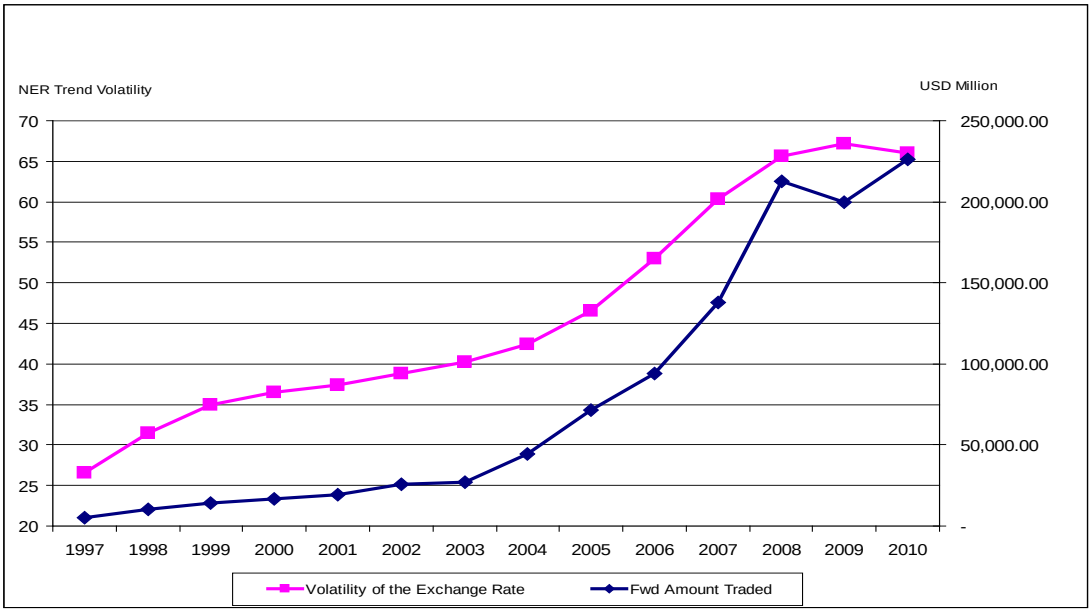
Graph 4

Private external debt and exchange rate volatility



Graph 5

Amount traded in currency forward operations and exchange rate volatility



the real exchange rate, both risk-averse creditors and debtors will increase the share of dollar-denominated assets and liabilities in their portfolios. Hence, financial intermediaries may be matched, but borrowers may incur large currency mismatches.

FX regulation and FX policy measures are the third factor that explains how the conditions for exchange rate flexibility and countercyclical monetary policy were achieved. The maintenance of an adequate level of international reserves has helped the country to cope with external shocks and has prevented depreciation pressures derived from the perception of an insufficient cushion of international liquidity. Prudential regulation that places limits on financial intermediaries' currency and external liquidity mismatches has also improved the resilience of the financial system in the presence of large external shocks. Temporary capital controls (eg the deposit requirement on foreign indebtedness) also support financial stability, by increasing the cost of external short-term debt with respect to that of r types of capital inflows with better risk characteristics (eg FDI, long-term debt or movements of residents' assets abroad).

The best example of the new regime's benefits is the behaviour of the economy during the global financial crisis (October 2008–March 2009). Despite a large nominal depreciation of the Colombian peso (comparable to the fall of other currencies in Latin America), policy interest rates were rapidly reduced after December 2008 (in a countercyclical policy response); the intervention of the central bank in the FX or foreign currency interbank markets was negligible compared with that of other inflation targeters in the region (Table 1).

Table 1

Foreign exchange market intervention October 2008–March 2009 (+purchases–sales)

USD millions	Total intervention (A+B+C+D)	Spot (A)	Options (B)	Reverse repo agreements	Foreign currency denominated loans	31 March 2009
Colombia	–109	0	–109*	0	0	41.30%
Peru	–4,602	–4,837	0	235	0	12.16%
Chile	–1,372	0	0	–1,372	0	15.46%
Brazil**	–2,490	3,440	0	3,483	–2,523	48.38%
Mexico***	–21,193	–21,193	0	0	0	41.20%

* Volatilily options: put options less call options.

** Includes data from January to March only.

*** Amounts do not include purchases of USD 2,152 million made by CBM for Pemex.

Source: Official websites of central banks.

A corollary of the foregoing argument is that low inflation and a flexible exchange rate favour the emergence of the conditions that help maintain low inflation, exchange rate flexibility, countercyclical policy and stable output after shocks hit the economy. Keeping inflation low and allowing the exchange rate to fluctuate generate low pass-through coefficients and small, manageable currency mismatches that permit an adjustment of the exchange rate and the adoption of countercyclical monetary policy, ie a virtuous circle. A simple model is presented in Appendix 2, which illustrates this idea.

4. FX intervention: rationale and experience

Colombia's Bank of the Republic has intervened in the FX market with three objectives: (i) to build up or sustain an adequate level of international reserves, (ii) to curb excessive volatility or to counter disorderly market behaviour and (iii) to correct a misalignment of the exchange rate.

As mentioned above, one of the reasons for the favourable adjustment of the economy to external shocks in recent years is the existence of sufficient buffers of international liquidity. Hence, the central bank continuously monitors international liquidity indicators to assess the need for additional purchases of international reserves. Traditional ratios of reserves to GDP, monetary aggregates and imports, and variations of the Guidotti-Greenspan rule are examined through time and in relation to a group of emerging economies. Measures of optimal reserves are periodically re-calculated and discussed.

Since the adoption of a floating regime in 1999, the central bank has used an automatic mechanism to sell or purchase FX in order to control excessive volatility. This consists of auctions of put (or call) options to buy (or sell) US dollars to (or from) the central bank. The auctions are triggered whenever the nominal exchange rate deviates from its 20-day average by more than a specified percentage. In recent years this mechanism was suspended when the central bank adopted measures to correct an overvaluation of the currency. It has been inactive since October 2009.

Exchange rate misalignments are considered harmful because they cause adverse, unsustainable effects on inflation (in the case of a depreciation) or on tradable output and employment (in the case of an appreciation). In addition, currency misalignments are sometimes related to speculative behaviour in other asset markets (eg public bond and stock markets) and may therefore endanger financial stability.

While it may be expedient to counter an over- or undervaluation of the currency, there are no implicit or explicit targets for the nominal or real exchange rate. Throughout the 1970s and 1980s, FX policy aimed to stabilise the real exchange rate (RER). In the end, this objective could not be accomplished and, instead, inflation rose and became highly persistent, as monetary policy was accommodative of various shocks and indexation spread. It took the independent central bank more than eight years to drive inflation back down to single digits. A lesson had been learned about the risks of real exchange rate targeting. In its communication strategy, the central bank repeatedly emphasises the idea that to persistently affect the RER, real (not nominal) instruments must be used, especially movements in aggregate saving.

It is as difficult to identify an exchange rate misalignment as it is to detect any asset price bubble. At the same time, (sterilised) FX intervention is costly in both fiscal and monetary terms. Hence, a careful examination of the costs and benefits involved must precede any decision to intervene against a presumed misalignment. As explained above, the central bank closely tracks the behaviour of the FX market, monitoring flows and transactions in both its spot and forward components to form an idea about the short-term exogenous developments affecting them. A weekly FX cash balance is analysed in depth to identify changes in the size and nature of the flows. This is complemented with information from the derivatives (forward) market to infer the movements of residents' and non-residents' FX exposure.

