THE RATIONALITY OF THE COLOMBIAN EXCHANGE MARKET

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ABSTRACT

This research analyzes the way agents participating in the Colombian exchange market form their expectations and how they arrive at an equilibrium price. The forward exchange rate was used as an approximation of the expected spot rate, implying the necessity to explain how its price is determined. Monte–Carlo techniques and three tests of the Forward Foreign Exchange Market Efficiency Hypothesis are conducted. Six hypotheses of behavior were tested, from static to rational expectations and from risk neutrality to risk premium and/or transaction costs. Weekly data from January 1997 to January 2006 presented signs of rational and adaptative expectations, together with risk neutrality.

INTRODUCTION

The tendency to promote a prosperous environment aimed at economic growth has become more pronounced during the last few years as worldwide economic integration has become consolidated. A series of events has confirmed this issue, such as the signing of commercial, scientific and technological cooperation agreements and internal norms being brought into line with international ones.

Colombia opened its capital account and reduced import barriers during the early 1990s. During this same period, the Banco de la República (BR), the country's monetary regulating authority, authorized exchange-rate cover operations for the Colombian peso - US dollar. By doing this, the BR tried to reduce exchange rate volatility and protect market participants.

Forward foreign exchange contracts involve two parties who agree to conduct transactions in foreign currency at an agreed exchange rate for a specified amount at some agreed future date. A forward contract eliminates the effect of future fluctuations on foreign exchange transfer rate. The forward exchange rate is calculated by using the current exchange and interest rates for both currencies and the contract maturity. Fulfilling the covered and uncovered parity condition of interest reveals a close relationship between spot and forward rates. If the Forward Foreign Exchange Market Efficiency Hypothesis (FMEH) holds under the assumption that agents have rational expectations and are neutral towards risk, the forward rate is an unbiased exchange rate predictor corresponding to the date of a contract's maturity. Thus the information contained in the agreed rate in the contracts for future delivery could be useful for predicting fluctuations in the Colombian exchange rate.

This study tries to determine whether some relationship exists between Colombia's forward and spot markets, assuming the rational behavior of agents participating in the exchange market and considering the implicit risk in forward contracts. Therefore, this article could be useful for those who participate in the exchange market or can be directly or indirectly affected by its dynamics. Market participants might use the information contained in the forward exchange rate for their own benefit without becoming involved in problems associated with drawing up complex prediction models and handling a wide-ranging database.

LITERATURE REVIEW

Economic theory starts with the study of agents' behavior patterns when faced with certain circumstances. The concept of rationality, understood as being people's reasoning ability for making decisions, must be considered for generalizing such conduct. Such disposition allows markets and the economy as a whole to make logical distinctions between the most and the least desired outcomes for each agent.

In the case of agents' order of preference and the psychological reasons surrounding their decisions, Bossert *et al.* (2005) and Cosmides & Tobby (1994) have shown that an element maximizes preferences, following natural selection processes until instinctively arriving at optimal situations. By contrast, the work of Haltiwanger & Waldman (1985) and Lovell (1986) have suggested that agents' rationality does not necessarily imply maximizing their utility levels because processing information cannot be related to rational action.

The concept of rationality can also be applied to processing information. If the evolution of economic variables follows a path and not just a random pattern, it is plausible to identify such behavior in generating expectations about future values. Agents must therefore be able to produce prediction models using all important and available information at a certain point in time, thereby implying continuous revision of predictions (and errors made in such predictions) to avoid making systematic errors.

Regarding handling exchange market information, Baillie *et al*. (1983) and Duarte & Stockman (2005) state that agents behave rationally and are risk-neutral as long as the exchange market remains efficient; however, they could change their rational beliefs associated with future exchange rate gains if additional information were available. Obstfeld (2005) has criticized models supposing homogenous agents, rational expectations, and complete markets, emphasizing levels of risk aversion and information asymmetry.

Simultaneously analyzing spot and forward exchange markets, Echols & Elliott (1976), Hsieh (1982), and Barnhart & Szakmary (1991) have shown that models must include terms relating the exchange rate's past and present behavior to verify agents' rationality associated with exchange rate expectation to avoid unit root problems between the spot and forward series.

Speculation and equilibrium prices are also related to forward rate behavior, a subject dealt with by Siegel (1972) and Radalj (2002) who found that speculation and variation in interest rate affected forward rate behavior. They concluded that agents assumed a level of risk if there were a lack of information and that variables did not tend towards equilibrium.

Zietz (1995) performed Monte–Carlo and linear regression experiments to verify efficiency and rational expectations in the forward market, finding that the authorities' intervention in the monetary market obeyed rational behavior and was compatible with covered interest rate parity, as stated by Rozen (1965). Nevertheless, the static expectations' hypothesis without risk premium was not rejected, as were expectations producing exchange market process and equilibrium.

Jeong & Maddala (1991), Cavaglia *et al*. (1994) and Corbae *et al*. (1992) have all rejected the rational expectations hypothesis, the first two groups using primary sources and the latter using market information. Cavaglia *et al*. (1994) and Corbae *et al*. (1992) have all tested risk premium, contradicting exchange market efficiency.

