PRICE TRANSMISSION DYNAMICS BETWEEN ADRs AND THEIR UNDERLYING FOREIGN SECURITY: THE CASE OF BANCO DE COLOMBIA S.A.- BANCOLOMBIA

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ABSTRACT

This paper analyzes the dynamics of the American Depositary Receipt (ADR) of a Colombian bank (Bancolombia) in relation to its pricing factors (underlying (preferred) shares price, exchange rate and the US market index). The aim is to test if there is a long-term relation among these variables that would imply predictability. One cointegrating relation is found allowing the use of a vector error correction model to examine the transmission of shocks to the underlying prices, the exchange rate, and the US market index. The main finding of this paper is that in the short run, the underlying share price seems to adjust after changes in the ADR price, pointing to the fact that the NYSE (trading market for the ADR) leads the Colombian market. However, in the long run, both, the underlying share price and the ADR price, adjust to changes in one another.

KEYWORDS

American Depositary Receipts, stationarity (unit root) tests, cointegration, vector error correction model, impulse response functions, forecast error variance decomposition

Classification: JEL: C32, G15 - COL: A.

I. INTRODUCTION

I.A. Bancolombia S.A.

Bancolombia (hereinafter 'BC') is domiciled in Colombia and operates under Colombian laws and regulations as a «sociedad comercial por acciones, de la especie anónima».

The Bank provides general banking products and services to companies and individuals. It has two main segments: retail and corporate. The products and services include depositary services, personal and corporate loans, credit and debit cards, electronic banking, cash management, warehousing services, fiduciary and custodial services, and dollar-denominated products. In addition, BC's customers have access to a large network of branches and ATMs in Colombia. BC believes that it has the largest service network of any private financial institution in Colombia, with 377 branch offices operating in 127 cities as of December 31, 2004.[1]

Since 1995, BC is a New York Stock Exchange, Inc. («NYSE») listed company and its American Depositary Shares[2] («ADSs») are traded under the symbol «CIB».

I.B. The ADSs

BC is a New York Stock Exchange, Inc. («NYSE») listed company, where its ADSs are listed under the symbol «CIB». This ADS is a Level III ADS (the highest level), meaning that these Receipts are sold in a Public Offering. The issuers register the offering under the 1933 Securities Act and report under the 1934 Exchange Act. Sponsored Level-III Depositary Receipts (like BC's) are listed on U.S. Exchange. Furthermore, BC must reconcile to U.S. GAAP and meet listing requirements of the U.S. Exchange on which it chose to list («NYSE»). The Depositary shares are registered on Form F-6, the deposited shares are registered on Form F-1 and the company registers on Form 20-F.

ADRs[3] evidencing ADSs are issuable by The Bank of New York, as Depositary, pursuant to the Deposit Agreement, dated as of July 25, 1995.

BC's ADRs, each of which represents the right to receive four Preferred Shares deposited in Colombia with the Custodian under the Deposit Agreement, have been listed on the NYSE since July 1995. The Preferred Shares have been listed on the Colombian Stock Exchange since July 1995. Through the ADRs, the NYSE is the principal U.S. trading market for the Preferred Shares.

Finally, to gain a clearer perspective of the ADR, a monthly trading summary and a graph of the prices (in US dollars) of the ADR (listed in New York) and the conversion value in US dollars of the Preferred Shares listed in the Colombian Stock Exchange are presented in Table 1 and Figure 1 respectively.

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1. See www.bancolombia.com
2. An American Depositary Share («ADS») is a U.S. dollar denominated form of equity ownership in a non-U.S. company. It represents the foreign shares of the company held on deposit by a custodian bank in the company's home country and carries the corporate and economic rights of the foreign shares, subject to the terms specified on the ADR certificate. See http://www.adr.com
3. An American Depositary Receipt («ADR») is a physical certificate evidencing ownership in one or several ADSs. In this paper, both terms (ADS and ADR) are used interchangeably.

