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Causality and Cointegration in Stock Markets: The Case of Latin America*

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Abstract

This paper analyzes causality and cointegration relationships among stock markets for Latin America and the United States. Within a simple framework causality and cointegration is tested for Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela and the US. We found no evidence of cointegration among these stock markets but short-run causality could not be rejected. Furthermore, we use impulse response functions to analyze the relative impact of shocks in the US stock index (Dow Jones) on Latin American indexes. Evidence suggests that the responses differ significantly among these countries. These findings imply that there are valuable opportunities to international investors from diversifying in US and Latin American stocks.

JEL Classification: G15
Keywords: Cointegration; Causality Test; Latin America; Impulse Response Function; Stock Market.

Resumo

Este artigo analisa relações de causalidade e cointegração entre mercados acionários para América Latina e Estados Unidos. Em um arcabouço analítico simples causalidade e cointegração é testado para Argentina, Brasil, Chile, Colômbia, Meéxico, Peru, Venezuela e US. Encontramos evidência de que não há cointegração entre estes países mas causalidade de curto prazo não pode ser rejeitada. Ainda, usamos funções reposta impulso para analisar os impactos relativos de índice americano (Dow Jones) sobre índices latino-americanos. A evidência sugere que as respostas diferem significativamente entre países. Estes resultados implicam que existem oportunidades para investidores internacionais diversificarem em ações americanas e latino-americanas.

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1. Introduction

From modern portfolio theory it is well known by academics and practitioners that diversification pays. By investing in their home country investors are bearing country risk which could be diversified away by investing in different countries. International investors are indeed seeking profitable opportunities in different countries and the benefits from international diversification. Moreover, international financial assets could represent opportunities not duplicated in an investor's home country.

The extraordinary expansion of Latin American stock markets in the 1990s brought the attention to these stock markets which indeed have received billions of dollars of portfolio inflows in the past decade. These stock markets may in fact represent interesting investment opportunities.

There is by now a voluminous literature on stock market linkages which is concerned with answering what are the linkages (if any) between stock markets. This literature has used cointegration techniques to search for long-run relationships between different stock markets, and causality tests and impulse response functions to study these relationships. Some examples of this literature can be found in Aggarwal and Rivoli (1989), Arshanapali and Doukas (1993), Cheung and Mak (1992), Gerrits and Yuce (1999), Kanas (1998) and Pagan and Soydemir (2000).

Kanas (1998) analyzes potential linkages between US stock markets and stock markets in UK, Germany, France, Switzerland, Italy and the Netherlands and found that the US does not share long-run relationships with any of these countries. However, on the other hand, contrasting results can be found in Gerrits and Yuce (1999) which found evidence that not only the US stock market is cointegrated with Germany, UK and the Netherlands, but also that the latter respond significantly to movements in the US stock market.

Pagan and Soydemir (2000) use impulse response functions to analyze the impact of innovations in the US stock market on Argentina, Brazil, Chile and Mexico and to study the relationships among these Latin American stock markets, using weekly data from December 1988 to September 1994. They found evidence suggesting that the US stock markets strongly influences Latin American markets but the responses are not homogeneous. Effects of US innovations were found to be more pronounced for Mexico than for Argentina, Chile or Brazil. Finally, Argentina and Chile seemed to be more responsive to a Brazilian market shock than to a shock originating from Mexico[1].

The objective of this paper is to provide further evidence on the linkages between Latin American equity markets and the US equity market. We focus on Argentina, Brazil, Chile, Colombia, Peru, Mexico and Venezuela and the US extending the number of countries which are usually used in studies of equity market integration.

Using the Johansen methodology, we search for a pairwise cointegration among Latin American stock markets and the US. Granger causality tests were used to study the interrelationships between these stock markets. We also test for short-run causality between Latin American stock markets, focusing on how these stock markets respond to shocks in the US stock market, using impulse response functions. We extend Pagan and Soydemir's (2000) study analyzing impulse response functions using daily data from January 1995 to March 2001.

Our findings suggest that Latin American equity markets are not cointegrated with the US equity market. However, shocks in the US equity stock market affect Latin American stock markets. Additionally, Latin American equity markets seem to respond differently to shocks in the US stock markets. Finally impulse response functions show evidence that Latin American equity markets respond more quickly for the current period than for the period covered by Pagan and Soydemir (2001). These findings are valuable to investors evaluating international portfolios.

The remainder of the paper is structured as follows. In the next section we present the data used in this study. Section 3 covers the methodology employed, while Section 4 shows the empirical evidence. Section 5 concludes the paper.

[1] The authors argue that results may be attributed to tighter trading relations between US and Mexico, and Argentina and Chile with Brazil.

2. The Data

The data set used in this study comprise daily close quotes for stock prices. We use (1) the Dow Jones Industrial Average (US), (2) the MERVAL from Argentina, (3) the IBOVESPA (Indice da Bolsa de Valores de São Paulo) from Brazil, (4) the IBB (Indice de la Bolsa de Bogota) from Colombia, (5) the IGPA (Indice General de Precios de Acciones) from Chile, (6) the IPC (Indice de Precios y Cotizaciones) from Mexico, (7) the IBC (Indice de la Bolsa de Caracas) from Venezuela, and (8) the IGBVL (Indice General de la Bolsa de Valores de Lima) from Peru. The daily indices were obtained from the Economatica database.

The Dow Jones Industrial Average is a price-weighted average of 30 blue chip stocks that are generally the leaders in their industry. The IBOVESPA is an equity index weighted by traded volume and is comprised of the most liquid stocks traded in the São Paulo Stock Exchange. The MERVAL Index is the market value of a stock portfolio, selected according to participation in the Buenos Aires Stock Exchange. The IPC is a capitalization-weighted index of the leading stocks traded on the Mexico Stock Exchange. The IGPA is a capitalization-weighted index of the majority of the companies traded on the Santiago Stock Exchange. The IBB is an index composed of shares from 20 companies whose volume has been the highest in the past 2 years. The IBC is a capitalization-weighted index of the 15 most liquid and highest capitalized stocks traded on the Caracas Stock Exchange. The IGBVL is an index composed of shares from 29 companies which are the most actively traded in the Peruvian stock market. Therefore, these indexes can be seen as their countries stock markets benchmarks.