Rationality and Efficiency in the Exchange Market

If the rational expectations hypothesis for an effective rate on the spot exchange market is fulfilled for period $t+k$ (s_{t+k}), then agents form their expectations in the following manner:

$$s_{t+k} = E_t\left(s_{t+k} \middle| I_t\right) + \varepsilon_{t+k} \tag{1}$$

Where $E_t(\bullet)$ is the conditional expectation given all information I during period t and ε_{t+k} is the prediction error. This must fulfill conditions regarding lack of orthogonal [$E\left(\varepsilon_{t+i}\varepsilon_{t+j}\right)=0, \quad i \neq j$] bias [$E\left(\varepsilon_{t+k}\right)=0$], respecting information [$E\left(\varepsilon_{t+k}I_t\right)=0$].

Aggarwal *et al*. (1995) stated that the rational expectations hypothesis could be tested in two ways; some authors use assets for measuring expectations (indirect tests) whereas others construct the hypothesis by means of surveys (direct tests) [a compilation of empirical evidence regarding direct tests can be found in Lovell (1986), Zarnovitz (1985), and Maddala (1990)]. In the first case, not only agents' rationality is tested but also how asset price is determined (market equilibrium).

The forward rate is used in this work as the expectation of the respective future spot exchange rate, supposing that covered and uncovered parity of interests is fulfilled. It is thus necessary to determine how equilibrium in the forward market can be achieved.

If risk is considered in the value of the forward rate, then investors demand a greater return on their investment [i.e. a premium (pr^e) for facing greater variability in the profit which they expect to earn]. According to results found by Grauer *et al*. (1976) and Stockman (1978), the forward rate fixed during period t, expiring during period $t+k$ is thus be equal to:

$$f_{t,t+k} = E_t\left(s_{t+k}\right) + pr_t^e, \quad \text{where } pr_t^e = f_{t,t+k} - E_t\left(s_{t+k}\right) \tag{2}$$

Risk aversion transforms the forward rate into a biased predictor of future spot exchange rate [i.e. one of the conditions of rationality would not be fulfilled as the risk premium is predictable with the present information]. Nevertheless, in the case where agents are risk-neutral [for example, if there is a sufficiently great number of risk-neutral agents or if the exchange risk is perfectly diversifiable] then consecutive deviations would not be committed if the forward rate were chosen to be a prognostic measurement of the spot exchange rate:

$$f_{t,t+k} = E_t\left(s_{t+k}\right) \tag{3}$$

Consequently, if the three conditions are united, the futures' market is efficient. The forward rate accurately predicts the spot rate and both rates quickly correct their values faced with any new relevant information:

$$s_{t+k} = f_{t,t+k} + \varepsilon_{t+k} \tag{4}$$

The last theory is known as the Forward Foreign Exchange Market Efficiency Hypothesis (FMEH), also known as the Forward Rate Unbiasedness Hypothesis (FRUH). If FMEH is not fulfilled, it might be that condition (1) or condition (3) is not being satisfied. The expectations model $E_t(\bullet)$ or the agents' claim for a risk premium is thereby rejected.

Risk Premium and Transaction Costs

Some models containing risk premium components, such as those used by Engel (1995), have shown that forward rate profits may not satisfy the condition of lack of bias due to forward contracts being conditioned to an adjacent asset (spot exchange rate). This is why variation in the expected value of the forward rate can be explained by present risk involved in exchange rate gain and a negative correlation between the discount rate of the forward rate; exchange rate variation may also appear.

In line with the above results, but including variation on time and its negative relationship with interest rate, Hodrick & Srivastava (1983) and Bansal (1997) have stated that the risk involved in profit can display variation in time, depending on interest rate variation, and may be due to the presence of heteroskedasticity in the models. Different tests must thus be designed with variation in the estimated parameters and the presence of heteroskedasticity.

Changes in time have been analyzed by Sakoulis & Zivot (1999), beginning with random walk models, leading to simulations where the absence of risk in exchange rate is allowed only if there are no structural changes in the forward series. It must also be considered that financial market participants are heterogeneous, allowing them to form expectations about inflation and profits in any contract different time stipulation.

Another aspect related to profits in exchange market contracts deals with assumed transaction costs at the time of negotiating with different financial intermediaries; this subject has been treated by Mark & Wu (1998) and Buser *et al*. (1996) when constructing optimal price models and estimating future exchange rate predictors from the present rate. Covered interest rate parity deviation in such models considers covariance between the marginal rate of the substitution of money and present value in forward contract speculation. The implicit value in transaction costs, as stated in their work, can lead agents to deciding between taking a forward contract or an asset on the exchange market; predicting the forward exchange rate assumes transaction costs based on interest rates and exchange rate trend.

METHODOLOGY

A Monte Carlo experiment was performed, following Zietz's methodology (1995), to separate assumptions about exchange market equilibrium from agents' expectations. Monte Carlo methodology leads to interpreting estimations used for verifying FMEH, explaining whether results found are inline with the expectation theories so presented. This is why a data generating process must be chosen which agrees with the estimated parameters and satisfies proposed equilibrium conditions and expectations.

This exercise ranges from the basic case (static expectations) to more complex ones (rational expectations, risk premium and transaction costs). The six cases considered in this document are presented in Table 1. The first type of hypothesis uses static expectations where the forward rate is equal to the spot rate's current value. In this case, no more information is necessary because the present rate contains the necessary information for predicting the future exchange rate [i.e. it follows a random walk].

Unlike the first model, the second model handles the concept of rational expectations. It not only uses the information contained in the current spot rate but also all available and relevant information for making the calculation. The third model includes an intermediate measurement between rational expectations and static ones, in which agents consider different prediction functions.

