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MONETARY NEUTRALITY IN THE COLOMBIAN REAL EXCHANGE RATE

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Abstract

We identified and estimated a SVAR model in the real and nominal exchange rates through the Blanchard and Quah decomposition. This enables us to provide results regarding the magnitude and length of nominal and real shock effects in the real and nominal exchange rate. We estimate that the fundamental sources of real exchange rate fluctuations are real factors. Our first result is that the real effect of nominal shocks die out in less than six months. Second, we find that convergence time has decreased since the implementation of exchange rate bands.

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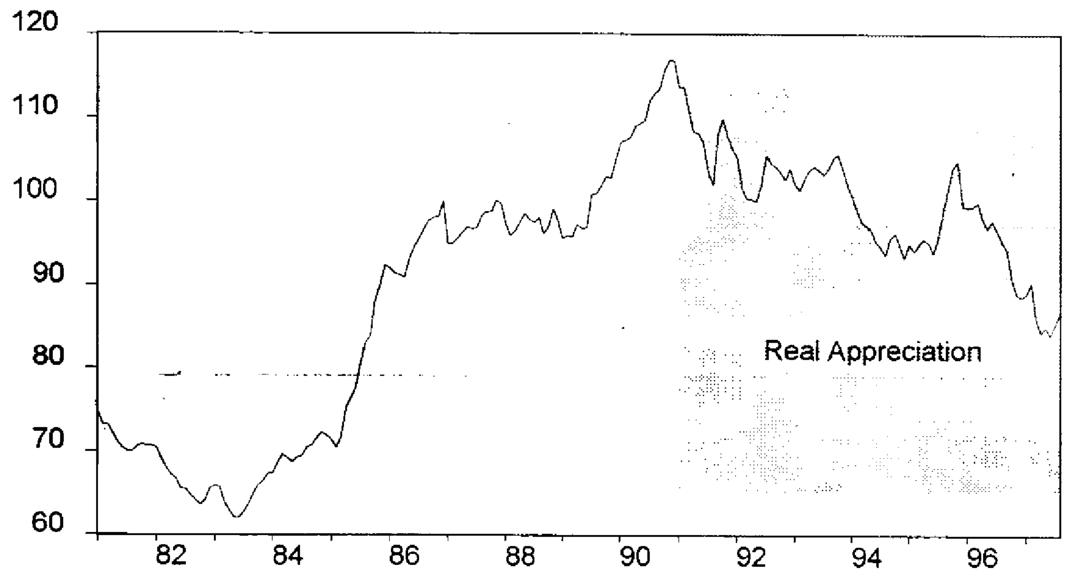
1. INTRODUCTION

During the 1990's a top issue of debate in Colombia has been the dynamics of the real exchange rate. The reason for this is simple : the Colombian peso has appreciated markedly during the nineties. Graph 1 shows the monthly evolution of a Real Exchange Rate Index. Comparing the mean of this index for the first quarter in 1990 with that of the third quarter in 1997, real appreciation of the peso would be 17.6%.

Graph 1
REAL EXCHANGE RATE INDEX



While most analysts argue that all real appreciation is due to shocks on economic fundamentals, and that all adjustment must come from fundamentals, others postulate that rigidities open an ample space for monetary policy to adjust what is viewed as an overvaluation.

If one accepts the view that in the short run monetary policy affects the real exchange rate, the important issue is then : ¿How long is the short run? In terms of the problem at hand, the question would be : ¿How long does it take for a nominal shock to fade away? The answer to this question is the main motivation of this paper.

To search for an answer to our motivating question, we propose an econometric approach capable of filling up technical gaps left behind by several articles which address the same issue. Specifically, we estimate a structural VAR using the Blanchard and Quah (1989) decomposition on the real and nominal exchange rate. We then find impulse-response functions and forecast error variance decomposition in order to determine not only the temporal length of the effect of nominal shocks on the real exchange rate, but also the proportion of the movements in both exchange rates that are due to nominal and real shocks.

Thus, the main contribution of this paper consists of some rigorous empirical results regarding the Colombian exchange rate behavior in the short and long run. Our main goal is to provide results about the magnitude and length of nominal shock effects in the real exchange rate. Policy recommendations may be taken from such results.

The structure of the paper is as follows. Section 1 is this introduction. In section 2 we make a brief survey of economic literature on the real exchange rate and its relationship with nominal shocks. Section 3 presents data and its main econometric features. In the fourth section the econometric model used for estimation is presented. Section 5 shows main results and section 6 concludes.

2. LITERATURE

There is consensus among economists that there are two types of factors explaining the real exchange rate : fundamental or real factors and nominal or monetary factors. The basic difference between them is that the former determine the equilibrium path of the real exchange rate, while the latter can only alter, temporarily, the observed rate. Such a transitory influence of nominal shocks is due to the fact that while some markets exhibit short run price rigidities there is a relative flexibility underlying the forex market. Nevertheless, only fundamentals[1] of the real exchange rate persist in the long run.

Rogoff (1996) sums up this idea in the following words : *"Even if there are short-term rigidities in domestic nominal prices, for example, long-term monetary neutrality implies that any effects of money shocks on the real exchange rate (the nominal exchange rate adjusted for price differentials) should die out in the long run ... In the short run, nominal exchange rate movements lead to real exchange rate movements due to nominal price rigidities. Over the longer term, however, deviations from purchasing power parity must be accounted for by real factors."* pg. 655, 658.

Theoretical and empirical research on this issue has been developed extensively in recent years. With respect to theory, for example, Calvo, Reinhart and Vegh (1995) develop an exogenous output model in which they show that, under perfect capital mobility, targeting the real exchange rate is only possible in the short run and at the cost of higher inflation.

Empirical studies vary widely in their results regarding long-term neutrality of nominal shocks on the real exchange rate. Frankel and Rose (1995) study PPP with a panel data set of 150 countries and 45 yearly observations. They find mean reversion (i.e. no random walk) in the real exchange rate thus supporting PPP. Their results also show that PPP deviations die at a rate of 15% annually (half-life of 4 years).

Rogoff (1996) finds an empirical paradox : very high short-term volatility in real exchange rates and slow rates at which PPP deviations die out. Instead of arguing for dominant roles of monetary and financial variables, Rogoff seems to find the answer

[1] Among real exchange rate fundamentals we find : public expenditure/GDP, private expenditure shocks, relative productivity between tradable and non-tradable sectors (i.e. the Balassa-Samuelson hypothesis), permanent income shocks (an oil boom for example) or the terms of trade.

to his puzzle in segmentation of international goods markets and trading frictions which still persist in the world economy.[2]

Apergis and Karfakis (1996) use structural VAR techniques in quarterly data of the nominal and real exchange rates of the Greek drachma over the period 1975 - 1993. They find that, in most cases, *"supply shocks are the dominant sources of exchange rate volatility"*. pg. 251. They conclude that *"demand shocks are absorbed by price levels over short horizons"*. pg 254.

In a more recent study Enders and Lee (1997) estimate a structural VAR model based on the Blanchard and Quah decomposition in an attempt to examine the effects of nominal shocks on real exchange rates between U.S. and Canada, Japan and Germany. They find that nominal shocks have had very short effects (6 months or less) on those real exchange rates and that real shocks explain practically all of their forecast error variance at any forecast horizon. They claim : *"... the effect of a nominal shock on the real exchange rate is temporary and becomes unnoticeable in a few months."* pg. 244.

