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The Role of Exchange Rate Fluctuations in the Volatility and Correlations in Emerging Markets

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Abstract

The recent episodes of sanctions on Russia by international communities and the quantitative easing by Japanese and European central banks highlight the importance of foreign exchange risk for international investors. This paper examines how and to what extent the volatility of exchange rate affect the volatility of local equity market for Latin American countries and transition economies. Compared to Mun [15], we find that the proportions of volatility of local equity market attributable to exchange rate fluctuations for Latin American countries and transition economies are much larger than those for more developed economies. Besides, an increase in exchange rate volatility is associated with an increase in the correlation between the local and the US equity markets for Latin American countries but with a decrease in the correlation for transition economies, both to a larger extend than developed countries. In particular, our study indicates that the sign of the conditional correlation coefficient between exchange rate and local equity market varies across countries and time, inconsistent with the prediction by the so called "equity parity condition" in Hau and Rey [8].

Keywords: Stock index, exchange rate, LACs, TEs, GARCH.

1. Introduction

Latin American countries (LACs) and transition economies (TEs) has become important markets for international investment since the past decade. For example, the annual net private capital flows in central and Eastern Europe areas are 140.54 billion US dollars in 2007 from 53.76 billion US dollars in 2002, and the net direct investment in these areas is 68.59 billion US dollars in 2007 from 24.08 billion US dollars in 2002 (IMF[9]). It is argued that the stabilization policies and structural reforms such as privatizations in LACs and TEs contribute to growth recoveries.

It is well known that international investment beyond domestic market will gain from global diversification, as long as the set of domestic investment opportunities does not span the set of foreign investment opportunities. From the perspective of US investors, the risk associated with investment in foreign equity market is composed of the risk in foreign equity market (in local currency) as well as the risk of exchange rate when the return is denominated in US dollar. When international equity markets are getting more integrated, gains from international diversification will be reduced. Whether international equity markets are integrated or segmented is an empirical issue. Previous studies concerning international market integration can be found in studies such as Kasa [11], Errunza et al. [7], Bekaert and Harvey [1], and Koedijk et al. [12], among others. Even if foreign equity index and the US equity index are integrated, fluctuations in exchange rate will entail significant risks on US investors when they invest in foreign equity markets.

Given that the US investors' returns from foreign assets are denominated in local currencies, it important to explore how the corresponding exchange rates affect the US and foreign equity indexes when exchange rates are considered exogenous. The linkage between equity and foreign exchange markets has been extensively documented. The studies related to this issue, whether in unconditional or conditional form, can be found in Chiang [4], Jorion [10], Dumas and Solnik [5], Malliaropulos [13], Morley and Pentecost [14] and Hau and Rey [8], to name a few. However, most previous studies concern the first moments in stocks and foreign exchange rates. Mun [15] develops an explicit way to investigate the role of exchange rate fluctuations in international stock markets and examines how and to what extent volatility and correlations in equity markets are influenced by exchange rate fluctuations. He finds, first, a higher foreign exchange rate variability increases local stock volatility but decreases volatility for the US stock market. The extent to which stock market volatility is influenced by foreign exchange volatility is greater for local markets than for the US market. Second, a higher exchange rate fluctuation marginally decreases the US/local equity correlation. Mun [15] argues that it is possibly due to positive correlation between the local stock market and the foreign exchange market, and that upward movement of local stock markets would trigger international investors to invest in local stock markets rather than the US market, causing outflow of funds from the US market, thus depreciating the US dollar. However, in Mun's study conditional correlation coefficients are significant for only two out of eight countries.

Mun's [15] arguments suggest that local stock market and foreign exchange rate tend to move in the same direction. However, such implication deserves to be further scrutinized. For example, Hau and Rey [8] develop an equilibrium model in which exchange rates, stock prices, and capital flows are jointly determined under incomplete foreign exchange risk trading. For 17 OECD countries, Hau and Rey [8] document that higher returns in the home equity market relative to the foreign equity market are associated with a home currency depreciation, and the negative correlations are more pronounced for more developed countries. It is argued that these observations are consistent with the prediction of their model. As a result, they argue their findings are consistent with "uncovered equity parity" condition. Brooks et al. [2] also documents negative correlations between European equity excess returns over U.S. equity and the euro-dollar exchange rates. However, Malliaropulos [13] and Morley and Pentecost [14] find results inconsistent with Hau and Rey [8]. Namely, stock markets outperform the US stock market in countries where the currency appreciates in real terms against the dollar. As a result, Mun's argument that local stock market and exchange rate tend to move in the same direction deserves to be further explored.

Most of the countries in the sample of Mun [15] are developed countries. This paper attempts to answer the question whether Mun's findings can be generalized and applied to LACs and TEs and how the dynamic relationships between exchange rates and equity market performances are interrelated in these regions in the period after the bankruptcy of Lehman Brothers in 2008. LACs and TEs undertook massive structural reforms since early 1990s including liberalization of financial markets, less trade barriers and privatizations. Although during the period LACs were a decade of intensive structural reform, and various macroeconomic stabilization programs were implemented, the growths turned out to be low and came accompanied by unexpected and severe financial crisis. For TEs, the collapse of the social system provided opportunities for potential growth, even though they were initial less competitive to the world market when they were first exposed to international competition. However, many of these economies were industrialized and could count on cheap yet educated workforce. From the perspective of foreign direct investment (FDI), which is perceived as a catalyst for technological advancement necessary for making them more competitive in the international market, Campos and Kinoshita [3] show that TEs has received less FDI than LACs through the 1990s, but the trend has reversed since 2002. Due to the liberalized financial markets and increasing FDI, international capital flows will in turn affect the exchange rates and equity market performances in LACs and TEs.

In sum, because LACs and TEs are regarded as markets with strong economic potentials, we believe the following issues are important for LACs and TEs. First, given Mun's findings provide important implications for international portfolio management, can his findings for developed economies be applied to LACs and TEs with high growth potential? Second, following aforementioned papers such as Malliaropulos [13], Morley and Pentecost [14], Brooks et al. [2] and Hau and Rey [8] in which whether exchange rate and local equity market performance relative to the US are positively or negatively correlated seems inconclusive, we believe this study concerning conditional correlation coefficients between exchange rate and equity market will also contribute to help solve this puzzle.

The remainder of this paper is organized as follows. Section 2 describes the methodology by Mun [15] which models the proportion of the stock market volatility and cross-market correlations which can be attributed exchange rate fluctuations. Section 3 provides a description of the data and econometric methodologies. Section 4 presents the empirical results. Section 5 is the concluding remarks.

2. The Model

This study is to investigate how and to what extent that stock market returns are affected by the fluctuations in exchange rates in a global setting from the perspective of US investors. Because US investors are exposed to exchange rate risk when they invest in foreign assets, it is important to know how exchange rate risk affects stock returns in foreign (local) as well as domestic (US) stock markets. The US dollar return in currency j stock market is given by:

$$R_{jt}^{USD} = \ln P_{jt}S_{jt} - \ln P_{jt-1}S_{jt-1} = (\ln P_{jt} - \ln P_{jt-1}) + (\ln S_{jt} - \ln S_{jt-1}) = R_{jt}^{LCD} + Z_{jt} \tag{2.1}$$

where R_{jt}^{USD} is the US dollar return in currency j stock market; P_{jt} is the price index in the currency j stock market at time t; $R_{jt}^{LCD} \equiv \ln P_{jt} - \ln P_{jt-1}$ is the local currency denominated index return in the currency j stock market at time t; $Z_{jt} =\equiv \ln S_{jt} - \ln S_{j-1}$ is the appreciation of local currency j relative to the US dollar at time t.