Up to this point, the models have not considered bias between expected and observed value in the exchange market. This can be associated with two causes: risk and/or costs involved in participating in the market. The fourth model includes rational expectations and risk premium, the latter interpreted as being spot rate coefficient of variation. The fifth model measures transaction costs as a portion of the amount of forwards transacted. The last case is a combination of simulations four and five.

Table 1: Monte – Carlo Simulations

Hypotheses	Expectations	Equilibrium Condition	Simulated Forward Rate
1	Static	Risk neutrality	$f_{t,t+k} = E_t\left(s_{t+k}\right) = s_t + \varepsilon_{1,t}$ $\varepsilon_{1,t} \sim N\left(0,\sigma_1^2\right)$
2	Rational	Risk neutrality	$f_{t,t+k} = E_t\left(s_{t+k}\right) = s_{t+k} - \varepsilon_{2,t+k}$ $\varepsilon_{2,t} \sim N\left(0,\sigma_2^2\right)$
3	Static – Rational	Risk neutrality	$f_{t,t+k} = E_t\left(s_{t+k}\right) = \omega\left(s_t + \varepsilon_{3.1,t}\right) + \left(1-\omega\right)\left(s_{t+k} - \varepsilon_{3.2,t+k}\right)$ $\omega \in \left(0,1\right)$ $\varepsilon_{3.1,t} \sim N\left(0,\sigma_{3.1}^2\right)$ $\varepsilon_{3.2,t} \sim N\left(0,\sigma_{3.2}^2\right)$
4	Rational	Risk premium	$f_{t,t+k} = E_t(s_{t+k}) + pr_t^e = s_{t+k} + pr_t^e - \varepsilon_{4,t+k}$ $pr_t^e = \psi_4 cv_t$ $\psi_4 > 0$ $\varepsilon_{4,t} \sim N(0,\sigma_4^2)$
5	Rational	Transaction costs	$f_{t,t+k} = E_t(s_{t+k}) + ct_t = s_{t+k} + ct_t - \varepsilon_{5,t+k}$ $ct_t = \delta_5 m_t$ $\delta_5 \in \left(0,1\right]$ $\varepsilon_{5,t} \sim N(0,\sigma_5^2)$
6	Rational	Risk premium – transaction costs	$f_{t,t+k} = E_t(s_{t+k}) + pr_t^e + ct_t = s_{t+k} + pr_t^e + ct_t - \varepsilon_{6,t+k}$ $pr_t^e = \psi_6 cv_t$ $ct_t = \delta_6 m_t$ $\psi_6 > 0$ $\delta_6 \in \left(0,1\right]$ $\varepsilon_{6,t} \sim N(0,\sigma_6^2)$

Note: In order to make the simulations, logarithms of all the variables were used $\left(s, f, cv, m\right)$

The previous hypotheses about how asset price is determined were tested by using the three estimations conventionally used for verifying FMEH (co-integration, differences and error correction). Table 2 shows the specification and assumptions of the three econometric models and some articles that test them.

Some dispersion measurements [norm, bias, and mean squared error (MSE)] were used for identifying similarity between simulated results and estimated ones to determine which hypothesis best adjusts to agents' behavior within this market.

Table 2: Estimations Used for Verifying FMEH

Estimation Commonly Used	**H_0: FMEH holds if**	**Some Articles**	**FMEH Holds**
Long run (cointegration)			
$s_{t+k} = \alpha_0 + \alpha_1 f_{t,t+k} + \nu_{t+k}$	s_{t+k} and $f_{t,t+k}$ are from the same integration level. $\alpha_0 = 0$ and $\alpha_1 = 1$. ν_{t+k} is white noise.	Cornell (1977), Levich (1979), Frenkel (1980, 1981), Edwards (1983), Chiang, T.C. (1988), Luintel & Paudyal (1998), Barkoulas *et al.* (2003), Delcoure *et al.* (2003)	Yes
Short run (differences)			
$s_{t+k} - s_t = \beta_0 + \beta_1 (f_{t,t+k} - s_t) + \upsilon_{t+k}$	$\beta_0 = 0$ $\beta_1 = 1$ $E(\mu_{t+k}) = 0$	Cornell (1977), Geweke & Feige (1979), Tryon (1979), Hansen & Hodrick (1980), Bilson (1981), Hakkio (1981), Meese & Singleton (1982), Cumby & Obstfeld (1981, 1984), Fama (1984)	No
Short and long run (error correction)			
$\Delta s_{t+k} = \lambda_0 + \lambda_1 \hat{\nu}_{t+k-1} + \sum_{j=1}^{J} \lambda_{j+1} \Delta f_{t-j,t+k-j} + \sum_{j=1}^{J} \lambda_{J+1} \Delta s_{t+k-j} + \xi_{t+k}$ $\hat{\nu}_{t+k-1} = s_{t+k-1} - \hat{\alpha}_0 - \hat{\alpha}_1 f_{t-1,t+k-1}$	$\lambda_0 = 0$ $-\lambda_1 = \lambda_2 = 1$ $\lambda_3 = \ldots = \lambda_{2J} = 0$	Hakkio & Rush (1989), Barnhart & Szakmary (1991), Naka & Whitney (1995), Zivot (2000)	Mixed results

Note: In order to make the estimations, logarithms of all the variables were used (s, f)

A database of weekly observations for the period of January 10 1997 to January 20 2006 was used in this research; all the information came from the BR, especially from the Operations and Market Development Division. The following variables were used for the proposed exercise:

$s_{sem:t}$: Logarithm of Colombian representative US dollar exchange rate, weekly average.