In Colombia, articles addressing the effects of nominal shocks over the real exchange rate are very common as well. First econometric studies, in contradiction with long-term monetary neutrality, find possible permanent effects of nominal shocks on the real exchange rate [Herrera (1989), Echavarría and Gaviria (1992), Langebaek (1993)].

More recent papers, also econometric in nature, tend to find no long run correlation between nominal variables and the real exchange rate [Carrasquilla, Galindo and Patrón (1994), Calderón (1995,1997), Herrera (1997), Gómez and Ocampo (1997), Joyce and Kamas (1997)].

General equilibrium and calibration analyses present similar results by showing that permanent movements in the Colombian real exchange rate can only be attributed to fundamental or real variables [Carrasquilla and Arias (1996,1997), Arias and Zuleta (1997)].

Despite general consensus on the long term neutrality of monetary shocks, there is still a major discrepancy in regards to the time duration of nominal shocks on the real exchange rate. According to Calderón (1995) a 1% increase in nominal devaluation increases the real exchange rate in 0.36% during one quarter but the effect disappears almost totally one year after the shock. Ocampo and Gómez (1997) find that nominal exchange rate shocks persist on the real rate for two years. In Joyce and Kamas (1997) it takes ten years for the real exchange rate to return to its equilibrium path after a shock on the nominal exchange rate.

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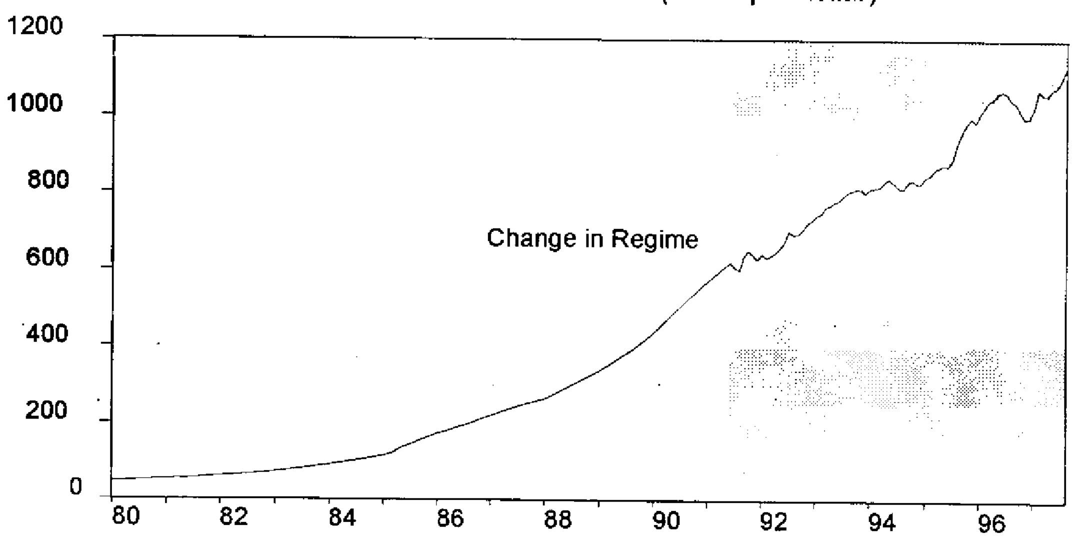
[2] Rogoff's paper includes an excellent survey of empirical studies of the PPP hypothesis. He begins with the failure of the Law of One Price on microeconomic data and goes on to mention different attempts to correct what he calls the "Random-Walk Model Embarrassment" like the usage of longer data sets in time series or cross country data sets.

3. DATA

We use monthly data of the nominal exchange rate and the real exchange rate index for the period 1980-1997. Graph 2 depicts the evolution of Colombia's nominal exchange rate for this period. This graph shows that 1980-1991 is a period of low volatility whereas 1991-1997 displays high variance in the Colombian nominal exchange rate[3]. A structural change in the exchange rate regime in 1991 underlies stylized facts.

Graph 2
NOMINAL EXCHANGE RATE (Pesos per dollar)



Indeed, prior to 1991 a crawling peg system guided the evolution of the nominal exchange rate. Under such a regime the real exchange rate was partly targeted through daily mini-devaluations. In June 1991 monetary authorities implemented an exchange certificate (or devaluation indexed bond) system. Such system might be viewed as an implicit crawling band itself [see Urrutia (1995)]. However, it was only until January 1994 that the central bank's board of directors effectively created the current crawling band regime. These are "*wide bands with central parities that are flexible enough to keep the band in line with the country's economic fundamentals*" [Williamson (1995)].

As expected, the devaluation indexed bond system initiated a period of relative flexibility in the exchange rate market that persists nowadays. Consequently, the strong contrast in nominal exchange rate volatility between both periods [(1980-1991) vs (1991-1997)] can be attributed to a structural detour in the exchange rate regime. As a result, we divide our sample into two subsamples, one running from 1980 to 1991 and the other one comprising the 1991 - 1997 subperiod.

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[3] During 1980 - 1991 the standard deviation of the nominal exchange rate is 145.1216. During 1991 - 1997 (august) the standard deviation of the same rate is 159.4067.

Variance stabilization of both series is achieved through a logarithmic transformation. Augmented Dickey-Fuller and KPSS unit root tests were performed on both variables. Table 1 of Appendix 1 shows the results of these tests. Under both tests and for both subsamples the real and nominal exchange rates are I(1) in levels and I(0) in first differences at an $\alpha = 10\%$ significance level.

The next logical step is cointegration analysis between both variables. There shouldn't be a cointegration relationship between the nominal and real exchange rates for a SVAR model to be the appropiate system describing the dynamics behind both variables. If there is cointegration the relevant model is a VEC or SVEC.

The Johansen procedure is used to test for cointegration. Adequate order of the VAR - which is to be estimated under the Johansen methodology - is determined with information criteria. Table 2 of Appendix 1 shows the results of the Akaike, Schwarz and Hannan-Quinn criteria. It follows that the optimal order of the VAR could be P = 2 or 3 for the first subsample and P = 1 or 2 for the second subsample.

Thus, these criteria are complemented with the adjusted Portmanteau test for multivariate autocorrelation in the residuals of the system and with a multivariate normality test also in the residuals. Results at an $\alpha = 5\%$ significance level are shown in Table 3 of Appendix 1. For subsample 1 (1980 - 1991) the optimal order of the VAR is set on P = 3 and for the other subsample (1991 - 1997) it's set on P = 2.

Finally, the Johansen cointegration test is performed using the selected VAR order for each subsample. Deterministic elements were modeled in two different ways : deterministic trend only in the variables vs deterministic trend in the variables and in the cointegrating vector. Table 4 of Appendix 1 reveals that, under both modeling schemes and for both subamples, there is no cointegrating relationship between the real and the nominal exchange rate. This is robust to other results found in the literature.

Having verified that the real and nominal exchange rates are both I(1) variables with no cointegration relationship between them, the next step is estimation of a standard and structural vector autoregressive model in the first differences of both rates.

4. THE MODEL

We estimate a bivariate SVAR model in which we decompose real and nominal exchange rate dynamics into those components explained by real and nominal shocks. The VAR in its standard form is :

$$\begin{bmatrix} \Delta r_t \\ \Delta e_t \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} \Delta r_{t-1} \\ \Delta e_{t-1} \end{bmatrix} + \begin{bmatrix} \upsilon_{1t} \\ \upsilon_{2t} \end{bmatrix}$$

where Δr_t is the first difference of the real exchange rate and Δe_t is the first difference of the nominal exchange rate; v_{1t} and v_{2t} are contemporaneously correlated white noise processes. $A_{ij}(L)$ are polynomials in the lag operator L (i,j = 1,2).