In addition, the behaviour of the Colombian peso is frequently compared to that of other emerging market currencies to control for global common factors; significant differences are also studied in some detail. Furthermore, the central bank routinely produces estimates of long-run or equilibrium exchange rates based on several methodologies: PPP, tradable/non-

tradable relative prices, BEER and FEER.[6] Confidence intervals are calculated for each methodology. The probability of misalignment is assessed by examining the position of the current real or nominal exchange rate with respect to those confidence intervals. Most methodologies are computed for a PPI-based, trade-weighted RER index, but other RER indices are carefully examined (eg CPI-based indices and indices of competitiveness in third markets). Appendix 3 describes the methodologies applied. The information derived from all these sources is used to judge the existence of a misalignment, which is, in turn, a key input in the FX intervention decision.

All FX interventions by the central bank are sterilised to the extent that is needed to keep short-term interest rates close to the policy interest rate. This means that not necessarily all dollar purchases are sterilised, since part of them would be absorbed by the increase in money demand. The choice of sterilisation mechanisms is not trivial and will be reviewed in the next section.

The effectiveness of an intervention depends greatly on how it is implemented. For the purpose of accumulating reserves or curbing excessive volatility, rules-based mechanisms have been used since the inception of the floating regime in 1999. This choice is justified by the explicit aim of avoiding unintended effects on the trend of the exchange rate. In the cases in which presumed misalignments were dealt with, the Colombian experience with different types of intervention is rich. Rules-based intervention, discretionary intervention, verbal intervention and daily purchases of fixed US dollar amounts have all been used in the past six years with varying degrees of success.

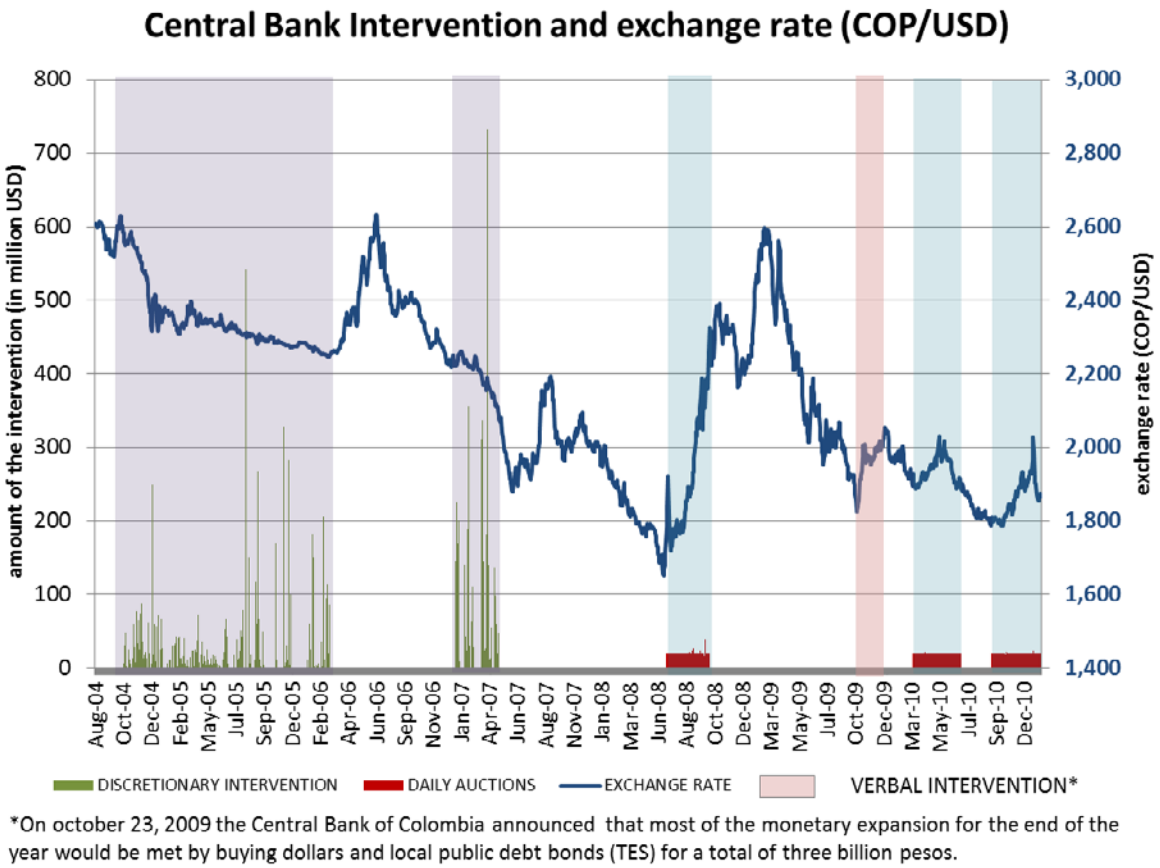
The empirical evidence in this regard is far from conclusive. A review of the literature presented by Rincón and Toro (2010, p. 29) suggests that, in general, interventions have a positive, small effect on the return of the nominal exchange rate and an ambiguous impact on its volatility. However, many of those econometric estimations exhibit shortcomings.[7] In an effort to comprehensively test for the effectiveness of intervention *and* capital controls, Rincón and Toro estimate more complete models of the return of the nominal exchange rate. They find no significant effects of intervention in general, except when accompanied by capital controls. Both intervention and capital controls are found to increase exchange rate volatility.

A summary of the experience of the central bank with FX intervention since 2004 is presented in Graph 5. It is clear that the large discretionary purchases of reserves in 2004–05 and, especially, 2007 seem to have been less effective than other forms of intervention. Indeed, throughout those years, the currency *appreciated* despite the interventions. In contrast, the subperiods of verbal intervention and daily purchases of fixed amounts exhibit some depreciation, at least initially.

[6] BEER stands for Behavioural Equilibrium Exchange Rate; FEER for Fundamental Equilibrium Exchange Rate. See Appendix 2.

[7] Specifically, with respect to the correct distribution of the residuals, the intervention measures, the treatment of endogeneity issues and the interpretation of some results.

Graph 5



*On october 23, 2009 the Central Bank of Colombia announced that most of the monetary expansion for the end of the year would be met by buying dollars and local public debt bonds (TES) for a total of three billion pesos.

Of course, a rigorous analysis must control for shifts in other determinants of the exchange rate. However, the difference in the reaction of the currency to the various forms of intervention is suggestive. In particular, the episodes of June 2008 and the last quarter of 2009 are worth highlighting. In the first one, the value of the US dollar jumped on the announcement of a programme of daily purchases of constant US dollar amounts. Afterwards, the Lehman crisis continued pushing down the currency.

In the second episode (October–December 2009), the central bank announced that it would satisfy the increased demand for base money during the last quarter of the year either through the purchase of US dollars or public bonds (TES). Information about the FX intervention was not disclosed until January 2010. The ambiguity created by the central bank seems to have had an impact on the exchange rate, as illustrated by the swift correction observed after the announcement. Interestingly, the central bank did not buy any US dollars in that period.

