REAL EXCHANGE RATE FLUCTUATIONS IN LATIN AMERICAN COUNTRIES

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Abstract - *The objective of this paper is to find the sources of fluctuations of the real exchange rate for Brazil, Chile, Colombia and Mexico. In the unrestricted VAR models as in the structural VAR models with sample data from January 1994 to August 2001 of the series real exchange rate, nominal exchange rate and interest rates, I found evidence that supports the hypothesis that the sources of fluctuations of the real exchange rate does not depend upon nominal factors.*

Keywords: *real exchange rate, nominal exchange rate, interest rate, structural VAR*

JEL Classification: E00

Introduction

Real exchange rate and nominal exchange rate are key variables in an open economy. Now that floating exchange rate regimes are established in 42% of the International Monetary Fund countries and 34% of them have a quasi floating exchange rate regimes (Fischer, 2001), the study of the sources of fluctuations in exchange rates has become more important. It is of substantial importance in countries that have experimented and gone through significant changes in their economic policy in the last decade, like Latin American countries.

It is important to identify the sources of real exchange rate fluctuations not only to validate theories like Purchasing Power Parity (PPP), but to effectively manage the instruments of economic policy. Furthermore, measuring the relative importance of permanent and transitory shocks in the real exchange rate is essential to model exchange rates. If exchange rates are mostly explained by real shocks, then the equilibrium approach of Stockman (1987) would be appropriate for analyzing their behavior. But if evidence suggests the contrary, the disequilibrium approach of Dornbusch (1976) should be considered as the alternative.

This research document analyzes the effects of nominal exchange rate and interest rate innovations in the real exchange rates of four Latin American

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economies: Brazil, Chile, Colombia and Mexico; it also aims to differentiate between real shocks, those which have permanent effects in the real exchange rate, and nominal shocks, those with merely transitory effects in nominal exchange rate. Lastrapes (1992) analyzed the relative importance and the dynamic effects of real and nominal shocks in exchange rates of five developed countries. He found conclusive evidence that demonstrates that innovations in real factors are more important than nominal factor innovations.

The objective of this work is to empirically demonstrate that the real exchange rate does not depend on nominal factors (e.g. nominal exchange rate, interest rate, monetary supply) and possibly it does depend of real factors (e.g., technology improvement, economic growth, productivity). The methodology used for analyzing the dynamics of exchange rates varies from regression models of ordinary least squares to non structural models like vector autoregressors. A derivation of this last technique proposed by Sims in 1980 was adopted to estimate the models in this paper. After Sims was criticized for proposing non-structural models (where the identification scheme is not justified) for analyzing economic variables, new models with structural restrictions were proposed. In the search for new identification schemes Blanchard and Quah (1989), Shapiro and Watson (1988), King et al (1992) and Gali (1992) imposed restriction with long run properties in the system, usually based in the neutrality postulate.

In this study, this neutrality postulate is used in a bivariate system of autoreggresive vectors where real exchange rate is modeled as a function of itself and other variable like interest rate or nominal exchange rate and the restriction that nominal shocks does not affect the level of real exchange rate is imposed. "This restriction is sensible given that the real exchange rate is a relative price (between domestic and foreign goods), and is consistent with disequilibrium and equilibrium models of exchange rate behavior." (Lastrapes, 1992).

Meese and Rogoff (1988) formulated a monetary model expressed in real terms that explains real exchange rates. Their model is based on three basic postulates: when a temporary shock occurs, it is expected that the real exchange rate returns to its long run equilibrium at a constant rate; it is also expected that the real exchange rate is a random process in the long run (non stationary); and finally real exchange rate should take a value such that the not covered interest parity in real terms is verified. Combining these three assumptions, the real exchange rate depends upon the real interest rate differential and on the equilibrium exchange rate with flexible prices. This approach permits to appreciate the effects in the real exchange rate and the relative importance of real innovations (observed in the real exchange rate) when compared with monetary disturbances, represented by real interest rate differentials. If both explicative variables are not stationary, their effects over the real exchange rate would be permanent, but if one of them is stationary, its effects would be merely transitory.

Pointing out in advance, it is expected that the real exchange rate fluctuations are independent of nominal exchange rate fluctuations, but not vice versa. Furthermore, interest rates fluctuations should not be a significant factor explaining real exchange rate because interest rates are a nominal factor.