$f_{sem:t,t+1}$: Logarithm of forward exchange rate for weekly contracts, weekly average.

$cv_{sem:t}$: Logarithm of coefficient of variation for the representative exchange rate, weekly average.

$m_{sem:t}$: Logarithm of weekly transacted amount in forward contracts, weekly maturity.

The Monte Carlo experiment was repeated 500 times for each forward rate produced, according to the raised hypotheses. σ_i ($i = 1,2,3.1,3.2,4,5,6$), ω, ψ_i ($i = 4,6$) and δ_i ($i = 5,6$) values were chosen according to the greater similarity with results obtained from real data in the three types of FMEH specification (mean average coefficient and respective average standard errors were considered as calibration guide).

EMPIRICAL RESULTS

The previously described methodology allows this section to be divided into three parts: analyzing long-term exchange market equilibrium mechanisms (indicating which simulation most agreed with the observed data), the same in the short-term and considering a model combining both types of information.

Long-term

Observed data $s_{sem:t}$ and $f_{sem:t,t+1}$ were analyzed to see whether they were stationary, to ascertain whether there were a long-term relationship between spot and forward rates. Unit root tests [Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatowski, Phillips, Schmidt and Shin (KPSS)] were used for determining that the series were I(1), meaning that an equilibrium relationship could have existed between the variables.

The spot rate was then estimated as a constant, as was the forward rate, without restricting the equation coefficients. Some co-integration Durbin-Watson (CRDW), Engle-Granger (EG) and Augmented Engle-Granger (AEG) tests were compared to R^2 [according to Granger and Newbold (1974), if CRDW>R^2, the residual of co-integration regression, is not I(1), then the spurious regression hypothesis is rejected and co-integration is accepted]. The hypothesis that there was a long-term relationship between spot and forward rates was not rejected in all the tests performed. The results agreed with the literature (see Table 2).

Then, six simulated series of the forward rate were produced following the previous procedure, one for each expectation and market equilibrium hypothesis. Table 3 shows the results obtained from the observed data and for those created randomly.

Table 4 presents the hypotheses` bias and MSE for the Co-integration specification. Notice the proximity of results for all the hypotheses concerning the α_1 coefficient and the best performance of models 2, 3 and 4 in the case of α_0. The objective of approaching the co-integration equation's observed coefficients with minimum rank variation was generally achieved (smaller standard errors), as observed in MSE, although the results were not satisfactory by t–statistics.

Analyzing the simulations' MSE behavior in more detail, hypotheses 2 and 3 displayed the greatest coefficient reliability and hypothesis 1 showed the greatest standard error precision. It was observed that the rational and static expectations' hypothesis (hypothesis 3) was nearest to real values when examining the joint performance of the coefficients and their respective standard errors (Figure 1).

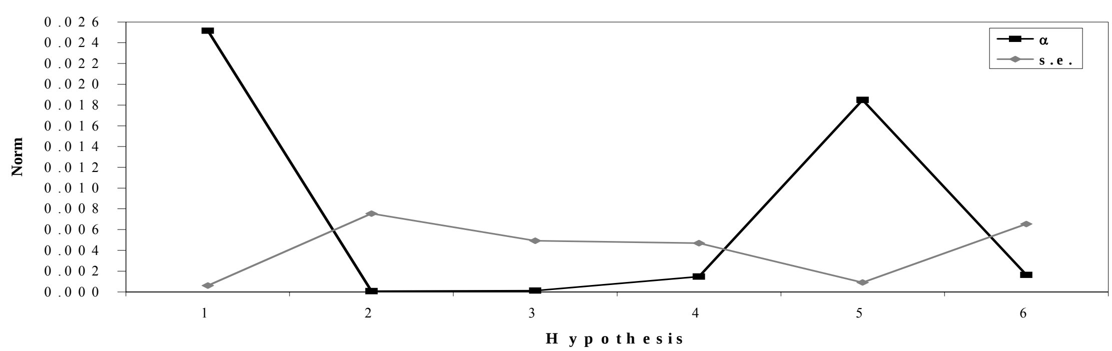
Table 3: Co-integration Equation Results for Real and Fictitious Data

