A Model of the Nominal and Real Exchange Rates in Colombia

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July 1999

Abstract

Using the Johansen's cointegration technique we develop an empirical model of the nominal and real exchange rates of Colombia. We find that the nominal exchange rate is determined by the nominal variables and the fundamentals and that the real exchange rate is determined by the fundamentals but neutral to the nominal variables. Changes in the real exchange rates take place through changes in the nominal exchange rate, thus the nominal and the real exchanges are correlated, however, the real exchange rate may not be modified by nominal exchange rate policy because, in the model, the nominal exchange rate is endogenous. We find that in the long run the nominal exchange rate of Colombia behaves as if it were flexible and the nominal anchor were money.

JEL Classification: F31; F41.

Keywords: Exchange rates; Fundamentals; Neutrality.

1 Introduction

The model we present in this paper is intended to capture a tradition in the formulation of exchange rate policy in Colombia. The rate of crawl of the nominal exchange rate (during the crawling peg) or the slope of the crawling band (during the period of a crawling band) is determined as the difference between inflation (or the inflation target) and international inflation, plus changes in the rate of devaluation or realignments of the crawling band when there are changes in the fundamentals.

Part two presents the model of the nominal and real exchange rates. Part three describes the data. Part four presents the estimation results. Part five simulate the behavior of the nominal and real exchange rates in counter factual scenarios for the nominal variables and the fundamentals. Part six compares the nominal exchange rates of Colombia and Australia. Part seven concludes.

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2 The Model

The model is simultaneously a model of the nominal and of the real exchange rates. We take as measure of real exchange rate the Index of Real Exchange Rate 1 (ITCR1) of the Banco de la República because it is the international inflation of this index the one that has had a primary role in the formulation of exchange rate policy in Colombia.

The ITCR1 is an average of real bilateral exchange rates with trade partners:

$$ITCR1 = \Pi_{j=1}^{18} \left(B_{COL}^{j} \right)^{\omega_j} \tag{1}$$

In Eq. (1) $j = 1...18$ are the main trade partners, ω_j is the weight of partner j in the Colombian foreign trade,

$$B_{COL}^{j} = E_{COL}^{j} \frac{P_j}{P_{COL}}$$

is the real bilateral exchange rate of Colombia vis a vis trade partner j, E_{COL}^{J} is the nominal exchange rate of Colombia, e.g. the number of pesos per unit of the country j's currency, and P_{COL} and P_j are the Colombian and the trade partner's price levels measured by IPP.

Eq. (1) can be written,

$$ITCR1 = E_{COL}^{USA} \frac{P_{INT}}{P_{COL}}$$

where international inflation P_{INT} is the trade partner's inflation measured in dollars:

$$P_{INT} = \Pi_{j=1}^{18} \left(\frac{P_j}{E_j^{USA}} \right)^{\omega_j}$$

International inflation (Figure 1) has two salient features: swings and average that, compared to Colombian inflation, is low. The swings are due to increases in inflation followed by devaluations mainly in Venezuela and Ecuador. The low average is explained by the high weight of developed, low inflation countries in Colombian trade, and the impossibility for an emerging trade partner to inflate without the corresponding correction of the exchange rate.

The reduced form of the model is:

$$E_{COL}^{USA} = \frac{P_{COL}}{P_{INT}} F(f) \tag{2}$$

where f is a vector of fundamentals.

In the determination of the nominal exchange rate, as implied by Eq. (2), there are nominal and real variables. The nominal variables are domestic and international inflation, the real variables are the fundamentals.

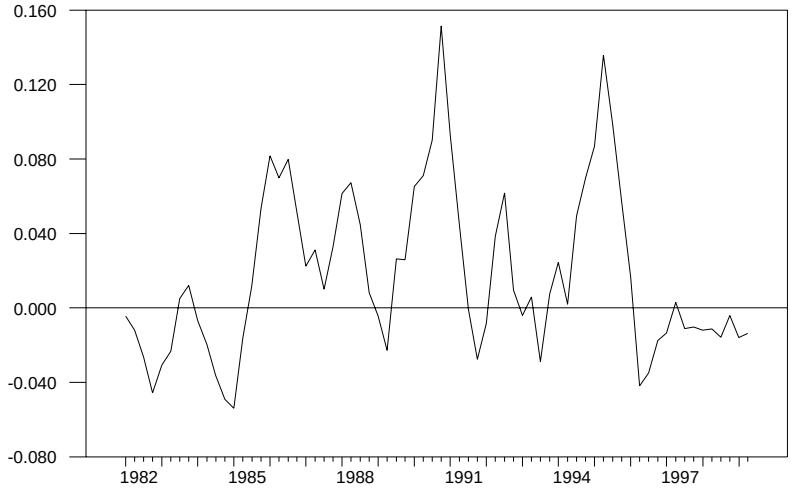

Figure 1: International Inflation

The reduced form (2) may also be written:

$$ITCR1 \equiv E_{COL}^{USA} \frac{P_{INT}}{P_{COL}} = F(f) \tag{3}$$

In the determination of the real exchange rate, the nominal variables (domestic and international inflation) play no role. The real exchange rate is determined by the fundamentals. In our ad. hoc. reduced form, the fundamentals are government expenditure G, the terms of trade T, and capital flows (inflows) K. Figure 2 shows government expenditure as a fundamental of the real exchange rate.