The rest of the paper is organized as follows: Section 2 presents the empirical model and the variables used in the structural VAR, Section 3 describes the main results obtained and finally, the principal conclusions and economic policy implications are summarized in the last section.

Empirical model and data

In order to analyze the dynamics between real exchange rates and nominal shocks a bivariate VAR was estimated imposing the restriction that nominal shocks have not a permanent effect in the real exchange rate. This restriction means that if the model is expressed as a function of its own innovations (moving average form) the polynomial matrix that multiplies the errors (innovations) will be inferior triangular, thus the nominal shocks wont have any effect over the real exchange rate. The formal derivation of the model can be found in Lastrapes (1992). I follow the same methodology that Lastrapes (1992) but additional to the real-nominal exchange rate models, models for real exchange rates and interest rates were also constructed. Two models were estimated for each country, the first one using real and nominal exchange rates (RER-NER models) and the second one using real exchange rate and interest rates (RER-IR models). From each model, the impulse response functions and the variance decomposition of real exchange rate were obtained. Impulse response functions track the effect of one standard deviation shock in the innovations of the endogenous variables and variance decomposition present information about the relative importance of each shock in every variable in the VAR system.

The group of analyzed variables was composed of: nominal exchange rate (domestic currency per US dollar) for Brazil, Chile, Colombia and Mexico; consumer price index (CPI) for each of the mentioned countries and the CPI of the United States; and the nominal interest rate of the shortest possible term. The time span is 90 months before October 10 of 2001. The model for Colombia used the interest rate of three months maturity commercial paper; the model for Mexico used 28 days CETE (Treasury Certificate) interest rate; the model for Brazil used one-month interest rate of the money market; and the model for Chile used the banks lending rate of 90 days. All interest rates are annualized or were annualized if they were not available in this form. In the case a country had various indexes for inflation, the more general index measure was chosen with the restriction it should also had 90 months of history. The real exchange rate was calculated with the bilateral exchange rate and the price indexes. The formula used for computing the real exchange rate (RER) is: (1) $RER = ln(NER)+ln(P_{us})-ln(P_{\mathrm{n}})$, where ln represents natural logarithm, NER is the nominal exchange rate, P_{us} is the consumer price index of the United States, and P_n is the domestic price index of country n. In Figure 1 it can be observed the graphs for all the series for Mexico, Colombia and Brazil. The data source of all the time series is Datastream, a service of Thomson Financial.

VAR models require time series to be stationary; therefore Dickey Fuller and augmented Dickey Fuller unit root test were applied using the method proposed by Perron (1995). Approximately two thirds of the time series in this study does not present a unit root in levels and all the series are stationary in first differences. It was not necessary to seasonal differentiate the time series to make them stationary. Because there were only 94 monthly observations for each series and the sample is small, the confidence grade of the unit root test is not very high.

Therefore, bivariate VAR in levels were also estimated. All time series are monthly and cover the period of January 1994 to August 2001. Only the model for Brazil starts in July 1994. The lag number for the VAR was chosen by the Akaike and Schwarz criteria and the correlograms of the series. Each model and test indicated a different number of lags, but just for convenience and homogeneity, all models were estimated with seven lags.

Results

Time series of real exchange rate, nominal exchange rate and interest rates of Mexico, Colombia and Brazil are shown in Figure 1. Before starting the analyzing models' results, it is important to note that the nominal exchange rate of Colombia and Brazil tracks the movements of their real exchange rate, but shows very different fluctuations to those of the nominal interest rate. The same happens in Chile. In Mexico, the real exchange rate follows a very similar pattern to that of the interest rate meanwhile it looks completely different to the nominal exchange rate. This graphic evidence suggests that relative prices could be very important in determining the nominal exchange rate in Brazil, Chile and Colombia.

The first evidence that the real exchange rate does not depend to the nominal shocks is in Figure 2. This figure reports the impulse response functions (IRF) of a unrestricted VAR model for the variables in levels. Each graph shows the dynamic response of a one standard deviation impulse in the innovations for a period of 24 months; the responses are to a nominal or real shock. Confidence intervals are also graphed and they were calculated using the sample standard deviation of the empirical distribution estimated from a 1000 iteration Montecarlo simulation.