Estimated model: $s_{sem:t+1} = \alpha_0 + \alpha_1 f_{sem:t,t+1} + \nu_{t+1}$

Statistics	Real data	Monte-Carlo simulations					
		H. 1	H. 2	H. 3	H. 4	H. 5	H. 6
α_o	0.0246	0.0496	0.0247	0.0246	0.0247	0.0063	0.0249
s.e.(α_o)	0.0115	0.0109	0.0190	0.0066	0.0161	0.0124	0.0180
T(α_o)	2.1459	4.5610	1.3011	3.7436	1.5325	0.5084	1.3868
α_1	0.9968	0.9937	0.9968	0.9969	0.9983	0.9992	0.9984
s.e.(α_1)	0.0015	0.0014	0.0025	0.0009	0.0021	0.0016	0.0024
T(α_1)	663.0326	696.7563	401.0641	1154.9302	471.3173	616.1130	423.6893
R^2	0.9990	0.9990	0.9971	0.9997	0.9979	0.9988	0.9975
CRDW	1.3506	1.4094	2.0677	1.5967	1.8160	2.0801	1.5543
EG[i]	-14.8596	-15.9739	-22.6383	-17.6632	-19.9303	-21.9848	-17.0501
C.V. EG 1%	-3.9200						
C.V. EG 5%	-3.3500						
AEG_1[ii]	-11.1537	-11.5180	-15.3814	-12.0251	-13.3455	-14.7076	-10.8955
C.V. AEG_1 1%	-3.9200						
C.V. AEG_1 5%	-3.3500						
AEG_2[iii]	-9.8025	-10.1115	-13.2976	-9.6693	-11.7638	-12.4580	-9.2582
C.V. AEG_2 1%	-3.9300						
C.V. AEG_2 5%	-3.3500						
AEG_3[iv]	-8.0319	-8.6511	-11.2189	-8.1632	-9.8173	-9.9051	-7.5544
C.V. AEG_3 1%	-3.9300						
C.V. AEG3 5%	-3.3500						

[I] Engle-Granger Test. H_0: no cointegration (unit root)
[ii] Augmented Engle-Granger Test with a lag. H_0: no cointegration (unit root)
[iii] Augmented Engle-Granger Test with two lags. H_0: no cointegration (unit root)
[iv] Augmented Engle-Granger Test with three lags. H_0: no cointegration (unit root)
CRDW: Durbin Watson of the Co-integration regression, T: t-statistic
C.V.: Critical value s.e.: Standard error of coefficient estimate

Figure 1: Co-integration Equation Coefficients Norm and Their Respective Standard Errors



Source: Authors' calculations

Table 4: Dispersion Measurement of the Co-integration Equation

Statistics	Hypothesis					
	1	2	3	4	5	6
Observed Bias						
α_o	0.0250	0.0000	0.0000	0.0001	-0.0183	0.0003
s.e.(α_o)	-0.0006	0.0075	-0.0049	0.0047	0.0009	0.0065
t(α_o)	2.4150	-0.8448	1.5976	-0.6134	-1.6375	-0.7592
α_1	-0.0031	0.0001	0.0001	0.0015	0.0024	0.0016
s.e.(α_1)	-0.0001	0.0010	-0.0006	0.0006	0.0001	0.0009
t(α_1)	33.7237	-261.9685	491.8976	-191.7153	-46.9196	-239.3433
R^2	0.0001	-0.0019	0.0007	-0.0011	-0.0002	-0.0015
Observed MSE						
α_o	6.24E-04	1.36E-09**	2.78E-10*	8.74E-09	3.36E-04	7.67E-08
s.e.(α_o)	3.60E-07*	5.59E-05	2.39E-05	2.17E-05	8.16E-07**	4.20E-05
t(α_o)	5.83E+00	7.14E-01	2.55E+00	3.76E-01*	2.68E+00	5.76E-01**
α_1	9.44E-06	2.59E-09*	1.42E-08**	2.17E-06	5.83E-06	2.61E-06
s.e.(α_1)	5.96E-09*	9.65E-07	4.10E-07	3.78E-07	1.40E-08**	7.28E-07
t(α_1)	1.14E+03*	6.86E+04	2.42E+05	3.68E+04	2.20E+03*	5.73E+04
R^2	5.38E-09*	3.49E-06	4.72E-07	1.14E-06	2.69E-08**	2.25E-06

* Lowest MSE
** Second lowest MSE

<u>Short-term</u>

Another model used for verifying FMEH comes from estimating spot exchange rate depreciation as a function of forward premium and a constant. The results reported in Table 5 reveal some interesting behavior for Colombia. The estimated β_1 coefficient was generally found to be negative, a different result from that supposed using FMEH (a problem known as forward discount puzzle). After running the regression indicated for Colombia, it was found that the β_0 coefficient was close to zero and the β_1 coefficient was positive, although negative values could not be ruled out if the confidence interval were considered. On the other hand, all the simulations taken together displayed behavior close to that obtained with the observed data, especially regarding the β_1 coefficient.

Table 6 reports individual dispersion measures of the coefficients and Figure 2 show its joint performance. In order to choose a more accurate model (having smaller bias but retaining efficiency), we analyzed the MSE of the hypotheses; finding that the hypothesis standing out from the coefficients was that regarding combined expectations. However, static expectations performed better in standard errors, confirmed when the norms for coefficients and standard errors were compared. The importance of static expectations and risk neutrality in the short-run were reaffirmed regarding the results obtained by Zietz (1995).

Table 5: Results of the Equation in Differences for Real and Fictitious Data

Estimated model: $s_{sem:t+1} - s_{sem:t} = \beta_0 + \beta_1 \left(f_{sem:t,t+1} - s_{sem:t} \right) + \upsilon_{t+1}$