Two hypotheses can be advanced to explain the observed difference of responses by the exchange rate to the different types of intervention. First, a discretionary intervention, especially when executed in large amounts, may signal that a particular level of the exchange rate is being defended, and this may induce additional capital inflows, spurred by the expectation that the currency will appreciate. This was the case in 2007, when a large, discretionary FX intervention occurred in a period when monetary policy was being tightened. Moreover, large interventions may indicate a reduced ability to intervene in the future (because of cost or monetary considerations) and could heighten expectations for an appreciation in the short run, thus inducing additional capital inflows.

Second, the effectiveness of the intervention seems to be influenced by the level of the exchange rate at which it is implemented. The more effective interventions after 2008 have

taken place at high values of the currency, in contrast to the interventions in 2004–07, which was undertaken at more depreciated peso rates. This would support the aforementioned procedure by which a decision to intervene is based on some evidence of misalignment.

5. Sterilisation of FX intervention

Over the last five years, the stock of international reserves has grown faster than base money demand (Table 2), creating a need for increased sterilisation operations. Starting from a net creditor position with respect to the financial system, the central bank has sterilised its FX purchases by adjusting its credit to financial institutions (by means of repos). It has also decreased its holdings of public debt bonds (TES) and mopped up liquidity through remunerated, non-reserve deposits offered to financial intermediaries (other non-monetary liabilities). In addition, government deposits at the central bank have continued to be an important sterilisation instrument (Table 2).

The choice of sterilisation mechanism is a complex one, given that every alternative has different costs and risks that create trade-offs for the central bank. In Colombia, this decision involves a regular benefit/cost analysis in which the sterilisation mechanisms are judged on the following criteria: (i) impact on capital flows, (ii) fiscal or quasi-fiscal costs, (iii) effects on financial intermediation, (iv) implications for the monetary policy stance, and (v) degree of control by the central bank.

The sterilisation instruments used or considered are the following: (i) reductions of repo and contraction through lower interest rates, or Lombard facilities, (ii) remunerated, non-reserve deposits, (iii) central bank securities, (iv) government deposits at the central bank, (v) sales of the central bank's holdings of government securities, and (vi) reserve requirements.

Reductions in repo operations have little impact on capital inflows because no new low-risk peso liabilities are being issued. Their quasi-fiscal cost is given by the difference between the policy (short-term) interest rate and the return on international reserves. They are totally under the control of the central bank and, as long as the latter remains a net creditor of the financial system, do not change the monetary policy stance. In this respect, a problem emerges when the sterilisation of FX purchases forces the bank to become a net debtor of the financial system. In this case, the excess liquidity must be absorbed through a Lombard facility at the central bank with an associated interest rate that is 100 basis points lower than the policy rate.

Hence, ceteris paribus, the transition from a net creditor to a net debtor position may affect the monetary policy stance, as short-term market interest rates could deviate (downwards) from the policy interest rate. In fact, some periods of the central bank's net debtor position coincide with such a deviation (Graph 6). Also, the transmission of monetary policy may be weakened by a reduction in the net creditor position. Vargas et al (2010) show that the pass-through from policy rates to deposit rates and to some lending rates (prime and treasury loans) falls if the central bank has a net debtor position, especially when the policy rate is raised.

Table 2

Balance sheet of the Bank of the Republic[1]

	2005	2006	2007	2008	2009	2010
			Billions of pesos			
Assets	**24.479**	**29.001**	**36.189**	**40.101**	**43.508**	**49.078**
International reserves [2]	19.010	20.932	30.775	36.470	39.439	44.283
Repos	2.271	5.557	3.839	3.070	3.255	2.896
Government securities – TES	3.198	2.512	1.575	561	814	1.900
Liabilities	**24.479**	**29.001**	**36.189**	**40.101**	**43.508**	**49.078**
Monetary base	18.062	22.374	26.674	30.227	33.865	37.781
Other non-monetary liabilities [3]	-	-	955	845	1.513	1.098
Government deposits	5.760	5.939	6.830	7.818	7.000	7.821
Other net	658	689	1.730	1.211	1.130	2.378
			Percentage of the total assets			
Assets	**100**	**100**	**100**	**100**	**100**	**100**
International reserves [2]	78	72	85	91	91	90
Repos	9	19	11	8	7	6
Government securities – TES	13	9	4	1	2	4
Liabilities	**100**	**100**	**100**	**100**	**100**	**100**
Monetary base	74	77	74	75	78	77
Other non-monetary liabilities [3]	-	-	3	2	3	2
Government deposits	24	20	19	19	16	16
Other net	3	2	5	3	3	5
			Absolute annual difference			
Assets	**6.742**	**4.522**	**7.188**	**3.912**	**3.408**	**5.570**
International reserves [2]	5.436	1.922	9.843	5.695	2.969	4.844
Repos	67	3.285	(1.717)	(770)	185	(359)
Government securities – TES	1.240	(685)	(938)	(1.014)	253	1.085
Liabilities	**6.742**	**4.522**	**7.188**	**3.912**	**3.408**	**5.570**
Monetary base	2.685	4.312	4.300	3.553	3.638	3.916
Other non-monetary liabilities [3]	(160)	-	955	(110)	668	(415)
Government deposits	3.772	179	891	988	(817)	821
Other net	445	31	1.041	(519)	(81)	1.248
			Annual growth rate			
Assets	**38,0**	**18,5**	**24,8**	**10,8**	**8,5**	**12,8**
International reserves [2]	40,0	10,1	47,0	18,5	8,1	12,3
Repos	3,0	144,6	(30,9)	(20,0)	6,0	(11,0)
Government securities – TES	63,3	(21,4)	(37,3)	(64,4)	45,1	133,3
Liabilities	**38,0**	**18,5**	**24,8**	**10,8**	**8,5**	**12,8**
Monetary base	17,5	23,9	19,2	13,3	12,0	11,6
Other non-monetary liabilities [3]	(100,0)			(11,5)	79,1	(27,4)
Government deposits	189,8	3,1	15,0	14,5	(10,5)	11,7
Other net	208,7	4,7	151,2	(30,0)	(6,7)	110,4