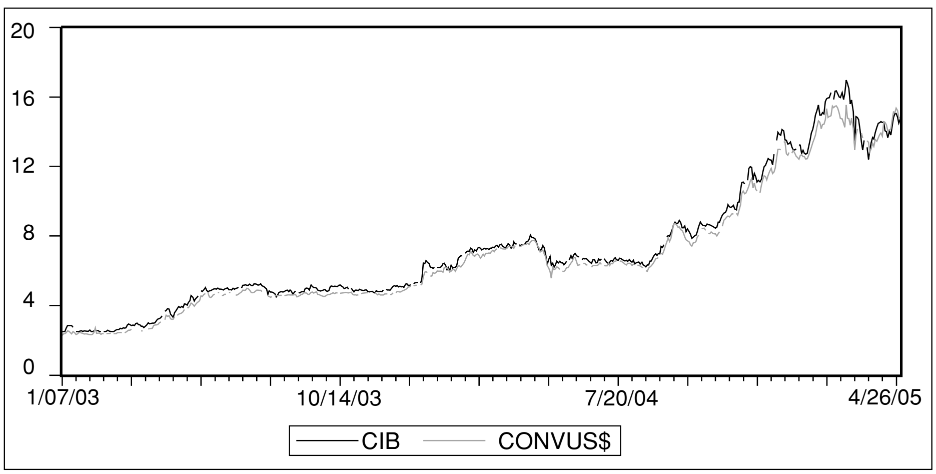
Table I. Monthly ADR Trading Summary: BC Preferred Shares.

Symbol: CIB; **CUSIP:** 05968L102; **Exchange:** NYSE; **DR TYPE:** Level III

Month	Month-End DR Price	DR Trading Volume	Avg. DR Closing Price	DR $ Trading Vol	Avg/Day DR Trading Vol	Avg/Day DR $ Trading Vol
▶Apr. 05	14.77	2,387,500	14.34	34,198,015	113,690	1,628,477
▶Mar. 05	13.36	7,906,600	14.74	116,423,032	359,391	5,291,956
▶Feb. 05	16.01	5,462,000	15.52	84,685,234	287,474	4,457,118
▶Jan. 05	13.92	3,721,700	13.20	49,234,590	177,224	2,344,504
▶Dec. 04	14.12	3,962,200	12.27	48,102,389	172,270	2,091,408
▶Nov. 04	11.99	4,178,800	10.13	44,116,764	198,990	2,100,798
▶Oct. 04	8.79	2,949,900	8.48	24,942,964	140,471	1,187,760
▶Sep. 04	8.10	2,988,300	8.28	24,950,817	142,300	1,188,134
▶Aug. 04	6.97	1,098,600	6.57	7,288,322	49,936	331,287
▶Jul. 04	6.65	749,900	6.60	4,945,083	35,710	235,480
▶Jun. 04	6.68	664,300	6.68	4,491,507	30,195	204,159
▶May. 04	6.54	2,219,200	6.65	14,829,037	110,960	741,452

Source: Bank of New York.

Figure 1. BC's ADR price (CIB) and conversion value (Pref US$).



Source: Economatica

Note. Conversion value = 4 x (Price of Preferred shares in Col. Pesos) x ($/ peso exchange rate).

Looking at Figure 1 which compares the conversion value (in US dollars) of the Preferred Shares listed in the Colombian Stock Exchange versus the value of the ADR (in US dollars), one can fairly say that the Law of One Price holds, and that both series may share a long term relation. Moreover, this positive evolution of the prices of both, the preferred shares trading in Colombia and the ADRs in New York, has coincided with a significant advance in Colombia's stock exchange index.

Taking into account these issues, mainly, the positive evolution of both price and volume of the ADRs and their close relation with the preferred shares in Colombia, the aim of this paper is to analyze the dynamics of the ADR and its pricing factors identified in the literature (preferred shares price, exchange rate and the US market index), to see if there is a co-integrating relationship among these variables that would indicate predictability. This would allow the use of multivariate models to examine through impulse response functions and variance decomposition techniques, how three different shocks (in the underlying prices, the exchange rate, and the US index) are transmitted to the price of the ADR.

This paper has been organized as follows: Section II is devoted initially to the description of the data and the methodology; the tests, models and analytic tools (e.g. impulse response functions, forecast error variance decomposition) used to analyze price transmission dynamics between ADRs and their underlying (preferred) shares in Colombia. Section III attempts to analyze the outcomes, by explaining in depth the output of the tests and models, supported on existing literature on the area. Finally, section IV provides concluding remarks. Further sections include references and appendices.

II DATA AND METHODOLOGY

II.A. Data

Daily closing prices of the ADR (hereinafter «CIB») and the preferred shares traded in Colombia (hereinafter «UND») come from Economatica. If there are stock splits or stock dividends, the prices are accordingly adjusted. The daily spot exchange rate against the US dollar (hereinafter «COL/US»), was obtained from Economatica, as well as closing values of the Dow Jones Industrials index (hereinafter «DJI»). DJI is used as a measure of general movements of the US stock market.[4]

The sample for all the above variables covers data from January 7th, 2003 to April 29th, 2005 for a total of 530 daily observations. The estimation of the model was performed using Eviews 3.1.

After a closer look of the daily data, it was suitable to work with data starting from 2003; since the problem of data availability for previous years was acute (e.g. no price was available for the underlying traded in the Colombian market for long periods).