In the first panel it can be observed that the response of the Brazilian exchange rate to a nominal shock is not significant for all the forecasted period. Meanwhile the response of the nominal exchange rate to a real shock is of 0.7% and it is almost constant for all the forecasted period but it becomes not significant from the 17^{th} to the 24^{th} month, which represents a very long interval of time being significant. In the second panel the IRF for the Mexican model are graphed. The response of the NER to a real shock is 0.3% approximately, greater than in the Brazilian case, and the impulses stabilizes around 0.1%, but the response of the RER to the nominal shock is not significant in all the forecasted horizon. In the third panel the IRF for Chile are graphed. The response of the NER to a real shock is even greater than in the former cases and it reaches 10% and continue growing up to 20% at the end of the forecasted period. The IRF of the RER to a nominal shock continues to be pretty similar to the former cases.

IRF's for the same models but imposing a structural decomposition in the VAR's using first order differences in the series are shown in Figure 3. As it can be observed, the restriction of the structural VAR takes off the permanent effect of the NER to the real shock, but the size and direction of the responses are very similar to those coming from the unrestricted VAR. RER continues to be independent from the nominal shocks. IRF for Chile are not in the Figure but they are very similar to the cases of the countries shown.

Structural VAR variance decomposition for the RER in levels up to 24 forecasted months is reported in Table 1. Variance decomposition measures the average relative contribution of each shock in a specific time horizon. The maximum horizon reported has a length of 24 months. The structural restriction constrains the analysis to the short run because this kind of restriction forces the real shocks to explain 100% of the variance in RER in an infinite time horizon. Lastrapes (1992) also explains that the main interest is in analyzing the explicative power of the RER in the short run. In Table 1 there are reported two types of models: the first type is a bivariate structural VAR for RER and NER (RER-NER models) and the second type of model is a bivariate structural VAR for RER and interest rate (IR), for convenience named RER-IR models. The second types of models include interest rates instead of NER as a nominal factor. If RER does not respond to nominal shocks it is expected that the variance of RER explained by the nominal variable should be small as in the first types of models.

In the model for Mexico, the real shock (in model 1) explains 92.42% of the variance in a 24 months horizon; meanwhile the nominal shock explains 7.58% in the same time horizon. The decomposition of variance in the model of interest rates and RER for Mexico is very similar to the variance decomposition of the model of NER and RER, the real shock explains 97.74% of the RER's variance and the nominal shock explains only 2.26% in an horizon of 24 months. In both types of models for Brazil the nominal shock explains 11% approximately in the same time horizon. The results for the model of Colombia are very alike to the Mexican results; in the short run, nominal shocks explain more than one fifth of the RER variance, but in the long run they explain between 4% and 6% of the forecasted variance in RER. The atypical case seems to be Chile. In the RER-NER model for Chile, the nominal shock explains 15% in the long run and up to 57% in the short run. In the RER-IR model nominal shocks explain less than 10% short run variance of RER.

Table 2 presents variance decomposition for RER for the structural VAR model in first differences. As it can be seen, the explicative power of the real shocks in the NER is notably lower. In the RER-NER model for Mexico, the nominal shock explains between 37 and 40% of the total RER variation. But in the RER-IR model the results are very similar to the results obtained from the model in levels. The nominal shock, in the RER-IR model, explains only 2.65% of the RER long run variation. In the models for Colombia, the results are similar to the former level models. The nominal shock, in the RER-NER model, explains 10.79% of the total long run variance of RER; but the nominal shock, RER-IR model, explains up to 44% of the variation of RER. For Chile and Brazil, the results are reinforced in the models that include IR, in which the nominal shock raise its relative importance 10%, when compared against the models in Table 1, and they get to explain up to one fifth of the variance in RER. In the RER-NER models for Brazil and Chile, nominal shocks become important and achieve explanatory power of 45% of the variance in RER. In summary, in the table are reported two models per country, and at least from one of them it can be concluded that the nominal shocks explain a maximum 21% of the RER variance.

IRF from the structural VAR models in levels of RER-IR of Mexico and Colombia are reported in Figure 4. In the upper panel it can be observed that the RER does not respond to the innovations of the IR and the IRF is not significant during all the forecast horizon. Meanwhile the interest rate responds with a raise of 4% and up to 6% in the third month when the RER depreciates. From the IRF it can be observed that the nominal shock is absorbed only by the interest rate in the short run, the interest rate response is about 3% to a nominal shock and its IRF becomes statistical not different from cero after the third month of the forecast period. In the second panel the IRFs for the Colombian model are reported. Again, the response of RER to innovation in the IR are not statistical significant during all the time horizon. For the Colombian case it can be concluded that the nominal shocks, in the short run, are absorbed by the interest rate. Colombian interest rate rises more than 1.5% in response to a nominal shock and its impulses are significant until the 11^{th} month in the forecast period. Meanwhile, RER response direction is negative, and it appreciates just as economic theory would indicate, but the confidence interval of the IRF includes cero and therefore the response is not significant, furthermore its response is very small, 0.02% approximately. This last figure serves as evidence that the real exchange rate depends on the real innovations and not on nominal shocks.

