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Mean and Volatility Spillover of the Latin American Stock Markets

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Abstract:
The main purpose of this study is to compare the influence of US (World leading) and Brazil (Latin American Region leading) stock markets on the other major Latin American stock markets (Mexico, Argentina, Chile and Peru) by using GARCH in mean (GARCH-M) approach. Empirical findings show that the intensity of mean spillover from US to other Latin American stock markets is higher as compared to the mean spillover from Brazil to other Latin American Stock Markets. Further, the mean spillover from US to other Latin American stock markets is positive as well. Moreover, the intensity of volatility spillover from Brazil to other Latin American stock markets is higher as compared to volatility spillover from US to other Latin American stock markets. The volatility transmission is positive from Brazil to Mexico, Argentina, and Peru, but it is negative to Chile. This negative volatility transmission from Brazil to Chile implies that there is a presence of portfolio diversification opportunities for portfolio managers and international investors.

Keywords: *Volatility Spillover, Stock Index, Market Index, Stock Market.*

1. Introduction

Financial liberalization and globalization have transformed different economies into the global village. Liberalization leads towards the increasing level of integration among the international financial markets. It

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creates different opportunities for the investors to manage and diversify their portfolios. Now, investors can invest in different markets with different demographics. Contrarily, high integration among stock markets decreases the benefits of diversification (Jebran, 2014). Shocks are transmitted between markets if these markets are highly integrated (Wei-Chong, Loo, Ling, & Ung, 2011). Investors may get the benefits of diversification if the markets are not financially integrated. So, mean and volatility spillover analysis can help the investor to diversify portfolio efficiently (Joshi, 2011).

Global and regional cooperation, market liberalization and deregulation of markets contribute towards the interdependence of financial markets (Fraser & Oyefeso, 2005). Some stock markets are highly integrated with world leading stock markets and some are highly integrated with their main regional stock market. So, it is important for portfolio manager to know whether these markets are dominated by world leading or regional leading stock markets. To explore this phenomenon, this study selects a Latin American (LA) region. Brazil is the leading stock market in the LA region having stock market capitalization of $954,715 million in 2017, while US is the world leading stock market having market capitalization of $22,081,367 million. Mexico, Chile, Argentina and Peru have market capitalization of $417,020, $294,675, $108,740 and $99,218 million respectively. Hence, this study aims to compare the spillover effect from US (World leading) and Brazil (Regional leading in LA) to the other major LA stock markets (Mexico, Argentina, Chile and Peru).

This study contributes to the current understanding of whether LA stock markets are dominantly affected by regional or global stock market. The level of integration among markets is changing rapidly and strengthens or weakens at a different point of time. Therefore, there is a need to continually examine spillover between markets to check the level of integration. This study will be helpful for portfolio managers because financial integration related information is important to take maximum benefit from portfolio diversification. (Markowitz, 1952) provides the concept of diversification in portfolio theory.

According to this theory, investment must be made in those securities which are uncorrelated (near zero) with each other to diversify the risk of investment loss. Investment in two highly integrated markets reduces the benefit of diversification because if markets are highly integrated in terms of volatility spillover then shock will definitely transfer across the markets (Wei-Chong et al., 2011). This study uses the GARCH in mean (GARCHM) approach to examine the mean and volatility spillover among different equity markets, as suggested by (Liu & Pan, 1997).

This study consists of five sections: Section 2 is Literature review, section 3 explains the research methodology and section 4 presents the empirical results. Finally, Section 5 consists of the conclusion of the study.

2. Literature Review and Theoretical Background

Capital flows have remarkably increased among international financial markets due to the liberalization of financial markets and technological innovation during the last two decades. These features have obviously increased the level of integration in different stock markets. Rich literature is available on integration across the different financial markets.

Numerous studies have been conducted in developed, developing and emerging markets in this regard. (Hu, Chen, Fok, & Huang, 1997) examine the mean and volatility spillover between developed markets (US and Japan) and four emerging market (Taiwan, Hong Kong, Shenzhen and Shanghai). Chou, Lin, and Wu (1999) find the significant mean and volatility transmission from the US to Taiwan equity market. Baele examines the mean and volatility spillover between US and 13 European stock markets and find the significant volatility transmission between US and majority European markets. (Wagner & Szimayer, 2004) provide an empirical evidence of the spillover between US and Germany. (Worthington & Higgs, 2004) provide the empirical evidence of volatility transmission from developed market of Japan to the emerging markets of Asia: Hong Kong, Indonesia and Korea. (Wang, Gunasekarage, & Power, 2005) investigate the volatility transmission from established markets like US and Japan to emerging equity markets of Asia.