In the definition of the ITCR1, the choice of the reference currency is arbitrary. Eq. (3) may also be written as $ITCR1 = E_{COL}^{EMU} P_{INT}/P_{COL}$ where $P_{INT} = \Pi_{j=1}^{18} \left(P_j/E_j^{EMU}\right)^{\omega_j}$ is international inflation in ECU. If the ECU depreciates with respect to the dollar (E_{USA}^{EMU} decreases), international inflation decreases, but, the real exchange does not change because the ECU also depreciates with respect to the peso (E_{COL}^{EMU} decreases).

The econometric form of Eq. (2) is:

$$\Delta \log E_{COL,\,t}^{USA} = \alpha_E(\beta_1 \log E_{COL,\,t-1}^{USA} + \beta_2 \log P_{INT,\,t-1} + \beta_3 \log P_{COL,\,t-1}$$

$$+\beta_4 \log G_{t-1} + \beta_5 \log T_{t-1} + \beta_6 \log K_{t-1} + \beta_7 t)$$

$$+ \sum_{j=1}^{n-1} \gamma_j^E \Delta \log E_{COL,\,t-j}^{USA} + \sum_{j=1}^{n-1} \gamma_j^{PINT} \Delta \log P_{INT,\,t-j} + \sum_{j=1}^{n-1} \gamma_j^P \Delta \log P_{COL,\,t-j}$$

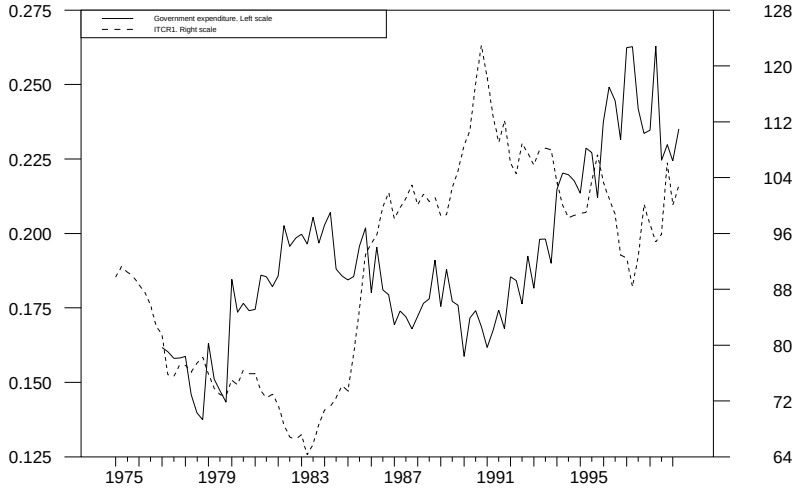

Figure 2: The Real Exchange Rate and Government Expenditure

$$+\sum_{j=1}^{n-1}\gamma_j^G\Delta\log G_{t-j}+\sum_{j=1}^{n-1}\gamma_j^T\Delta\log T_{t-j}+\sum_{j=1}^{n-1}\gamma_j^P\Delta\log K_{t-j}$$

$$+\delta_1 d_{1,\,t}+\delta_2 d_{2,\,t}+\delta_3 d_{3,\,t}+c+\varepsilon_t \tag{4}$$

where d_1, d_2, and d_3, are centered seasonal dummies, c is the constant, ε is the error term, and n is the number of lags. There are two additional equations similar to Eq. (4) each equation for each of the variables that we considered potentially endogenous, that is, domestic prices and capital flows.

We are interested in testing the following properties of the model: homogeneity of degree one of the nominal exchange rate in domestic prices, homogeneity of degree (minus) one of the nominal interest rate in foreign prices, and exogeneity of domestic prices and capital flows. Normalizing the cointegrating vector by $\beta_1 = 1$, the homogeneity property is a test on $\beta_2 = -\beta_3 = 1$, and exogeneity of domestic prices and capital flows is a tests on $\alpha_P = \alpha_K = 0$. The joint homogeneity and exogeneity test has four restrictions.

If the homogeneity property holds, by Eq. (3), the nominal exchange rate model is also a model of the real exchange rate. If both the homogeneity and the exogeneity properties hold, the nominal anchor is money, a property that Sjaastad (1998) calls "monetary independence", and the real exchange rate is neutral to domestic and international inflation.

Monetary independence and neutrality of the real exchange rate to the nominal variables are easy to visualize in Eqs. (2), and (3). If the domestic price level increases, the nominal exchange rate increases in the same proportion leaving the real exchange rate unchanged. If the international price level increases, the nominal exchange rate decreases in the same proportion leaving the real exchange rate unchanged. In response to changes in the international price level, the endogenous and homogenous nominal exchange rate adjusts, international inflation in domestic currency is thus unaltered. The pass through of international inflation is zero and also the real exchange rate is unchanged.

If the homogeneity and exogeneity properties hold for the Colombian data, monetary independence implies that the authorities have administered the crawling peg and the crawling band *as if* the nominal exchange rate where endogenous to the nominal variables and the fundamentals.

Although in the long run exchange rate policy may behave as if the nominal exchange rate floated, market efficiency may not be achieved because the exchange rate has been crawling pegged or floated within a crawling band.

As the nominal variables are exogenous, changes in the fundamentals change the real exchange through the nominal exchange rate. As the real exchange rate changes through changes in the nominal exchange rate, the nominal and real exchange rates may be correlated, but it is not possible to analyze whether the real exchange rate is neutral to the nominal exchange rate because the nominal exchange rate is endogenous. We believe this type of argument follows theoretical models like Stockman (1980, 1983, 1987), and Helpman and Razin (1982), and empirical models like Sjaastad (1998).