The data begins in January 3 1995 and ends in March 1 2001. All series are in US dollars. In table 1 descriptive statistics for returns on these stock indexes are shown. As we can see only Chile, Colombia and Peru have standard deviations lower than the Dow Jones. Normality is rejected for all series as the Jarque-Bera (JB) statistics shown in table 1 are quite large.

Table 1. Descriptive Statistics

	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Venezuela	US
Mean	-2.57E-05	0.00032	-0.00017	-0.00068	0.000278	-0.000359	0.000238	0.000661
S. Dev.	0.022569	0.02866	0.014031	0.012135	0.021952	0.013986	0.022522	0.017865
Skew.	-0.33872	0.19547	0.395209	0.034216	-0.53293	-0.123478	-0.96692	-0.13145
Kurt.	8.4673	10.962	8.7420	7.1968	9.8547	10.14596	34.2503	8.47199
JB	2001.89	4191.86	2215.929	1162.06	3174.13	3372.165	64660.45	1979.53
n	1584	1584	1584	1584	1584	1584	1584	1584

The series had some missing observations at different points of time as the holiday days may differ among countries. We used the PROC EXPAND procedure in SAS to fill in the gaps, using cubic spline interpolation[2].

In figure 1 we plot all indexes.

3. Methodology

In this section we describe the methodology employed in this paper. In the first sub-section we show the unit root tests which were employed to assess the integration order of all series employed in this study. The second sub-section presents briefly the Johansen methodology. In the third sub-section we present the causality tests which were used. Finally, in the last sub-section we present impulse response functions which were used in this study. Since these methods are now well established, only a short account will be given.

3.1. Unit Root Tests

When testing for relationships between stock markets it wouldn't be appropriate to use a t-distribution to conduct statistical inference if the variables in a regression contain stochastic trends (time series processes with unit roots)[3]. In that sense unit root tests are used to test whether the series contain stochastic trends.

[2] For more on this procedure see SAS/ETS. The results are robust to filling the gaps with the last observation.

[3] See Hamilton (1994).

In order to assess if the indexes have unit roots a widely accepted test is the Augmented Dickey and Fuller (1979) test. Let X_t be a time series. The ADF test involves estimating the equation below:

$$\Delta X_t = \alpha + \beta t + (\rho - 1)X_{t-1} + \sum_{i=1}^{k-1} \varphi_i \Delta X_{t-i} + \varepsilon_t \quad (1)$$

and testing whether $\rho = 1$. In this equation $\Delta = 1 - L$ (where L is a lag operator); t is a trend; and ε_t is a white noise term. Phillips and Perron (1988) tests were also conducted, which allow for more general error terms (heteroskedastic and autocorrelated errors).

3.2. Cointegrating tests

Let's consider a VAR of order p, where Xt is a p-vector of I(1) variables and ε_t is a vector of innovations, as given in equation (2).

$$X_t = A_1 X_{t-1} + \cdots A_p X_{t-p} + \varepsilon_t \quad (2)$$

We can rewrite this expression as:

$$\Delta X_t = \Pi X_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta X_{t-j} + \varepsilon_t \quad (3)$$

where

$$\Pi = \sum_{j=1}^{p} A_j - I \quad \text{and} \quad \Gamma_j = -\sum_{i=j+1}^{p} A_i \quad (4)$$

If the coefficient matrix Π has reduced rank $r < p$, then there exist p x r matrices and α and β such that $\Pi = \alpha\beta'$, and $\beta'Xt$ is stationary, i.e., the hypothesis of cointegration is formulated as a restriction on the matrix Π where the number of cointegrating relations is given by r. Johansen's method involves estimating the Π matrix in an unrestricted form and then testing whether the restrictions implied by the reduced rank of Π can be rejected[4].

We test for r (the maximum number of cointegrating relationships) using the λ_{trace} statistic, where

$$\lambda_{trace} = -n \sum_{i=r+1}^{p} \ln\left(1-\hat{\lambda}_i\right) \tag{5}$$

where $\hat{\lambda}_i$ is the i-th largest eigenvalue λ_{trace} is a test of the null of r cointegrating rank against the alternative of a p cointegrating rank.

We also use the maximum eigenvalue statistic (λ_{max}). We use this statistic to improve the power of the test by limiting the alternative to a cointegrating rank just one more than under the null. This statistic is given by:

$$\lambda_{max} = -n \ln\left(1-\hat{\lambda}_i\right) \tag{6}$$

where this statistics tests the null of rank equal to r against the alternative of r+1.

3.3. Causality Tests

To test whether there are contagion effects (short-run causality) within stock market indexes we use the following vector auto-regression (see Granger (1969)):

$$\Delta x_{1t} = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta x_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta x_{2t-i} + \varepsilon_{1t} \tag{7}$$

$$\Delta x_{2t} = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \Delta x_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta x_{2t-i} + \varepsilon_{2t} \tag{8}$$

[4] Cointegration theory implies that for a vector of time series, the variables are said to be cointegrated if linear combinations are stationary without differencing, even if the individual elements of the vector need to be differenced at least once to become stationary. The reader is referred to Johansen (1988, 1990) and Johansen and Juselius (1990) for a complete description of the estimation technique.

where Δ is the first difference operator and we have assumed that X_1 and X_2 are not cointegrated. If the α_{2i} are statistically different from zero for different lags then we can reject the absence of granger causality and we can say that X_2 granger causes X_1. If the β_{1i} are statistically significant the direction of causality is from X_1 to X_2. If both are different from zero then we can say that there exists bicausality.