Conclusions

In this brief study, vector autoregressive models were used to explain the dynamics of the RER. In almost all the models the evidence indicates that the explicative power of the nominal shocks over the real exchange rate is not greater than the real shocks. The economic policy implications is that when a country faces a raise or a nominal shock in the nominal exchange rate, authorities can expect its effect to be transitory because the real exchange rate is not affected by the nominal shocks. This supposes a return of the nominal exchange rate to its equilibrium in the short run. And this looks to be the case for Brazil, Chile and Colombia, where the nominal exchange rate seems to adjust gradually to the changes in the relative prices and relative prices do not respond greatly to nominal shocks; therefore, a return to the equilibrium should not be expected. But in the Mexican case, nominal exchange rate does not seems, at least visually, to adjust to changes in relative prices and a return to its equilibrium could be expected. The study of returns to equilibrium should be part of future research and is not an essential part of this study. In general, it is possible to show arguments and evidence for Brazil, Chile, Colombia and Mexico that the real exchange rate does not respond to, and it is not mainly explained by, fluctuations in nominal variables.

REFERENCES

Blanchard, O. J., Quah, D., 1989. The Dynamic Effects of Aggregate Demand and Supply
Disturbances. American Economic Review 79, 655--673.

Dornbusch, R., 1976. Expectations and Exchange Rate Dynamics. Journal of Political Economy
84, 1161--1176.

Fischer, S., 2001. Exchange Rate Regimes: Is the Bipolar View Correct?. Journal of Economic
Perspectives 15, 3--24.

Lack, C., Lenz C., 1998. A Program for the Identification of Structural VAR models. Available
online at: http://www.unibas.ch/wwz/mako/svar/ [October 10th, 2001].

Lastrapes, W., 1992. Sources of Fluctuations in Real and Nominal Exchange Rates. Review of
Economics and Statistics 74, 530--9.

Meese, R., Rogoff, K., 1988. Was it Real? The Exchange Rate-Interest Rate Differential
Relation over the Modern Floating-rate Period. Journal of Finance 43, 1029--1035.

Ng, Serena and Pierre Perron (1995) Unit Root Test in ARMA models with Data Dependent
Methods for the Selection of the Truncation Lag, Journal of the American Statistical
Association 90, 268--281.

Shapiro, M., Watson, M., 1988. Sources of Business Cycle Fluctuations, in: Fischer, S. (Ed.),
NBER Macroeconomics Annual. Cambridge: MIT Press.

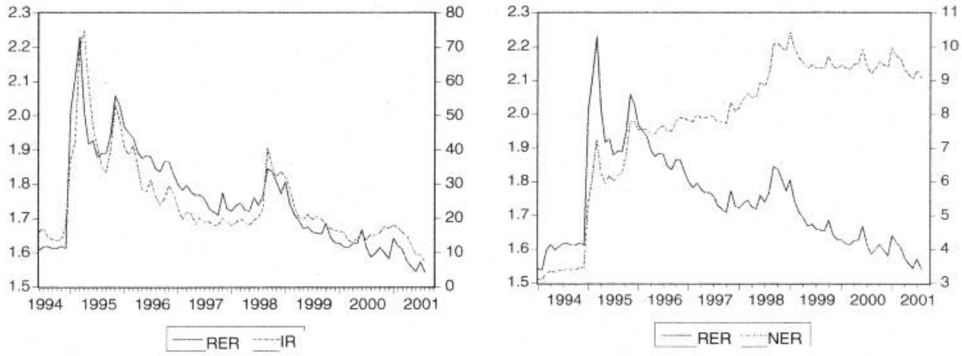
Sims, C., 1980. Macroeconomics and Reality. Econometrica 48, 1--47.

Stockman, A. C., 1987. The Equilibrium Approach to Exchange Rates. Economic Review,
Federal Reserve Bank of Richmond, March-April, 12--30.