3 The Data

Data are quarterly for the period 1981:2 1999:2. The series on the nominal exchange rate, domestic, and international prices are the ones used for the computation of the ITCR1. Data on government expenditure are from Departamento Nacional de Planeación (DNP) and include central government, "entidades descentralizadas" and "entidades de seguridad social". Following Sjaastad (1998), the change in the terms of trade is measured in units of GDP, that is, the changes in the price of exports are weighted by the share of exports in GDP, and a similar computation for the price of imports. Capital flows are approximated by the inverse of merchandise trade and as a percentage of GDP. Data on the nominal exchange rate, domestic and foreign prices and the terms of trade are geometric averages.

4 Results

For the estimation we follow Johansen and Juselius (1992) who estimate a model of the exchange rate for the United Kingdom and prove theoretical implications with tests on linear restrictions in the long run parameters of the cointegration.

The estimation consisted of a cointegration test, a joint homogeneity and exogeneity test, autocorrelation tests, and a tests of foreign exchange market efficiency. We did the estimation with the CATS procedure of the RATS program. The test of market efficiency was done in a regression like (4) imposing to the homogeneity and exogeneity restrictions.

We, a priori, assumed that international inflation, government expenditure, and the terms of trade were exogenous. With this assumption we proceeded to prove cointegration. We then permitted that the nominal exchange rate, domestic prices and capital flows were potentially endogenous. Once cointegration was not rejected, we could not reject the joint homogeneity and exogeneity hypothesis. We ended up with a model where all variables but the nominal exchange rate were exogenous and where the homogeneity property holds, these are the necessary conditions for monetary independence and neutrality of the real exchange rate to the nominal variables.

Table 1 shows the cointegration test. At the usual significance level, the hypothesis of rank zero is rejected and the hypothesis of rank one cannot be rejected; there is cointegration of rank one. Table 2 shows that, at a p-value of 0.13, the joint homogeneity and exogeneity hypothesis cannot be rejected. Table 3 shows the error term does not have autocorrelation.

Following Sjaastad (1998), if the foreing exchange market is efficient, all information about the international price level is incorporated in the nominal exchange rate. In Eq. 4 market efficiency implies $\gamma_j^E = \gamma_j^{PINT}$ where the implied $\gamma_0^E = 1$. The market efficiency hypothesis was rejected at a p-value of 0.000.

The set of tests show that the data for Colombia behave as if the nominal exchange rate were endogenous, monetary policy independent, the foreign exchange market not efficient, and the real exchange rate neutral.

5 Simulations

The counter factual simulations intend to show the time path of the nominal and real exchange rates when there are change in the nominal variables or the fundamentals.

Endogenous variables		Nominal exchange rate, dDomestic prices, capital flows.	
Exogenous Variables		International inflation, government expenditure, terms of trade.	
Sample		1981:1 1999:2	
Eigenvalue Test	Critical Value	Null Hypothesis	Result
29.08	16.13	Rank = 0	Rejected
11.02	12.39	Rank = 1	Not rejected
Trace est	Critical Value	Null hypothesis	Result
49.26	39.08	Rank = 0	Rejected
20.18	22.95	Rank = 1	Not rejected

Table 1: Cointegration Analysis

Likelihood ratio test $\chi^2_{(4)} = 7.18$, p-value= 0.13.

Nominal exchange rate	Interna– tional inflaton	Domestic prices	Government expenditure	Terms of trade	Capital inflows	Time trend
1.000	1.000	−1.000	2.081	1.079	1.243	−0.006
-	-	-	(1.121)	(1.358)	(0.606)	(0.001)
α_E	−0.205					
T-value	−5.217					

Table 2: Joint Homogeneity and Exogeneity Test

Test	P-value
Long Box (17), $\chi^2_{(132)} = 124.787$	0.66
Lagrange multiplier (1), $\chi^2_{(9)} = 10.091$	0.34
Lagrange multiplier (4), $\chi^2_{(9)} = 11.291$	0.26
Normality, $\chi^2_{(6)} = 1.0167$	0.12

Table 3: Autocorrelation Tests

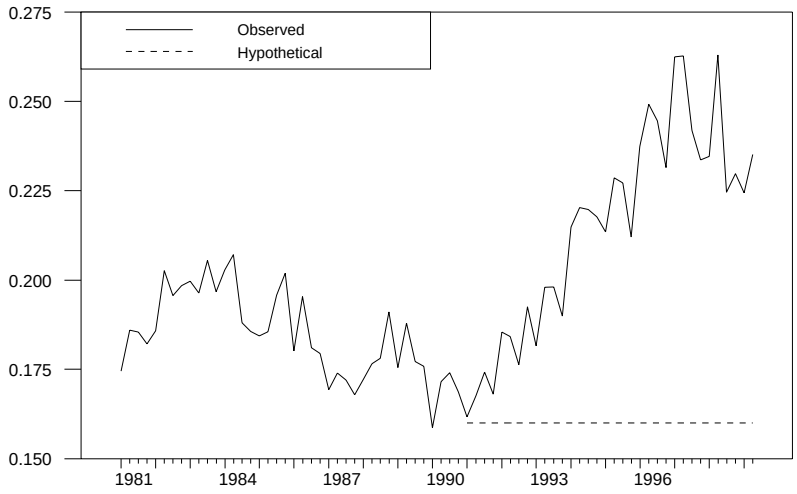

Figure 3: Observed and Hypothetical Paths of Government Expenditure

5.1 Change in the Fundamentals

Figure 3 shows the observed and counter factual paths of government expenditure. The hypothetical path assumes that, starting the first quarter of 1991, government expenditure remains at 16.0%. Figure 4 shows the impact of the change in government expenditure on the nominal exchange rate. The nominal exchange rate increases to $1,940.89 in the second quarter of 1992, compared to the observed level a devaluation of 18.5%. Figure 5 shows the observed and hypothetical paths of the ITCR1. The bigger the relative demand for tradables increases the real exchange rate through the increase in the nominal exchange rate. The real devaluation is also 18.5%.