4. For a plot of the variables in returns see appendix 1.

This problem was very evident for the years 1999 - 2001.

II.B. Methodology

First, a test to decide whether CIB, UND, COLUS, and the DJI index are stationary (all series in logarithms, denoted by «l») is performed. Broadly speaking, a series is deemed stationary if it has a constant mean, constant variance and constant autocovariances for any given lag. The Augmented Dickey Fuller (ADF) test is used to test for unit roots (stationarity) in the time series. The lag length is selected using the Schwartz information criterion. In the test equation, two specifications are considered. The first specification includes only an intercept, and the second, includes both a trend and an intercept. A test for a unit root in the first difference of the l series is also conducted (in other words, the logarithmic returns denoted by «r»).

If, as expected, each variable in logs is integrated of order one, I(1), then the next step would be to test for cointegration (existence of a long term relation) among the variables, using the test specification provided by Johansen.[5] The test is designed to test for the number of linearly independent cointegrating vectors, existing among the variables. Five specifications of the cointegration test under different assumptions about the intercept and the trend using a sufficient number of lags for the endogenous differenced variable (1 to 5) are estimated. The best model is the one minimizing the Schwartz information criterion.

Then, the model (variables in logs) is run to find the number of cointegrating equations at a 5% significance level. The test statistics for cointegration is formulated as follows:

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i) \qquad (1)$$

Where $\hat{\lambda}_i$ is the estimated value for the ith ordered eigenvalue from the π matrix,[6] and:

- λ_{trace} tests the null that the number of cointegrating vectors is less than or equal to r against an unspecified alternative. λ_{trace} equals zero when all the $\lambda_i = 0$, so it is a joint test.

If, as expected, a cointegrating relation is found, a vector error correction model (VECM) is estimated. This estimation is used to calculate the impulse response function (IRF) of the VECM system. The IRF traces the impact of a shock in a variable onto the system, over a time period (in this case 10 days). Thus, it is possible to measure how rapidly information is transmitted across different markets. More specifically, an impulse response function traces the effect of a one standard deviation shock to one of the innovations (error terms) and its im-

5. See Brooks, Chris (2002).

6. The Johansen test is computed using the following VAR model: $\Delta yt = \mathbf{\Pi}\, yt\text{-}k + \mathbf{\Gamma}1\, \Delta yt\text{-}1 + \mathbf{\Gamma}2 \Delta yt\text{-}2 + \ldots + \mathbf{\Gamma}k\text{-}1\, \Delta yt\text{-}(k\text{-}1) + ut$. The $\mathbf{\Pi}$ matrix is a gxg square matrix. The test for cointegration between the *y*'s is calculated by looking at the rank of the Π matrix via its eigenvalues.

pact on current and future values of the endogenous variables (RCIB, RUND, RCOLUS and RDJI).

While impulse response functions trace the effects of a shock to one endogenous variable onto the other variables in the VECM, variance decomposition separates the variation in an endogenous variable into the component shocks of the model. Thus, variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VECM. For instance, variance decompositions seek to determine what proportions of the changes in CIB's (forecasted) returns, can be attributed to changes in the lagged explanatory variables (RUND, RCOLUS and RDJI).

III. RESULTS

III.A. Stationarity tests

In order to check for stationarity on the variables, both in levels (l) as well as in first differences (r), ADF tests[7] were conducted. According to the Schwartz information criterion, the appropriate lag for the test was chosen. Two specifications were used regarding the exogenous variables for the test: one considering only a constant and the second one including a constant and a linear trend. Both specifications leaded to the same conclusions.

Table II reports the results for the ADR, the underlying shares, the DJI index and the exchange rate for the whole sample.

Table II. Stationarity tests - Augmented Dickey - Fuller (ADF) unit root tests.

Variable	Specification	ADF test statistic	Critical value (5%)
LCIB	Constant	-1.14	-2.87
LCIB	Constant and linear trend	-2.57	-3.42
RCIB	Constant	**-17.33** (*)	-2.87
RCIB	Constant and linear trend	**-17.32** (*)	-3.42
LUND	Constant	-1.36	-2.87
LUND	Constant and linear trend	-2.05	-3.42
RUND	Constant	**-21.47**(*)	-2.87
RUND	Constant and linear trend	**-21.46** (*)	-3.42
LCOLUS	Constant	-0.07	-2.87
LCOLUS	Constant and linear trend	-2.31	-3.42
RCOLUS	Constant	**-19.76** (*)	-2.87
RCOLUS	Constant and linear trend	**-19.75** (*)	-3.42
LDJI	Constant	-1.13	-2.87
LDJI	Constant and linear trend	-1.49	-3.42
RDJI	Constant	**-25.91** (*)	-2.87
RDJI	Constant and linear trend	**-25.89** (*)	-3.42

(*) Significant at 5%.