If they are cointegrated these equations would need an additional error correction term, and the appropriate test would be given by

$$\Delta x_{1t} = \alpha_0 + \delta_1 (x_{1t-1} - \gamma x_{2t-1}) + \sum_{i=1}^{k} \alpha_{1i} \Delta x_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta x_{2t-i} + \varepsilon_{1t} \tag{9}$$

$$\Delta x_{2t} = \beta_0 + \delta_2 (x_{1t-1} - \gamma x_{2t-1}) + \sum_{i=1}^{k} \beta_{1i} \Delta x_{1t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta x_{2t-i} + \varepsilon_{2t} \tag{10}$$

The term $(x_{1t-1} - \gamma x_{2t-1})$ is an error correction term determined from the level form estimate of the long-run relationship between X_1 and X_2. Causality now can be asserted by the significance of the parameters α_{2i} , β_{1i} , δ_1 and δ_2. If δ_1 is significantly different from zero but δ_2 is not then if X_1 and X_2 drift apart the X_1 variables will correct to restore equilibrium. If δ_1 is not significantly different from zero δ_2 but δ_1 is then X_2 makes the correction. If both δ_1 and δ_2 are significant then both X_1 and X_2 will have a correction to restore equilibrium[5].

3.4. Impulse response functions

In order to analyze the effects of shocks in one stock market into the other we use a well known technique in the literature which is called impulse response functions.

A VAR can be written in a vector MA(∞) such as

$$y_t = \mu + \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \Psi_3 \varepsilon_{t-3} + \cdots \tag{11}$$

In this case the matrix Ψ has the following interpretation:

$$\Psi_s = \frac{\partial y_{t+s}}{\partial \varepsilon_t} \tag{12}$$

The row i, column j, of Ψ_s identifies the consequences of a one-unit increase in the *j*th variable's innovation at date t, holding all other innovations constant[6]. These are called impulse response functions (IRF). We can use these IRF to analyze the impact of shocks in the US stock market on Latin American stock market indexes. This will be done in the next section.

4. Empirical Results

In this section we present the empirical results found for the data set employed in this study. Sub-section 4.1 presents unit root test results while sub-section 4.2. cointegration tests. Sub-section 4.3 presents Granger causality tests and finally in sub-section 4.4 impulse response functions are analyzed.

4.1. Unit root tests results

In table 2 results for unit root tests are presented. As it can be seen, for all variables one cannot reject the null of integration of order 1. The unit root hypothesis cannot be rejected in levels but it is rejected at the 99% level of confidence with first differences, which suggests that these stock indexes are I(1) and not I(2).

The number of lags in the ADF tests was chosen running regression (1) with 22 lags of the dependent variable. Then we checked whether this lag was significant, if it wasn't significant we reduced by 1 the number of lags and repeated this procedure until either a statistically significant lag was found or there were no lags at all (conventional Dickey and Fuller test)[7].

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[5] See Engle and Granger (1987).
[6] For more on these impulse response functions the reader is referred to Hamilton (1994).
[7] In the interest of space, Phillips and Perron (1988) unit root tests are not reported. However, these unit root tests yield qualitatively identical results.

Table 2. Unit Root Tests

Country	Level			First Difference		
	(1)	(2)	(3)	(1)	(2)	(3)
Argentina	-2.4706	-2.4764	-0.0986	-9.0965*	-9.1147*	-9.0997*
	(16)	(16)	(16)	(15)	(15)	(15)
Brazil	-1.9527	-2.3680	0.3072	-11.7119*	-11.7099*	-11.7071*
	(10)	(19)	(10)	(9)	(9)	(9)
Chile	-2.2457	-3.0015	-0.3374	-8.3300*	-8.3284*	-8.3286*
	(18)	(18)	(18)	(17)	(17)	(17)
Colombia	-0.8278	-1.7912	-1.3265	-7.5731*	-7.5756*	-11.5416*
	(8)	(8)	(21)	(20)	(20)	(7)
Mexico	-2.3451	-3.1875***	0.5483	-7.8948*	-7.8935*	-7.8762*
	(20)	(20)	(20)	(22)	(22)	(22)
Peru	-1.7067	-2.7757	-0.4843	-7.0717*	-7.1158*	-7.0623*
	(22)	(22)	(22)	(21)	(21)	(21)
Venezuela	-1.4569	-1.5042	0.2303	-8.8212*	-8.8183*	-8.8169*
	(21)	(21)	(21)	(20)	(20)	(20)
Dow Jones	-2.2365	-1.6442	2.6111	-10.2719*	-10.4471*	-8.6631*
	(17)	(17)	(17)	(16)	(16)	(18)

* Rejection of the null with 99% confidence
*** Rejection of the null with 90% confidence
number of lags used are in parentheses
the (1), (2) and (3) stands for a model with an intercept, intercept and trend or neither

4.2. Cointegration test results

The unit root tests suggest that all stock indexes are I (1) and therefore cointegration tests may be used to assess whether these indexes share common trends.

We use both the Schwarz and Akaike information criteria to determine the appropriate lag length. Using the Schwarz criterion the optimal lag found happened to be one in all cases. Using the Akaike information criterion we choose different lag lengths for all pairs. However, results given by both information criteria are qualitatively the same.

Results are shown in table 3. The Brazilian stock index does not cointegrate with all other stock indexes. We present the λ_{max} statistic for all pairs, however results given by λ_{trace} statistics are qualitatively the same[8].

[8] Cheung and Lai (1993) examine the issue of the importance of no normality in finite samples in the trace and maximal eigenvalues tests. They found evidence suggesting that both the trace and max test are relatively robust to excess kurtosis and skew ness.