Statistics	Real Data	Monte-Carlo Simulations					
		H. 1	H. 2	H. 3	H. 4	H. 5	H. 6
β_o	0.0014	0.0017	0.0015	0.0013	0.0078	-0.0356	-0.0003
s.e.(β_o)	0.0005	0.0004	0.0004	0.0004	0.0006	0.0042	0.0004
t(β_o)	2.5868	3.9833	3.8890	3.3361	12.9979	-8.4138	-0.6353
β_1	0.1695	0.1687	0.1696	0.1695	0.1696	0.1652	0.1694
s.e.(β_1)	0.2073	0.1449	0.0186	0.0191	0.0132	0.0187	0.0142
t(β_1)	0.8177	1.1643	9.1095	8.8607	12.8134	8.8510	11.9682
R^2	0.0015	0.0029	0.1503	0.1434	0.2593	0.1463	0.2386
DW	1.3303	1.3516	1.4835	1.4487	1.5161	1.2999	1.4873
Q[i]	80.7783	88.6158	68.6054	83.6993	53.2901	120.7793	54.8488
p-value(Q)	0.0000						
LM[ii]	57.3281	58.7576	46.0468	52.4321	38.0831	72.3637	40.3103
p-value(LM)	0.0000						
ARCH[iii]	43.0315	50.7769	40.3821	48.2455	34.4135	36.9019	36.4679
p-value(ARCH)	0.0000						
White[iv]	3.8590	2.8095	7.4444	11.1466	38.7963	14.7788	36.4705
p-value(White)	0.1452						
JB[v]	158.3709	147.7357	145.2882	108.9471	62.9665	79.5286	66.4487
p-value(JB)	0.0000						
Chow[vi]	8.8786	8.9966	10.6997	13.9344	8.1001	22.7503	10.0346
p-value(Chow)	0.0002						

[i] Ljung-Box Q test. H_0: no serial correlation up to order k=4

[ii] Breusch-Godfrey Lagrange multiplier test. H_0: no serial correlation up to order h=4

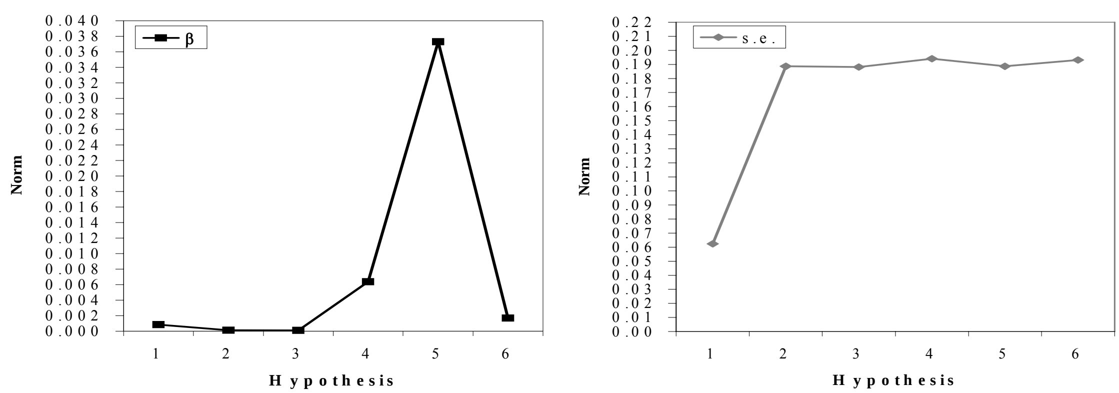
[iii] Autoregressive Conditional Heteroskedasticity (ARCH) Lagrange multiplier test. H_0: no ARCH up to order q=4

[iv] White test without cross terms. H_0: no heteroskedasticity

[v] Jarque-Bera test. H_0: normally distributed errors

[vi] Chow test, we partitioned the sample in two sub-samples of the same size. H_0: no structural change

Figure 2: Equation Coefficients Norm and their Respective Standard Errors, in Differences



Source: Authors` calculations

Table 6: Dispersion Measurement of the Equation in Differences

Statistics	Hypothesis					
	1	2	3	4	5	6
Observed bias						
β_o	0.0003	0.0001	-0.0001	0.0064	-0.0371	-0.0017
s.e.(β_o)	-0.0001	-0.0002	-0.0001	0.0001	0.0037	-0.0001
T(β_o)	1.3965	1.3021	0.7492	10.4111	-11.0006	-3.2221
β_1	-0.0008	0.0000	0.0000	0.0001	-0.0043	-0.0002
s.e.(β_1)	-0.0624	-0.1887	-0.1882	-0.1941	-0.1887	-0.1932
T(β_1)	0.3466	8.2918	8.0430	11.9957	8.0333	11.1505
R^2	0.0014	0.1489	0.1419	0.2578	0.1449	0.2372
Observed MSE						
β_o	7.85E-08	1.31E-08**	8.27E-09*	4.07E-05	1.37E-03	2.80E-06
s.e.(β_o)	1.46E-08**	2.35E-08	2.25E-08	2.87E-09*	1.36E-05	1.85E-08
T(β_o)	1.95E+00	1.70E+00**	5.61E-01*	1.08E+02	1.21E+02	1.04E+01
β_1	6.27E-07	1.02E-09**	3.82E-10*	3.73E-09	1.88E-05	2.71E-08
s.e.(β_1)	3.89E-03*	3.56E-02	3.54E-02**	3.77E-02	3.56E-02	3.73E-02
T(β_1)	1.20E-01*	6.88E+01	6.47E+01	1.44E+02	6.45E+01**	1.24E+02
R^2	2.02E-06*	2.22E-02	2.02E-02**	6.65E-02	2.10E-02	5.63E-02

* Lowest MSE
** Second lowest MSE

Short-term and Long-term

The error correction model was the last one used in this work. It contained short-term and long-term information in a single equation [an *a priori* supposition regarding the existence of weak forward rate exogeneity regarding spot rate]. The error correction equation was chosen considering some information criteria (Akaike, Schwarz) to avoid problems related to autocorrelation, heteroskedasticity and instability. As in the other specifications, the coefficients results presented in Table 7 were near to the observed data, but were not satisfactory by t–statistics.