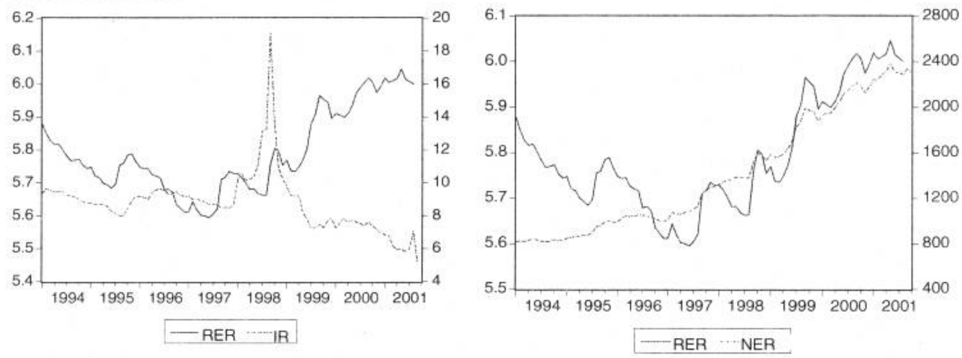
GRAPHS AND TABLES

Figure 1. Real Exchange Rate, Interest Rates and Nominal Exchange Rates are reported below.

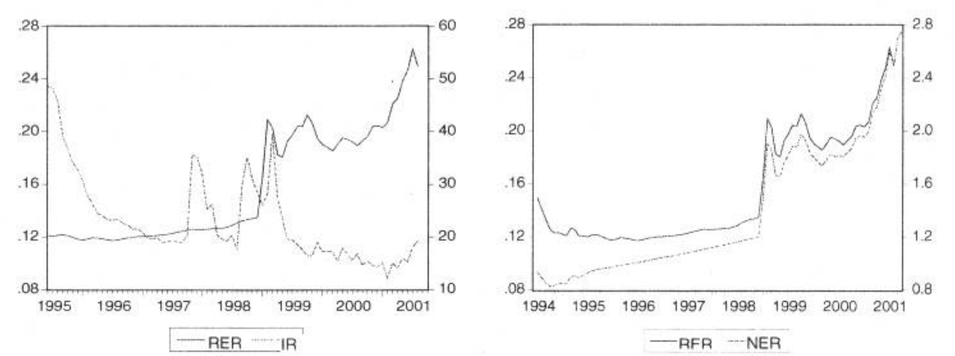
Panel A. Mexico



Panel B. Colombia



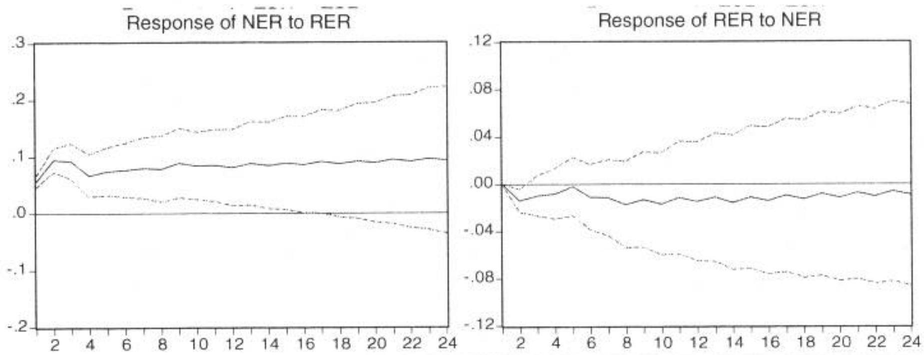
Panel C. Brazil



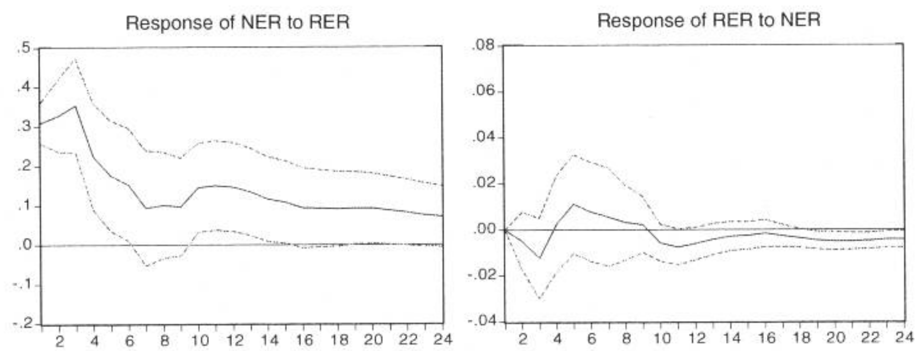
Left axis always represents the natural logarithm of Real Exchange Rate (RER) and the right axis corresponds to the nominal exchange rate (NER) or interest rate (IR). For Colombia and Brazil the nominal exchange rate seems to track the movements in the relative prices, but that does not happen in Mexico.