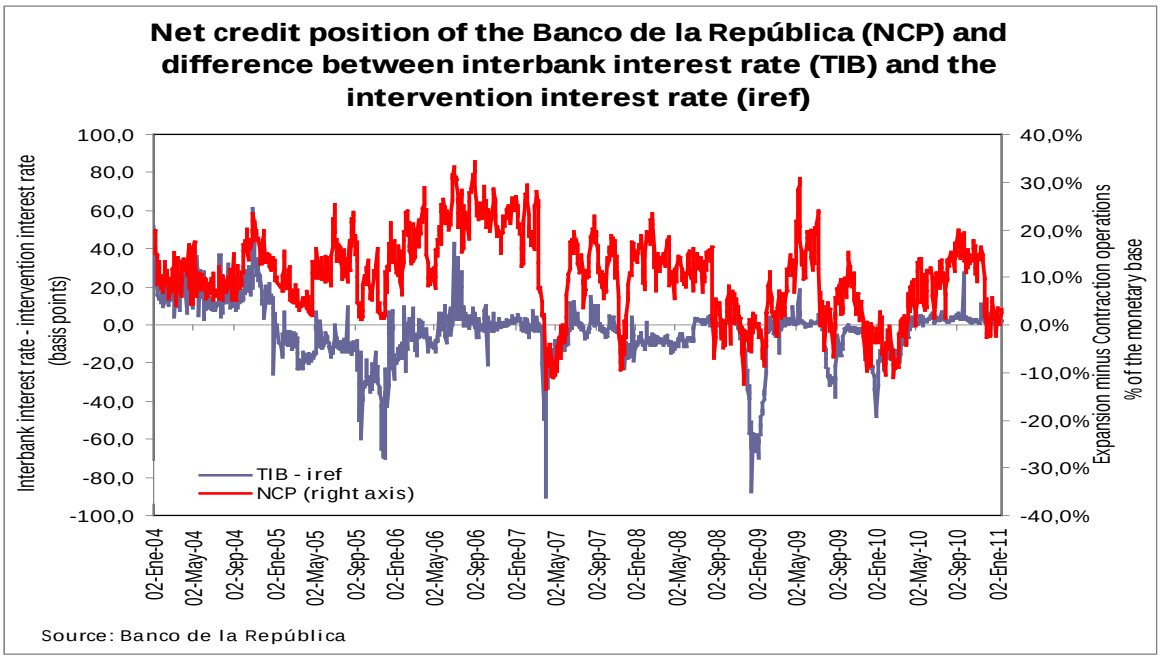
Source: Bank of the Republic.

[1] Yearly average of montly data.

[2] It excludes the price effect (dollar-peso) of the international reserves.

[3] It includes reverse repo and remunerated deposits of the financial system.

Graph 6



Remunerated non-reserve deposits are used precisely when the central bank becomes a net debtor of the financial system. They pay an interest rate that is close to the policy rate, so that the monetary policy stance is unaffected by sterilised intervention and the quasi-fiscal cost is similar to the cost of reducing repos. The deposit terms are a crucial parameter. If the deposits are overnight, then the effect from a policy transmission point of view is almost perfect, but large capital inflows may be attracted if domestic short-term interest rates are higher than foreign ones. After all, such deposits carry no credit risk (they are peso liabilities of the central bank) or liquidity or market risk (if overnight). Furthermore, if overnight deposits coexist with repos, the interbank market will be severely hindered, as the incentives for banks to lend to each other are diminished.

On the other hand, longer maturities may discourage capital inflows due to higher liquidity risk (deposits are not tradable), but control over liquidity is weakened. The central bank has offered deposits with seven-, 14-, 30- and 60-day maturity, but only the seven- and 14-day deposits have been taken up. Thus, nothing guarantees that all the excess liquidity will actually be mopped up, thus putting at risk the monetary policy stance, the inflation target and even financial stability, particularly when the situation is allowed to persist.

The issuance of (tradable) central bank securities could help alleviate the illiquidity of remunerated deposits, but may attract more capital. To remedy this situation, securities would need to have relatively long maturities, thus entailing higher market risk and larger quasi-fiscal costs. The control of short-term interest rates is not at risk in this case but, depending on the amounts issued, the central bank operations could influence longer-term rates. Further, central bank paper may compete with government securities, leading to coordination problems, distortion of the sovereign yield curve and higher financing costs for the government. In Colombia, a 2009 law authorised the central bank to issue its own bonds, but none have been sold so far. The sale of central bank holdings of government securities has similar implications. However, unlike the issuance of central bank paper, the use of this instrument is limited by the initial size of the holdings.

Government deposits at the central bank have allowed the latter to maintain a net creditor position with the financial system, thereby contributing to the sterilisation of FX purchases by means of reductions in repos. The central government is committed to managing all its liquidity through central bank deposits that carry an interest rate close to the policy rate.

Nevertheless, these deposits depend on the government's cash flow and are beyond the central bank's control. As a result, when the level of international reserves is high, fluctuations of these deposits may shift the central bank's position from that of net creditor to net debtor of the financial system, or significantly increase a net debtor position, with all the difficulties that this change entails.

Finally, increases in reserve requirements may be used to raise the demand for base money and absorb the monetary expansion resulting from FX intervention. In this case, quasi-fiscal costs are non-existent because they are passed to the financial system. The flipside is, of course, the distortion of financial intermediation and the rise in interest rate spreads, which, if long lasting, may be very costly or induce "innovations" to evade the reserve requirements. Those "innovations" may cause financial disintermediation and increase the risks for financial stability. In addition, the effects on the policy stance and the transmission of monetary policy are unclear (lending interest rates go up, but deposit rates may fall) and difficult to gauge. For the same reason, the impact of reserve requirements on capital inflows is also unclear. Higher lending rates may spur external borrowing by residents with access to foreign financing, but potentially lower deposit rates may discourage some inflows.

All these considerations are taken into account when deciding on the sterilisation mechanism to be used. The alternatives are evaluated according to the above-mentioned criteria and their relative merits in the macroeconomic context to determine the central bank's choice.

6. Conclusions

Exchange rate flexibility is a key feature of Colombia's extended inflation targeting monetary strategy. In this setting, the exchange rate works as a shock absorber, a monetary policy transmission channel and a critical asset price. This means that the implementation of monetary policy requires a view on the long-run RER trend and its determinants. Also, the exchange rate regime, FX regulation and FX policy determine the economy's resilience in the face of external shocks and allow for the possibility of countercyclical monetary policy responses. A virtuous circle is created in which the volatility present in a flexible exchange rate regime improves the conditions for the functioning of a flexible exchange rate regime.

In spite of the flexible exchange rate inflation targeting regime, the central bank has actively intervened in the FX market with the purpose of maintaining an adequate level of international reserves, or curbing excessive volatility or disorderly behaviour in the FX market, and countering exchange rate misalignments. A close monitoring and analysis of the FX market in the short run, as well as a set of long-run or equilibrium RER models are used to judge the probability of a misalignment. In this case, the type of intervention and the level of the exchange rate at which it is undertaken seem to be important determinants of its effectiveness.

In the past five years, international reserves have grown faster than money base demand, making sterilisation of FX intervention a relevant issue for the central bank. The choice of sterilisation instrument is guided by criteria related to the effects of the available mechanisms on the monetary policy stance and monetary transmission, capital inflows and financial intermediation, as well as by their quasi-fiscal costs and control by the central bank. In this context, the central bank's transition from a net creditor position to a net debtor position with respect to the financial system seems to have important consequences on the monetary policy stance and its transmission.

Appendix 1:
Changing pass-through and output-RER elasticity coefficients and exchange rate volatility[8]

Pass-through:

A time-varying coefficient is estimated that measures the transmission from the exchange rate to local tradable goods prices. The estimation used quarterly data from 3Q 1989 to 3Q 2010 and was based on the state-space representation of a system of two equations:

$$\pi_t = \alpha_1 \pi_{t-1} + \gamma_t \left(\pi^*_{t-1} + \delta_{t-1} - \delta^z_t \right) + (1 - \alpha_1 - \gamma_t) \pi^E_t + \sigma_\pi \in_{\pi,t}$$

π_t is the annualised quarterly tradable goods inflation, π^*_t is a measure of external inflation, δ_t is the nominal depreciation of the Colombian peso, δ^z_t is the long-run real depreciation of the currency (measured as the annualised quarterly change of the RER index trend) and

$$\pi^E_t = 0.56 \pi^4_{t-1} + 0.44 \pi^4_{t+1}$$

is a measure of annual inflation expectations.