This study is evident of return and volatility spillover from developed markets to the emerging markets of the Asia. Li and (Li & Majerowska, 2008) investigate the volatility transmission from Frankfurt and US to Warsaw and Budapest stock exchanges. This study finds the significant volatility transmission from developed markets (US and Frankfurt) to the Warsaw and Budapest stock markets. (Diebold & Yilmaz, 2009) examine the spillover between seven developed markets (Germany, France, Japan, Hong Kong, US, and UK) and 12 emerging markets (Taiwan, South Korea, Chile, Brazil, Argentina, Singapore, Malaysia, Thailand, Mexico, and Philippines).

Recent Literature on mean and volatility analysis reveals that this topic carries considerable significance for researchers, investors and other relevant stakeholders. (Xiao & Dhesi, 2010) examine the spillover effect between four indices (CAC, DAX, S&P 500 and FTSE 100) and find

significant volatility transmission between US and European markets. (Joshi, 2011) investigates the mean and volatility spillover among six Asian countries: China, India, Korea, Hong Kong, Indonesia and Japan. This study finds significant bi-directional returns spillover for the following markets: Korea and Japan, Hong Kong and Korea, India and Hong Kong and China and Indonesia. (Sakthivel & Kamaiah, 2011) examine the volatility transmission among Australia, UK, US, Japan and India. (Li & Giles, 2015) investigate the linkages of stock markets across the US, Japan and six Asian developing countries: China, Malaysia, India, Thailand, the Philippines and Indonesia. (Jebran, Chen, Ullah, & Mirza, 2017) examine the spillover among China, Hong Kong, India, Pakistan and Sri Lanka based stock markets. These studies examined the spillover between developed and developing equity markets.

Literature on spillover between LA Stock markets is very rare. (Choudhry, 1997) finds significant co-integration among six LA stock markets during studying the long-run relationship. (De Santis et al., 1997) examines the mean and volatility spillover in emerging LA stock markets.(Barry & Rodriguez, 1998) find that LA stock markets are highly volatile and compounded annual return of LA stock markets are higher as compare to the returns in emerging markets of other regions. (Verma & Ozuna, 2008) examine the mean and volatility spillover among US, Brazil, Chile and Mexico and find an evidence of spillover from US to Mexico and Chile. (Hwang, 2014) examines the mean and volatility spillover among Brazil, Chile, Mexico, Argentina and Chile during subprime crisis of 2008. (Cardona, Guti´errez, & Agudelo, 2017) examine the volatility spillover between US and Six LA stock markets and find an evidence of volatility spillover from US to Six LA stock markets.

Literature shows that researchers examine the spillover from US to LA stock Markets but there is also a need to compare the spillover effect from US (World Largest) and Brazil (Regional Largest) to other LA stock Markets as well. Some stock markets are linked tightly with the major regional stock market but some markets are connected tightly with the major global stock markets. Many studies have examined the spillover between developed and developing market but comparison on largest regional and world stock markets on different stock markets is rarely available in literature. So, this study focuses on LA stock American Markets to check whether these markets are highly influenced by regional largest stock market (Brazil) or world largest stock market. The dynamics of regional equity markets are important for institutional investors especially to diversify their portfolios. It is very important for the investor to understand whether specific stock market is dominantly affected by largest regional or

world stock markets player because it will help them to efficiently diversify their portfolios.

3. Research Methodology

3.1 Data Description

This study compares the regional and global equity market spillover effect on markets of Mexico, Argentina, Chile and Peru. The population of study consists of the all equity markets of North American region countries and US. The study's sample consists of five North American equity markets including Brazil as well as US. The daily equity market index data is used for analysis and sample period is taken from 2002 to 2015 according to their respective stock exchange (see Table 1).