Figure 2. Unrestricted VAR Impulse Response Functions (IRF)

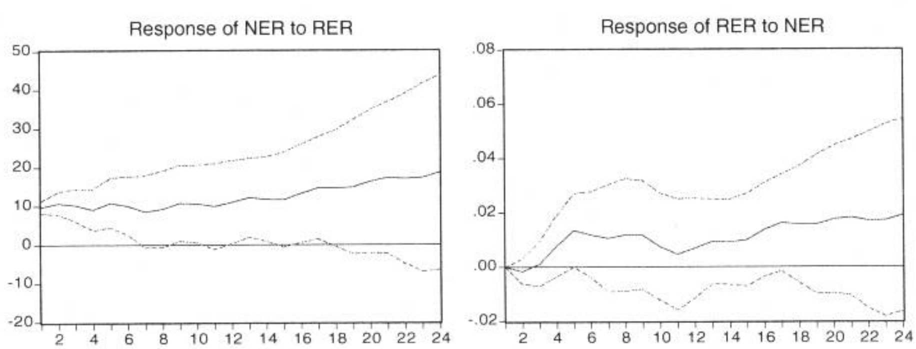
Panel A. Brazil



Panel B. México



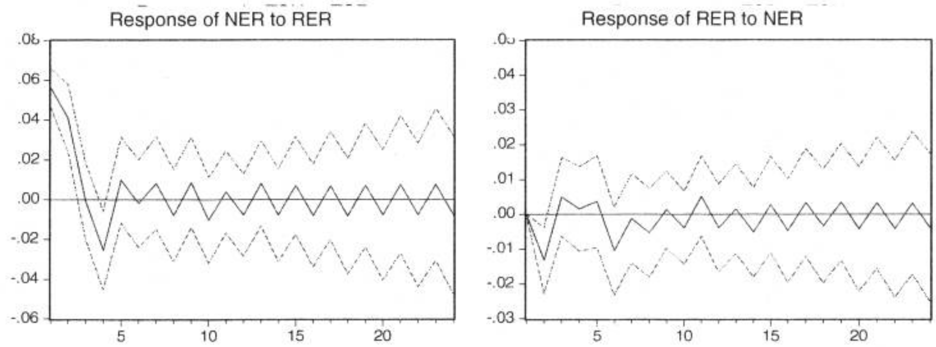
Panel C. Chile



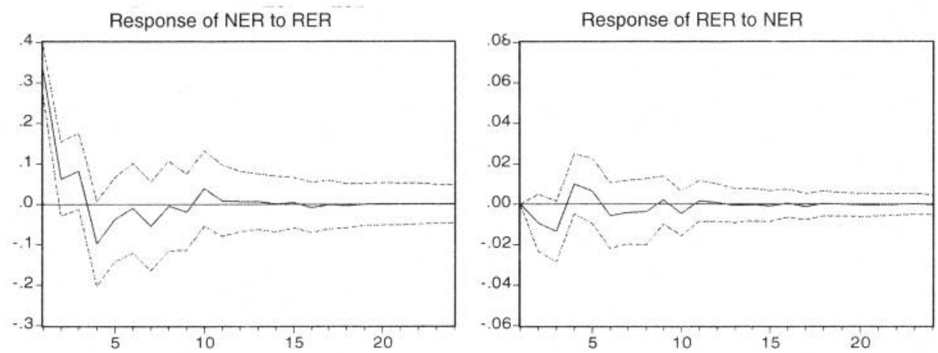
RER refers to real exchange rate, NER refers to nominal exchange rate. All the unrestricted models show evidence that imposing a structural restriction where the real exchange rate (RER) is constrained not to respond to innovations in the nominal exchange rate (NER) seems to be very well supported by the unrestricted VAR models.