7. Phillips-Perron tests were also conducted to check the order of integration of the variables. They leaded to the same conclusions. Tests' results are available from the author upon request.

From the table, it is clear that all the variables in levels are not stationary, since the ADF test statistics (in absolute value) are below the critical values at a 5% significance level. However, after differencing (once) all the variables (see bold) are stationary. In short, all the variables in log-levels are integrated of order 1 and their returns are I(0).

Hence, the results show that the ADRs and their corresponding foreign shares tend to have similar temporal properties. The results for the DJI and the Colombian exchange rate in levels also show that they are I(1), in line with previous studies.

III.B. Johansen's cointegration test

Johansen's cointegration test is a useful method to check the existence of a long term relationship among the four variables of interest. Initially, a lag interval from 1 to 1 up to 5 lags (1 week) was used to determine the order of the VAR (vector autoregressive model). The lag interval 1 to 1 minimized the Schwartz criterion. Moreover, among the 5 different specifications of the test (e.g no intercept or trend in the cointegrating equation; intercept, no trend; etc), the best specification was the simplest one, a model without intercept and trend. Table III shows the results for the number of cointegrating relationship using the trace eigenvalues.

Table III. Johansen's cointegration test - Number of cointegrating relations.

Rank / Number of cointegrating equations	Trace statistic	
None	75.50 (*)	(39.89)
At most 1	17.99	(24.31)
At most 2	4.27	(12.53)
At most 3	0.007	(3.84)

Note: (*) Denotes rejection of the hypothesis at the 5% level. 5% critical values in parentheses.

In sum, the trace test indicates that for all the variables, there exists at least one cointegrating relationship at the 5% significance level.[8]

III.C. Vector error correction model

Given the results in the last section, a vector error correction model that includes one cointegrating equation (upper part of the table) is the next step in the analysis.

8. To confirm the previous results, the cointegrating residuals were analyzed to check their stationarity. Under different specifications and lags using the Augmented Dickey Fuller tests, one can reject the hypothesis of the existence of a unit root. In consequence, the cointegrating residuals are stationary (see appendix 2). Results of the tests are available from the author upon request.

Table IV. Vector Error Correction Model (VECM) Estimates.

Sample(adjusted): 1/09/2003 4/29/2005
Included observations: 408 after adjusting endpoints
Standard errors & t-statistics in ( )

Cointegrating Eq:	LCIB(-1)	LUND(-1)	LCOLUS(-1)	LDJI(-1)
CointEq1	1.000000	-1.046776	0.733342	0.115170
		(0.02915)	(0.07611)	(0.09064)
		(-35.9119*)	(9.63573*)	(1.27061)
Error Correction:	RCIB	RUND	RCOLUS	RDJI
CointEq1	-0.131826	0.138635	-0.002065	0.003209
	(0.04222)	(0.03580)	(0.00777)	(0.01432)
	(**-3.12258***)	(**3.87277***)	(-0.26555)	(0.22401)
RCIB(-1)	-0.009732	0.091314	-0.004437	-0.029406
	(0.06177)	(0.05238)	(0.01138)	(0.02096)
	(-0.15754)	(1.74338)	(-0.38999)	(-1.40300)
RUND(-1)	0.009210	-0.066258	-0.013972	0.037235
	(0.06692)	(0.05674)	(0.01232)	(0.02271)
	(0.13763)	(-1.16770)	(-1.13370)	(1.63990)
RCOLUS(-1)	-0.338691	0.020935	0.148195	-0.049270
	(0.26997)	(0.22892)	(0.04972)	(0.09160)
	(-1.25455)	(0.09145)	(2.98067*)	(-0.53786)
RDJI(-1)	0.528363	0.103581	-0.070831	-0.072895
	(0.14795)	(0.12546)	(0.02725)	(0.05020)
	(3.57112*)	(0.82564)	(-2.59952*)	(-1.45201)
C	0.003103	0.002572	-0.000137	-2.36E-05
	(0.00122)	(0.00104)	(0.00023)	(0.00042)
	(2.53410*)	(2.47773*)	(-0.60854)	(-0.05688)
R-squared	0.058883	0.069357	0.054230	0.014192
F-statistic	5.030408	5.991868	4.610132	1.157450
Log likelihood	939.6464	1006.945	1629.954	1380.628

*Significant at 5% significance level.