To take into account contemporaneous relationships between the variables in the system, we must specify the VAR in its structural or primitive form[4]. Infinite VMA representation of the SVAR model in terms of pure shocks is :

$$\begin{bmatrix} \Delta r_t \\ \Delta e_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

where ε_{1t} and ε_{2t} represent nominal and real exogenous shocks respectively. We assume they are independent white noise disturbances. $C_{ij}(L)$ are polynomials in the lag operator L. Normalizing shocks so that $var(\varepsilon_{1t}) = var(\varepsilon_{2t}) = 1$ and calling the variance-covariance matrix of structural innovations $\Sigma\varepsilon$ we have :

$$\Sigma_{\varepsilon} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = I_2$$

In equations, the pure bivariate moving average representation of the $\{\Delta r_t\}$and $\{\Delta e_t\}$sequences is :

$$\Delta r_t = \sum_{k=0}^{\infty} c_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{\infty} c_{12}(k)\varepsilon_{2t-k}$$

$$\Delta e_t = \sum_{k=0}^{\infty} c_{21}(k)\varepsilon_{1t-k} + \sum_{k=0}^{\infty} c_{22}(k)\varepsilon_{2t-k}$$

As in any VAR model, identification of the structural parameters (and of the pure VMA representation) from estimated residuals of the standard VAR requires proper identifying restrictions. In line with the long-term monetary neutrality hypothesis, Blanchard and Quah (1989) propose the following identifying restriction :

$$\sum_{k=0}^{\infty} c_{11}(k)\varepsilon_{1t-k} = 0$$

Our identifying restriction implies that only real shocks have permanent effects in the real exchange rate whereas both monetary and real shocks may affect permanently the nominal exchange rate. Then, nominal shocks have no long run effect on the real exchange rate. Its sequence is only explained by fundamentals.

[4] In Misas (1997) a clear and pedagogic exposition of the structural VAR and theBlanchard and Quah decomposition methodology is presented.

In our model, standard VAR errors $[v_{1t}\ v_{2t}]$ are linear combinations of structural innovations $[\varepsilon_{1t}\ \varepsilon_{2t}]$ (see Appendix 2). This we can represent in the following equations :

$$v_{1t} = c_{11}(0)\varepsilon_{1t} + c_{12}(0)\varepsilon_{2t}$$

$$v_{2t} = c_{21}(0)\varepsilon_{1t} + c_{22}(0)\varepsilon_{2t}$$

Considering that Σ_v can be estimated from the standard VAR, Blanchard and Quah obtain the following system of three equations and four unknowns :

$$Var(v_{1t}) = c_{11}{}^2(0) + c_{12}{}^2(0)$$

$$Var(v_{2t}) = c_{21}{}^2(0) + c_{22}{}^2(0)$$

$$Cov(v_{1t}, v_{2t}) = c_{11}(0)c_{21}(0) + c_{12}(0)c_{22}(0)$$

The four unknown variables are : $\{c_{11}(0), c_{12}(0), c_{21}(0), c_{22}(0)\}$. Clearly enough, we need a fourth equation to identify the system. Such equation is obtained from Blanchard and Quah's identifying restriction [see Appendix 2]:

$$\left[1 - \sum_{k=0}^{p} a_{22}(k)\right] c_{11}(0) + \sum_{k=0}^{p} a_{12}(k) c_{21}(0) = 0$$

We then have a four equation-four variable system. Since it's nonlinear, this multiequational system will provide four possible solutions to the matrix C_0[5]. We will use that solution that is economically feasible in terms of the impulse - response functions. With a chosen solution for matrix C_0 impulse-response coefficients can be recovered for a proper innovation accounting analysis.

5. RESULTS

Optimal lag length of the standard VAR is determined with the Akaike, Schwarz and Hannan-Quinn information criteria. Results are reported on Table 1 of Appendix 3. Again, information criteria are complemented with the Portmanteau test and a multivariate normality test in the residuals of the system. As can be seen from Table 2 of Appendix 3, optimal order for the standard VAR is set on P = 2 for subsample 1 and on P = 1 for subsample 2.

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[5] $C_0 = \begin{bmatrix} c_{11}(0) & c_{12}(0) \\ c_{21}(0) & c_{22}(0) \end{bmatrix}$

Estimation of the standard VAR is via OLS. OLS estimators are consistent and asymptotically efficient. Eventhough there's contemporaneous correlation in the errors of the system, a SUR methodology doesn't add to the efficiency of the estimation procedure since both regressions have identical right hand side variables [see Enders (1995)].

Estimation of the standard VAR includes estimation of the variance-covariance matrix of the standard VAR errors Σ_v. With this matrix and with estimation of the standard VAR coefficients $a_{22}(k)$ and $a_{12}(k)$ ($k = 0, \ldots, P$) we construct the four equation - four variable system specified in the previous section. Such system provides four possible solutions to the elements of the matrix C_0. We keep that solution that is economically feasible. Our chosen solution for matrix C_0 enables the recovery of the impulse-response coefficients for a proper innovation accounting analysis.

Impulse-response functions of the real and nominal exchange rates to nominal and real shocks and their respective confidence intervals are depicted in graphs 3 and 4 for the first and second subsamples respectively. Results are shown in levels of the (log of) both exchange rates.

Subsample 1

For subsample 1 (graph 3a), which is the period of a crawling peg regime, several features are observable. First, *a monetary shock to the log of the real exchange rate creates a positive but decreasing response. Furthermore, the shock disappears completely after one year and six months approximately. That is, under the crawling peg regime long-term monetary neutrality is effective after a year and a half.* This result is robust to that obtained in a pioneering paper for the Colombian case by Carrasquilla et. al. (1994).

Second, nominal shocks to the log of the nominal exchange rate produce negative, decreasing and permanent responses, with the nominal exchange rate converging to its new long-run level after a year and a half[6].

Third, a real shock to the log of both the nominal and the real exchange rate generates negative and decreasing responses. These shocks are of permanent nature and real and nominal exchange rates converge to their new long-run levels approximately after a year and a half. This appreciation shock causes a greater impact on the real exchange rate.

This result is intuitive and suggestive of the following hypothesis for the crawling peg years : monetary attempts aimed at offsetting real appreciation forces (or artificially targeting the real exchange rate) produced inflation and, consequently, a more than proportional adjustment of the real exchange rate vis a vis the nominal exchange rate.