Figure 3. Structural VAR Impulse Response Funtions

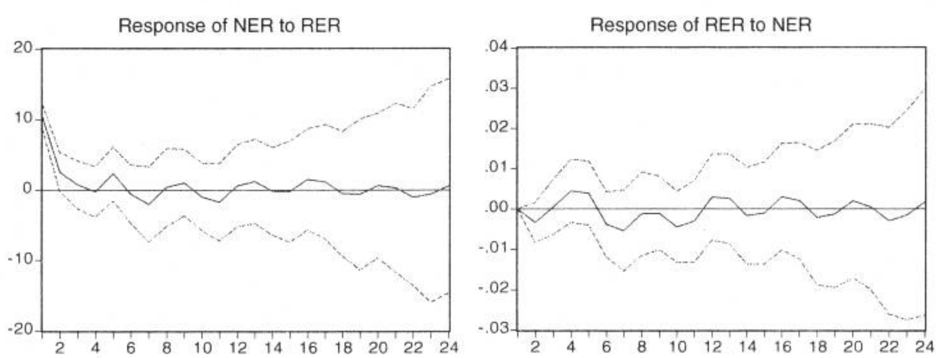
Panel A. Brasil



Panel B. Mexico



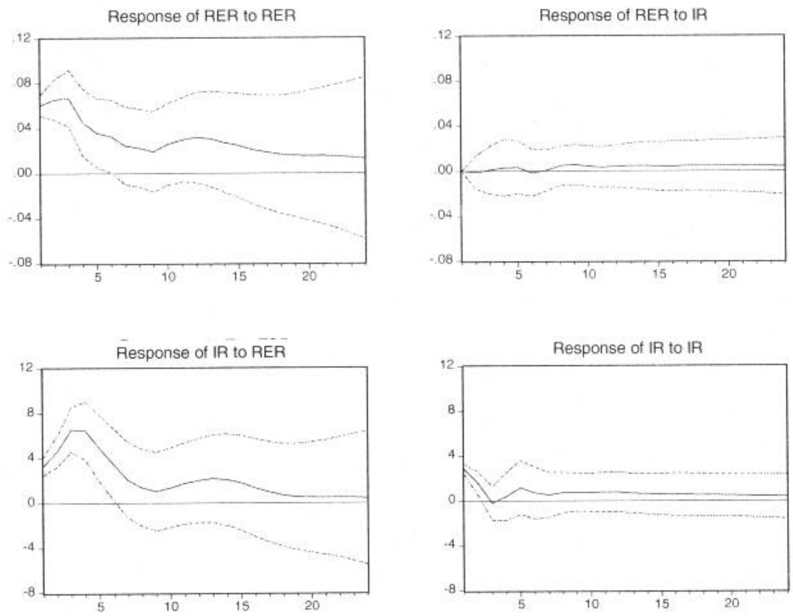
Panel C. Chile



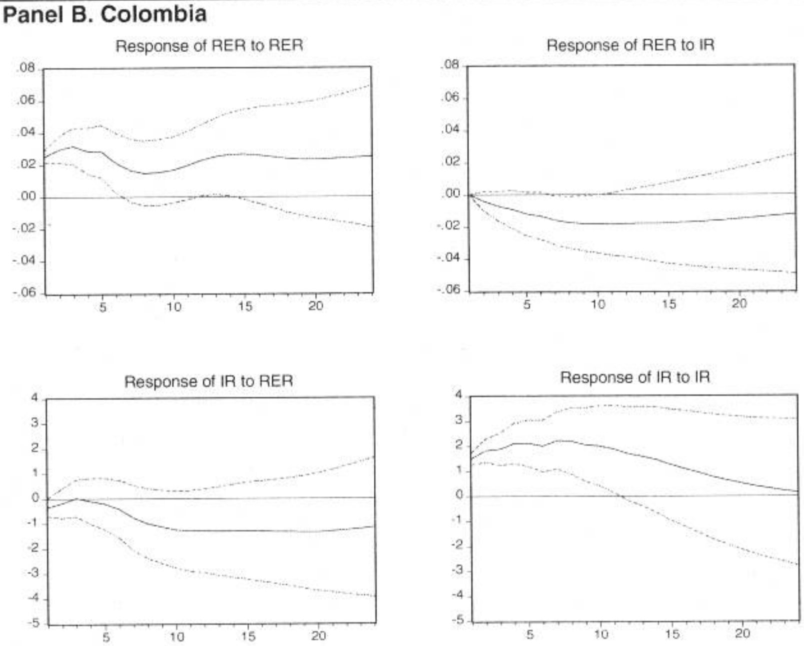
RER refers to real exchange rate, NER refers to nominal exchange rate.The impulse response funtions (IRF) of the structural models show the same pattern than the IRF of the unrestricted VARs but the magnitude of the response is smaller when the restriction is imposed. It is important to note that real shocks are absorved almost completly in the short run and that nominal innovations continue