Table 3. Johansen Cointegration Tests (Trace Statistics) – Brazil

			Schwarz			Akaike		
Countries	H_0	H_a	Eigenvalues	λ_{max}	Lag	Eigenvalues	λ_{max}	Lag
Argentina	r = 0	r = 1	0.0046	7.37	1	0.0092	14.58	10
	r ≤ 1	r = 2	0.0038	6.15**	1	0.0039	6.23	10
Chile	r = 0	r = 1	0.0053	8.52	1	0.0059	9.34	11
	r ≤ 1	r = 2	0.0019	3.10	1	0.0020	3.20	11
Colombia	r = 0	r = 1	0.0035	5.67	1	0.0030	4.76	22
	r ≤ 1	r = 2	0.0002	0.41	1	0.0005	0.81	22
Mexico	r = 0	r = 1	0.0055	8.79	1	0.0034	5.33	22
	r ≤ 1	r = 2	0.0019	3.01	1	0.0032	5.00	22
Peru	r = 0	r = 1	0.0028	4.59	1	0.0050	7.85	22
	r ≤ 1	r = 2	0.0007	1.22	1	0.0013	2.15	22
Venezuela	r = 0	r = 1	0.0074	11.85	1	0.0060	9.53	20
	r ≤ 1	r = 2	0.0012	2.03	1	0.0015	2.43	20

** Rejection of the null with 95 % confidence

Critical values are taken from Osterwald-Lenum (1992).

Granger (1988) noted that cointegration between two variables is a sufficient condition (but not necessary) for the presence of causality in at least one direction. We cannot reject the null of no cointegrating vectors as shown in tables 3 and 4. Therefore, we can test for causality using equations (7) and (8), which do not have an error correction term.

In table 4, results for cointegration tests between the US stock market and Latin American stock markets are shown. As we can see, none of these stock markets cointegrate with the US. Again, causality tests can be performed with the use of equations (7) and (8).

Table 4. Johansen Cointegration Tests (Trace Statistics) - US

				Schwarz			**Akaike**	
Countries	H_0	H_a	Eigenvalues	λ_{max}	Lag	Eigenvalues	λ_{max}	Lag
Argentina	r = 0	r = 1	0.0048	6.36	1	0.0042	6.63	10
	r ≤ 1	r = 2	0.0017	2.72	1	0.0019	3.13	10
Brazil	r = 0	r = 1	0.0039	6.27	1	0.0032	5.12	12
	r ≤ 1	r = 2	0.0024	3.87**	1	0.0028	4.52	12
Chile	r = 0	r = 1	0.0057	9.06	1	0.0050	8.05	7
	r ≤ 1	r = 2	0.0021	3.33	1	0.0023	3.71	7
Colombia	r = 0	r = 1	0.0028	4.45	1	0.0028	4.45	1
	r ≤ 1	r = 2	0.0005	0.86	1	0.0005	0.86	1
Mexico	r = 0	r = 1	0.0052	8.33	1	0.0064	10.12	11
	r ≤ 1	r = 2	0.0032	5.12**	1	0.0032	5.08	11
Peru	r = 0	r = 1	0.0035	5.55	1	0.0070	11.11	22
	r ≤ 1	r = 2	0.0010	1.61	1	0.0016	2.51	22
Venezuela	r = 0	r = 1	0.0026	4.17	1	0.0029	4.61	3
	r ≤ 1	r = 2	0.0014	2.35	1	0.0012	1.90	3

** Rejection of the null with 95% confidence
Critical values are taken from Osterwald-Lenum (1992).

4.3. Causality tests results

The null hypothesis that changes in the X stock market do no Granger cause changes in the Y stock market is tested for all combinations with the Brazilian stock market. The lags in these causality tests were chosen by three different criteria: Akaike and Schwarz information criteria and Likelihood ratio tests.

Table 6 shows that the null that the Brazilian stock market does not Granger cause other Latin American stock markets are rejected in all cases. Additionally, only Chile and Colombia do not Granger cause changes in the Brazilian stock market.

Table 6. Causality Tests

	Schwarz		Akaike		LR	
Null	χ^2 statistic	Lag	χ^2 statistic	lag	χ^2 statistic	lag
Brazil →/→ Argentina	3.7642	2	31.9123*	11	31.9123*	11
Argentina →/→ Brazil	9.2893*	2	47.6326*	11	47.6326*	11
Brazil →/→ Chile	9.7717*	2	26.1987**	12	29.3797**	15
Chile →/→Brazil	0.6438	2	19.2940***	12	20.2580	15
Brazil →/→Colombia	18.0092*	2	18.0092*	2	36.0141*	11
Colombia →/→ Brazil	0.5562	2	0.5562	2	6.8420	11
Brazil →/→ Mexico	16.0498*	2	49.1722*	16	49.1722*	16
Mexico →/→ Brazil	28.1718*	2	90.6971*	16	90.6971*	16
Brazil →/→ Peru	41.3492*	2	56.7537*	15	67.6761*	21
Peru →/→ Brazil	6.4614**	2	34.7000*	15	41.1631*	21
Brazil →/→ Venezuela	19.0864*	2	38.6316*	17	40.6992*	20
Venezuela →/→ Brazil	6.8068*	2	42.9255*	17	52.2503*	20

Null: X does not Granger cause (→/→) Y
* Reject the null with 99% confidence
** Reject the null with 95% confidence
*** Reject the null with 90% confidence

In table 7 results for causality tests between Latin American countries and the US are shown. Only the Mexican stock market seems to have some impact on the US stock market, if we use both the Akaike or Likelihood Ratio statistics to determine the appropriate lag lengths[9]. On the other hand, the US stock market seems to affect Colombia, Mexico, Peru and Venezuela whatever the criteria used to choose the lag length.

If we use the Schwarz information criteria the null of no causality cannot be rejected between Argentina, Brazil and the US. However, both the Akaike and Likelihood Ratio statistics suggest that the US stock markets affects Brazil, while only if we use the Akaike information criteria to choose the lag length we find this result for Argentina. Nonetheless, it seems that the US stock market is able to influence Latin American stock markets.