Eq.(2.1) states that US dollar return on foreign stock index is composed of index return in local currency and exchange rate return when converted to the US dollar. The proportion of the US dollar local market volatility attributable to exchange rate fluctuations, Ψ, is thus given by:

$$\Psi = 1 - \frac{\mathrm{Var}\,(R_{jt}^{LCD})}{\mathrm{Var}\,(R_{jt}^{USD})} = \frac{\mathrm{Var}\,(Z_{jt}) + 2\,\mathrm{Cov}\,(R_{jt}^{LCD}, Z_{jt})}{\mathrm{Var}\,(R_{jt}^{USD})}. \tag{2.2}$$

Eq.(2.2) states the proportion of the variance of US dollar returns affected by exchange rate fluctuations, which includes the variance of exchange rate variance and the covariance between the j currency stock returns and the exchange rate returns.

Next the correlation coefficient between the currency j stock market return in US dollar and the US stock market return, R_t , is (see (A.2) in Appendix A):

$$\rho(R_{jt}^{USD}, R_t) = \rho(R_{jt}^{LCD}, R_t)\sqrt{\frac{\mathrm{Var}\,(R_{jt}^{LCD})}{\mathrm{Var}\,(R_{jt}^{USD})}} + \rho(Z_{jt}, R_t)\sqrt{\frac{\mathrm{Var}\,(Z_{jt})}{\mathrm{Var}\,(R_{jt}^{USD})}}. \tag{2.3}$$

The proportion of the correlation coefficient between the US and the local market returns that can be attributable to exchange rate fluctuations, Φ, is (see (A.3) in Appendix A):

$$\Phi = \frac{\rho(Z_{jt}, R_t)}{\rho(R_{jt}^{USD}, R_t)}\sqrt{\frac{\mathrm{Var}\,(Z_{jt})}{\mathrm{Var}\,(R_{jt}^{USD})}}. \tag{2.4}$$

3. Data and Methodology

3.1. Data

The sample in this study includes daily stock indexes and exchange rates from Argentina (Argentina Merval- price index), Brazil (Brazil Bovespa — total return index), Chile (Chile Santiago SE general- price index), Czech Republic (Prague SE PX — price index), Hungary (Budapest — price index), Mexico (Mexico IPC — price index), Poland (Warsaw general index-total return index), Russia (Russian Micex index-price index), and the US (S&P 500 composite). Because our study concerns the relationship between

Table 1: Summary statistics.

	Argentina	Brazil	Chile	Czech	Hungary	Mexico	Poland	Russia
Equity market								
Mean(%)	0.137727	0.017751	0.032657	0.011768	0.024900	0.040939	0.041788	0.063692
	(0.07)	(0.01)	(0.04)	(0.01)	(0.02)	(0.04)	(0.04)	(0.04)
S.D.	1.954101	1.489479	0.754590	1.279417	1.543642	1.090621	1.178044	1.735802
FX market								
Mean(%)	-0.080114	-0.016260	0.000944	-0.015664	-0.024142	-0.007076	-0.014893	-0.046202
	(-0.08)	(-0.02)	(0.00)	(-0.02)	(-0.02)	(-0.01)	(-0.01)	(-0.04)
S.D.	0.999121	0.771867	0.601404	0.815222	1.088553	0.719120	1.296616	1.030785
Return correlation								
US and local equity market	0.56930	0.64436	0.51822	0.40964	0.39234	0.70664	0.45477	0.43616
Local equity and FX market	-0.04821	0.36041	0.09835	0.37859	0.30367	0.47479	0.32207	-0.01899

Number in parentheses are t-statistics.

exchange rates and equity markets, we need those with less government restrictions and more liberal financial markets and these LACs and TEs represent relatively larger economies in these regions. The exchange rate is defined as the US dollar price of one foreign currency. All the data are daily, and are collected from Datastream. The sample period is from January 2$^{\text{nd}}$, 2009 to March 6$^{\text{th}}$, 2015, and thus the number of observations for each variable is 1,613.

The time-plots of stock indexes and exchange rates are shown in Figure 1. Stock index uses left scale and exchange rate uses right scale. During our sample period, it can be observed that the value of foreign currency for Argentina tends to move inversely with stock index. In this case, if US investors have invested in the equity market of Argentina, the gain or loss is significantly offset by the inverse movements in its foreign exchange rate. This is in line with the equity parity condition. For the other countries, stock indexes and foreign exchange rates tend to move in tandem; stock indexes and foreign exchange rates tend to move in the same direction. However, for these countries except Brazil, stock indexes tend to move stronger than foreign exchange rate after 2013, indicating more aligned with equity parity condition during the later period. The case of Russia is noteworthy. Because of the sanctions imposed on Russia by the international governments due to the crisis in Crimea, the value of Russian ruble has tumbled by a half, but at the same time Russian stock index has ratcheted up to regain the high in 2010. This is because the devaluation of Russian ruble has boosted their foreign corporate earnings when denominated in its own currency.

Summary statistics for the equity indexes and foreign exchange rate returns from the eight foreign countries are reported in Table 1. During our sample period, it is found that the standard deviation of Brazilian exchange rate returns is very large. In comparison with those in Mun [15], we find (1) for the countries in our sample except those in Latin America, the correlations between the US equity index returns and local equity