Figure 4. Impulse Response Functions real exchange rate (RER) and interest rate (IR)

Panel A. México



Panel B. Colombia



RER refers to real exchange rate, NER refers to nominal exchange rate and IR refers to interest rate.The models that include real exchange rate (RER) and interest rate (IR) use the interest rate as the nominal factor instead of using the nominal exchange rate. From the impulse response functions (IRF) reported above it can be noticed that for Colombia the IR responses to RER are not significant meanwhile for Mexico the same responses are sgnificant. Going back to Figure 1 can visually confirm this very different results. RER and IR in Mexico follow a similar pattern meanwhile in Colombia RER and nominal (NER) follow a similar pattern.

Table 1. Variance Decomposition -- Structural VAR in levels

México					Chile				
	RER-NER		RER-IR			RER-NER		RER-IR	
Time	Schock^R	Schok^N	Schock^R	Schok^N	Time	Schock^R	Schok^N	Schock^R	Schok^N
1	100.00	0.00	96.60	3.40	1	42.99	57.01	89.25	10.75
3	97.80	2.20	96.50	3.50	3	42.16	57.84	94.68	5.32
5	96.46	3.54	96.98	3.02	5	62.37	37.63	97.06	2.94
7	95.50	4.50	96.84	3.16	7	70.89	29.11	96.56	3.44
12	94.14	5.86	97.31	2.69	12	75.39	24.61	97.20	2.80
24	92.42	7.58	97.74	2.26	24	84.56	15.44	98.94	1.06
Brazil					**Colombia**				
	RER-NER		RER-IR			RER-NER		RER-IR	
Time	Schock^R	Schok^N	Schock^R	Schok^N	Time	Schock^R	Schok^N	Schock^R	Schok^N
1	99.18	0.82	82.71	17.29	1	100.00	0.00	79.87	20.13
3	91.92	8.08	89.93	10.07	3	99.47	0.53	89.05	10.95
5	92.69	7.31	87.20	12.80	5	96.25	3.75	93.05	6.95
7	91.36	8.64	79.25	20.75	7	95.18	4.82	93.54	6.46
12	87.65	12.35	82.25	17.75	12	94.16	5.84	92.03	7.97
24	88.32	11.68	89.92	10.08	24	93.60	6.40	95.57	4.43

Tabla 2. Variance Decomposition -- Structural VAR in first differences

Mexico					Chile				
	RER-NER		RER-IR			RER-NER		RER-IR	
Time	Schock^R	Schok^N	Schock^R	Schok^N	Time	Schock^R	Schok^N	Schock^R	Schok^N
1	59.23	40.77	99.91	0.09	1	93.08	6.92	85.51	14.49
3	61.94	38.06	99.77	0.23	3	92.67	7.33	86.53	13.47
5	67.39	32.61	99.57	0.43	5	85.80	14.20	83.32	16.68
7	65.69	34.31	98.93	1.07	7	78.38	21.62	80.18	19.82
12	66.00	34.00	97.40	2.60	12	73.34	26.66	79.09	20.91
24	65.99	34.01	97.35	2.65	24	67.20	32.80	78.91	21.09
Brazil					**Colombia**				
	RER-NER		RER-IR			RER-NER		RER-IR	
Time	Schock^R	Schok^N	Schock^R	Schok^N	Time	Schock^R	Schok^N	Schock^R	Schok^N
1	51.21	48.79	97.63	2.37	1	100.00	0.00	59.72	40.28
3	67.72	32.28	94.89	5.11	3	99.33	0.67	61.99	38.01
5	66.34	33.66	84.13	15.87	5	94.92	5.08	61.12	38.88
7	65.07	34.93	79.36	20.64	7	95.12	4.88	57.19	42.81
12	61.24	38.76	78.51	21.49	12	91.81	8.19	56.23	43.77
24	54.55	45.45	78.30	21.70	24	89.21	10.79	55.95	44.05

RER-NER refers to real exchange rate and nominal exchange rate model, RER-IR refers to the model of real exchange rate and interest rate. Schock^R refers to a real shock and Shock^N refers to a nominal shock. This table is supportive evidence that real exchange rate does not respond to nominal shocks. Nominal shocks explain an average of 16.05%, when including in the average all models, countries and periods.