[9] This interesting result calls for additional research. This could be due to a greater integration between these stock markets.

Table 7. Causality Tests

	Schwarz		Akaike		LR	
	χ^2 statistic	Lag	χ^2 statistic	lag	χ^2 statistic	lag
US →/→ Argentina	4.5654	2	7.1707***	3	11.4416	11
Argentina →/→ US	4.2116	2	4.2579	3	10.0238	11
US →/→ Brazil	1.4658	1	15.0136**	6	31.4379**	18
Brazil →/→ US	1.2450	1	8.3615	6	23.0049	18
US →/→Chile	5.2660***	2	4.6600	3	13.8426	11
Chile →/→ US	3.6915	2	4.4005	3	15.3044	11
US →/→Colombia	12.1179*	2	12.1179*	2	26.2018*	11
Colombia →/→ US	1.1146	2	1.1146	2	4.0649	11
US →/→ Mexico	5.1111**	1	19.8613**	11	19.8613**	11
Mexico →/→ US	1.0428	1	21.2813*	11	21.2813*	11
US →/→ Peru	12.5607*	2	12.5927*	4	28.9691**	15
Peru →/→ US	1.7918	2	3.5745	4	15.2985	15
US →/→ Venezuela	11.4801*	2	15.4356*	4	18.0501*	9
Venezuela →/→ US	0.5096	2	2.0263	4	2.9062	9

Null: X does not Granger cause (→/→) Y
* Reject the null with 99% confidence
** Reject the null with 95% confidence
*** Reject the null with 90% confidence

In order to better analyze the influence that the US stock market has on Latin American stock market indexes we use impulse response functions in the next sub-section.

4.4. Impulse Response Functions

We present the impulse response functions for Latin American stock market indexes. Parameters were estimated using the VAR described in section 2.3. Each impulse response function (IRF) comes from shocking one of the variables, while holding other variables constant. These IRF are shown with a 95% confidence interval, which were obtained running Monte Carlo simulation (1000 repetitions). In the VAR's the lags were chosen using the Schwarz information criterion (more parsimonious model).

Using these IRF we can see that although there is bicausality between Argentina and the Brazilian stock market the responses are quite different. The peak impact in Argentina is felt with a one-day lag while in Brazil with a two-days lag. Furthermore, the magnitude of the impact is much greater in Argentina than in Brazil, approximately 0.016 and 0.0018, respectively. This is true also when we compare the responses between Mexico and Brazil.

The Brazilian equity market is not affected by shocks in stock market of Chile, Colombia and Venezuela. Shocks in the Brazilian stock market tend to dissipate on average after 4 to 5 days in the Chilean, Colombian, Peruvian and Venezuelan stock markets. The peak impact occurs with one lag in Chile, Peru and Venezuela, while in Colombia the peak impact occurs only with a two-days lag.

Shocks in the US stock market tend to dissipate only after 4 to 5 days in Chile, Colombia, Peru and Venezuela. Our results are in line with Pagan and Soydemir (2000), which found evidence that Latin American stock markets respond differently to shocks in the US equity market. However, our results shows that the responses do not last as long as in the period covered by Pagan and Soydemir (2000), which could be due to greater efficiency in these equity markets. This will be subject of future research.

5. Final Remarks

There seems to be no cointegration among Latin American stock markets and between these stock markets and the US stock market. This results would lead to the conclusion that US investors could benefit from diversification by investing in Latin American stock markets.

However, there is some short-run relationship among these stock markets and Granger causality tests have detected causality between the Brazilian stock market and other Latin American stock markets.

Shocks in the US stock market have an heterogenous effect on Latin American stock markets a result which is in line with Pagan and Soydemir (2000). The Mexican stock market suffers a much greater impact than other stock markets, which could be explained to a greater integration between the US and Mexico.

Additional research could focus on the effect of possible structural breaks in these stock markets and the linkages between them. Finally, macroeconomic variables could be introduced in the analysis to link stock market relationships which were found in this paper with variables such as exports, business cycles and monetary policy.