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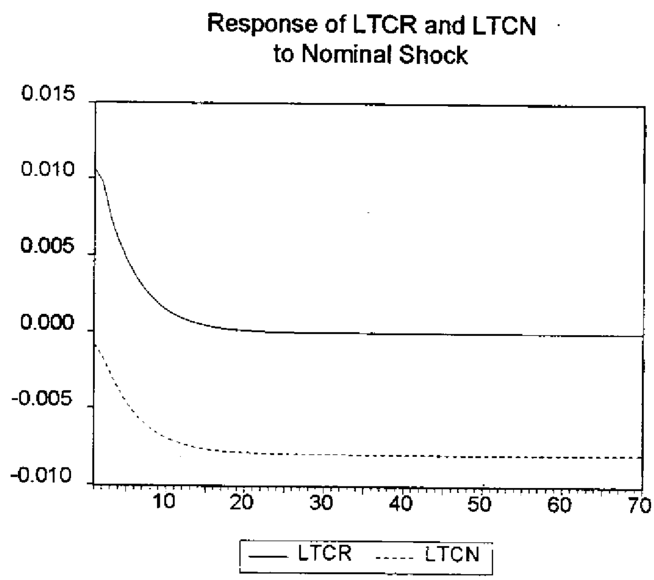
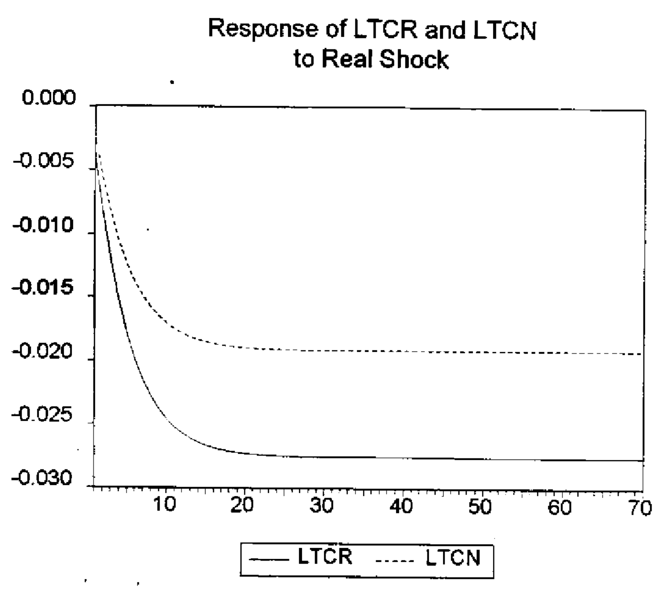
[6] This result is weird because with a positive nominal shock that appreciates transitorily the real exchange rate, one expects the nominal exchange rate to jump (i.e. depreciate) and then converge (if so) to a new permanent level.

As can be seen from the corresponding confidence interval analysis (graph 3b), in subsample 1 all responses to both types of shocks are statistically significant at 95%.

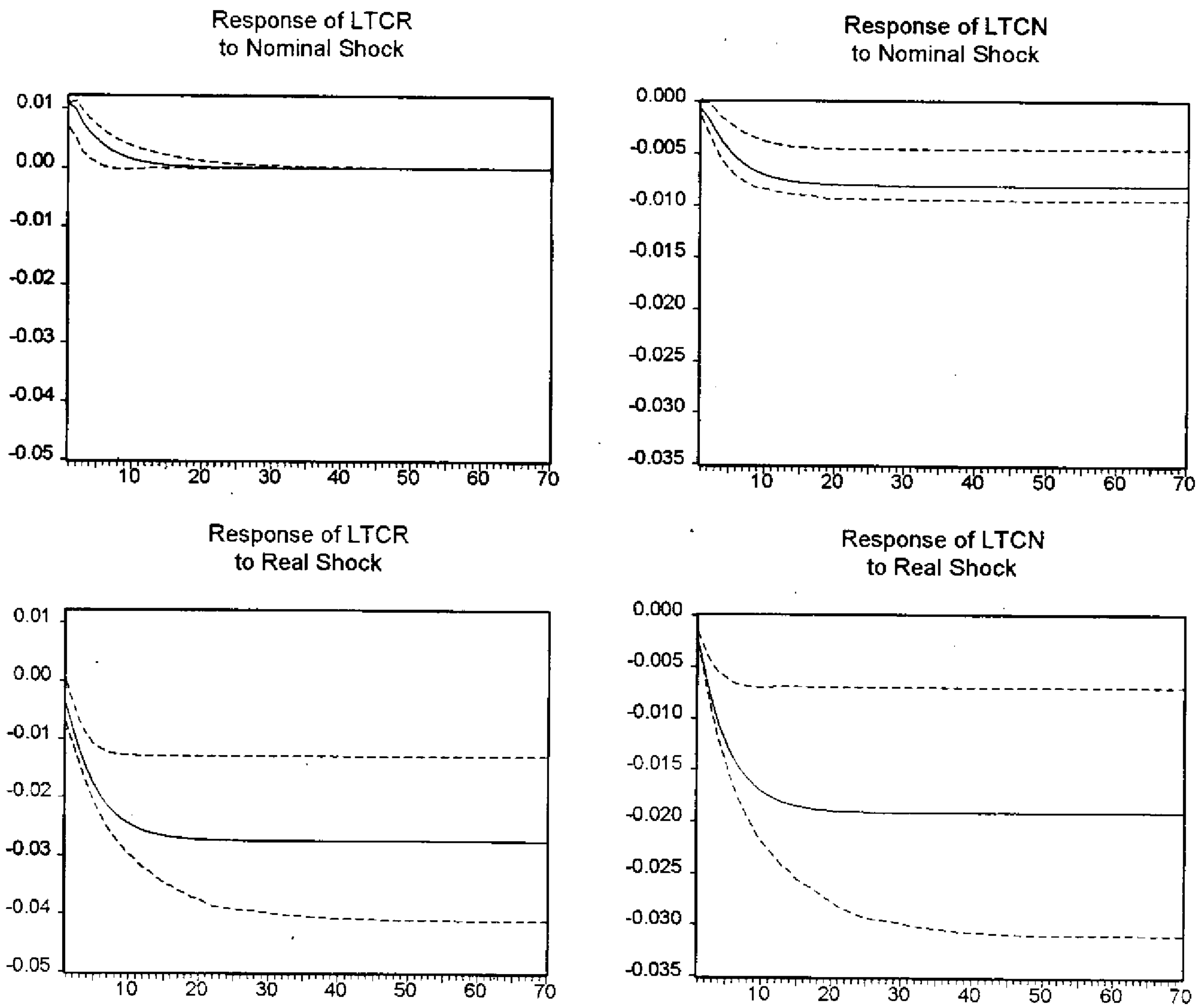
Graph 3a
Impulse - Response Analysis
Sample 1





* LTCR = Log of Real Exchange Rate ; LTCN = Log of Nominal Exchange Rate.

Graph 3b
Impulse - Response Analysis with Confidence Intervals (95%)
Sample 1



*Confidence Intervals of Impulse-Response Functions were estimated using the Bootstrap technique at a 95% level of statistical significance.

Subsample 2

In subsample 2 (graph 4a), the period of target zones or crawling bands, similar results are obtained. *Even though the response of the log of the real exchange rate to a nominal shock is positive, the shock disappears completely after four to five months. In other words, under the target zone system long-run monetary neutrality begins in five months. Furthermore, most part of the nominal shock has vanished after three or four months.*

Note also that the effect of the nominal shock over the real exchange rate is negligible in comparison with that over the nominal rate in the same subsample and that over the real rate in subsample 1.

Secondly and as found in subsample 1, responses of the log of the nominal exchange rate to nominal shocks are negative, decreasing and permanent. After the shock, the nominal exchange rate converges to its new long-run level after four to six months.

Third, responses of the log of both the nominal and the real exchange rate to real appreciation shocks are negative, decreasing and, as expected, permanent in nature. After the appreciation shock, real and nominal exchange rates converge in equal proportion to their new long-run levels in four to six months.