Table 1: Indices, Countries and Time

Index	Stock Exchange	Country	Local time		GMT
			Open	Close	
S&P 500	NYSE	US	09:30	16:00	(UTC-4)
IPC (Bolsa)	Mexican Stock Exchange	Mexico	08:30	15:00	(UTC-5)
MERVAL	Buenos Aires Stock Exchange	Argentina	10:30	17:00	(UTC-3)
IBOVESPA	BM&FBOVESPA S.A	Brazil	09:45	17:00	(UTC-3)
IPSA	Santiago Stock Exchange	Chile	09:00	16:30	(UTC-3)
S&P/BVL	Lima Stock Exchange	Peru	09:30	14:00	(UTC-5)

Bekaert, Ehrmann, Fratzscher, and Mehl (2014) used these indexes (S&P 500, IPC-Bolsa, MERVAL, IBOVESPA and IPSA) to examine the contagion between different stock markets. The S&P 500 index includes 500 leading companies and captures approximately 80% of available market capitalization. The S&P/BVL index is composed of the largest and most-liquid stocks listed on Peru stock exchange. It captures approximately more than 50% of available market capitalization. The IPC index consists of 35 largest and the most liquid stocks listed on the Mexican stock exchange. It captures approximately more than 50% of available market capitalization. The Ibovespa index is based on free float and consists of 70 largest and most liquid stocks on the Brazil stock exchange. It captures approximately more than 70% of available market capitalization. Merval stock index consists of 23 companies (in 4th quarter of 2016) and the index composition is based on

most liquid companies. The IPSA index consists of 40 largest and most liquid stocks listed on the Santiago Stock exchange.

3.2 Research Model

(Liu & Pan, 1997) have specified two stages GARCH-in-mean. GARCH-M has been used to study the mean and volatility spillover between different financial markets. At first stage, relevant regional and global return series are estimated through ARMA (1,1)-GARCH(1,1)-M models, which are as follows:

$$rk,t = \varphi 0 + \varphi 1 rk,t-1 + \varphi 2 vk,t + \varphi 3 \varepsilon k,t-1 + \varepsilon k,t, \varepsilon k,t \sim N(0, vk,t) \quad (1)$$

$$vk,t = \alpha 0 + \alpha 1 vk,t-1 + \alpha 2 \varepsilon^2_{k,t} - 1_{t-1} \quad (2)$$

Where denotes the daily return for stock market index k at time is the residual term whereas denotes the conditional variance. ARMA (1,1) or MA(1) model are used to adjust the possible problem of serial correlation in the data. For second stage, mean and volatility spillover across the markets are estimated from the standardized residual square of the first stage and then substituting these squares in mean and volatility equations of others markets as follows:

$$rj,t = \alpha\varphi 0 + \varphi j,1 rj,t-1 + \varphi j,2 vj,t + \varphi j,3 \varepsilon j,t-1 + \lambda j \varepsilon k,t + \varepsilon j,t, \varepsilon j,t \sim N(0, vj,t) \quad (3)$$

$$vj,t = \alpha j,0 + \alpha j,1 vj,t-1 + \alpha j,2^{\varepsilon} 2_{j,t} - 1 + \gamma j^{e} 2_{k,t} \quad (4)$$

Where $e_{k,t}$ in the above equation is the residual series for regional index, which shows the mean return spillover effect from these sources. To examine the volatility spillover, exogenous variable is included in the conditional volatility equation, defined as where j in equation 3 and 4 refers to one of the LA region equity market.

4. Results and Discussion

4.1 Summary Statistics

Descriptive statistics of six equity markets returns are reported in Table 2. The results show that daily mean stock returns of Argentina's stock market are highest and having value of 0.0010, while mean stock returns of US's stock market are lowest and having value of 0.00016. Furthermore, return's standard deviation is highest for Argentina stock market and having

a value of 0.0205, but return's standard deviation is lowest for stock market of Chile and having value of 0.0099. So, equity market of Argentina is highly volatile and high returns oriented as compare to all other equity markets of Latin America and US. Furthermore, the skewness of US, Brazil and Argentina market is negative but skewness of Mexico, Chile and Peru is positive. The Kurtosis of Peru's equity market returns is highest as compared to all other markets. This indicates that their daily stock return series has a fat tailed distribution, while for Argentina's stock market returns has lowest Kurtosis. The Jarque-Bera test statistics is significant for all equity market returns; and shows that all equity market returns are not normally distributed.