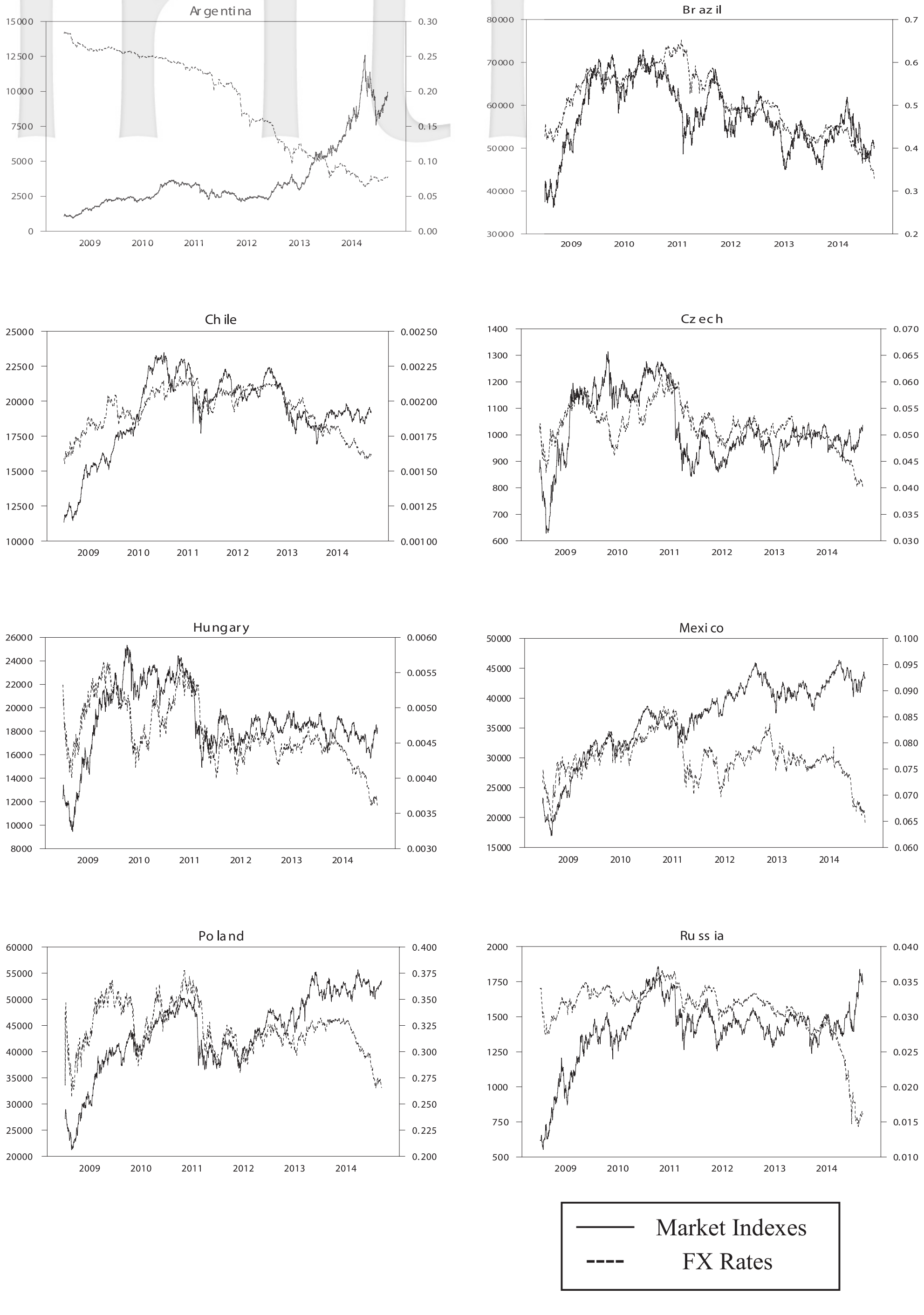

Figure 1: Market indexes and FX rates.

index returns tend to be smaller than those reported in Mun [15], and (2) the correlation coefficients between equity index returns from local markets and corresponding exchange rate returns can be positive and negative, these are inconsistent with those reported in Mun [15], in which the correlation coefficients are universally positive. From the perspective of portfolio balance approach, whether an increase in local equity market return is associated with an increase or decrease in exchange rate is inconclusive by this unconditional approach.

3.2. Methodology

Given that the purpose of this study is to examine the proportion of variance in the US dollar local market returns and the proportion of correlation between the US dollar local market return and the US market return attributable to exchange rate fluctuations, we investigate these issues within bivariate GARCH(1,1) with dynamic conditional correlation (DCC-GARCH(1,1)) framework by Engle [6]:

$$r_{1,t} = \alpha_{1,0} + \alpha_{1,1} r_{1,t-1} + \varepsilon_{1,t} \tag{3.1a}$$

$$r_{2,t} = \alpha_{2,0} + \alpha_{2,1} r_{2,t-1} + \varepsilon_{2,t} \tag{3.1b}$$

$$h_{11,t} = c_1 + a_1 \varepsilon^2_{1,t-1} + b_1 h_{11,t-1}, \tag{3.1c}$$

$$h_{22,t} = c_2 + a_2 \varepsilon^2_{2,t-1} + b_2 h_{22,t-1}, \tag{3.1d}$$

$$h_{12,t} = \rho_{12,t} \sqrt{h_{11,t}} \sqrt{h_{22,t}}, \tag{3.1e}$$

$$\rho_{12,t} = \frac{q_{12,t}}{\sqrt{q_{11,t} q_{22,t}}}, \tag{3.1f}$$

and

$$Q_t = (1 - A - B) Q_0 + A \varepsilon_{t-1} \varepsilon'_{t-1} + B Q_{t-1} \tag{3.1g}$$

where $r_{i,t}$ = the return at time t for market i, $i = 1, 2$; $\varepsilon_{i,t}$ is the residual; $h_{ij,t}$ $(i, j = 1, 2)$ are conditional variances and covariance. h_{11} and h_{22} are the actual conditional variances generated by univariate GARCH models, and h_{12} is generated by Eq.(3.1e). $\rho_{12,t}$ is the conditional correlation coefficient at time t; Q_t is the conditional covariance matrix with the (i, j)-th element $q_{ij,t}$. Q_0 is the unconditional covariance matrix; α's, a's, b's, c's, A and B are coefficients. $i = 1$ and 2 correspond to following three pairs of time series variables: (1) the exchange rate return ($i = 1$) and the local equity market return ($i = 2$), (2) the US dollar local equity market return ($i = 1$) and the US equity market return ($i = 2$).

4. Empirical Results

4.1. Exchange rate returns and local equity market returns

Estimates of conditional volatility in foreign exchange rate and local equity index returns within the framework of DCC-GARCH(1,1) are plotted in Figure 2 and reported in Table 2.

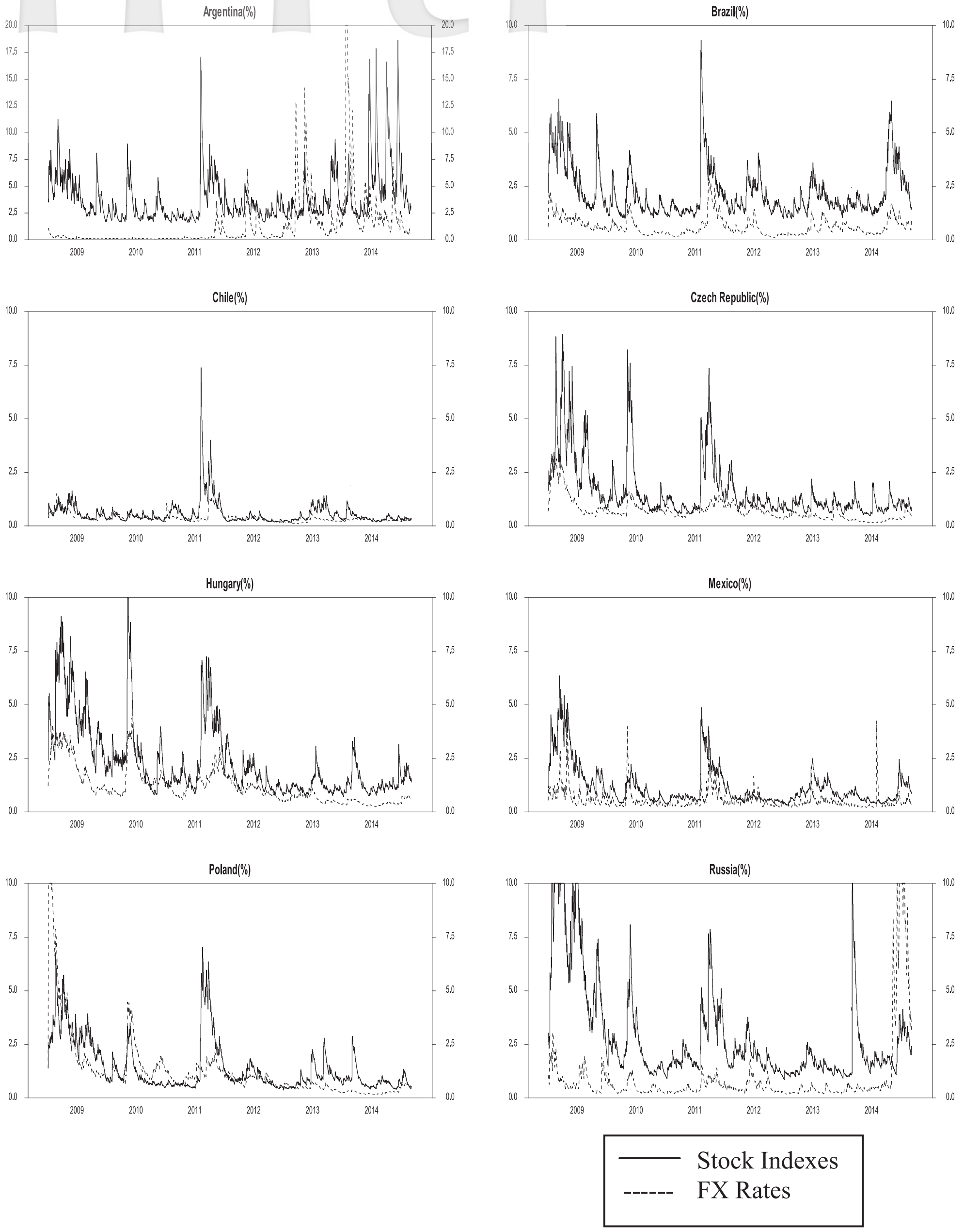

Figure 2: Conditional volatility: Local equity index and FX Rate.