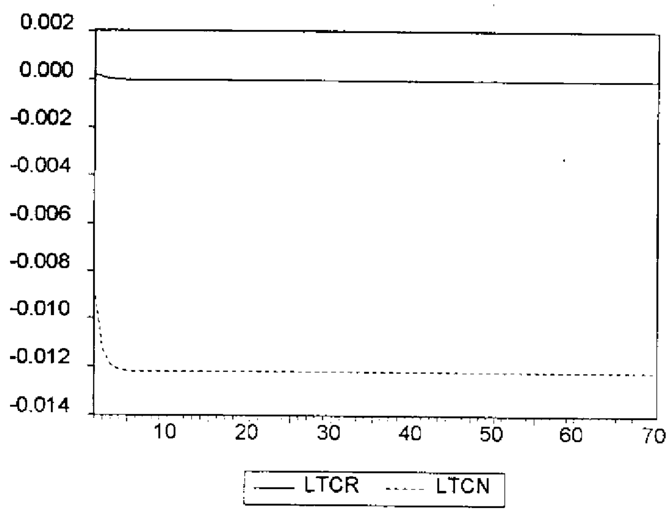
This is the expected result when a more flexible exchange rate regime (i.e. target zones) operates. In fact, when fundamentals lead toward real appreciation a more flexible forex market allows the real exchange rate to respond via the nominal rate and not only through prices. Furthermore, all adjustment could be through a nominal revaluation.

Confidence intervals (graph 4b) reveal that, for subsample 2, all responses to both types of shocks are statistically significant at 95% except the response of the real exchange rate to the nominal shock.

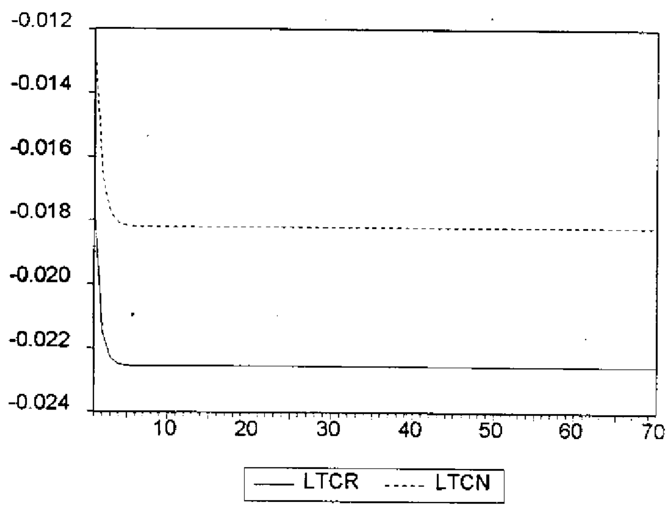
The fact that in subsample 2 the effect of the nominal shock over the real exchange rate is very small and statistically insignificant (at 95%) is a result that must be taken cautiously. Theory indicates that short term rigidities in some prices of the economy should allow for some significant, though transitory, impact of a nominal shock over the real exchange rate. That is, despite the high speed of convergence of the real exchange rate after a nominal shock (4/5 months), one expects this immediate and short term response to be statistically significant. Hence, this super neutral result must be examined further in future papers. It could be a sample problem associated to the fundamental forces which constantly appreciated the real exchange rate in Colombia during the nineties.

Graph 4a
Impulse - Response Analysis
Sample 2

Response of LTCR and LTCN
to Nominal Shock

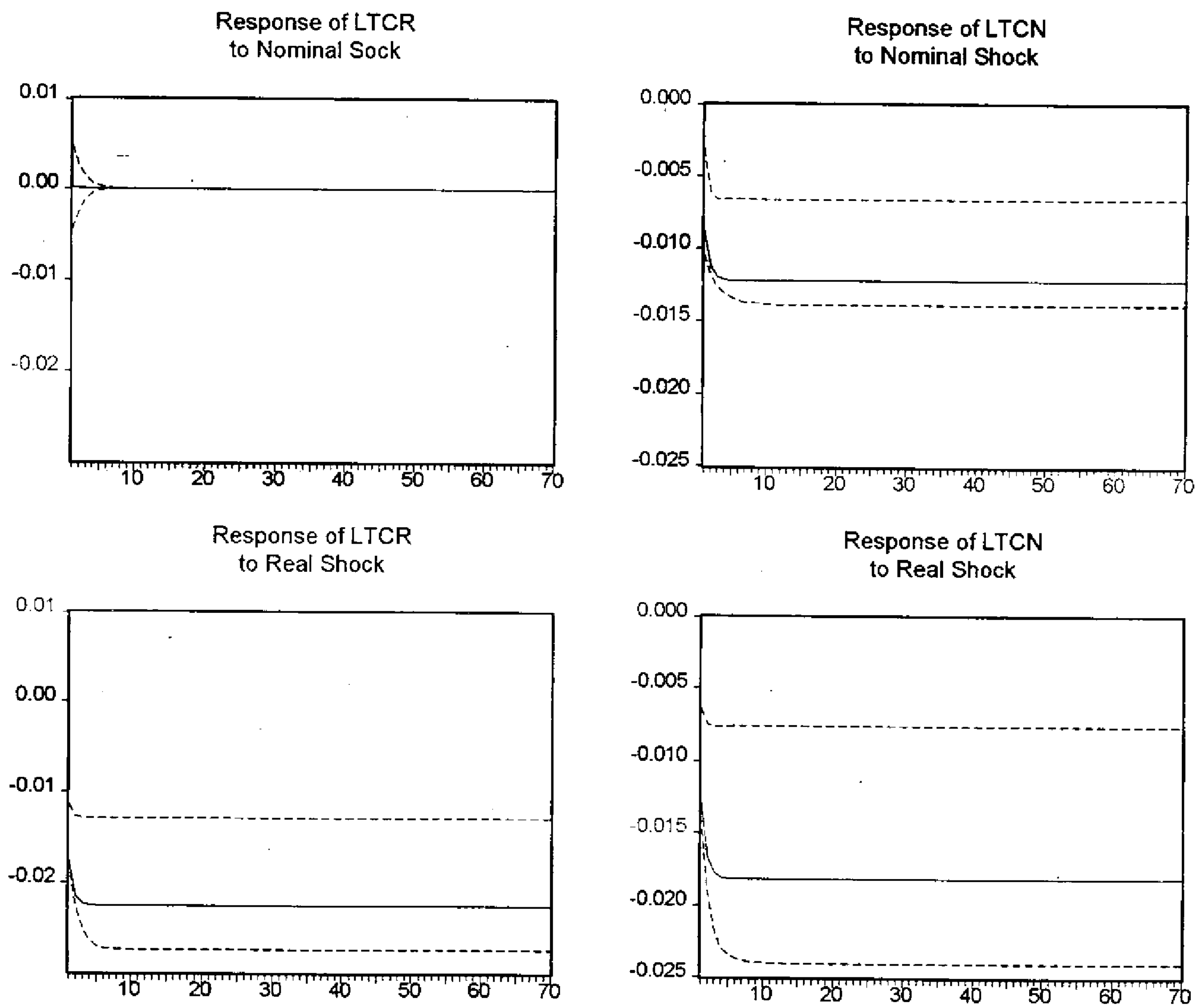


Response of LTCR and LTCN
to Real Shock



* LTCR = Log of Real Exchange Rate ; LTCN = Log of Nominal Exchange Rate.

Graph 4b
Impulse - Response Analysis with Confidence Intervals (95%)
Sample 2



*Confidence Intervals of Impulse-Response Functions were estimated using the Bootstrap technique at a 95% level of statistical significance.

Forecast Error Variance Decomposition

Forecast error variance decomposition results are portrayed in Table 1. Under the crawling peg regime nominal shocks explain almost all of the forecast error variance of the differences of the real exchange rate (at any forecast horizon) while real shocks do so for the forecast error variance of the differences of the nominal exchange rate. This means that prior to 1991 nominal shocks play the major role in explaining movements in the real devaluation rate whereas economic fundamentals (i.e. real shocks) account for most of the movement in the nominal devaluation rate.