4.2 Regression Analysis

4.2.1 Mean and Volatility Spillover Effect

a) H0: No mean and volatility Spillover from US to Brazil. The mean and volatility spillover effect from US to Brazil are reported in Table are the indicators of Mean and volatility spillover respectively from US to Brazil. The findings reveal that the effect of mean spillover from US to Brazil is 0.9103 which is positive and significant. The volatility spillover is also significantly positive from US to Brazil. The spillover effect of US equity market is positively transmitted to the Brazil.

b) H0: No mean and volatility spillover from US to other LA stock markets (Except Brazil) The mean and volatility spillover effect from US to other LA equity markets (Mexico Argentina, Chile and Peru) are reported in Table 4. are the indicators of Mean and volatility spillover respectively from US to Mexico, Argentina, Chile and Peru. The results depict that equity market of US is evident of the positive and significant mean spillover transmission to the stock markets of Mexico Argentina, Chile and Peru. While equity market of US provides significant evidence of positive volatility transmission to the stock markets of Mexico Argentina, Chile and Peru.

c) H0: No mean and volatility spillover from Brazil to other LA stock markets (Except Brazil) The mean and volatility spillover effect of Brazil to other LA stock markets (Mexico Argentina, Chile and Peru) are reported in Table 5. are the indicators of Mean and volatility spillover respectively from Brazil to Mexico, Argentina, Chile and Peru. The mean spillover from Brazil is positive for Mexico, Argentina, Chile and Peru. Further, volatility transmission from Brazil is positive for Mexico, Argentina, and Peru but negative and significant for Chile.

4.2.2 Comparison of Mean and Volatility Spillover Effect

H0: Mean and volatility spillover effect of Brazil is stronger as compared to US on other LA stock markets The mean spillover coefficient from US to Mexico is 0.6668, which is higher than the mean spillover coefficient 0.3944 from Brazil to Mexico. While coefficient of the volatility spillover from US to Mexico is 1.9E-06, which is lower as compared to volatility spillover coefficient 4.0E-06 from Brazil to Mexico. This suggests that equity market of Mexico is more influenced by US as compared to Brazil with respect to both mean; but equity market of Mexico is less influenced by US as compare to Brazil with respect to volatility transmission. The mean spillover coefficient from US to Argentina is 0.8407, which is higher than the mean spillover coefficient 0.5718 from Brazil to Argentina. Further, coefficient of the volatility spillover from US to Argentina is 4.7E-06, which is lower as compared to volatility spillover coefficient 5.1E-06 from Brazil to Argentina. This suggests that equity market of Argentina is more influenced by US as compared to Brazil with respect to mean spillover, while equity market of Argentina is less influenced by US as compare to Brazil with respect to volatility transmission. The mean spillover coefficient from US to Chile is 0.3351, which is higher than the mean spillover coefficient 0.2778 from Brazil to Chile.

Further, coefficient of the volatility spillover from US to Chile is 1.9E-06, which is lower in magnitude as compare to volatility spillover coefficient -3.3E-06 from Brazil to Chile. This suggests that equity market of Chile is more influenced by US as compared to Brazil with respect to mean spillover, while equity market of Chile is less influenced by US as compared to Brazil with respect to volatility transmission. So volatility transmission from Brazil to Chile is negative. This negative volatility transmission from Brazil to Chile shows that when volatility of Brazil equity market increases then volatility of Chile equity market decreases; and this implies that there is an existence of portfolio diversification opportunities for portfolio managers and international investors. The mean spillover coefficient from US to Peru is 0.2701, which is higher than the mean spillover coefficient 0.1794 from Brazil to Peru. While coefficient of the volatility spillover from US to Peru is 5.1E-06, which is lower as compared to volatility spillover coefficient 7.1E-06 from Brazil to Peru.

This suggests that equity market of Peru is more influenced by US as compared to Brazil with respect to both mean, but equity market of Peru is less influenced by US as compared to Brazil with respect to volatility transmission. Mean spillover effect from US to LA equity markets (except

Brazil) is higher and positively significant as compare to the mean spillover effect from Brazil to other LA stock markets. So, influence of US is higher on other LA stock markets as compared to the Brazil with respect to mean spillover effect. Moreover, volatility spillover effect of Brazil is higher overall on the all other LA stock markets as compared to US. So, influence of Brazil is higher on other LA stock markets as compared to the US with respect to volatility spillover effect.

5. Conclusion

This study aims to compare the influence of US (world leading) and Brazil (Latin American Region leading) stock markets on the other major Latin American (LA) stock markets (Mexico, Argentina, Chile and Peru). GARCH in mean (GARCHM) approach is employed as suggested by (Liu & Pan, 1997). This study uses a daily frequency stock indexes data from 2002 to 2015.