Table 2. DCC-GARCH(1,1)- Exchange rate return ($i = 1$) and local equity market return ($i = 2$).

	Argentina	Brazil	Chile	Czech	Hungary	Mexico	Poland	Russia
$\alpha_{1,0}$	-0.0232(-2.82)***	0.0099(0.72)	-0.0094(-0.99)	-0.0238(-1.50)	-0.0301(-1.42)	0.0309(2.48)**	-0.0268(-1.67)*	0.0044(0.29)
$\alpha_{1,1}$	0.1622(6.46)***	0.0723(3.03)***	0.1419(5.74)***	-0.0620(-2.77)***	-0.0437(-1.80)*	-0.0401(-1.68)*	-0.2419(-53.18)***	0.0746(3.07)***
$\alpha_{2,0}$	0.1249(2.96)***	0.0298(0.95)	0.0386(2.71)***	0.0080(0.34)	0.0233(0.76)	0.0616(3.06)***	0.0365(1.88)*	0.0669(2.03)**
$\alpha_{2,1}$	0.0661(2.40)**	-0.0834(-3.58)***	0.1658(6.63)***	0.0183(0.79)	-0.0616(-2.45)**	0.0536(2.29)**	0.0359(-1.49)	0.0058(0.21)
c_1	0.0006(2.65)***	0.0066(4.22)***	0.0041(24.28)***	0.0042(8.09)***	0.0058(7.64)***	0.0344(25.00)***	0.0027(2.49)**	0.0127(6.66)***
a_1	0.1252(56.05)***	0.0771(11.37)***	0.0440(41.41)***	0.0515(41.10)***	0.0437(30.32)***	0.1425(24.10)***	0.0474(6.54)***	0.1017(10.44)***
b_1	0.8997(866.12)***	0.9144(124.11)***	-0.9450(1393.13)***	0.9438(898.79)***	0.9505(800.08)***	0.7947(176.17)***	0.9496(135.09)***	0.8802(115.95)***
c_2	0.1554(17.24)***	0.0588(5.43)***	0.0117(10.42)***	0.0372(4.19)***	0.0367(8.07)***	0.0179(7.90)***	0.0144(4.63)***	0.0581(5.24)***
a_2	0.0929(23.52)***	0.0710(10.90)***	0.0971(25.51)***	0.0895(7.07)***	0.0730(21.15)***	0.0701(19.36)***	0.0638(17.70)***	0.0650(7.20)***
b_2	0.8677(252.28)***	0.9021(99.43)***	0.8810(274.70)***	0.8868(56.79)***	0.9105(195.53)***	0.9135(420.79)***	0.9257(262.49)***	0.9129(81.16)***
A	0.0257(2.97)***	0.0075(3.15)***	0.0000(1.05e-08)	0.0167(14.26)***	0.0195(2.59)***	0.0340(1.91)*	0.0186(9.37)***	0.0034(0.28)
B	0.9190(28.63)***	0.9914(359.85)***	0.5905(6.52e-04)	0.9826(705.48)***	0.9558(41.63)***	0.3427(1.12)	0.9770(332.99)***	0.5531(0.79)
$\rho_{12,t}$	-0.0453(-23.27)***	0.3630(138.30)***	0.1018(4.07e+12)***	0.3221(65.24)***	0.3035(149.75)***	0.4753(602.94)***	0.3418(113.04)***	-0.0190(-162.21)***

Number in parentheses are t-statistics.
*indicates significant at 10% significance level. **indicates significant at 5% significance level. ***indicates significant at 1% significance level.

GARCH effects are present for exchange rate as well as stock index returns, given very significant coefficients of a_1, a_2, b_1 and b_1 in Eqs.(3.1c) and (3.1d). DCC coefficient B in Eq.(3.1g) is not significant only for Chile, Mexico and Russia. In Figure 2, similar to Figure 1, stock index returns use left scale and exchange rates use right scale, from which we can observe extreme values of stock market return volatility have similar patterns, especially the event of the European sovereign debt crisis in 2011. The relationship between the conditional volatility in exchange rate returns and the conditional volatility in local equity returns often exhibit similarities, especially for Brazil, Hungary, Poland and Russia. For the case of Russia, foreign exchange volatility had been much larger than stock index volatility during the late 2014. These indicate the equity index return and exchange rate are related through a certain long term economic relationship. From the perspective of US investors, risk in foreign equity markets are also coupled with risk in foreign exchange markets.

The conditional correlation coefficients between the local equity market returns and exchange rate returns are plotted in Figure 3. Conditional correlation coefficients for Brazil, Czech Republic, Hungary, Poland and later period of Argentina exhibit patterns mimicking a unit root process, due to a large coefficient value of B in Eq.(3.1g). Overall, Most of the conditional correlation coefficients fall in the positive region, and we can conclude the correlation coefficient between local stock market return and exchange rate return is positive for most of the countries, except for Argentina and Russia.

4.2. The US dollar local equity market return and the US equity market return

The estimates of DCC-GARCH(1,1) model between the US dollar local equity market return and the US equity market return are reported in Table 3. First, ARCH/GARCH effects are present for all the countries. Second, Coefficient B are very significant for all except for Russia. Coefficient A is also very significant for all except for Czech Republic. Overall dynamic conditional correlation coefficient is significant for all countries, indicating time-varying correlation coefficients. Figure 4 indicates that when the foreign stock index is denominated in USD, returns in the U.S. Equity and foreign local indexes exhibit similar ups and downs. However, most of the countries have more volatile returns than that of U.S. Figure 5.

Figure 5 shows the conditional correlations fall in the positive regions. Compared to Figure 3, the correlations are much larger in Figure 5. This indicates strong cointegrations in the international equity markets when they are all denominated in USD. The equity markets of Argentina, Brazil, Chile and Poland exhibit processes close to unit processes, given their values of coefficient B in Eq.(3.1g) are close to one.