Results are somewhat different under the crawling band regime (1991-1997). Nominal shocks explain practically none of the forecast error variance of the changes in the real exchange rate (at any forecast horizon) and explain only 30% of the forecast error variance of the changes in the nominal exchange rate (at any forecast horizon).

In synthesis, *after 1991 nominal shocks play practically no role at all in explaining movements in the real devaluation rate and play a minor role in explaining fluctuations in the nominal devaluation rate. In other words, since 1991 economic fundamentals (or real shocks) are responsible for all movement in the real depreciation rate and for most of the movements in the nominal depreciation rate.*

Table 1
Percent of Forecast Error Variance
due to nominal shocks

Horizon (Months)	**Sample 1**		**Sample 2**	
H	Δ LITCR	Δ LTCN	Δ LITCR	Δ LTCN
2	76.300	7.643	0.0207	31.667
7	63.098	13.018	0.0225	31.641
13	62.022	13.390	0.0225	31.641
19	61.962	13.410	0.0225	31.641
25	61.959	13.411	0.0225	31.641

6. CONCLUSIONS

This paper contributes to academic and political debate in providing rigorous empirical results regarding the Colombian exchange rate behavior in the short and long run. Specifically, we identified and estimated a SVAR model in the real and nominal exchange rates through the Blanchard and Quah decomposition. This enables us to provide results regarding the magnitude and length of nominal and real shock effects in the real and nominal exchange rate.

In order to account for the structural break in the exchange rate regime that took place in Colombia, two periods of analysis were considered separately : 1980-1991 which is the crawling peg period and 1991-1997 which are the target zone years. Such break is particularly relevant for the analysis because it marked the beginning of a period of relative flexibility and higher volatility in the forex market.

As expected, the results for both subsamples are qualitatively similar but differ in magnitude. *Under both regimes only real or fundamental shocks have permanent effects on both the nominal and the real exchange rate. Under the crawling peg system exchange rates converge to their new long-run level after a year and a half approximately. With the crawling band or target zone regime, convergence is achieved after four to five months.*

During both periods nominal shocks have had only transitory effects on the real exchange rate. During the crawling peg years monetary neutrality is effective only after one year and six months approximately. Under the target zone system, however, the effects of nominal shocks on the real exchange rate are small, die out completely in five months and, furthermore, after the third month practically all of the shock has faded away.

One can conjecture on different explanations to the faster convergence of the real exchange rate (after a nominal shock) during the target zone regime when compared with its speed of convergence during the crawling peg years (4/5 months vs 18 months). A satisfactory explanation relies on the structural break in the exchange rate regime and economic reform that took place in 1991. In fact, in 1991 a crawling band or target zone system was implemented and the period of mini devaluations or crawling peg was left behind. The new regime gave more flexibility to the nominal exchange rate.

Additionally, in 1991 economic reform allowed for more capital mobility across national borders. Colombia, as many others of the so called emerging markets, experienced enormous capital inflows depicted in the evolution of the private external debt, the capital and the current account.

More capital mobility, a greater volume of capital movements, and a more flexible exchange rate regime permitted a more easy and agile validation of agents' expectations in the forex market. That is, the exchange rate market behavior began to reflect exchange rate expectations more clearly. Indeed, expectations of appreciation due to capital inflows and other fundamental forces moving the equilibrium real exchange rate dominated the market at least until mid 1997.

In consequence, any nominal shock on the real exchange rate during the period 1991-1997 was soon overweighted by real appreciation expectations which guided the real exchange rate back to its equilibrium path. Clearly enough, nominal shocks on the real exchange rate lost strength and duration after 1991.

As well, our results do not mean that under a crawling peg system a lengthier targeting of the real exchange rate is easier than under the crawling band structure. This issue corresponds to other type of studies. Recall that the nominal devaluation of 1984-

1985[7] generated real devaluation until 1989 because the observed nominal exchange rate was overvalued. This fact could have influenced our results for subsample 1.

This paper aims in the same direction of recent evidence suggesting that the Colombian economy is more classical than how it is commonly perceived by policymakers. Thus, our results are useful to policymakers in giving them a scope of the tradeoff that exists between real exchange rate targeting and inflation.

A shift of the real exchange rate's equilibrium path with nominal devaluation seems to be an illusion. Only economic fundamentals are capable of doing so. All adjustment must come from fundamentals. There seems to be no space for monetary policy to adjust what is viewed as an overvaluation.

Current characteristics of the Colombian economy imply that the benefits of short sighted real exchange rate targeting are paid with high inflation. The benefits of such policies die out soon enough (three-five months) for them to be worthwile at the expense of price stability.

[7] Which was complemented with fiscal adjustment.

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APPENDIX 1 : DATA

Table 1
Unit Root Tests

Variables	Dickey-Fuller Test			KPSS** Test	
	Statistic	Critical Values (α=10%)	Ljung-Box* over residuals	Statistic	Critical Values (α=10%)
Sample 1 : January 1981 - December 1990					
Ln (TCN)	τ_τ=-2.384	-3.15	28.38 (0.49)	η_τ=0.1375	0.119
Δ ln(TCN)	τ_μ=-3.510	-2.58	27.54 (0.54)	η_μ=0.2737	0.347
LITCR	τ_τ=-2.911	-3.15	30.05 (0.41)	η_τ=0.297	0.119
Δ ln(ITCR)	τ =-4.079	-1.61	35.08 (0.20)	η_μ=0.2233	0.347
Sample 2 : January 1991 - August 1997					
Ln (TCN)	τ_τ=-2.947	-3.16	26.35 (0.16)	η_τ=0.0751	0.119
Δ ln(TCN)	τ_μ=-7.003	-2.59	25.32 (0.19)	η_μ=0.066	0.347
LITCR	τ_τ=-3.151	-3.16	22.30 (0.32)	η_τ=0.2284	0.119
Δ ln(ITCR)	τ =-6.782	-1.61	17.78 (0.60)	η_μ=0.1791	0.347

* Estimation of the statistic based on T/4 lags for the autocorrelation coefficients. In parenthesis we report its p-value.

** In the estimation of Barlett's window L8 is used.

It's important to note that for sample 2 and for variable LTCN, DF test shows a unit root whereas KPSS test reveals stationarity. In this exercise we considered this variable as I(1).

Table 2

Information Criteria for Cointegration System : {LITCR - LTCN}

	Sample 1			Sample 2		
	Akaike	Schwarz	Hannan-Quinn	Akaike	Schwarz	Hannan-Quinn
1	-19.229	-19.130	-19.189	-18.016	-17.885	-17.964
2	-20.748	-20.549	-20.667	-18.072	-17.811	-17.969
3	-20.758	-20.460	-20.637	-17.997	-17.605	-17.842
4	-20.736	-20.338	-20.575	-17.931	-17.409	-17.724
5	-20.709	-20.212	-20.507	-17.891	-17.238	-17.633
6	-20.711	-20.115	-20.469	-17.863	-17.080	-17.553
7	-20.645	-19.950	-20.363	-17.886	-16.972	-17.524
8	-20.596	-19.801	-20.273	-17.912	-16.868	-17.499
9	-20.561	-19.666	-20.198	-17.878	-16.703	-17.412
10	-20.527	-19.534	-20.125	-18.029	-16.723	-17.511
11	-20.512	-19.419	-20.069	-18.232	-16.796	-17.663
12	-20.522	-19.331	-20.039	-18.380	-16.813	-17.759

For sample 1 AIC selects P = 3 while SBC and H-Q select P = 2. For sample 2 AIC selects P = 12 (we reject it due to sample size), SBC selects P = 1 and H-Q selects P = 2. Thus, results are complemented with the Portmanteau test for autocorrelation in the residuals and with a multivariate normality test also in the residuals.