From the cointegrating equation (first row of the table), one can notice that 2 of the coefficients are significant (those for lagged values of LUND and LCOLUS). Moreover, checking below the coefficients of RCIB and RUND in the error correction model and its significance (see t-statistics in bold), it is evident that in the long run, both the ADR and the underlying shares, adjust to changes in their long term relation (represented by the cointegrating equation).

For instance, the positive coefficient[9] (0.138635) of the cointegrating relation in the RUND equation means that the return of the underlying goes up when the cointegrating equation shows positive values (direct relationship). In other words, when $LCIB_{(-1)}$ is above the combination of $LUND_{(-1)}$, $LCOLUS_{(-1)}$ and $LDJI_{(-1)}$, included in the cointegrating equation.

This makes sense since ones expects, in the long run, that increases in the ADR levels should induce increases in UND returns and viceversa. But in the short run, the returns on the ADR seem to lead the returns on the underlying (see underlined coefficient).[10] In consequence, the underlying returns seem to adjust after changes in the ADR's returns in the short term.

Granger causality tests support this assertion. These tests are useful in measuring the predictive ability of time series models. A time series Yt Granger causes another time series Xt if present values of Xt can be better predicted by including past values (among other variables, e.g. past Xt values) of Yt instead of not doing so. More formally, Y Granger causes X,[11] provided some a_i is not zero in equation 2:

$$X_t = c_0 + \sum_{i=l}^{m} a_i Y_{t-i} + \sum_{j=l}^{m} b_j X_{t-j} + e_t \quad (2)$$

An F-test is used to prove the existence of causality. The F-test is calculated by estimating the above equation in both unconstrained and constrained forms [(full and reduced (omitting past values of Y_t)].

$$F_1 = \frac{(SSE_r - SSE_f) / \mathrm{m}}{SSE_f / (T - 2m - 1)} \qquad (3)$$

Where SSE_r and SSE_f represent the residual sum of squares of the reduced and full models respectively. T stands for the number of observations and m for the number lags. The number of lags used in the test was set equal to five days (1 week); a reasonable time over which one of the variables could help predict the other. The F-statistic follows a X^2/m distribution and it is equivalent to a Wald test. Table V show the results of the causality tests for the variables in the VECM.

9. In a vector error correction model, the coefficients of the cointegrating equation represent long-term adjustment coefficients while those of the other variables (RCIB(-1), RUND(-1), RCOLUS(-1), RDJI(-1) and C) represent short-term adjustment coefficients.

10. Though significant at a 10% significance level. Also notice that lagged values of RUND don't have (coefficient equal to 0.009210) a statistically significant power explaining RCIB.

11. To test if X Granger causes Y a similar test is conducted. If one finds that both Y causes X and Y causes X, there is feedback.

Table V. Granger causality tests.

Pairwise Granger Causality Tests
Sample: 1/07/2003 4/29/2005
Lags: 5

Null Hypothesis:	Obs	F-Statistic	Probability
RUND does not Granger Cause RCIB	230	0.81159	0.54249
RCIB does not Granger Cause RUND		2.26061 (*)	0.04951
RCOLUS does not Granger Cause RCIB	403	1.22886	0.29472
RCIB does not Granger Cause RCOLUS		1.71692	0.12961
RDJI does not Granger Cause RCIB	446	2.71557 (*)	0.01978
RCIB does not Granger Cause RDJI		0.68044	0.63847
RCOLUS does not Granger Cause RUND	311	1.62952	0.15194
RUND does not Granger Cause RCOLUS		1.00764	0.41329
RDJI does not Granger Cause RUND	237	1.38301	0.23154
RUND does not Granger Cause RDJI		0.18238	0.96904
RDJI does not Granger Cause RCOLUS	410	1.18752	0.31448
RCOLUS does not Granger Cause RDJI		0.23873	0.94523

(*) Significant at 5% level

The test suggests that Granger causality runs one - way (no feedback) from RCIB to RUND and not the other way. Moreover, analyzing the trading volume of the ADR and the underlying shares, one finds that during the sample period, an average of 269.000 preferred shares were traded daily in Colombia, and an average of 109.000 ADRs were traded in New York. However, since an ADR represents 4 preferred shares, the trading in New York would be equivalent to the trading of 436.000 preferred shares. In consequence, trading volume in the NYSE is far larger (62%) and that market, at least in the short run, becomes the primary market where price discovery occurs.

In addition, there is evidence of causality from the Dow Jones index to the ADR in the sense that changes in the index returns precede (and significantly help to explain) changes in the ADR.