4.3. Volatility and correlation attributable to exchange rate fluctuations

Volatility and correlation coefficient attributable to exchange rate fluctuations are reported in Table 4 and Figure 6 and Figure 7. The percentage of volatility of US dollar local market return attributable to exchange rate fluctuations are shown to be

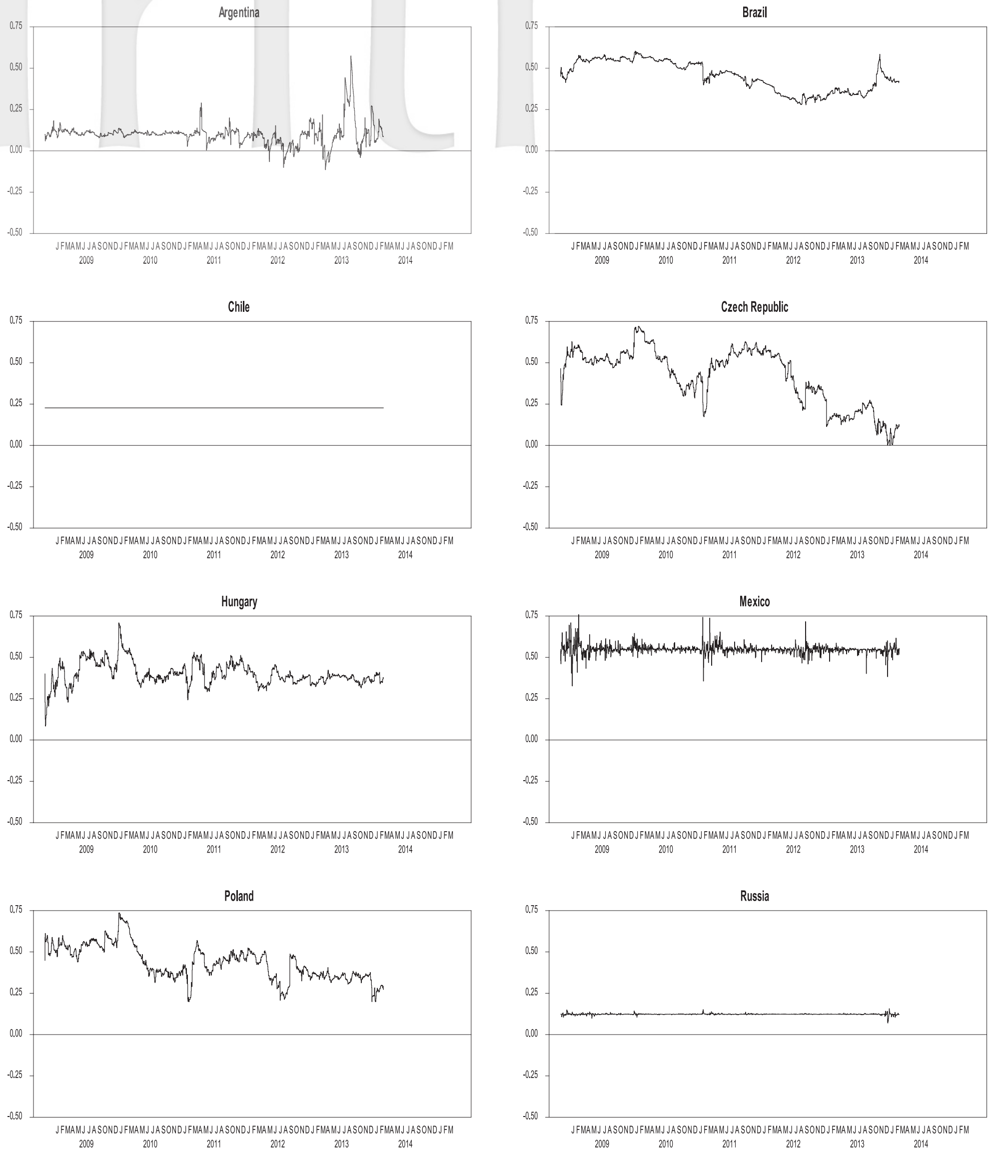

Figure 3: Conditional Correlation: Local equity index and exchange rate.

time-varying within the framework of DCC-GARCH(1,1) model. Table 4 shows that the estimate of Ψ is the largest for Chile at 66.2%, followed by Argentina at 53.2% and Brazil at 41.7%. These indicate that LACs have much larger equity market volatility attributable to exchange rate fluctuations than TEs.

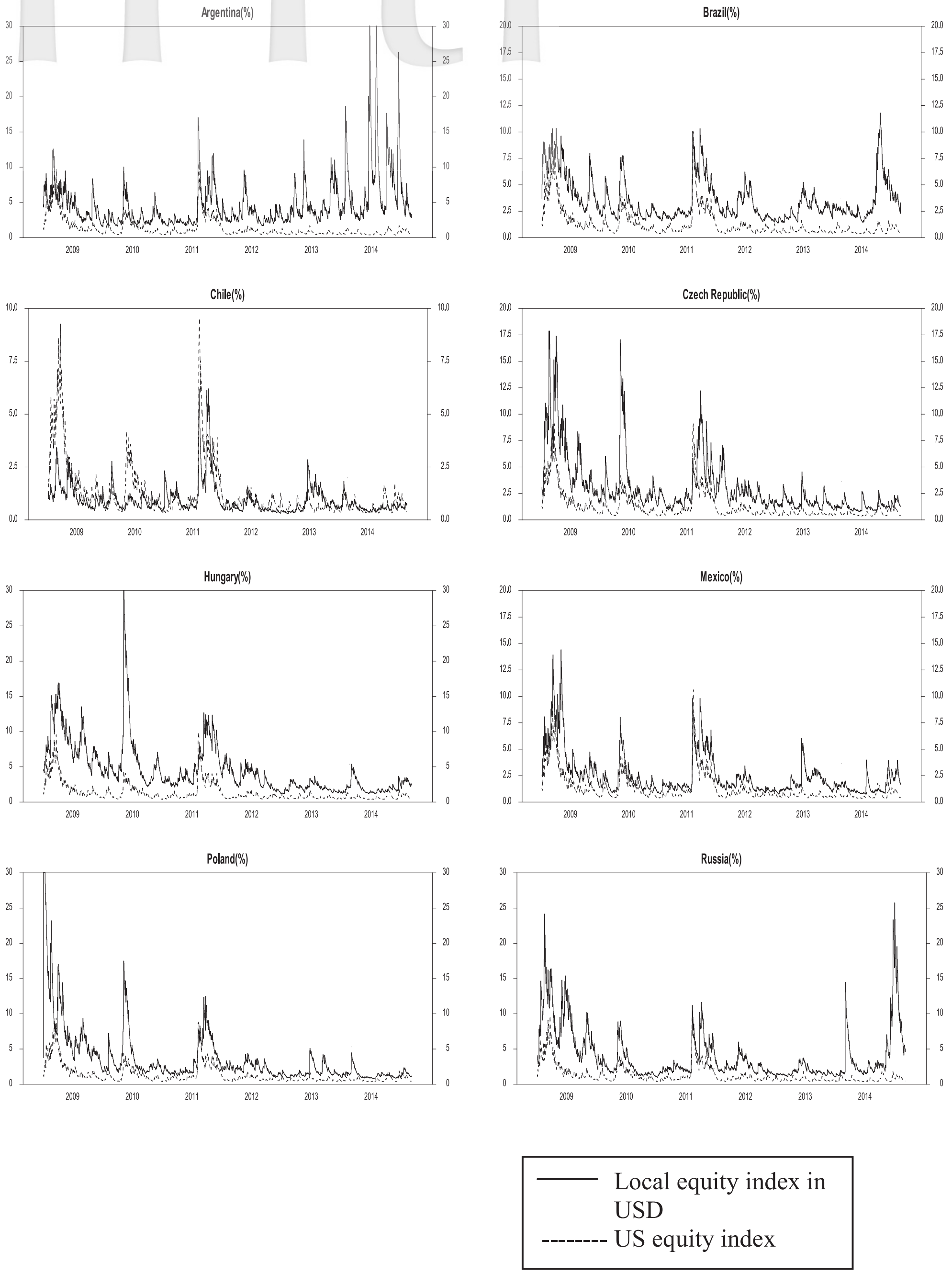

Figure 4: Conditional volatilities for Local equity index in USD and US equity index.

Table 3. DCC-GARCH(1,1)- Local equity market return in US dollar ($i = 1$) and US equity market return ($i = 2$).