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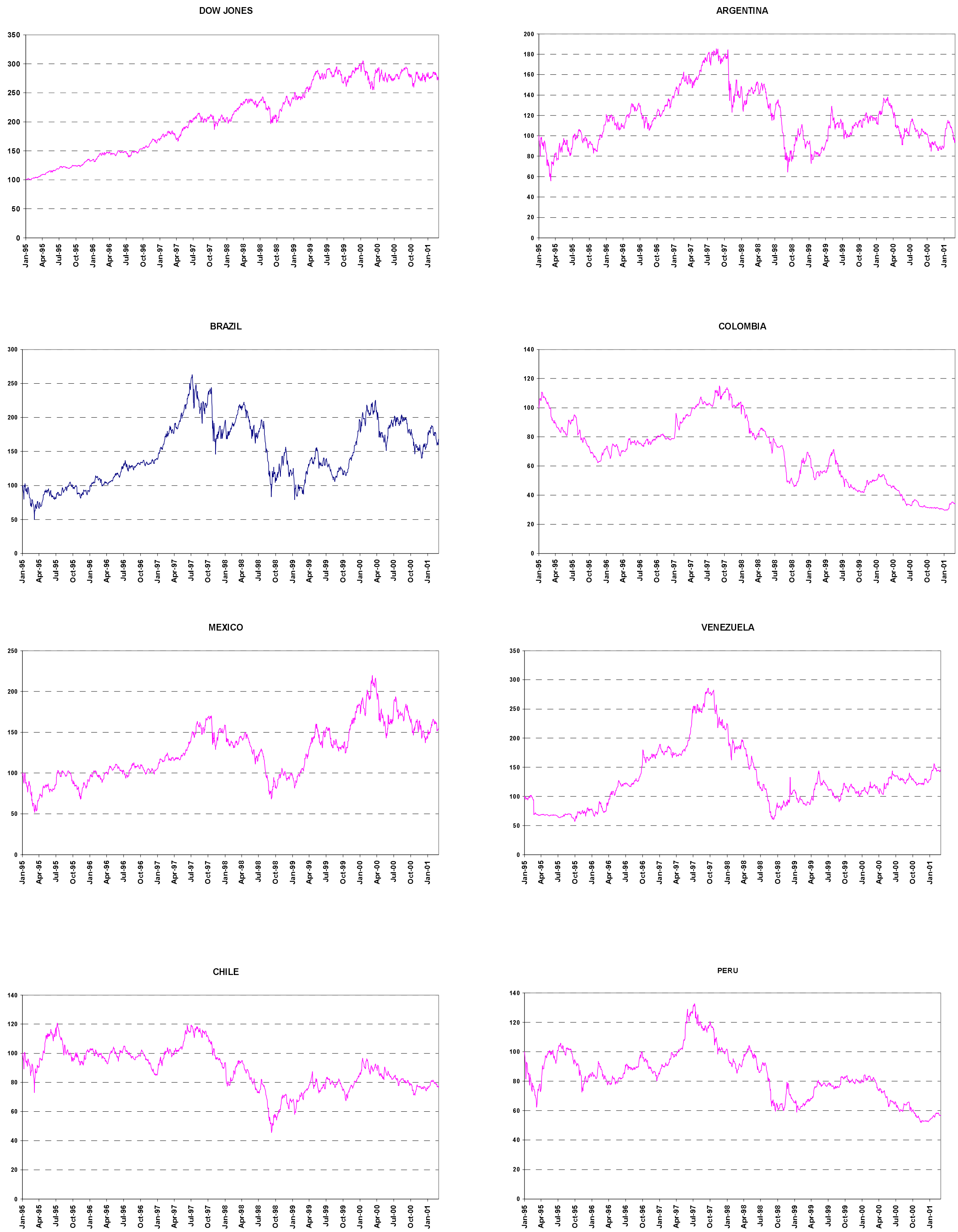