The empirical findings of this study suggest that the mean spillover effect of the US is dominant as compared to Brazil on the Mexico, Argentina, Chile, and Peru stock exchanges. The mean spillover effect from the US to other LA countries is positive as well, which indicates that whenever returns of US increases; it will positively affect the returns of other LA stock markets. So, Mexico, Argentina, Chile and Peru equity markets are more influenced by the World largest US Stock market and less influenced by their regional major equity market of Brazil with respect to mean return transmission.

The volatility spillover effect of Brazil is dominant as compared to US on Mexico, Argentina, Chile and Peru. The volatility spillover effect is positive from Brazil to Mexico, Argentina, and Peru, while negative from Brazil to Chile. This negative volatility spillover from Brazil to Chile implies that there is an existence of portfolio diversification opportunities for portfolio managers and international investors. So, Mexico, Argentina, Chile and Peru equity markets are more influenced by the Brazil equity market and less influenced by equity market of the US with respect to volatility returns transmission.

Based on these findings, it is concluded that all American Markets are highly integrated because all coefficient of mean and volatility spillover from US and Brazil to other LA stock markets are highly significant at 1% level of significance. Further, US equity market dominantly transmits mean spillover and Brazil equity market dominantly transmits volatility spillover

to equity markets of the Mexico, Argentina, Chile and Peru. These findings are crucial for international portfolio management in US and LA region. For policy makers and market authorities, an increase in volatility transmission among US and LA stock markets implies that the stability of the financial system in one country can be deeply affected by the disturbance in another country.

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Appendix

Table 2: Summary Statistics

	RUS	RBRAZ	RMEX	RARG	RCHIL	RPERU
Mean	0.000162	0.000323	0.000540	0.001017	0.000321	0.000602
Median	0.000656	0.000000	0.000500	0.000440	0.000143	0.000241
Maximum	0.109572	0.136766	0.104407	0.111200	0.118034	0.323408
Minimum	-0.094695	-0.120961	-0.072661	-0.129516	-0.072363	-0.294176
Std. Dev.	0.012501	0.017678	0.012430	0.020589	0.009965	0.016312
Skewness	-0.217735	-0.066499	0.093043	-0.430680	0.013991	0.197601
Kurtosis	12.33284	7.592857	8.783607	6.937434	12.80618	82.67184
Jarque-Bera	12817.29	3099.949	4916.676	2385.356	14119.77	932062.6
Observations	3524	3524	3524	3524	3524	3524

Table 3: Mean and Volatility Spillover Effect from US to Brazil

	US	Brazil
φ_0	0.00042 (2.446)	-0.0003 (-0.997)
φ_1	0.7526 (9.244)	0.4062 (1.488)
φ_2	1.3687 (0.819)	7.3065 (3.311)
φ_3	-0.8040 (-11.07)	-0.4527 (-1.700)
λ_1		0.9103 (48.36)
α_0	1.8E-06 (7.525)	-5.0E-07 (-0.738)
α_1	0.8902 (104.9)	0.9221 (106.1)
α_2	0.0943 (12.64)	0.0594 (8.492)
λ_2		3.8E-06 (5.462)

Table 4: Mean and Volatility Spillover Effect from US to other Latin American Countries (Except Brazil)

	US	MEXICO	ARGENTINA	CHILE	PERU
φ_0	0.000042	7.7E-05	0.0010	0.0004	0.000
	(2.446)	(0.326)	(2.601)	(2.329)	(3.354)
φ_1	0.7526	-0.2005	-0.2606	-0.0186	0.1024
	(9.244)	(-0.468)	(-0.578)	(-0.141)	(0.727)
φ_2	1.3687	13.064	1.6767	4.4602	0.5182
	(0.819)	(3.740)	(1.130)	(1.347)	(0.375)
φ_3	-0.8040	0.2384	0.2963	0.1535	0.0352
	(-11.07)	(0.560)	(0.664)	(1.165)	(0.248)
λ_1		0.6668	0.8407	0.3351	0.2701
		(57.65)	(39.25)	(29.62)	(20.22)
α_0	1.8E-06	6.1E-08	1.0E-07	6.6E-07	5.0E-06
	(7.525)	(0.183)	(0.128)	(1.703)	(5.215)
α_1	0.8902	0.8987	0.9053	0.8518	0.6779
	(104.9)	(91.25)	(142.8)	(69.44)	(45.29)
α_2	0.0943	0.0740	0.0815	0.1124	0.3108
	(12.64)	(9.986)	(14.65)	(10.45)	(21.23)
λ_2		1.9E-06	4.7E-06	1.9E-06	5.1E-06
		(6.553)	(6.105)	(4.970)	(6.284)