The time-varying parameter γ_t shows the evolution of the exchange rate pass-through in time. The dynamics of this parameter are given by:

$$\gamma_{t+1} = \mu + \gamma_t + \sigma_\gamma \in_{\gamma,t+1},$$

Parameters μ and σ_π were estimated. The corresponding estimates are –0.0003 and 0.0241324, respectively. The parameter α_1 was taken from the central bank's model of transmission mechanisms. σ_γ was calibrated at 0.006738, substantially lower than σ_π.

Output-RER elasticity:

A time-varying coefficient is estimated that measures the evolution of the sensitivity of the output gap to the RER gap. The sample is made up of quarterly data from 1Q 1990 to 3Q 2010. The estimation is based on the state-space representation of a system of two equations. The first one is:

$$\gamma_t = \alpha_1 \gamma_{t-1} + \gamma_t z_{t-1} + \alpha_2 r_{t-1} + \sigma_\pi \in_{\pi,t}$$

γ_t is the output gap, z_t es is the RER gap and r_t is the real interest rate gap. All variables are obtained from the central bank's model of transmission mechanisms.

The time-varying parameter γ_t shows the evolution of the response of the output gap to the RER gap. The evolution of this parameter is given by:

$$\gamma_{t+1} = \gamma_t + \sigma_\gamma \in_{\gamma,t+1},$$

[8] Macro-Modelling Department, Bank of the Republic.

Parameters σ_γ and σ_π were calibrated at 0.0025 and 0.0656, respectively. The value of parameter α_1 was taken from the central bank's model of transmission mechanisms.

Exchange rate volatility:

For the calculation of the nominal exchange rate volatility we use daily data for the spot exchange rate (TRM) for the period 4Q 1996 to 3Q 2010.

The formula of the quarterly volatility is:

$$\sigma_1 = \frac{1}{T}\sum_{i=1}^{T}\left(e_{t,i} - \bar{e}_t\right)^2$$

where $e_{t,i}$ is the spot exchange rate of the i-th day of the quarter t, T is the number of daily observations in the t quarter and

$$\bar{e}_t = \frac{1}{T}\sum_{i=1}^{T} e_{t,i}$$

Appendix 2:
Exchange rate flexibility supports exchange rate flexibility: a simple model

The following model illustrates the possibility that low (high) exchange rate volatility generates the conditions in which the central bank's optimal responses to exogenous shocks produce and validate low (high) exchange rate volatility. Specifically, if low exchange rate volatility induces a high pass-through from the exchange rate to prices, then the central bank will optimally respond to exogenous shocks in a way that will involve low exchange rate volatility, thus supporting the persistence of a high pass-through. Hence, economies may end up being "trapped" in low exchange rate volatility/high pass-through equilibria. Conversely, high exchange rate volatility may imply low pass-through coefficients and may induce the central bank to optimally preserve a high exchange rate volatility regime in equilibrium.

Suppose a simple open economy described by the following equations:

$$\pi = \pi^E + \pi_y y + \pi_e e + \varepsilon \qquad \text{Phillips curve}$$

$$y = y_i\ (i - \pi^E - \bar{r}) + y_e\ (e - \pi^E - \bar{q}) + \mu \qquad \text{IS curve}$$

$$i = i^* + (e^E - e) + \rho \qquad \text{UIP}$$

Foreign inflation is assumed to be zero. ε, μ, and ρ are uncorrelated supply, demand and external interest rate shocks, respectively. The output gap in the IS curve responds to a RER gap measured with respect to *expected* inflation. A rationale for this may be based on pre-determined nominal wages that are fixed for the period of analysis, so that a nominal depreciation increases the production of net exports. The standard assumptions are made with respect to the signs of the coefficients: $\pi_y > 0, \pi_e > 0, y_i < 0, y_e \geq 0$.

The key parameter of this model is the response of inflation to the nominal exchange rate, π_e. According to the arguments presented in Section 3, the less volatile the exchange rate, the larger this coefficient. This is so because movements in the exchange rate are likely to represent *persistent* shifts in nominal marginal costs (in the Phillips curve). In consequence, the pass-through coefficient is greater.

Formally, defining σ_e as the volatility of the exchange rate, the following relation is posited:

$$\pi_e = f(\sigma_e) > 0, \quad f' < 0 \qquad (1)$$

However, exchange rate volatility, σ_e, is itself an endogenous variable, determined by the volatility of the exogenous shocks, σ_ε, σ_μ, and σ_ρ, and the response of the central bank to them. Such a response is found by assuming that the central bank discretionally chooses its instrument, *i*, to minimise a standard loss function, $\frac{\pi^2}{2} + \lambda\ \frac{y^2}{2}$

In its optimisation process, the central bank takes expectations of inflation and the exchange rate as given and is able to observe the exogenous supply, demand and foreign interest rate shocks. Private sector expectations are assumed to be formed before the shocks occur. Thus, the central bank completes its optimisation problem as follows:

$$\underset{i}{Min}\ \frac{\pi^2}{2} + \lambda\ \frac{y^2}{2}$$

s.t.

$$\pi = \pi^E + \pi_y y + \pi_e e + \varepsilon$$

$$y = y_i(i - \pi^E - \bar{r}) + y_e(e - \pi^E - \bar{q})$$

$$i = i^* + (e^E - e) + \rho$$

Or, in abbreviated terms:

$$\underset{i}{Min}\ \frac{\pi(y(i, e(i)), e)^2}{2} + \lambda\ \frac{y(i, e(i))^2}{2}$$

Here *e(i)* is the UIP equation: $e = i^* - i + e^E + \rho$

The FONC for this problem is:

$$\pi\ \left(\pi_y\left(y_i + y_e e_i\right) + \pi_e e_i\right)\ +\ \lambda\ y\ \left(y_i + y_e e_i\right)\ =\ 0$$

Notice that e_i = *-1* and define $K \equiv \left(y_i - y_e\right)/\left(\pi_y\left(y_i - y_e\right) - \pi_e\right) > 0$. The FONC may then be expressed as:

$$\pi\ +\ \lambda\ K\ y\ =\ 0 \tag{2}$$

The trade-off between inflation and output will depend on the pass-through coefficient, π_e. The greater the pass-through, the greater the marginal benefit of correcting an inflation deviation (from zero) through a movement in the interest rate, relative to the output marginal cost of such a move. As a result, the central bank is more willing to sacrifice output to correct the inflation deviation:

$$\frac{\partial K}{\partial \pi_e} = \left(y_i - y_e\right)/\left(\pi_y\left(y_i - y_e\right) - \pi_e\right)^2 < 0 \tag{3}$$