According to some dispersion measurements, we summarize our process selection of best performance hypothesis in Table 8 and Figure 3. Hypothesis 1 generally displayed MSE having greater similarity with real data [comparable to Zietz's findings (1995)], followed by hypothesis 3, results being confirmed as shown in Figure 3.

Table 7: Error Correction Equation Results for Real and Fictitious Data

Estimated model: $\Delta s_{sem:t+1} = \lambda_0 + \lambda_1 \left(s_{sem:t} - \hat{\alpha}_0 - \hat{\alpha}_1 f_{sem:t-1,t} \right) + \lambda_2 \Delta f_{sem:t,t+1} + \lambda_3 \Delta f_{sem:t-1,t} + \lambda_4 \Delta s_{sem:t} + \xi_{t+1}$

Statistics	Real Data	Monte-Carlo Simulations					
		H. 1	H. 2	H. 3	H. 4	H. 5	H. 6
λ_o	0.0006	0.0008	0.0010	0.0009	0.0011	0.0007	0.0008
s.e.(λ_o)	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
t(λ_o)	1.2561	1.8965	2.5716	2.3671	3.0208	1.8665	2.2440
λ_1	-0.1206	-0.1326	-0.1733	-0.1410	-0.1373	-0.1403	-0.1451
s.e.(λ_1)	0.1821	0.1038	0.0318	0.0430	0.0193	0.0285	0.0233
t(λ_1)	-0.6621	-1.2769	-5.4435	-3.2774	-7.0993	-4.9165	-6.2283
λ_2	0.1846	0.1606	0.1441	0.1626	0.1728	0.1883	0.1801
s.e.(λ_2)	0.2160	0.0714	0.0173	0.0256	0.0147	0.0188	0.0165
t(λ_2)	0.8545	2.2487	8.3144	6.3492	11.7812	10.0407	10.9403
λ_3	0.0722	0.0832	-0.0149	0.0324	-0.0071	0.0319	0.0025
s.e.(λ_3)	0.0495	0.0403	0.0185	0.0254	0.0166	0.0210	0.0186
t(λ_3)	1.4603	2.0667	-0.8075	1.2775	-0.4281	1.5138	0.1363
λ_4	0.2267	0.2617	0.2888	0.2441	0.2048	0.2411	0.2223
s.e.(λ_4)	0.2298	0.0944	0.0453	0.0532	0.0434	0.0456	0.0445
t(λ4)	0.9865	2.7730	6.3785	4.5842	4.7234	5.2868	4.9918
R^2	0.1102	0.1233	0.2229	0.1780	0.3267	0.2779	0.3065
DW	2.0148	2.0191	2.0628	2.0603	2.0382	2.0693	2.0283
Q	5.8760	4.1255	14.8256	15.0536	11.5098	12.8065	12.8624
p-value(Q)	0.2086						
LM	8.8661	5.6332	16.6571	17.9592	12.7571	16.2886	15.1966
p-value(LM)	0.0645						
ARCH	58.6262	65.4645	70.6840	62.3275	30.4613	45.4703	30.3820
p-value(ARCH)	0.0000						
White	104.8199	129.9609	92.6678	79.2201	109.5424	76.7778	104.5011
p-value(White)	0.0000						
JB	175.7742	133.4022	151.8948	114.9149	116.9973	95.5578	111.9197
p-value(JB)	0.0000						
Chow	1.8973	1.7471	2.6037	2.7117	3.3340	1.6474	1.9892
p-value(Chow)	0.0936						

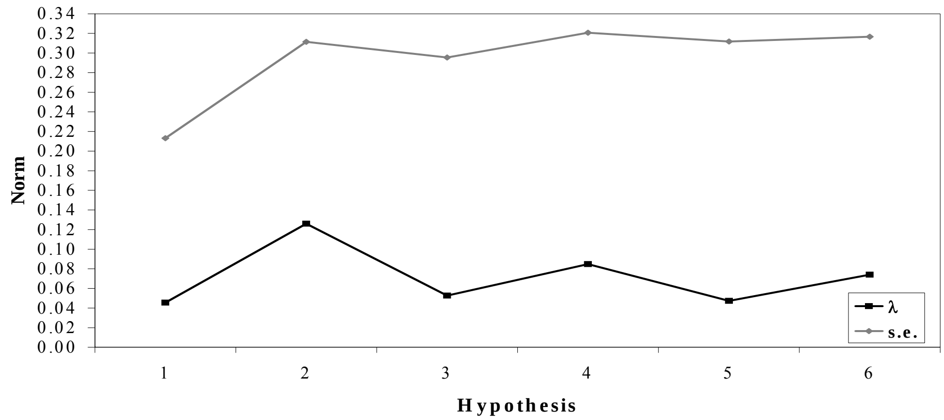
The cointegration coefficients for the real data were the same from Table 3