Accordingly, given the nature of the short term adjustment as seen in the VECM and causality tests, the NYSE becomes the dominant market for determining prices in the short run. This is in line with Howe *et al.* (2001) findings for the case of ADRs of 35 countries. Basically, they tried to determine where prices are discovered and where the information is processed (in the ADR market or the underlying security market) through the analysis of volatility in certain moments of the trading day. In particular, they argue that differences in the opening volatility of the ADR and increases (or decreases) in volatility of the ADRs after the underlying market closes, help to understand which market is dominant and by and large, how the flow of information is disseminated.

The authors argue that if a dominant market for trading ADRs exists, then the market where the underlying asset is traded may be dominant during periods when both markets are open. In this case, when trading in the underlying asset closes (in our case at noon in Colombia), an increase in volatility in the ADRs would reflect a shift in dominance to the NYSE from the underlying asset's market.

Alternatively, the NYSE may be dominant before the underlying market closes. In that case there will be no increase in volatility at the close of the underlying market.

They test two hypotheses. In our case, the relevant hypothesis is hypothesis 2:[12]

- H2: Volatility of ADR returns will not change when the underlying asset's market closes.

The authors couldn't reject H2, suggesting that the NYSE has already become the dominant market during periods of concurrent trading in the ADR and the underlying asset. Furthermore, the NYSE is also dominant during periods in which the underlying market is closed.[13]

To gain further understanding of the adjustment of the variables to shocks of all the variables in the system, impulse response functions and forecast errors variance decompositions are estimated.

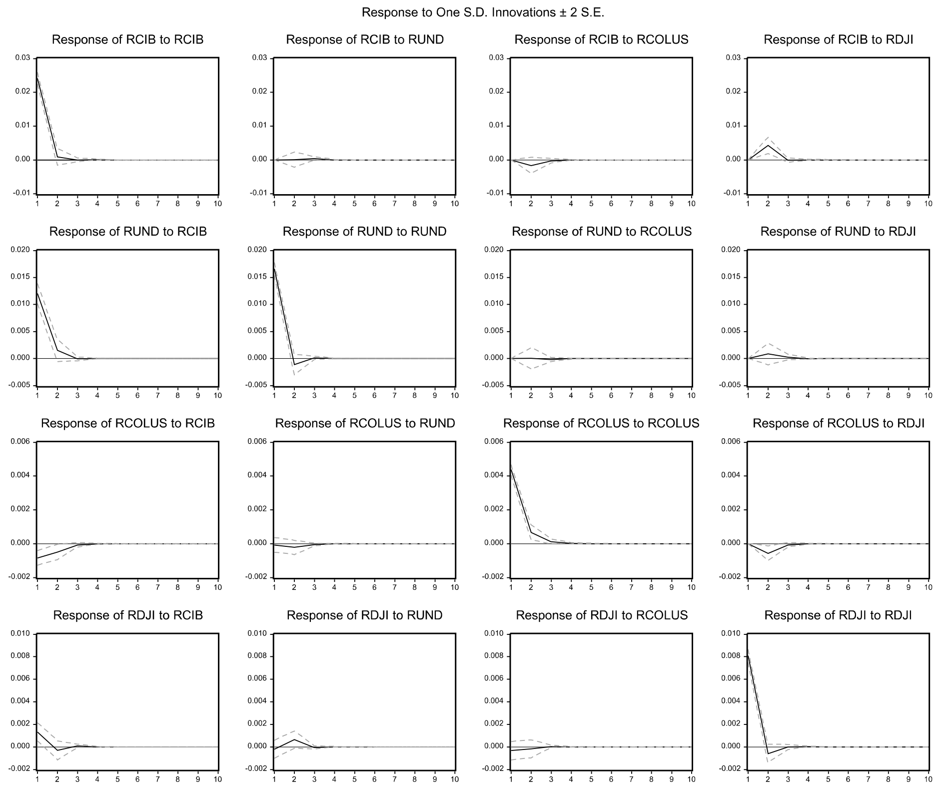
III.D. Impulse response functions

Since VECM models may be difficult to interpret, impulse response functions and variance decompositions are analyzed. Impulse response functions trace the effect and persistence of one market's shock to other markets, which tells us how fast information transmits across markets. These responses are the time paths of one or more variables, as a function of a one-time shock, to a given variable or set of variables. Impulse responses are the dynamic equivalents of elasticities.[14]

In our dynamic system, changes in CIB returns are a function of, for instance, changes in the underlying shares return (innovations) over two weeks (10 trading days). Figure 2 reports the impulse responses for the ADR to a unit innovation (standard deviation) in corresponding underlying shares prices, exchange rate against the US dollar, and the DJI index. Figure 2 also shows 95% confidence interval of the impulse response functions (dotted lines). The analysis of the impulse response functions will follow Runkle's[15] criticism, in that providing impulse response functions without confidence intervals, is equivalent to using regression coefficients without t-statistics. In this sense, if the impulse response confidence interval contains the value of zero, even though the point estimate is different from zero, it is very likely that the impulse response function is not financially or statistically significant.