Table 2
Multivariate Test Results :
White Noise and Normality in Residuals
System : {Δ LITCR - Δ LTCN}

	White Noise	Normality		
P	Adjusted Portmanteau	Skewness	Kurtosis	Joint
	$\overline{P}_h$ $\chi^2\left(k^2\left(h-p\right)\right)$	$\hat{\lambda}_1$ $\chi^2(k)$	$\hat{\lambda}_2$ $\chi^2(k)$	$\hat{\lambda}_3$ $\chi^2(2k)$
Sample 1				
1	54.33 (0.136)	16.65 (0.000)	56.26 (0.000)	72.91 (0.00)
2	46.81 (0.213)	11.65 (0.003)	10.70 (0.005)	22.35 (0.000)
Sample 2				
1	55.77 (0.109)	0.822 (0.662)	5.78 (0.06)	6.61 (0.157)

In parenthesis the p-value associated with each test is reported.

For subsample 1 the VAR order is set on P = 2 and residuals follow a multivariate white noise process (no normality) at a $\alpha = 5\%$ significance level. For subsample 2 optimal lag length is set on P = 1 and at a $\alpha = 5\%$ significance level a multivariate normal white noise process is observed in the residuals.

Table 3
Results of multivariate tests :
White Noise and Normality in residuals of Cointegration.
System : {LITCR - LTCN}

	White Noise	Normality		
P	Adjusted Portmanteau	Skewness	Kurtosis	Joint
	$\overline{P}_h$ $\chi^2\left(k^2\left(h-p\right)\right)$	$\hat{\lambda}_1$ $\chi^2(k)$	$\hat{\lambda}_2$ $\chi^2(k)$	$\hat{\lambda}_3$ $\chi^2(2k)$
Sample 1				
2	53.01 (0.081)	22.54 (0.000)	42.76 (0.000)	65.30 (0.000)
3	46.55 (0.1118)	14.89 (0.000)	8.477 (0.014)	23.34 (0.000)
Sample 2				
1	65.97 (0.017)	1.409 (0.494)	6.765 (0.033)	8.175 (0.085)
2	53.29 (0.077)	0.711 (0.700)	6.464 (0.039)	7.175 (0.126)

In parenthesis the p-value associated with each test is reported.

For subsample 1 the VAR order is set on P = 3 since there's no autocorrelation at a $\alpha = 5\%$ significance level. Nonetheless, residuals don't exhibit a normal multivariate process. For subsample 2 optimal lag length is set on P = 2 because at a $\alpha = 5\%$ significance level a multivariate normal white noise process is observed in the residuals.

Table 4
Johansen's Cointegration Test
System : {LITCR - LTCN}

		Model with deterministic linear trend in variables		Model with deterministic linear trend in variables and in the cointegrating vector	
Sample 1					
H_o	**H_a**	Trace Statistic	Critical value $\alpha = 10\%$	Trace Statistic	Critical value $\alpha = 10\%$
$r = 0$	$r \geq 1$	6.56	13.31	19.40	22.95
$r = 1$	$r = 2$	0.20	2.71	5.96	10.56
Sample 2					
H_o	**H_a**	Trace Statistic	Critical value $\alpha = 10\%$	Trace Statistic	Critical value $\alpha = 10\%$
$r = 0$	$r \geq 1$	8.90	13.31	19.57	22.95
$r = 1$	$r = 2$	0.64	2.71	7.88	10.56

Under both deterministic component modeling schemes and for both subsamples the variables of the system are not cointegrated at a $\alpha = 10\%$ significance level.

APPENDIX 2 : The Structural VAR and the Blanchard and Quah (1989) decomposition.

Let

$$X_t = \begin{bmatrix} \Delta r_t \\ \Delta e_t \end{bmatrix}, \quad E_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}, \quad V_t = \begin{bmatrix} \upsilon_{1t} \\ \upsilon_{2t} \end{bmatrix}$$

Our standard VAR is

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \quad \dots \quad + A_p X_{t-p} + V_t \tag{1}$$

Each A_i (i = 1, ... , p) is a 2 x 2 matrix of standard VAR coefficients. In more compact form, system (1) is :

$$\begin{bmatrix} \Delta r_t \\ \Delta e_t \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} \Delta r_{t-1} \\ \Delta e_{t-1} \end{bmatrix} + \begin{bmatrix} \upsilon_{1t} \\ \upsilon_{2t} \end{bmatrix}$$

where ν_{1t} and ν_{2t} are contemporaneously correlated white noise processes. $A_{ij}(L)$ are polynomials in the lag operator L (i,j = 1,2). Let the variance-covariance matrix of this system be Σ_v .

Estimation of the standard VAR and Σ_v is via OLS. OLS estimators are consistent and asymptotically efficient [see Enders (1995), Ch 5, part 6]. Eventhough there´s a contemporaneous correlation between ν_{1t} and ν_{2t} , SUR estimation doesn't improve the efficiency of estimation because both regressions in the system have identical variables on the right hand side.

Since it's a stationary system, the standard VAR has an infinite bivariate moving average representation due to Wold´s decomposition theorem :

$$X_t = \Phi_0 V_t + \Phi_1 V_{t-1} + \Phi_2 V_{t-2} + \quad \dots \tag{2}$$

where $\Phi_0 = I_2$.

Contemporaneous relationships between the variables in the system are modeled through the VAR in its structural or primitive form. The SVAR has an associated infinite VMA representation in terms of pure shocks [see Enders (1995), Ch. 5, part 4] :

$$X_t = C_0 E_t + C_1 E_{t-1} + C_2 E_{t-2} + \quad \dots \tag{3}$$

In more compact form system (2) is :

$$\begin{bmatrix} \Delta r_t \\ \Delta e_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

where ε_{1t} and ε_{2t} represent nominal and real exogenous shocks respectively. We assume they are independent white noise disturbances. $C_{ij}(L)$ are polynomials in the lag operator L. After proper normalization of shocks so that $var(\varepsilon_{1t}) = var(\varepsilon_{2t}) = 1$, the variance-covariance matrix of structural innovations is :

$$\Sigma_\varepsilon = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = I_2$$

In equations, the pure bivariate moving average representation of the $\{\Delta r_t\}$ and $\{\Delta e_t\}$ sequences is :

$$\Delta r_t = \sum_{k=0}^{\infty} c_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{\infty} c_{12}(k)\varepsilon_{2t-k} \quad (4)$$

$$\Delta e_t = \sum_{k=0}^{\infty} c_{21}(k)\varepsilon_{1t-k} + \sum_{k=0}^{\infty} c_{22}(k)\varepsilon_{2t-k} \quad (5)$$