Figure 1: Stock Indexes

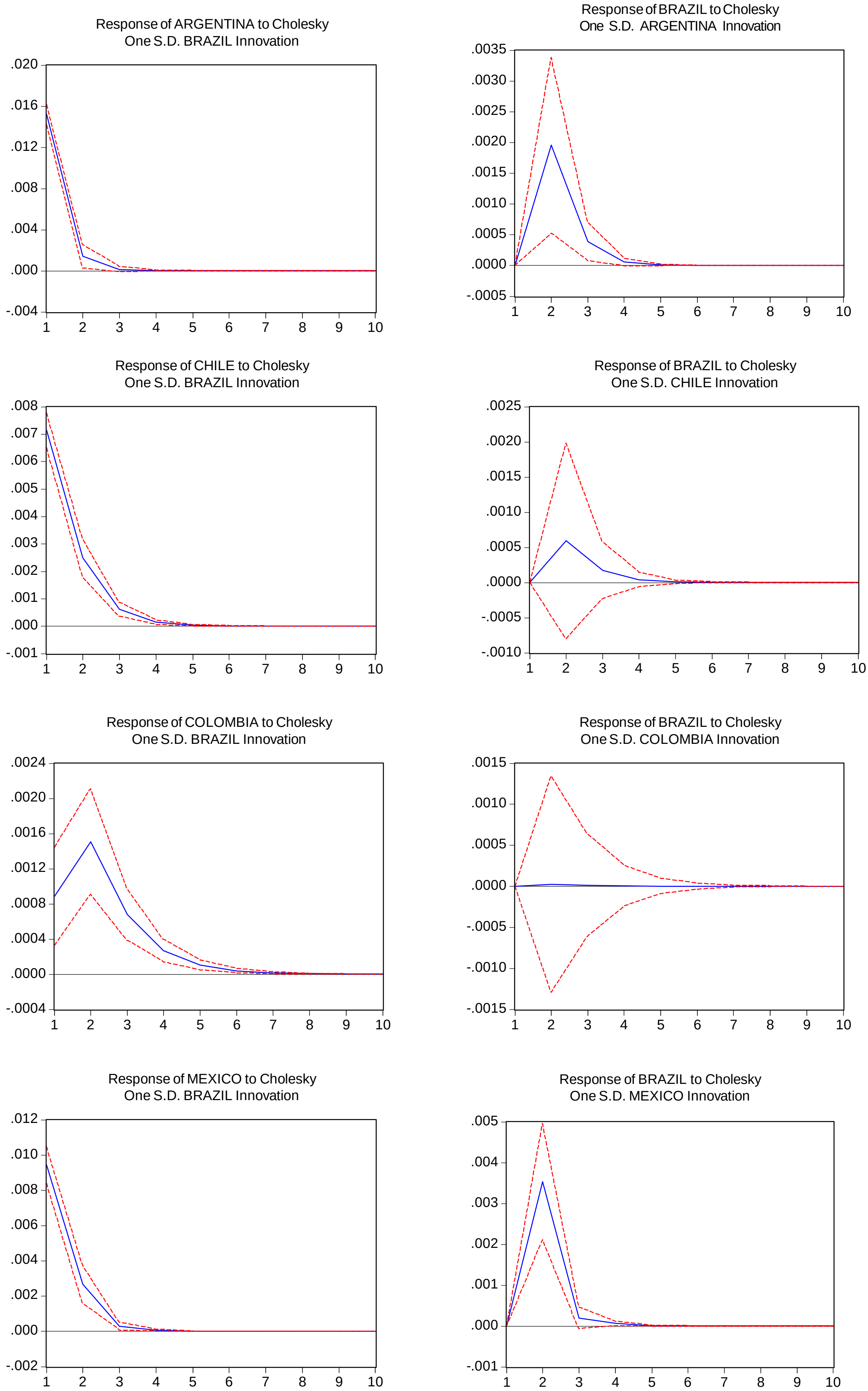

Figure 2: Impulse Response Functions

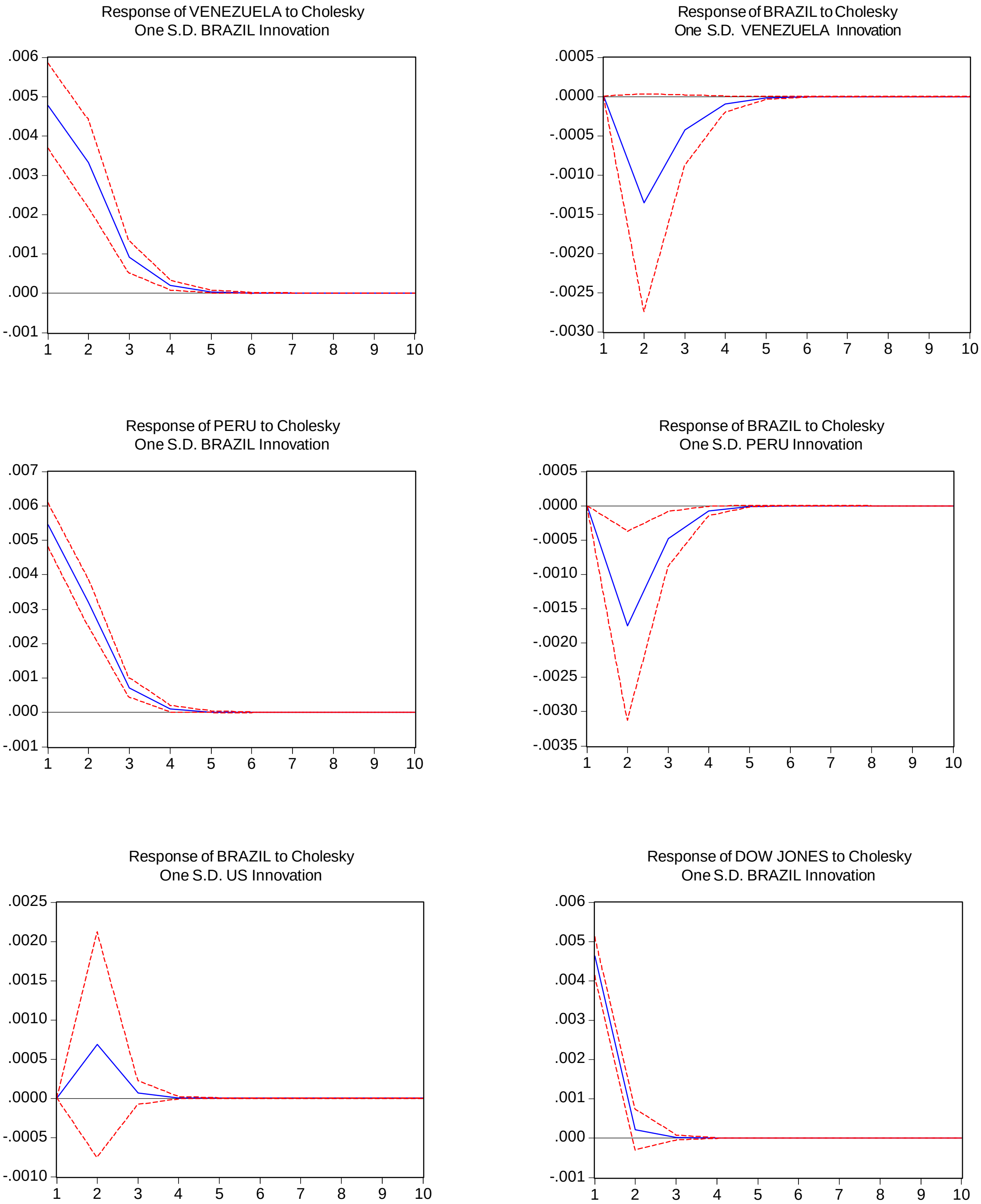

Figure 3: Impulse Response Functions