12. Since during part of the year (non-saving daylight times), the NYSE and Bogotá's Stock Exchange open at the same time.
13. The NYSE always closes after the Colombian Stock exchange.
14. Ribeiro Ramos, Francisco Fernando (2003).
15. Runkle, David E. (1987).

Figure 2. Impulse response functions of the variables to a one standard deviation shock.



The first two rows[16] of graphs show the response of the ADR and the underlying to one standard deviation shocks to the variables in the system. The effect of shocks in the variables themselves materializes 1 day later and the effect of shocks in other variables is felt two days later. In general, all the effect of innovations vanishes after 3 or 4 days.

Looking at the first row, only the shocks of the ADR itself cause a (positive) response one day ahead. And surprisingly, shocks of the DJI (2 days ahead), have a statistically significant effect (the confidence interval does not include the value zero). The responses of the ADR to innovations in the US market are null in the first day ahead, positive and significant 2 days ahead and then collapse to zero in day 3 and afterwards.

The magnitude of the impulse response (point estimate) due to currency shocks (RCOLUS), is slightly larger (in absolute terms and with the expected sign) compared to that of the underlying shares' shocks. Responses after currency shocks vanish 4 days later.

16. The third and fourth rows of graphs are shown merely for illustration purposes.

This higher magnitude could be explained following Bin et. al (2003) whose findings suggest «that when the corresponding currency appreciates unexpectedly, the values of ADR-originating foreign firms also appreciate via joint effects on both earnings prospects and currency translation gains. Therefore, US investors expect a higher rate of return on ADRs».

Furthermore, looking at the impulse response functions of the underlying shares to shocks in other variables (second row), one can notice that the underlying shares adjust to changes (in a positive fashion) in the ADRs. This response is statistically significant one day ahead. Three days later, the effect of the shock disappears. In a similar fashion, the UND responds to shocks in itself and this response is different one (positive) and two (negative, though not statistically significant) days ahead. Finally, as expected, innovations in the exchange rate and the US market don't have an impact in the underlying returns.

III.E. Forecast error variance decomposition

Variance decompositions give the proportion of the h-periods-ahead forecast error variance of a variable that can be attributed to another variable. The pattern of the variance decomposition also indicates the nature of Granger causality among the variables in the system, and, as such, can be very valuable in making at least a limited transition from forecasting to understanding.[17]

Table VI presents the decomposition of forecast error variance from the four-variable VECM. These decompositions show similar patterns when compared with the impulse response functions previously analyzed.

Table VI. Decomposition (%) of 1, 2 and 5 days ahead forecast error variance.

	Variables	By innovations in:			
Days	**explained**	**ADR**	**UND**	**COLUS**	**DJI**
	ADR	100	0	0	0
1	UND	34.38554	65.61446	0	0
	COLUS	3.603146	0.028841	96.36801	0
	DJI	2.601606	0.072433	0.176635	97.14933
	Variables	**By innovations in:**			
Days	**explained**	**ADR**	**UND**	**COLUS**	**DJI**
	ADR	96.53304	0.000632	0.455907	3.010421
2	UND	34.58804	65.24601	0.000733	0.16521
	COLUS	4.586177	0.275157	93.56929	1.569376
	DJI	2.715995	0.668701	0.227388	96.38792
	Variables	**By innovations in:**			
Days	**explained**	**ADR**	**UND**	**COLUS**	**DJI**
	ADR	96.48785	0.027535	0.471779	3.012841
5	UND	34.57928	65.23227	0.006881	0.181571
	COLUS	4.608286	0.294298	93.50356	1.59386
	DJI	2.72465	0.677721	0.228852	96.36878

17. Ribeiro Ramos, Francisco Fernando (2003).

Each number in the table denotes the percentage of 1, 2 and 5-days ahead forecast error variance of the left-hand side variables explained by innovations in the variables on the top. Among the four variables in the VAR system, the ADR, the Dow Jones Index and the exchange rate, turned out to be most exogenous in that most of their forecast error variances is explained by their own innovations (approximately 95%). For example, ADR innovations account for 96.49% of its own 5-days ahead forecast error variance, and innovations in the Colombian peso explain 93.50% of its own 5-days ahead variance.