To obtain the optimal response of the central bank to exogenous shocks, totally differentiate first-order condition (2):

$$\pi_y\left[y_i di + y_e\left(d\rho - di\right) + d\mu\right] + \pi_e\left(d\rho - di\right) + d\varepsilon = -\lambda K\left[y_i di + y_e\left(d\rho - di\right) + d\mu\right]$$

$$\Rightarrow di\left[\left(\pi_y + \lambda K\right)\left(y_i - y_e\right) - \pi_e\right] = -d\varepsilon - d\mu\left(\pi_y + \lambda K\right) - d\rho\left[y_e\left(\pi_y + \lambda K\right) + \pi_e\right] \tag{4}$$

Define $H \equiv \left(\pi_y + \lambda K\right)\left(y_i - y_e\right) - \pi_e < 0$. Then the interest rate response to the shocks derived from (4) is:

$$di = -\frac{d\varepsilon}{H} - d\mu\frac{\left(\pi_y + \lambda K\right)}{H} - d\rho\frac{\left[y_e\left(\pi_y + \lambda K\right) + \pi_e\right]}{H} \tag{5}$$

The positive coefficients in equation (5) mean that the central bank will raise interest rate after a supply, demand or external interest rate shock. A supply shock ($d\varepsilon > 0$) increases inflation above zero and forces the central bank to accept a loss of output to stabilise inflation. A demand shock ($d\mu > 0$) produces a deviation of both inflation and the output gap from zero. The central bank then increases interest rates to stabilise inflation and output. An external interest rate shock ($d\rho > 0$) generates a depreciation of the currency that pushes

inflation and the output gap away from zero, requiring a tightening response from the central bank.

Integrating equation (5) and using the UIP equation ($e = i^* - i + e^E + \rho$), the following expression for the equilibrium nominal exchange rate is obtained:

$$e = \tilde{e} + \frac{\varepsilon}{H} + \mu\frac{(\pi_y + \lambda K)}{H} + \rho\left[1 + \frac{[y_e(\pi_y + \lambda K) + \pi_e]}{H}\right] \quad (6)$$

$\tilde{e}$ is the component of the equilibrium exchange rate that does not depend on the shocks. In particular, because of the assumption about the timing of the formation of expectations, neither inflation expectations nor expected exchange rates are affected by current shocks. Those expectations are included in $\tilde{e}$.

Following the reaction of nominal interest rates, the currency will appreciate in the face of supply and demand shocks (coefficients of ε and μ in equation (6) – recall that *H<0*). An external interest rate shock, ρ, will cause a depreciation of the currency whose magnitude will be moderated by the response of the central bank (the coefficient of ρ in equation (6) is less than 1 because *H<0*).

Furthermore, assuming that future expectations of inflation or the exchange rate are not influenced by current shocks (eg if shocks are not persistent), the variance of the exchange rate over long periods of time will depend only on the volatility of the shocks. From equation (6):

$$\sigma_e = \frac{\sigma_\varepsilon}{H^2} + \sigma_\mu\left[\frac{(\pi_y + \lambda K)}{H}\right]^2 + \sigma_\rho\left[\frac{y_i(\pi_y + \lambda K)}{H}\right]^2 \quad (7)$$

σ_e is the variance of the nominal exchange rate and σ_μ, σ_ε and σ_ρ are the variances of the exogenous shocks. In equation (7) the coefficient of σ_ρ has been simplified using the definition of $H \equiv (\pi_y + \lambda K)(y_i - y_e) - \pi_e$. The pass-through coefficient, π_e, has an impact on exchange rate volatility through its influence on the coefficients of the shock variances in equation (7):

Define those coefficients as follows:

$$w_\varepsilon \equiv \frac{1}{H^2}$$

$$w_\mu \equiv \left[\frac{(\pi_y + \lambda K)}{H}\right]^2$$

$$w_\rho \equiv \left[\frac{y_i(\pi_y + \lambda K)}{H}\right]^2$$

$$so \quad that:$$

$$\sigma_e = w_\varepsilon\sigma_\varepsilon + w_\mu\sigma_\mu + w_\rho\sigma_\rho$$

Therefore,

$$\frac{\partial w_{\varepsilon}}{\partial \pi_e} = -2\frac{1}{H^3}\frac{\partial H}{\partial \pi_e}$$

$$\frac{\partial w_{\mu}}{\partial \pi_e} = 2\left[\frac{\left(\pi_y + \lambda K\right)}{H}\right]\left[\frac{\lambda}{H}\frac{\partial K}{\partial \pi_e} - \frac{\left(\pi_y + \lambda K\right)}{H^2}\frac{\partial H}{\partial \pi_e}\right] \tag{8}$$

$$\frac{\partial w_{\rho}}{\partial \pi_e} = 2\left[\frac{y_i\left(\pi_y + \lambda K\right)}{H}\right]\left[\frac{\lambda y_i}{H}\frac{\partial K}{\partial \pi_e} - \frac{y_i\left(\pi_y + \lambda K\right)}{H^2}\frac{\partial H}{\partial \pi_e}\right]$$

so that:

$$\frac{\partial \sigma_e}{\partial \pi_e} = \frac{\partial w_{\varepsilon}}{\partial \pi_e}\sigma_{\varepsilon} + \frac{\partial w_{\mu}}{\partial \pi_e}\sigma_{\mu} + \frac{\partial w_{\rho}}{\partial \pi_e}\sigma_{\rho}$$

Given that $\frac{\partial K}{\partial \pi_e} < 0$ (equation (3)) and $H < 0$, the sign of the derivatives $\frac{\partial w_{\varepsilon}}{\partial \pi_e}$, $\frac{\partial w_{\mu}}{\partial \pi_e}$ *and* $\frac{\partial w_{\rho}}{\partial \pi_e}$ in (8) will depend crucially on the sign of $\frac{\partial H}{\partial \pi_e}$. In particular, if $\frac{\partial H}{\partial \pi_e} < 0$, then inspection of the partial derivatives above (equation (8)) indicates that all the coefficients will respond negatively to an increase in the pass-through coefficient, π_e. As a result, exchange rate volatility will decline with pass-through. From the definition of $H = \left(\pi_y + \lambda K\right)\left(y_i - y_e\right) - \pi_e$, it follows that:

$$\frac{\partial H}{\partial \pi_e} = \left(y_i - y_e\right)\lambda\frac{\partial K}{\partial \pi_e} - 1 = \lambda K^2 - 1 \tag{9}$$

Result 1:

$\frac{\partial H}{\partial \pi_e} < 0$ and $\frac{\partial \sigma_e}{\partial \pi_e} < 0$ for low enough values of λK. This follows from equations (8) and (9).