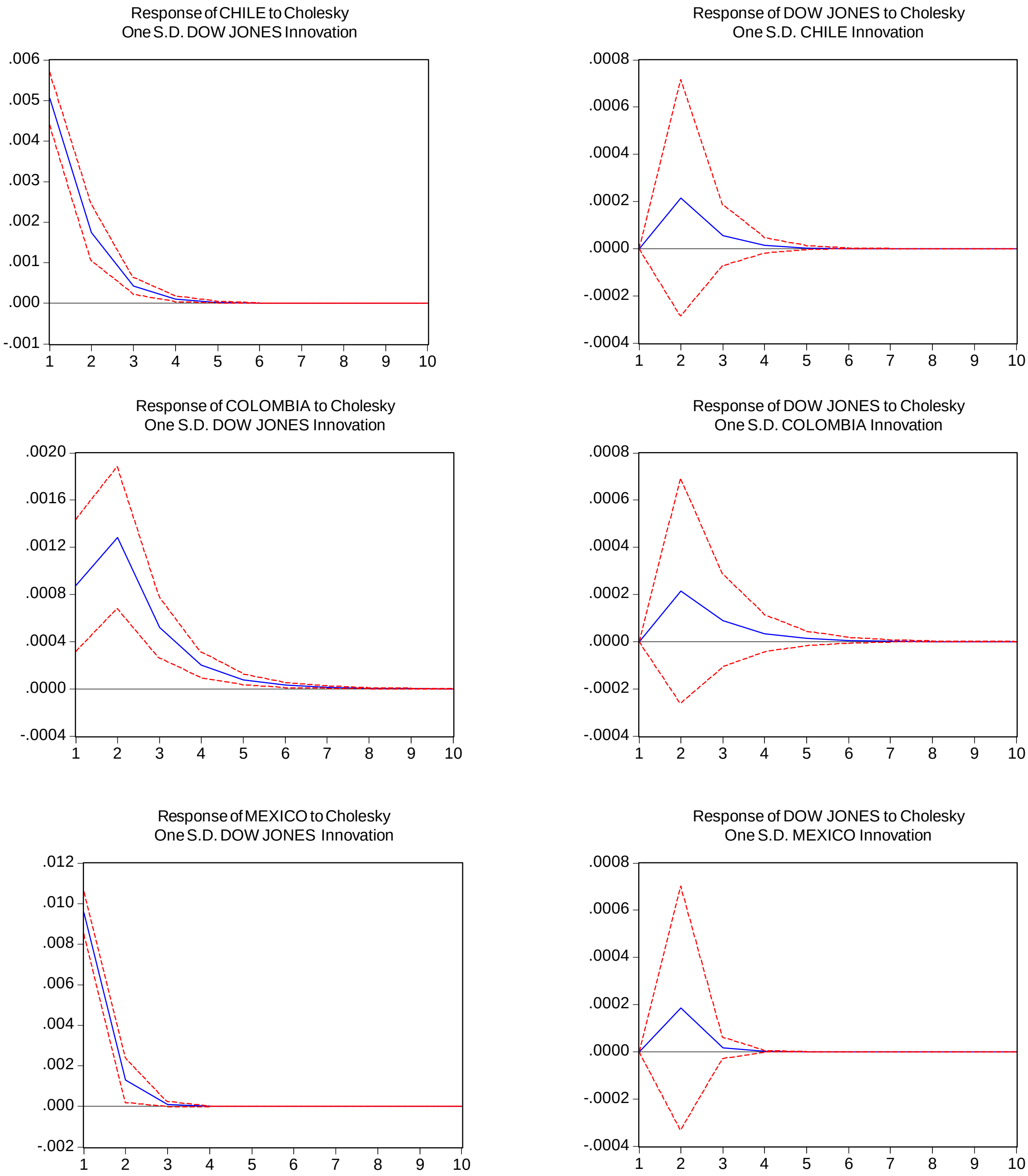

Figure 4: Impulse Response Functions

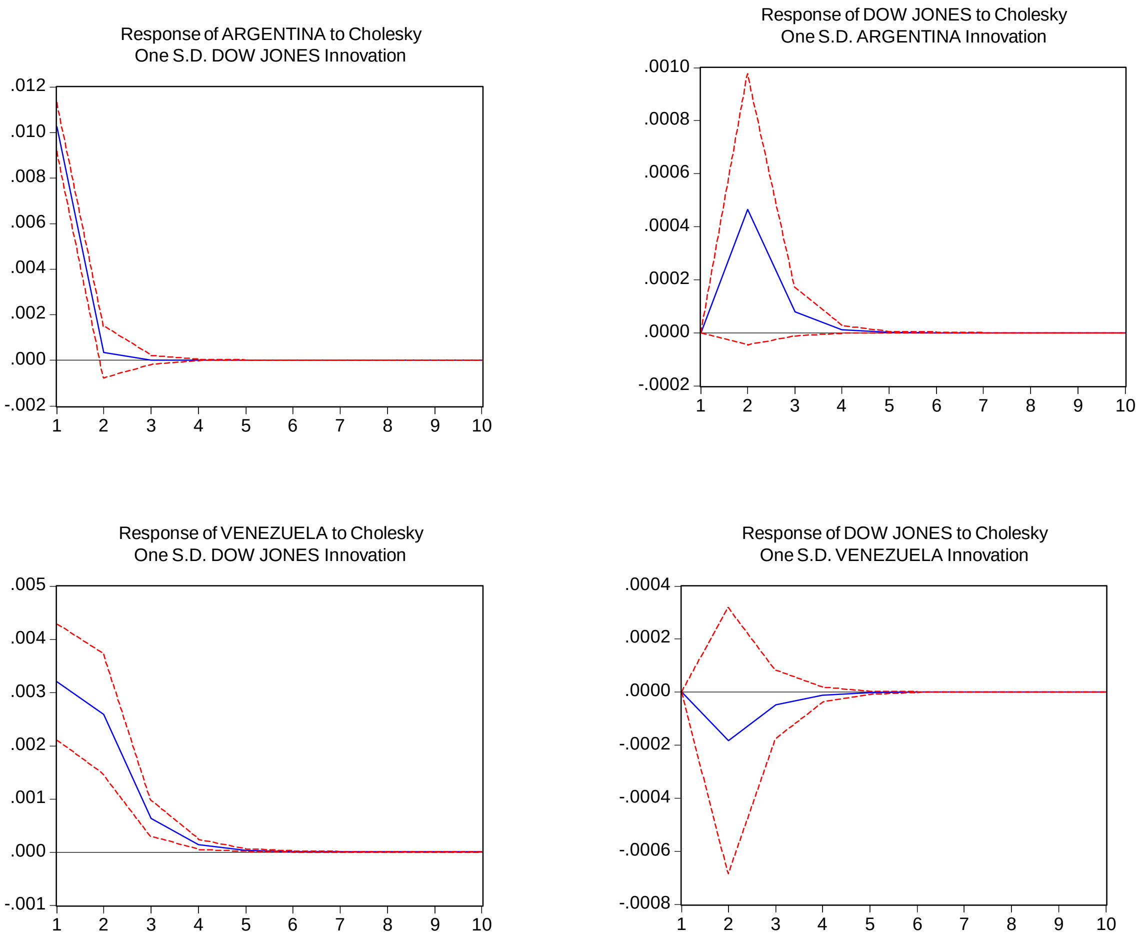

Figure 5: Impulse Response Function

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