Table 8: Error Correction Equation Dispersion Measurements

Statistics	**Hypothesis**					
	1	**2**	**3**	**4**	**5**	**6**
Observed Bias						
λ_o	0.0002	0.0004	0.0003	0.0004	0.0001	0.0002
s.e.(λ_o)	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
t(λ_o)	0.6404	1.3155	1.1110	1.7647	0.6104	0.9879
λ_1	-0.0120	-0.0528	-0.0204	-0.0167	-0.0197	-0.0245
s.e.(λ_1)	-0.0783	-0.1502	-0.1391	-0.1628	-0.1536	-0.1588
t(λ_1)	-0.6148	-4.7814	-2.6153	-6.4372	-4.2544	-5.5662
λ_2	-0.0240	-0.0405	-0.0220	-0.0118	0.0037	-0.0045
s.e.(λ_2)	-0.1446	-0.1987	-0.1904	-0.2014	-0.1973	-0.1996
t(λ_2)	1.3942	7.4599	5.4947	10.9267	9.1862	10.0858
λ_3	0.0110	-0.0871	-0.0398	-0.0793	-0.0404	-0.0697
s.e.(λ_3)	-0.0092	-0.0310	-0.0241	-0.0329	-0.0284	-0.0309
t(λ_3)	0.6064	-2.2678	-0.1828	-1.8885	0.0535	-1.3240
λ_4	0.0351	0.0621	0.0174	-0.0219	0.0144	-0.0043
s.e.(λ_4)	-0.1354	-0.1845	-0.1765	-0.1864	-0.1842	-0.1852
t(λ4)	1.7865	5.3920	3.5977	3.7369	4.3003	4.0052
R^2	0.0131	0.1127	0.0678	0.2164	0.1676	0.1963
Observed MSE						
λ_o	3.72E-08**	1.24E-07	9.18E-08	1.98E-07	6.28E-09*	4.26E-08
s.e.(λ_o)	4.81E-09*	1.49E-08	1.20E-08**	2.21E-08	1.52E-08	1.72E-08
t(λ_o)	4.10E-01**	1.73E+00	1.23E+00	3.11E+00	3.73E-01*	9.76E-01
λ_1	1.44E-04*	2.79E-03	4.17E-04	2.80E-04**	3.89E-04	6.00E-04
s.e.(λ_1)	6.12E-03*	2.26E-02	1.93E-02**	2.65E-02	2.36E-02	2.52E-02
t(λ_1)	3.78E-01*	2.29E+01	6.84E+00**	4.14E+01	1.81E+01	3.10E+01
λ_2	5.77E-04	1.64E-03	4.85E-04	1.39E-04	1.38E-05*	2.06E-05**
s.e.(λ_2)	2.09E-02*	3.95E-02	3.63E-02**	4.06E-02	3.89E-02	3.98E-02
t(λ_2)	1.94E+00*	5.56E+01	3.02E+01**	1.19E+02	8.44E+01	1.02E+02
λ_3	1.21E-04*	7.59E-03	1.58E-03**	6.29E-03	1.63E-03	4.86E-03
s.e.(λ_3)	8.43E-05*	9.61E-04	5.79E-04**	1.08E-03	8.08E-04	9.52E-04
t(λ_3)	3.68E-01	5.14E+00	3.34E-02**	3.57E+00	2.86E-03*	1.75E+00
λ_4	1.23E-03	3.86E-03	3.02E-04	4.78E-04	2.08E-04**	1.86E-05*
s.e.(λ_4)	1.83E-02*	3.40E-02	3.12E-02**	3.47E-02	3.39E-02	3.43E-02
t(λ4)	3.19E+00*	2.91E+01	1.29E+01**	1.40E+01	1.85E+01	1.60E+01
R^2	1.71E-04*	1.27E-02	4.59E-03**	4.68E-02	2.81E-02	3.85E-02

* Lowest MSE
** Second lowest MSE

Figure 3: Error Correction Equation Coefficients Norm and their Respective Standard Errors



Source: Authors' calculations

FINAL COMMENTS

After analyzing, using Monte-Carlo simulations, weekly expectations and equilibrium conditions for the Colombian exchange market, evidence indicated that agents tended to be risk-neutral and had equally static and rational expectations. These findings confirm those of Zietz (1995) with monthly data for the US dollar – German mark exchange market and differ from those found with surveys by Jeong & Maddala (1991) and Cavaglia *et al*. (1994).

The results implied that the agents gave preponderance to both the present behavior of the spot exchange rate but also to events, which might affect it in future short-term periods, such as a week. However, as we analyzed just six possibilities, then others should be analyzed, especially those referring to equilibrium, as well using other techniques involving a more detailed analysis of the agents and capturing their differences (i.e. interrelationships).

Bias in prediction caused by risk premiums and transaction costs were not relevant for price formation. This could have been associated with the exchange rate up to September 1999 (exchange bands) and the later reduction of exchange pressure when the brake on inflation was imposed (increasing monetary authority credibility) in the floating exchange regime, thereby providing for a relatively stable exchange rate behavior for the period being analyzed. Regarding transaction costs, the composition of the assets portfolio (in the presence of a diversity of options) allowed costs to become diluted amongst the differing ways to invest in the financial market.

Although this study's objective was not to verify the Market Efficiency Hypothesis, the results obtained suggested that agents do not need a great amount of information to form their weekly expectations about future spot exchange rates and are risk-neutral. This could have resulted from the Colombian exchange market not being very dynamic and the limited number of agents who participate in the market. Future research might examine data with different observation frequencies. Doing so will allow the researchers to identify the role of changes in expectations.

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