	Argentina	Brazil	Chile	Czech	Hungary	Mexico	Poland	Russia
$\alpha_{1,0}$	0.0977(2.74)***	0.0507(1.70)*	0.0342(1.99)**	0.0196(0.67)	0.0167(2.41)**	0.0803(3.93)***	0.0324(0.93)	0.0799(2.61)***
$\alpha_{1,1}$	0.0409(1.70)*	0.0350(1.84)*	0.2665(11.87)***	-0.0114(-0.49)	0.0434(1.96)**	-0.0174(-1.10)	-0.0677(-12.04)***	0.0804(3.38)***
$\alpha_{2,0}$	0.0792(4.74)***	0.0875(5.65)***	0.0889(4.89)***	0.0869(7.41)***	0.0844(5.03)***	0.0938(6.87)***	0.0845(4.41)***	0.0967(5.30)***
$\alpha_{2,1}$	-0.0626(-2.52)**	-0.0800(-3.92)***	-0.1348(-5.51)***	-0.1716(-8.48)***	-0.1367(-5.33)***	-0.0994(-6.09)***	-0.2123(-8.45)***	-0.0968(-3.68)***
c_1	0.1462(16.45)***	0.0726(13.02)***	0.0226(10.99)***	0.0640(12.94)***	0.0420(8.76)***	0.0538(18.55)***	0.0412(5.44)***	0.0699(23.02)***
a_1	0.1003(33.44)***	0.0634(28.44)***	0.0880(30.35)***	0.0947(30.48)***	0.0641(30.63)***	0.0829(37.41)***	0.0721(14.89)***	0.0837(38.88)***
b_1	0.8692(377.56)***	0.9149(454.05)***	-0.8880(302.30)***	0.8814(111.17)***	0.9259(343.53)***	0.8948(472.10)***	0.9113(390.37)***	0.8984(529.88)***
c_2	0.0248(12.23)***	0.0275(13.95)***	0.0275(7.91)***	0.0305(14.79)***	0.0292(13.20)***	0.0294(14.19)***	0.0281(10.41)***	0.0312(13.52)***
a_2	0.1078(30.60)***	0.1037(28.91)***	0.1064(22.20)***	0.1068(27.90)***	0.1138(23.46)***	0.1160(30.71)***	0.1113(25.83)***	0.1185(26.04)***
b_2	0.8730(322.93)***	0.8713(312.62)***	0.8677(141.18)***	0.8627(104.19)***	0.8588(246.79)***	0.8609(288.21)***	0.8614(265.89)***	0.8533(237.64)***
A	0.0220(17.27)***	0.0157(16.67)***	0.0214(2.87)***	0.0085(0.67)	0.0479(17.03)***	0.0645(8.89)***	0.0064(4.39)***	0.0456(2.07)**
B	0.9751(632.82)***	0.9807(655.94)***	0.9506(46.50)***	0.6514(34.75)***	0.6759(10.93)***	0.8457(46.21)***	0.9910(485.29)***	0.0000(3.26e-10)
$\rho_{12,t}$	0.5129(101.63)***	0.6210(167.24)***	0.4183(247.57)***	0.0.4169(1426.37)***	0.0.3759(255.22)***	0.7354(478.50)***	0.4203(248.52)***	0.3961(378.37)***

Number in parentheses are t-statistics.
*indicates significant at 10% significance level. **indicates significant at 5% significance level. ***indicates significant at 1% significance level.

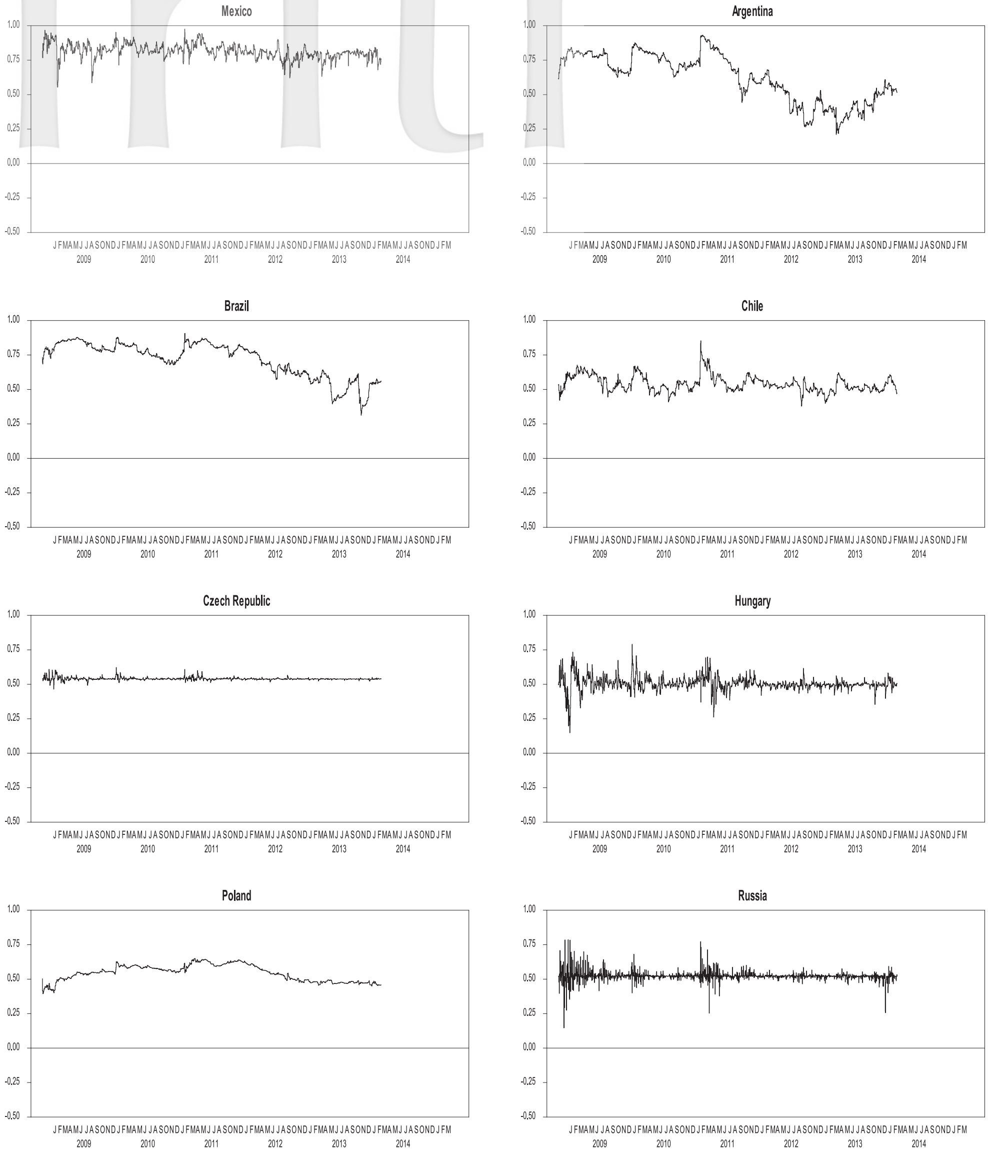

Figure 5: Conditional Correlations for Local equity index in USD and US equity index.

To visually observe the proportion of volatility of US dollar local equity market return attributable to exchange rate fluctuations, Ψ, the plots are given in Figure 6. Figure 6 shows that the proportion of volatility of US dollar local equity market return attributable to exchange rate fluctuations changes dramatically over time, and it seems that there are no similar patterns among these countries. However, all show exchange rate volatility does contribute a significant portion in equity volatility when these equity indexes are denominated in USD. In particular, equity volatility for Russia attributable to its exchange rate fluctuations has picked up dramatically after the mid-2014 given the ruble crisis.