Figure 6 presents the observed and assumed paths for capital inflows approximated by the inverse of the trade balance. The counter factual path assumes that the capital inflow of the nineties did not take place. The

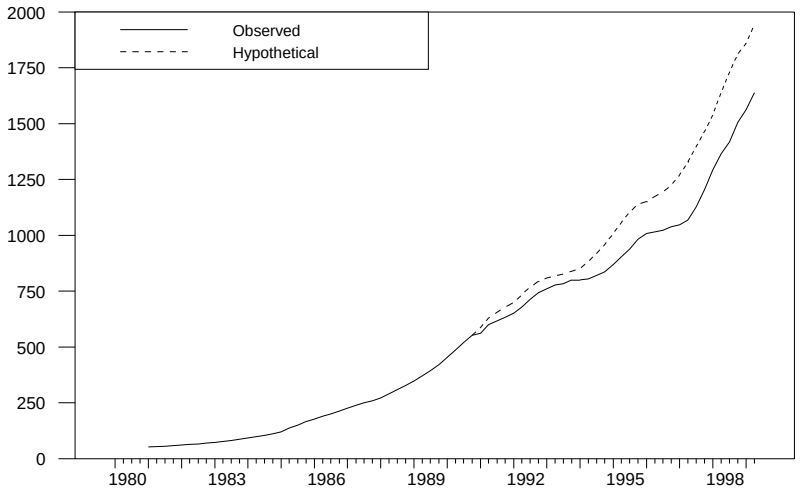

Figure 4: Effect of Government Expenditure on the Nominal Exchange Rate

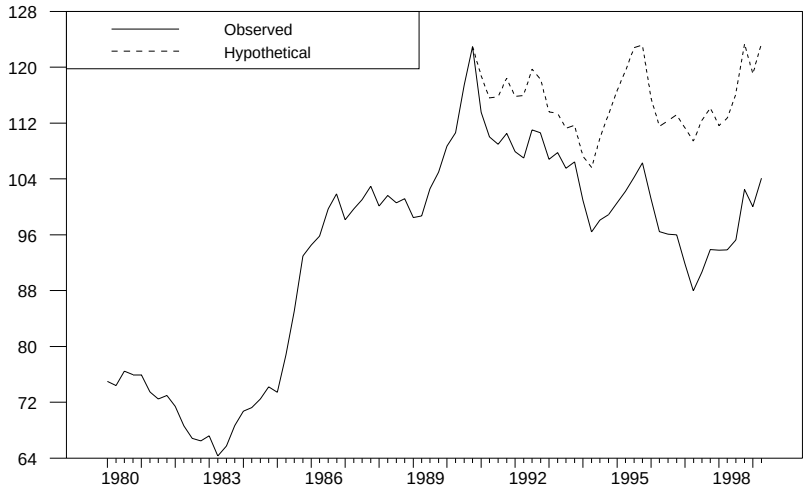

Figure 5: Effect of Government Expenditure on the Real Exchange Rate

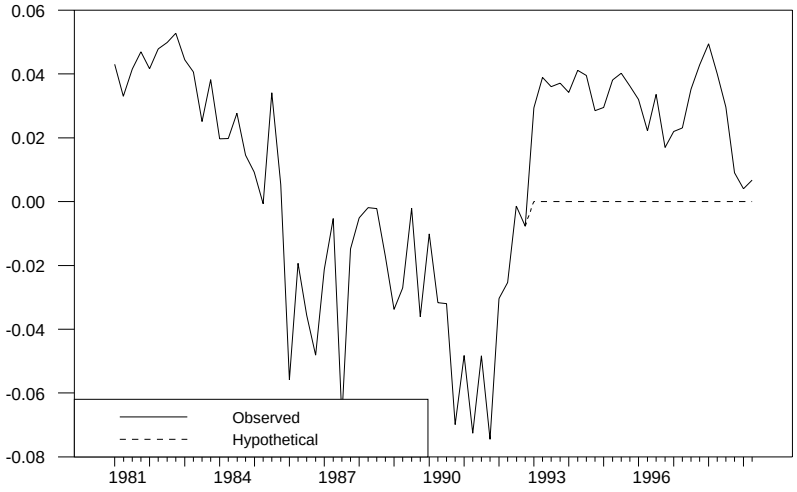

Figure 6: Observed and Hypothetical Paths of Capital Inflows

nominal and real exchange rates depreciate as shown in Figures 7 and 8.

Figures 9 and 10 show the observed and hypothetical paths of the change in the terms of trade and the level of the terms of trade. We assume there is a decrease in the terms of trade of 5.0% of GDP at the beginning of the nineties. As shown in Figures 11 and 12 the impact of the terms of trade on the nominal and real exchange rates is qualitatively the same as the one produced by the change in the other fundamentals.