Innovations from the underlying shares, explain the lowest portion of innovations in the corresponding ADR; 0%, 0.000632% and 0.027535% for the 1, 5 and 10 days forecast error variance respectively. In addition, the impact of innovations in the currency market is relatively small (less than 1%) with a slightly increasing pattern. In line with the findings in the previous section, the Dow Jones index plays a part in explaining roughly 3% of the forecast error variance decomposition of the ADR returns. This coincides with Suh's findings (2003). He computes an index of weekly premiums[18] (PDI) as the arithmetic average of premiums or discounts of the ADRs in and its weekly changes (Δ PDI) in a sample of ADRs from emerging markets. Then, he conducts a regression analysis of the form:

$$\Delta PD_t = \boldsymbol{\alpha} + \sum_{j=-l}^{+l} ß_j FMR_{t+j} + \sum_{j=-l}^{+l} \gamma_j \Delta e_{t+j} + vUSMR_t + \varepsilon_t \qquad (4)$$

Where **Δ**PDt is the change in the ADR premium, FMRt-1, FMRt, and FMRt+1 are the lagged, contemporaneous and leading returns on the foreign market index return. Δet-1, Δet, Δet+1 are the lagged, contemporaneous, and leading returns on the exchange rate between the U.S. dollar and the foreign currency, respectively. USMRt is the return on the U.S. market index. The coefficient of interest is v, which is positive and statistically significant. This indicates that premium movements are associated with U.S. market index returns, after controlling for several factors. By and large, this proves that ADRs are not exactly foreign shares as commonly thought, since prices are formed reflecting U.S. market sentiment.

Finally, concentrating in the underlying forecast error variance decomposition, one sees that innovations in CIB explain one third of that variance, a larger share than CIB's forecast error variance explained by innovations in UND.

18. The premium is equivalent to the (positive) difference between the ADR price and its conversion value. When the difference is negative, it is said that ADRs trade at a discount.

IV. CONCLUSION

The findings of this paper support the idea that the ADR, underlying shares, exchange rate and SP500 share one long-term relation (cointegrating relation) in which the underlying share price, in the short run, adjusts after changes in the ADR. This confirms findings by other authors that argue that the NYSE becomes the dominant market, both when the underlying shares and the ADRs trade together, and when the ADR trades alone (after the underlying shares' market closes). Nonetheless, in the long run, both series influence one another.

Analyzing impulse response functions, I found that currency shocks tend to have a greater impact than the underlying shares in affecting the ADRs returns. Thus, it provides further evidence that the NYSE and foreign investors have a big say in determining prices in ADR and underlying shares' markets. These functions also reconfirm that UND adjusts to changes in CIB, since shocks in CIB have a larger impact in the underlying, rather than the other way. The forecast error variance decomposition analysis shows a similar picture, since CIB has predictive power in explaining/ forecasting UND (almost one third of the forecast error variance).

Finally, as an extension of this paper, it would be worthwhile to test if (statistically significant) excess returns (relative to a buy and hold strategy) could be obtained following a trading rule that uses the predicted ADR and UND returns from the VECM. For instance, following a trading rule that suggests taking a long position in the ADR or UND, when the predicted returns are positive and earning the risk free rate, when the predicted returns are negative.

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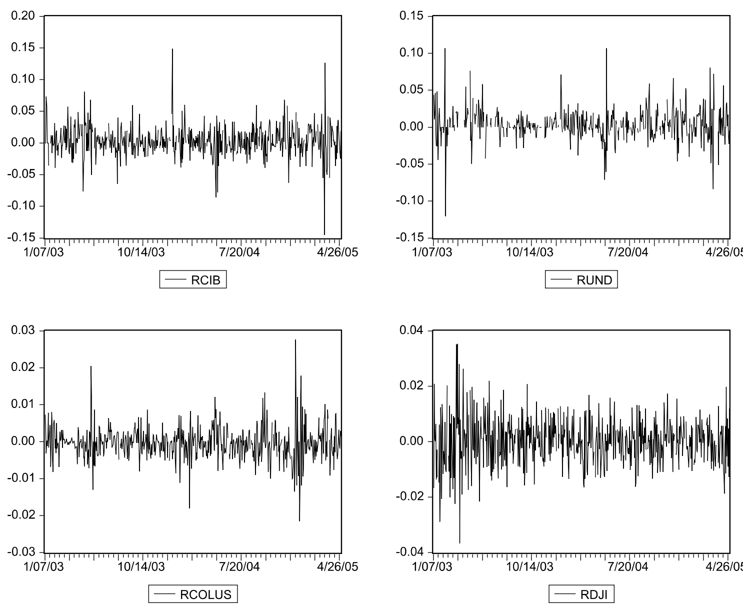
VI. APPENDICES

VIA Appendix 1 - Plot of the variables in returns



VIB Appendix 2 - Cointegrating residuals