Due to different sample countries, it is important to compare our results with those reported by Mun [15]. Because the sample in Mun [15] consists of more developed economies while our sample consists of LACs and TEs, comparisons between these two studies may yield important economic implications. Mun [15] shows that the proportion of volatility of US dollar local equity market return attributable to exchange rate fluctuations Ψ is no more than 20% (19.44% for unconditional and 18.85% for conditional estimates for UK), while in this study two countries' Ψ are more than 50%. The average of conditional Ψ in Mun [15] is 6.84% while the average of conditional Ψ in our study is 38%, suggesting exchange rates affect the volatility of local equity market return to a much larger extent for emerging countries than for more developed countries.

For the correlations attributable to exchange rate fluctuations, or Φ, Brazil, Czech Republic, Hungary, Mexico and Poland have the strongest coefficients in their unconditional and conditional forms. The unconditional and conditional correlation coefficients are negative only for Argentina. According the Eq.(2.3), the sign of the unconditional correlation coefficient depends on the correlation between exchange rate and the US equity return, given the correlation coefficient between foreign equity index in USD and US equity index is always positive. Because Argentina is the only country with negative correlation between its exchange rate and the US equity index, it is the only country with negative unconditional as well as conditional Φ. Furthermore, if the volatility of exchange rate is large relatively to the volatility of local equity market in USD, Φ will be large in absolute value.

To visually observe the proportion of correlation coefficient attributable to exchange rate fluctuation for these eight countries, we plot the estimates of Φ in Figure 7.

Mun [15] reports that the means of Φ are all negative, and significant for UK and Australia only. Our results differ from Mun [15] in two aspects. First, for both LACs and TEs, the signs of Φ are positive, suggesting exchange rates are positively associated with the US/local equity market returns.

Besides, unlike Mun [15], in our study all the eight countries show significant conditional correlation coefficients. Second, Mun [15] shows that the absolute value of the mean of Φ is very small except for UK (-7.99%) and Australia (-15.51%), while our study shows the means of Φ go from -2% to 36%. That is, exchange rate is shown to have a much larger impact on the US/local equity market correlation for emerging countries than for developed countries.

5. Concluding Remarks

In this paper we follow the DCC-GARCH approach similar to Mun [15] and examine how and to what extend the volatility of exchange rate affects the local and the US equity market performances in Latin American countries (LACs) and transition economies (TEs). The purpose is to investigate if Mun's results can be applied to these developing regions given these regions provide growth potentials and investment opportunities beyond more developed economies after massive stabilization policies and structural reforms in the past decade.

Table 4. Volatility and correlation attributable to exchange rate fluctuations.

Country	$\text{Var}(Z_{jt})$	$\text{Cov}(R_{jt}^{LCD}, Z_{jt})$	$\text{Var}(R_{jt}^{USD})$	$\rho(Z_{jt}, R_t)$	$\rho(R_{jt}^{USD}, R_t)$	Volatility attributable to exchange rate fluctuations (Ψ) (%)		Correlation attributable to exchange fluctuations (Φ) (%)	
						Unconditional	Conditional	Unconditional	Conditional
Argentina	0.99762	-0.09407	4.62562	-0.01568	0.50981	17.50	18.96 (27.11)***	-1.43	-2.28 (-22.13)***
Brazil	0.59541	0.41410	3.64078	0.34770	0.64345	39.10	39.28 (162.13)***	21.85	23.33 (111.43)***
Chile	0.36146	0.04461	1.01973	0.03633	0.40875	44.20	52.33 (137.44)***	5.29	6.25 (172.54)***
Czech	0.66417	0.39463	3.08932	0.25442	0.41606	47.05	48.77 (107.63)***	28.35	30.35 (123.95)***
Hungary	1.18421	0.50995	4.58546	0.17355	0.37094	48.07	49.93 (209.09)***	23.78	24.53 (89.68)***
Mexico	0.51681	0.37214	2.44981	0.54007	0.74029	51.48	54.61 (185.51)***	33.51	35.76 (146.40)***
Poland	1.68017	0.49164	4.05038	0.11220	0.33838	65.76	61.13 (122.11)***	21.36	23.00 (92.47)***
Russia	1.06186	-0.03395	4.00510	0.03313	0.39524	24.82	19.93 (42.33)***	4.32	3.65 (86.18)***

Number in parentheses are t-statistics.

***indicates significant at 1% significance level.

Z_{jt}, R_{jt}^{LCD}, R_{jt}^{USD}, and R_t denote exchange rate return for country j at time t, equity market return for country j at time t, US dollar return for country j's equity market, and the US equity market return, respectively.

The variance, covariance and correlation coefficients in the Table are used to calculate the unconditional Ψ and Φ. The conditional Ψ and Φ are calculated by DCC-GARCH(1,1) models.

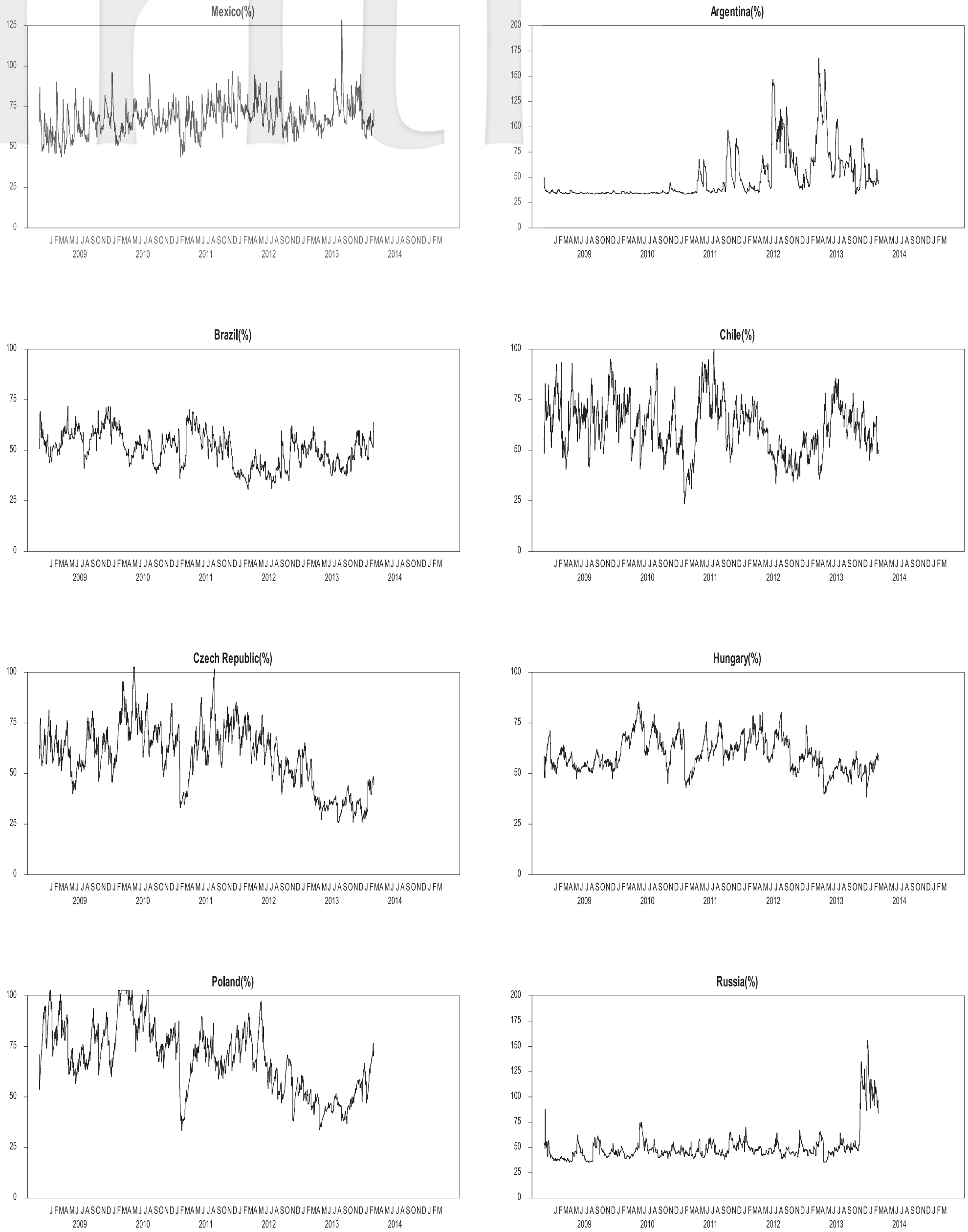

Figure 6: Volatility attributable to FX fluctuations Ψ.