Changes in the fundamentals impact on the nominal and the real exchange rates. The change in the real exchange rate takes place through the change in the nominal exchange rate. The nominal and real exchange rate hence, are correlated. One could conclude that a devaluation could change the real exchange rate, but this conclusion does not follow from this model because the nominal exchange rate is endogenous to the fundamentals.

5.2 Changes in the Nominal Variables

Figure 13 show the observed and hypothetical paths of international inflation. Figures 14 and 15 show the effect of the decrease in international inflation on the exchange rates, nominal and real. The figures reveal that the decrease in the international price level induces an increase of the same proportion but of different sign in the nominal exchange rate rendering the real exchange rate unchanged.

Figure 16 shows the historical and counter factual evolution of the price level. Figures 17 and 18 show the impact of the hypothetical decrease in inflation on the exchange rates. The nominal exchange rate decreases in the

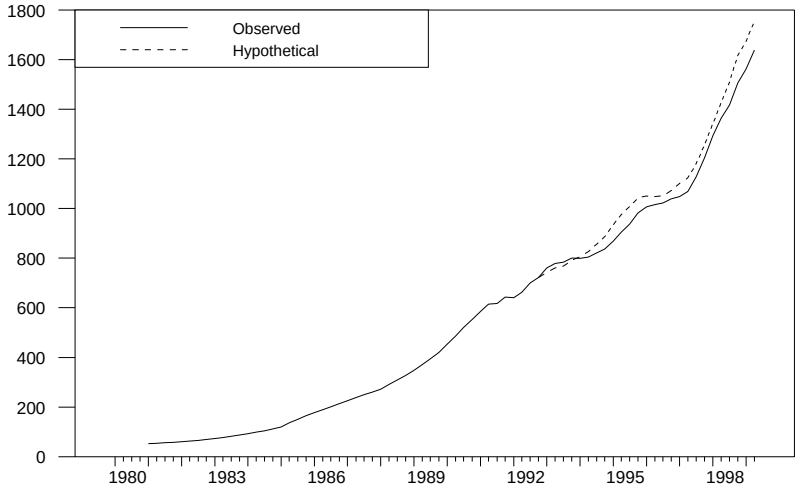

Figure 7: Effeect of Capital Inflows on the Nominal Exchange Rate

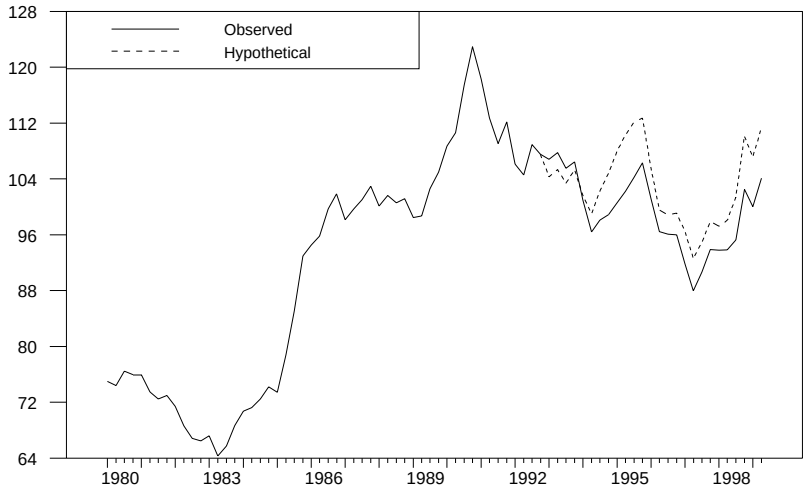

Figure 8: Effect of Capital Inflows on the Real Exchange Rate

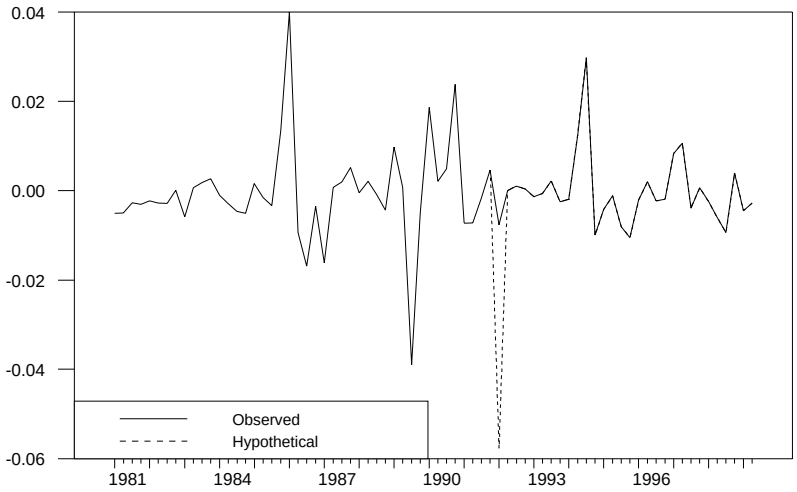

Figure 9: Observed and Hypothetical Change in the Terms of Trade

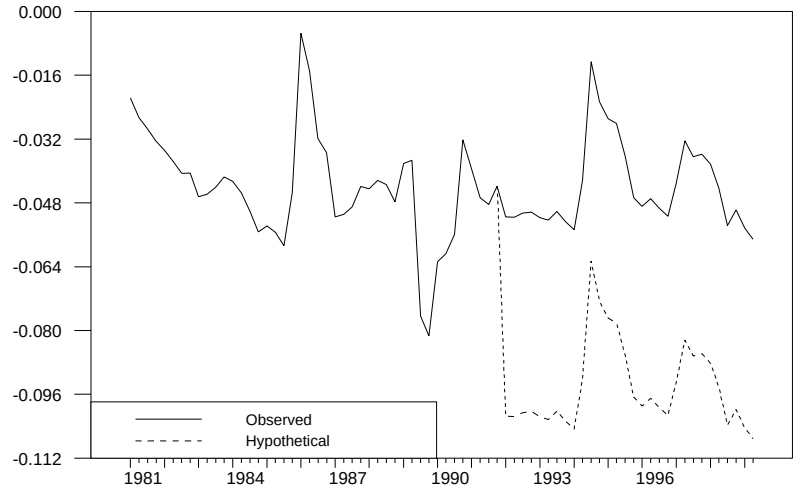

Figure 10: Observed and Hypothetical Level of the Terms of Trade

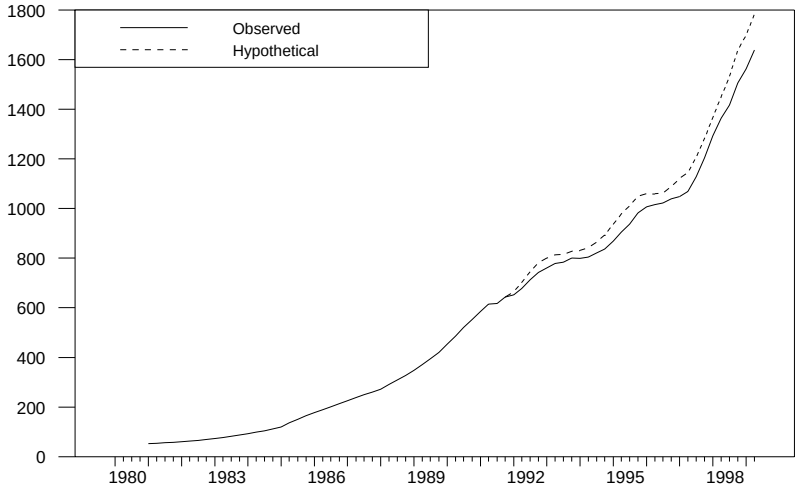

Figure 11: Effect of the Terms of Trade on the Nominal Exchange Rate

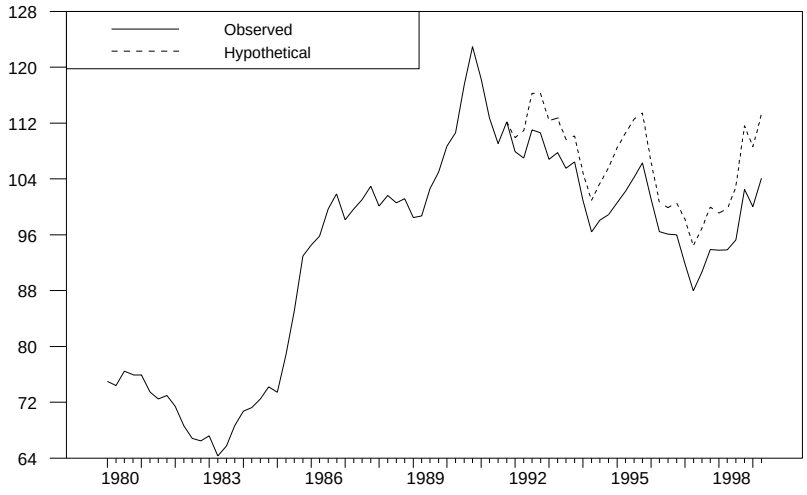

Figure 12: Effect of the Terms of Trade on the Real Exchange Rate

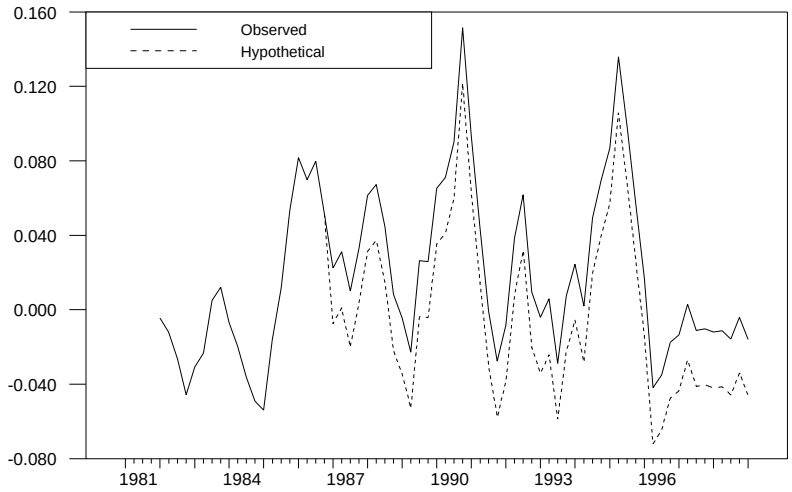

Figure 13: Observed and Assumed Paths of International Inflation

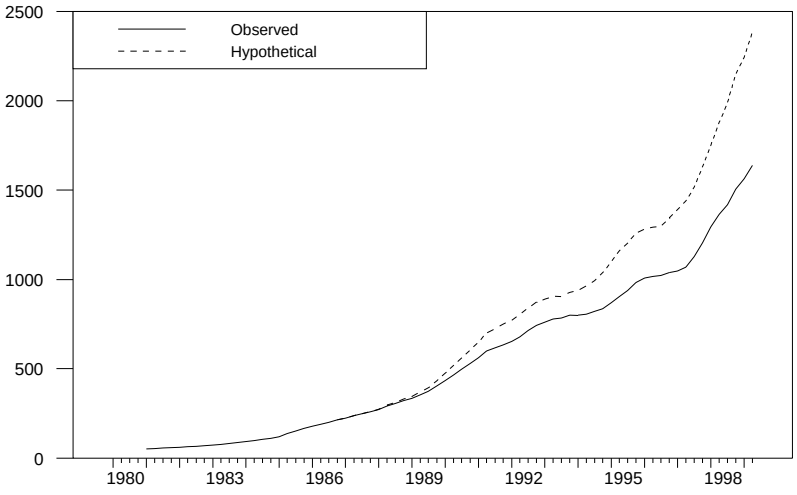

Figure 14: Effect of International Inflation on the Nominal Exchange Rate

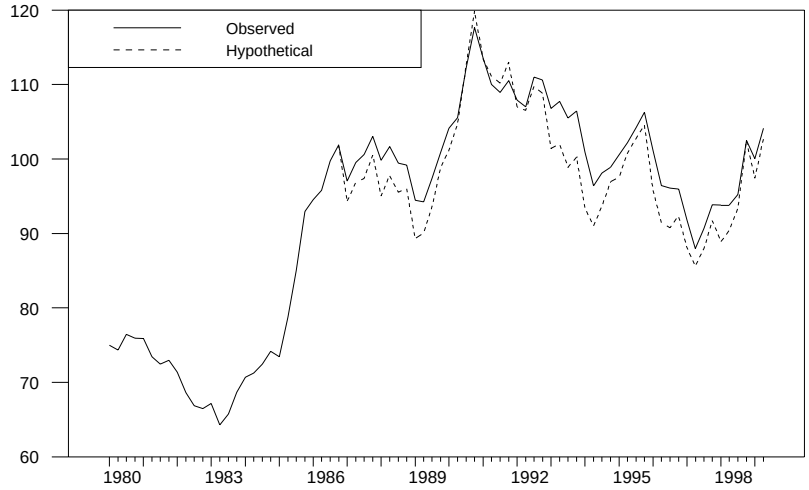

Figure 15: Effect of International Inflation on the Real Exchange Rate

same proportion as the decrease in the domestic price level so that the real exchange rate does not change.

Changes in the nominal variables (domestic and international inflation) change the nominal exchange rate but not the real one.

6 Comparison of the Nominal Exchange Rates of Colombia and Australia

We have proved that the nominal exchange rate of Colombia, although not with the efficiency of a float, has enough flexibility to make money the nominal anchor. In this section we compare the nominal exchange rate of Colombia with the one of Australia, a country that adopted a float by 1984. To make the two nominal exchange rates comparable we compare the error term of the regressions:

$$\log E_t = c + \log P_t + \varepsilon_t^1$$

and

$$\log E_t = c + \delta t + \varepsilon_t^2$$

for the two countries.

In the first regression we control for prices, because it is the continued increase in prices what explains the sustained increase in the nominal exchange rate in Colombia. In the second regression we control with a time