From (2) and (3) :

$$X_t = \Phi(L)V_t = C(L)E_t$$

where $\Phi(L)$ and $C(L)$ are 2 x 2 matrices whose components are polynomials in the lag operator L. Assuming $C_0 = C(0)$ is nonsingular, the following holds :

$$\Phi(L)V_t = C(L)C_0^{-1}C_0E_t$$

Thus :

$$\Phi(L) = C(L)C_0^{-1} \quad (6)$$

and

$$V_t = C_0E_t \quad (7)$$

Estimation of $\Phi(L)$ is possible from the standard VAR. Hence, identification of C_0 and equation (6) allow us the recovery of the $C(L)$ matrix which, in turn, defines the impulse - response functions. As well, from (7) it can be seen that standard VAR errors $[v_{1t}\ v_{2t}]$ are linear combinations of structural innovations $[\varepsilon_{1t}\ \varepsilon_{2t}]$. This we can represent in the following equations :

$$v_{1t} = c_{11}(0)\varepsilon_{1t} + c_{12}(0)\varepsilon_{2t} \tag{8}$$

$$v_{2t} = c_{21}(0)\varepsilon_{1t} + c_{22}(0)\varepsilon_{2t} \tag{9}$$

Recalling that ε_{1t} and ε_{2t} are independent white noise disturbances, from (8) and (9) the upcoming equations are easily obtained :

$$Var(v_{1t}) = c_{11}^{\ 2}(0) + c_{12}^{\ 2}(0) \tag{10}$$

$$Var(v_{2t}) = c_{21}^{\ 2}(0) + c_{22}^{\ 2}(0) \tag{11}$$

$$Cov(v_{1t}, v_{2t}) = c_{11}(0)c_{21}(0) + c_{12}(0)c_{22}(0) \tag{12}$$

Due to the fact that the elements in the Σ_v matrix are obtained from estimation of the standard VAR, (10), (11) and (12) constitute a three equational system with four unknown variables : $c_{11}(0)$, $c_{12}(0)$, $c_{21}(0)$, $c_{22}(0)$. Clearly enough a proper identifying restriction is required.

The next step is to formulate such a restriction. However, this requires some algebraic manipulation. Note that (1) can also be expressed as :

$$X_t = A(L)X_{t-1} + V_t$$

A(L) is a 2 x 2 matrix whose components are polynomials in the lag operator L. This last equation is equivalent to :

$$X_t = A(L)LX_t + V_t$$

Then :

$$\left[I_2 - A(L)L\right]X_t = V_t$$

or :

$$X_t = \left[I_2 - A(L)L\right]^{-1}V_t \tag{13}$$

As in Enders (1995), denote the determinant of matrix $[I_2\text{-}A(L)L]$ by D. Consequently (13) is :

$$\begin{bmatrix} \Delta r_t \\ \Delta e_t \end{bmatrix} = \frac{1}{D}\begin{bmatrix} 1 - A_{22}(L)L & A_{12}(L)L \\ A_{21}(L)L & 1 - A_{11}(L)L \end{bmatrix}\begin{bmatrix} \upsilon_{1t} \\ \upsilon_{2t} \end{bmatrix}$$

Denoting the coefficients of the $A_{ij}(L)$ polynomial as $a_{ij}(k)$ the preceding system can be rewritten as :

$$\begin{bmatrix} \Delta r_t \\ \Delta e_t \end{bmatrix} = \frac{1}{D}\begin{bmatrix} 1 - \sum_{k=0}^{\infty} a_{22}(k)L^{k+1} & \sum_{k=0}^{\infty} a_{12}(k)L^{k+1} \\ \sum_{k=0}^{\infty} a_{21}(k)L^{k+1} & 1 - \sum_{k=0}^{\infty} a_{11}(k)L^{k+1} \end{bmatrix}\begin{bmatrix} \upsilon_{1t} \\ \upsilon_{2t} \end{bmatrix}$$

Then the following holds :

$$\Delta r_t = \frac{1}{D}\left\{\left[1 - \sum_{k=0}^{\infty} a_{22}(k)L^{k+1}\right]\upsilon_{1t} + \left[\sum_{k=0}^{\infty} a_{12}(k)L^{k+1}\right]\upsilon_{2t}\right\}$$

Using (8) and (9) to substitute for v_{1t} v_{2t} we obtain :

$$\Delta r_t = \frac{1}{D}\left\{\begin{array}{l} \left[1 - \sum_{k=0}^{\infty} a_{22}(k)L^{k+1}\right]\left[c_{11}(0)\varepsilon_{1t} + c_{12}(0)\varepsilon_{2t}\right] \quad + \\ \qquad \left[\sum_{k=0}^{\infty} a_{12}(k)L^{k+1}\right]\left[c_{21}(0)\varepsilon_{1t} + c_{22}(0)\varepsilon_{2t}\right] \end{array}\right\}$$

Rearranging terms :

$$\Delta r_t = \frac{1}{D}\left\{\left[1 - \sum_{k=0}^{\infty} a_{22}(k)L^{k+1}\right]c_{11}(0) + \left[\sum_{k=0}^{\infty} a_{12}(k)L^{k+1}\right]c_{21}(0)\right\}\varepsilon_{1t} \quad +$$
$$\frac{1}{D}\left\{\left[1 - \sum_{k=0}^{\infty} a_{22}(k)L^{k+1}\right]c_{12}(0) + \left[\sum_{k=0}^{\infty} a_{12}(k)L^{k+1}\right]c_{22}(0)\right\}\varepsilon_{2t}$$

(14)

To construct an identifying restriction Blanchard and Quah (1989) suggest imposition of long run monetary neutrality on the system. From (4) this implies :

$$\sum_{k=0}^{\infty} c_{11}(k)\varepsilon_{1t-k} = 0 \tag{15}$$

In other words, nominal exogenous shocks have no long run effect on the real exchange rate. Using equation (14), nominal primitive shocks will have no long run effect on the real exchange rate if:

$$\left[1-\sum_{k=0}^{\infty} a_{22}(k)L^{k+1}\right]c_{11}(0)+\left[\sum_{k=0}^{\infty} a_{12}(k)L^{k+1}\right]c_{21}(0)=0 \tag{16}$$

Equations (10), (11), (12) and (16) make up a system of four equations and four unknown variables : $c_{11}(0)$, $c_{12}(0)$, $c_{21}(0)$, $c_{22}(0)$. The system is identified and permits us identification of matrix C_0. As mentioned in a previous paragraph, knowing matrix C_0 makes possible the recovery of matrix $C(L)$ which, in turn, determines the impulse - response functions that we need for a proper innovation accounting analysis.

Note, however, that system (10), (11), (12) and (16) is non linear. This means that C_0 will have four possible solutions. We adhere to that solution that is economically feasible according to impulse - response analysis.

APPENDIX 3 : RESULTS

Table 1
Information Criteria for the Standard VAR
System : {Δ LITCR - Δ LTCN}

	Sample 1			Sample 2		
	Akaike	Schwarz	Hannan-Quinn	Akaike	Schwarz	Hannan-Quinn
1	-20.7316	-20.6317	-20.6911	-18.1029	-17.9712	-18.0508
2	-20.7738	-20.5740	-20.6928	-18.0317	-17.7684	-17.9275
3	-20.7381	-20.4384	-20.6166	-17.9479	-17.5531	-17.7917
4	-20.7157	-20.3160	-20.5537	-17.9225	-17.3961	-17.7142
5	-20.7072	-20.2076	-20.5047	-17.8671	-17.2089	-17.6066
6	-20.6472	-20.0476	-20.4041	-17.9006	-17.1108	-17.5881
7	-20.5973	-19.8979	-20.3138	-17.9181	-16.5996	-17.5535
8	-20.5583	-19.7589	-20.2342	-17.8883	-16.8353	-17.4716
9	-20.5219	-19.6226	-20.1574	-17.9065	-16.7219	-17.4377
10	-20.5082	-19.5090	-20.1031	-17.8938	-16.5776	-17.3730
11	-20.4908	-19.3917	-20.0452	-17.9987	-16.5508	-17.4257
12	-20.4412	-19.2422	-19.9552	-17.9630	-16.3835	-17.3380

For sample 1 AIC and H-Q select P = 2 while SBC selects P = 1. For sample 2 all three criteria select P = 1.