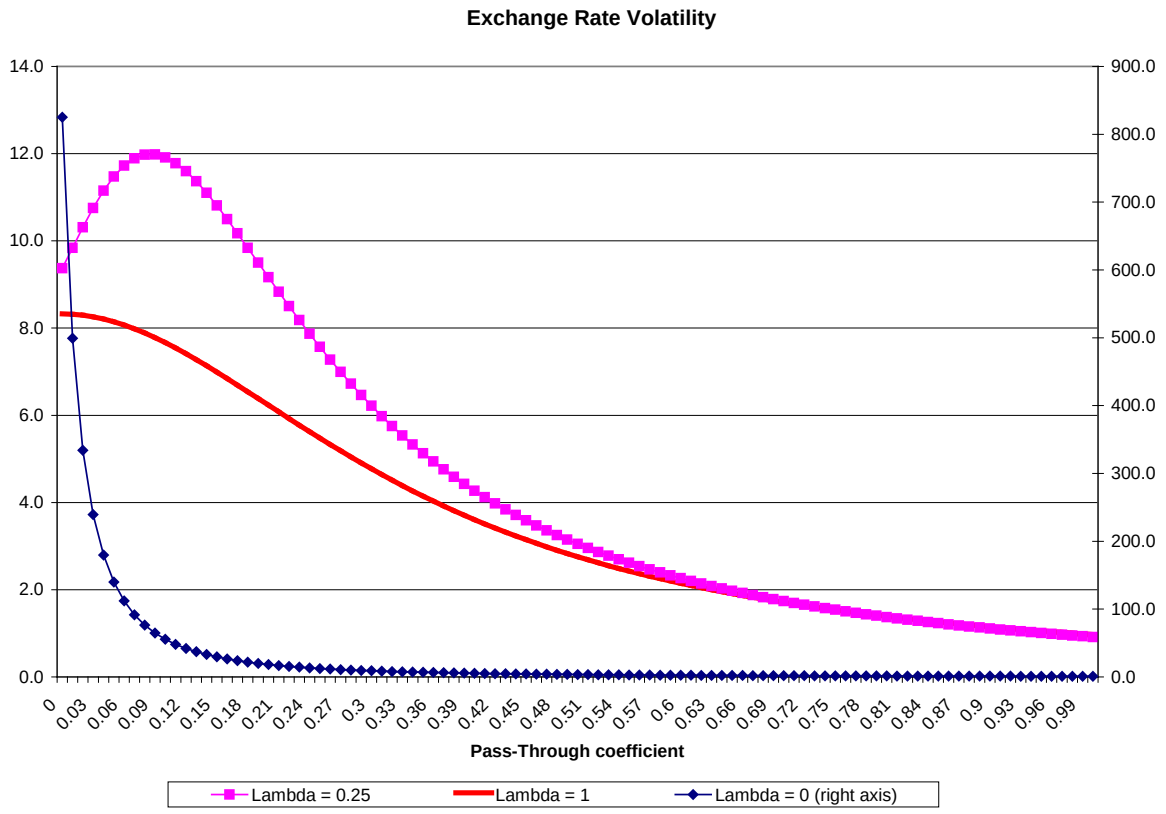
Intuitively, an increase in the pass-through coefficient, π_e, has two effects on the monetary policy response to shocks. On the one hand, it requires a lower adjustment of the interest rate by the central bank in response to a shock that causes inflation to deviate from its optimal level. That is, monetary policy is more powerful because of a larger pass-through and both the interest rate and the exchange rate (through the UIP) do not need to move much.

On the other hand, a larger pass-through, π_e, reduces the importance of the output gap in the inflation-output trade-off, K, as the marginal benefit of correcting an inflation deviation is greater (due to a larger impact of an interest rate move on inflation) relative to the output marginal cost. In consequence, the central bank is more willing to allow the interest rate to respond strongly to shocks that move inflation and, through the UIP, produces more exchange rate volatility.

The second effect is more important, the greater the output weight, λK. Hence, according to equation (3) ($\frac{\partial K}{\partial \pi_e} < 0$), when λ is large enough or the pass-through coefficient, π_e, is very small, an increase in π_e could actually increase exchange rate volatility (equation (8)). Otherwise, there will be a negative relationship between exchange rate pass-through and exchange rate volatility because the first effect prevails.

Nevertheless, low values of the preference weight parameter, λ, do not necessarily lead to a positive relationship between pass-through and volatility. Equation (8) shows that the coefficients of σ_μ and σ_ρ may fall when the pass-through coefficient, π_e, rises because $\frac{\partial K}{\partial \pi_e} < 0$. Intuitively, as mentioned above, an increase in pass-through reduces the importance of output in the central bank's preferences (K falls). Since demand and external interest rate shocks shift output, the lower output weight means less incentive for the central bank to correct the shocks through interest rate (and exchange rate) movements. This effect is greater when λ is large. Hence, it is possible that high values of λ lead to a negative relationship between pass-though and exchange rate volatility. Graph A2-1 illustrates the different configurations of this relationship for set of parameter values.[9]

Graph A2-1



[9] y_i = -0.3, y_e = 0.05, π_y = 0.1, $\sigma_\varepsilon = \sigma_\rho = \sigma_\mu = 1$.

Hitherto a relationship was posited in which the pass-through coefficient, π_e, depends on exchange rate volatility, σ_e (equation (1)). The smaller exchange rate volatility, the larger the response of local prices to movements in the exchange rate, for the latter would signal persistent shifts in marginal costs. At the same time, a relationship was established in which exchange rate volatility, σ_e, depends on the pass-through coefficient, π_e (equation (7)). For high enough values of π_e in combination with appropriate values of λ, increases in the pass-through coefficient will incentivise the central bank to deliver lower exchange rate volatility. This is so because greater pass-through coefficients make monetary policy more powerful and require smaller adjustments in the exchange rate in the face of exogenous shocks to inflation. Also, greater pass-through reduces the incentive for the central bank to correct output deviations caused by demand or external interest rate shocks.

An equilibrium in this economy occurs when the exchange rate volatility, σ_e, that produces the pass-through coefficient, π_e, in equation (1) coincides with the exchange rate volatility, σ_e, generated by the pass-through coefficient, π_e, in equation (7). This equation includes the fulfilment of the relationships that describe the economy (Phillips curve, IS and UIP), as well as the optimising behaviour of the central bank. Formally then, the macroeconomic equilibrium is given by:

$$\pi_e = f(\sigma_e) > 0, \quad f' < 0 \tag{1}$$

$$\sigma_e = g(\pi_e) \equiv \frac{\sigma_\varepsilon}{H^2} + \sigma_\mu \left[\frac{(\pi_y + \lambda K)}{H} \right]^2 + \sigma_\rho \left[\frac{y_i (\pi_y + \lambda K)}{H} \right]^2 \tag{7}$$

Result 2:

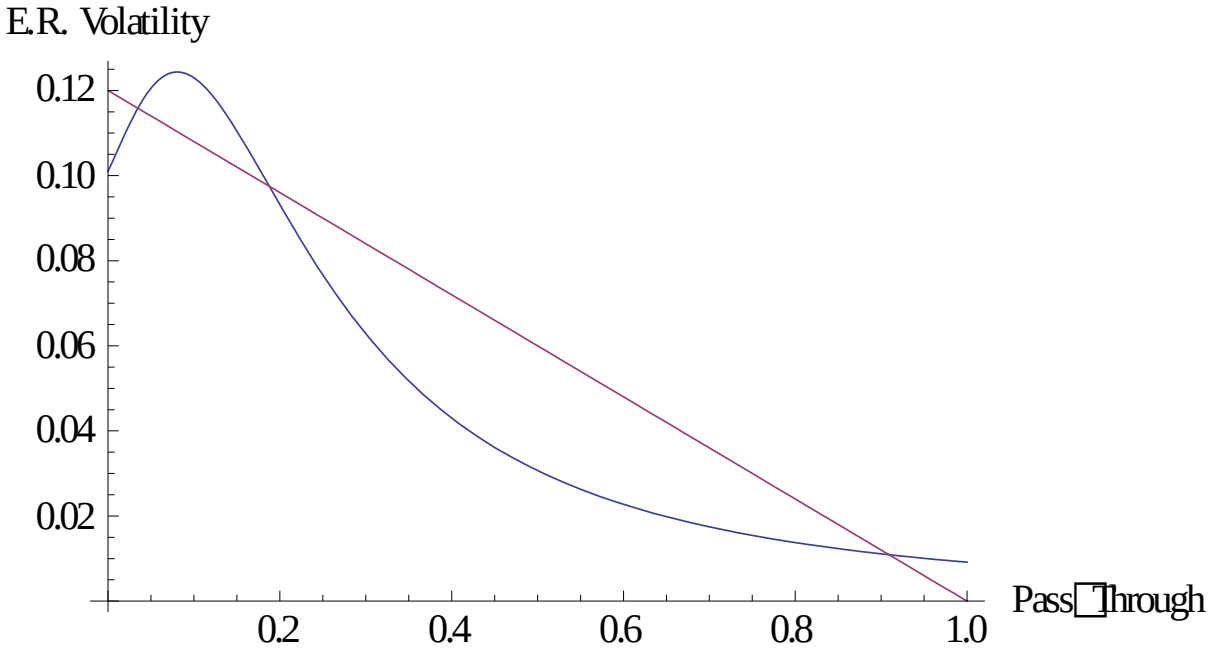
Depending on the shapes of $\pi_e = f(\sigma_e)$ (equation (1)) and $\sigma_e = g(\pi_e)$ (equation (7)), there may be multiple pairs (π_e, σ_e) that are macroeconomic equilibrium points. Given the assumption of $f'(\sigma_e) < 0$, some equilibria will display higher pass-through and lower exchange rate volatility than others.

In other words, there may be multiple equilibria. In some of them, economies with low exchange rate volatility will persistently display high pass-through and, consequently, central banks will deliver low exchange rate volatility. These cases may co-exist with economies in which high exchange rate volatility induces low pass-through and, therefore, allows the central bank to tolerate high exchange rate volatility in equilibrium. Graph A2-2 illustrates these situations for a specification of $\pi_e = f(\sigma_e)$ and a set of parameter values.[10] Points A and B correspond to equilibria with high exchange rate volatility and low pass-through. In contrast, an economy in point C has low exchange rate volatility and high pass-through in equilibrium.

Finally, it is worth emphasising that multiple equilibria are a *possibility* in this model. This is not necessarily the only outcome. Depending on the shapes of $\pi_e = f(\sigma_e)$ and $\sigma_e = g(\pi_e)$, there may be situations with a unique equilibrium.

[10] The pass-through function is as follows: $\pi_e = 1 - 8.33\ \sigma_e$. Other parameter values: $\lambda = 0.25$, y_i = -0.3, y_e = 0.05, π_y = 0.1, $\sigma_\varepsilon = \sigma_\rho = \sigma_\mu$ = 0.01.

Graph A2-2


E.R. Volatility
0.12
0.10
0.08
0.06
0.04
0.02
0.2
0.4
0.6
0.8
1.0
Pass Through

Appendix 3:
Methodologies used to estimate equilibrium or long-run exchange rates[11]

PPP methodologies:

- *Big Mac indices*: Yearly frequency. Two estimates: one with respect to the United States and the other with respect to a (trade-weighted) basket of countries. Confidence intervals are constructed on the basis of the standard deviations of the difference between the NER and the Big Mac index measures.
- *Historical averages for RER*: Monthly frequency. We examine long-run averages for the RER (since 1970) and allow for structural breaks (Perron and Yabu (2009) test). Confidence intervals are constructed as explained above.

Tradable/non-tradable relative price methodologies: We acknowledge the possibility of large swings in the relative prices of tradable and non-tradable goods that may emerge as equilibrium responses to policy or other exogenous shocks/trends affecting the economy. Long-run trends and international comparisons are computed to evaluate possible misalignments of the currency.

- *Hodrick-Prescott filters*: Monthly frequency. Estimated since 1970. Confidence intervals estimated as explained above.
- *"Penn Tables" Balassa-Samuelson effect*: Yearly frequency. The following relationship is exploited:

  NER_i / PPP-NER_i = f (per capita GDP_i / per capita GDP USA)

  for a cross-section of countries *i*, where the PP-NER is obtained from the IMF. According to the Balassa-Samuelson effect, the richer the country, the more appreciated its currency should be in real terms. One could examine the misalignment of the currency after controlling for this effect. The confidence intervals in this case are obtained from the standard error of the regression.

BEER methodologies: Again, allowing for fluctuations of the relative price of tradable and non-tradable goods, the behaviour of the RER is modelled as a function of "fundamentals" obtained from conventional theory (net foreign assets, terms of trade, public consumption, productivity differentials, income of trading partners etc). Reduced forms are estimated and used to evaluate a possible misalignment of the RER, using confidence intervals:

- *SVEC*: Structural VEC. Yearly frequency (based on Echavarría et al (2007))
- *VEC*: Quarterly frequency.
- *"Smoothed" VEC*: Quarterly frequency. The cointegration vector obtained in the previous methodology is applied to Hodrick-Prescott-filtered series of the fundamentals (Mac Donald and Ricci (2003)).

FEER Methodologies: The fundamental equilibrium exchange rate is defined as the one that results when the economy is in internal and external equilibrium. The latter occurs, in turn, when the current account deficit is at its long-run level (Williamson (1983)). Following an IMF methodology, a "required RER adjustment" is calculated as:

[11] Based on Banco de la República–DPI (2010).

(CC* - CCtrend) / mtc

*CC** is the equilibrium level of the current account, *CCtrend* is the H-P trend of the current account and *mtc* is the elasticity of imports and exports with respect to the exchange rate. The definition of the equilibrium level of the current account may be arbitrary, but we use several measures: the average of the last X years, or the level that would leave the ratio net foreign assets / GDP unchanged, given some assumptions on domestic GDP long-term growth and long-run external inflation.

References

Banco de la República-DPI (2010) “Medidas de tasa de cambio real de equilibrio”, internal document, Observatorio de tasa de cambio real, Departamento de Programación e Inflación,

Echavarría, J, E López and M Misas (2007) “La Tasa de Cambio Real de Equilibrio en Colombia y su desalineamiento: estimación a través de un modelo SVEC”, *Borradores de Economía*, no 472, Banco de la República.

Ize, A and E Levy-Yeyati (2003): “Financial dollarization”, *Journal of International Economics*, no 59.

Rincón, H and J Toro (2010): “Are capital controls and central bank intervention effective?”, *Borradores de Economía*, no 625, Banco de la República.

Taylor, J (2000): “Low inflation, pass-through, and the pricing power of firms”, *European Economic Review*, vol 44.

Vargas, H, Y Betancourt, C Varela and N Rodríguez (2010): “Effects of reserve requirements in an inflation targeting regime: the case of Colombia”, in *The global crisis and financial intermediation in emerging market economies*, *BIS Papers*, no 54, December.