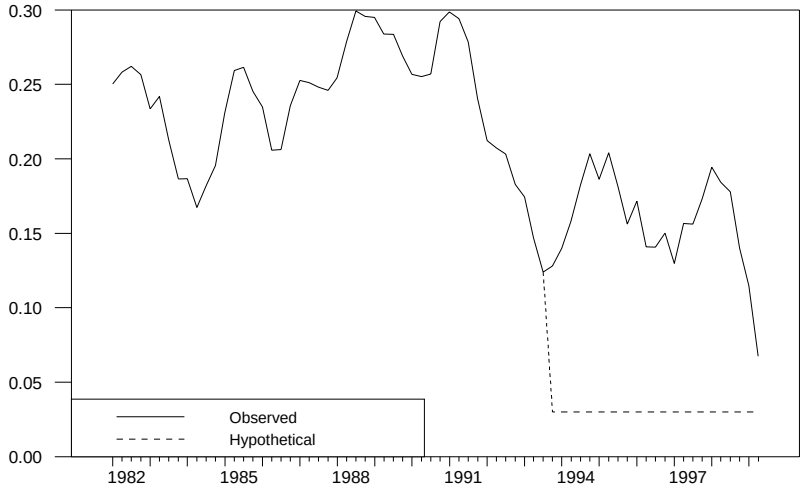

Figure 16: Observed and Hypothetical Evolution of Domestic Prices

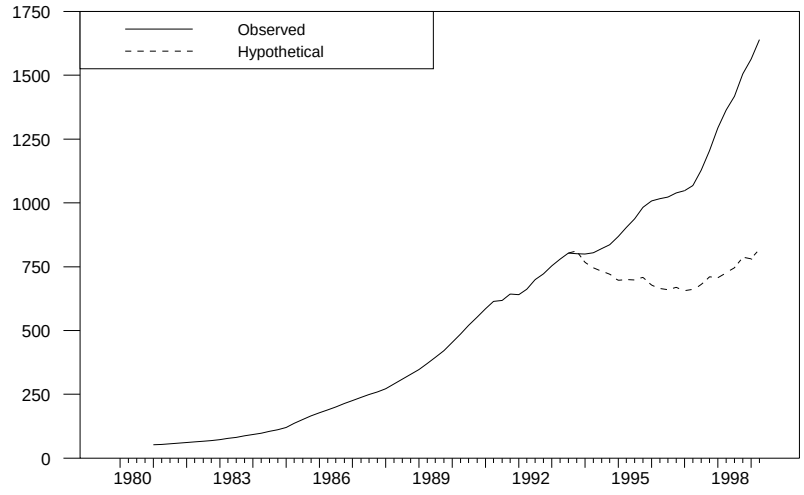

Figure 17: Effect of Domestic Prices on the Nominal Exchange Rate

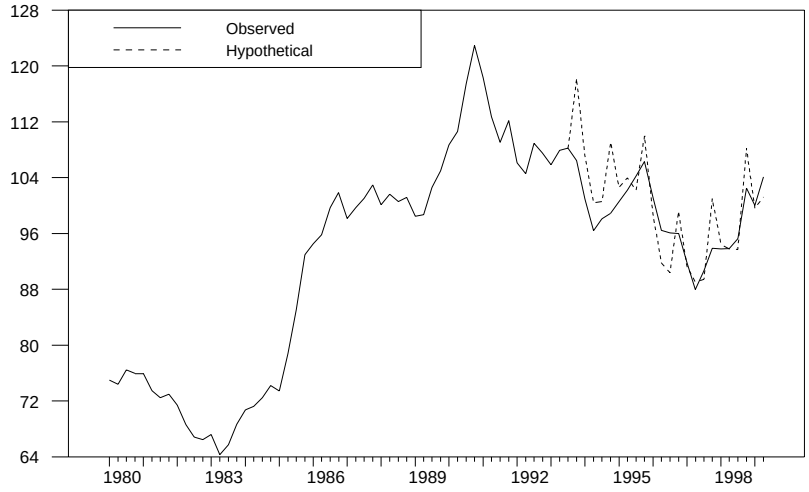

Figure 18: Effect of Domestic Prices on the Real Exchange Rate

trend. Figures 19 and 20 compare the errors ε^1 and ε^2 in the two countries. The standard deviation of the Colombian nominal exchange rate is bigger. The relative variability of the exchange rates should be compared controlling for the variability of the nominal variables and the fundamentals, but this is beyond the scope of this paper. We conclude that the Colombian nominal exchange rate as maintained a considerable degree of flexibility.

7 Conclusions

We conclude that, although not with the efficiency of a float, the nominal exchange rate of Colombia has enough flexibility to make money the nominal anchor. In the model, the nominal exchange rate was determined by the nominal variables and the fundamentals, and the real exchange rate was determined by the fundamentals. Changes in the real exchange rate took place through the nominal exchange rate thus generating a correlation between the nominal and the real exchange rates. In our model, the correlation of the nominal and real exchange rates cannot be exploited by policy because the nominal exchange rate is endogenous. The real exchange rate was neutral to the nominal variables, that is, to international and domestic inflation.

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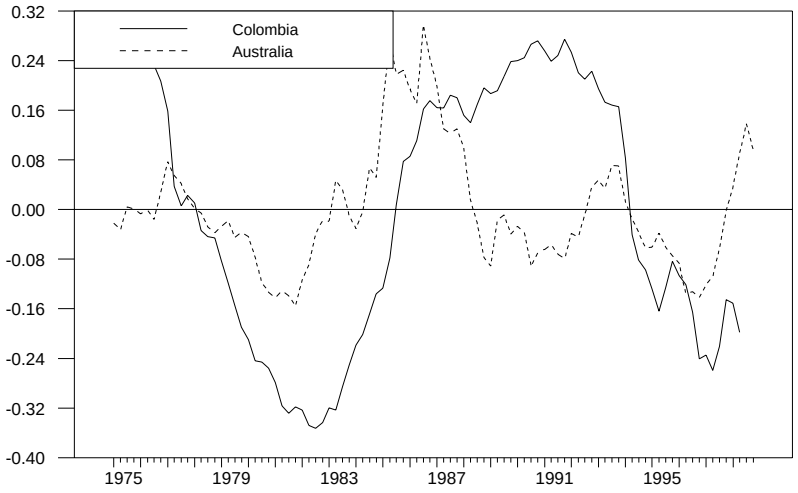

Figure 19: Comparison of the Nominal Exchange Rates of Colombia and Australia

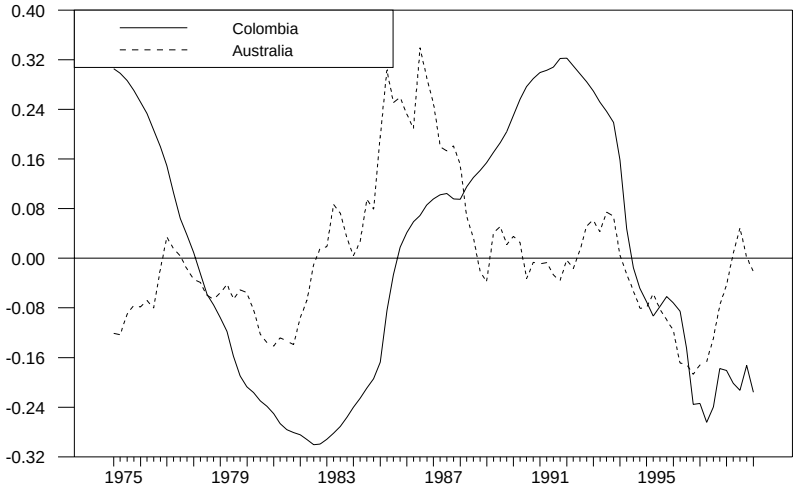

Figure 20: Comparison of the Nominal Exchange Rates of Colombia and Australia

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