Our major findings are summarized as follows. First, we find that the conditional correlation coefficients between local equity market and exchange rate tend to be positive for LACs and TEs, although the sign of conditional correlation coefficient varies across countries and over time. Second, for both LACs and TEs, conditional correlation between local equity market in US dollar and the US equity market falls in the positive region

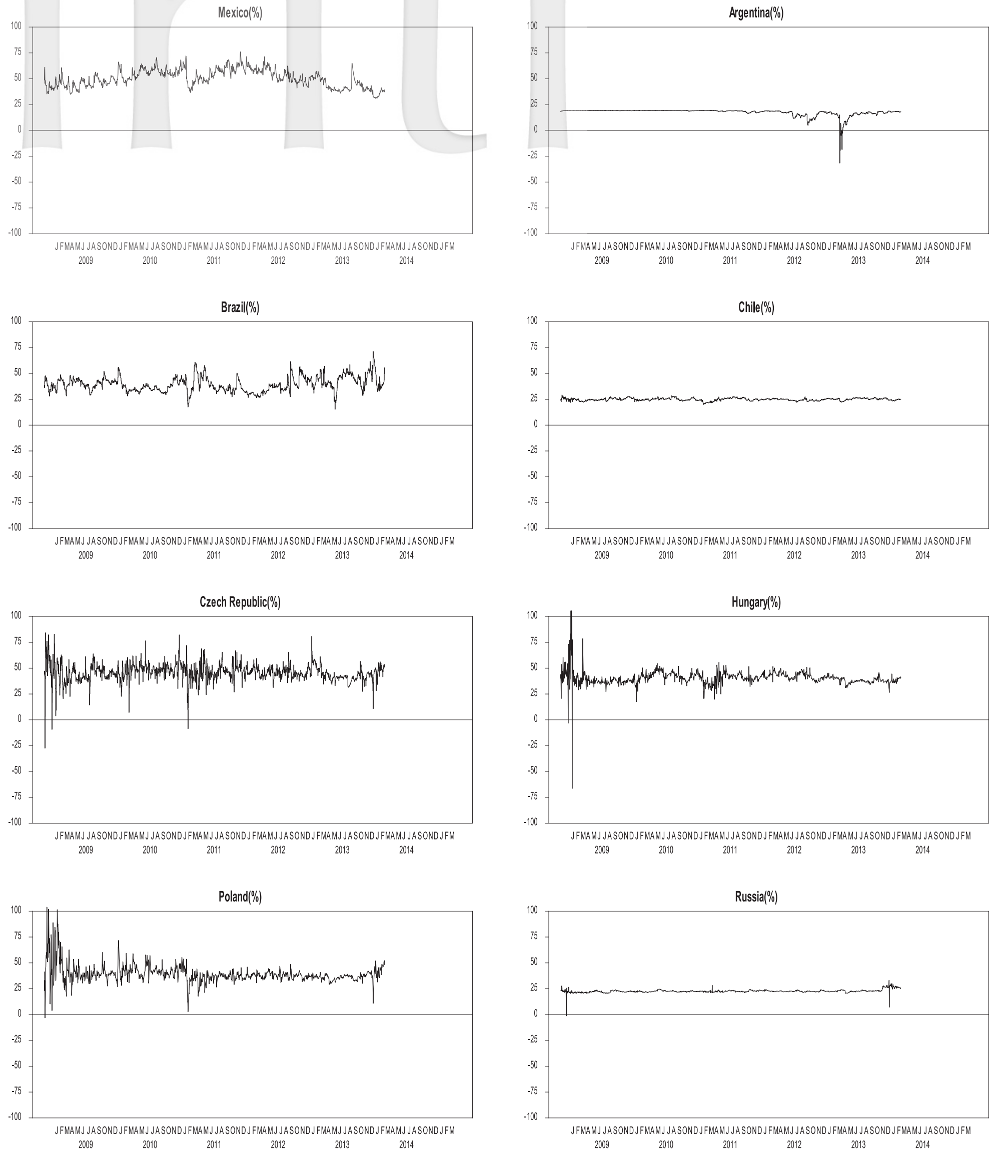

Figure 7: Correlations attributable FX fluctuations Φ.

for most of the sample period. This suggests that even if exchange rate exhibits does not move in the same direction as the US equity market, local equity market and the US equity market are strongly integrated and thus local equity market in dollar term still moves in the same direction as the US equity market. Third, the proportions of volatility of local equity market attributable to exchange rate fluctuation in both LACs and TEs are much larger than more developed economies compared to Mun [15], suggesting US investors will expose to much more exchange rate risk in LACs and TEs.

Finally, our results show that on average the proportions of conditional correlation coefficient between the local equity market in US dollar term and the US equity market attributable to exchange rate fluctuations for LACs and TEs are much larger than those reported in Mun [15], suggesting the volatility of exchange rate relative to the volatility of local equity market in LACs and TEs is much larger than more developed economies.

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Appendix

Because $R_{jt}^{USD} = R_{jt}^{LCD} + Z_{jt}$, and by definition of variance,

$$\text{Var}\,(R_{jt}^{USD}) = \text{Var}\,(R_{jt}^{LCD}) + 2\,\text{Cov}\,(R_{jt}^{LCD}, Z_{jt}) + \text{Var}\,(Z_{jt}),$$

the proportion of the US dollar local market volatility attributable to exchange rate fluctuations, Ψ, is thus given by:

$$\Psi = 1 - \frac{\text{Var}\,(R_{jt}^{LCD})}{\text{Var}\,(R_{jt}^{USD})} = \frac{2\,\text{Cov}\,(R_{jt}^{LCD}, Z_{jt}) + \text{Var}\,(Z_{jt})}{\text{Var}\,(R_{jt}^{USD})}. \tag{A.1}$$

The correlation coefficient between the currency j stock market return in US dollar and the US stock market return, R_t, is:

$$\begin{aligned}
\rho(R_{jt}^{USD}, R_t) &= \frac{\text{Cov}\,(R_{jt}^{USD}, R_t)}{\sqrt{\text{Var}\,(R_{jt}^{USD})}\sqrt{\text{Var}\,(R_t)}} \\
&= \frac{\text{Cov}\,(R_{jt}^{LCD}, R_t)}{\sqrt{\text{Var}\,(R_{jt}^{USD})}\sqrt{\text{Var}\,(R_t)}} + \frac{\text{Cov}\,(Z_{jt}, R_t)}{\sqrt{\text{Var}\,(R_{jt}^{USD})}\sqrt{\text{Var}\,(R_t)}} \\
&= \frac{\rho(R_{jt}^{LCD}, R_t)\sqrt{\text{Var}\,(R_{jt}^{LCD})}\sqrt{\text{Var}\,(R_t)}}{\sqrt{\text{Var}\,(R_{jt}^{USD})}\sqrt{\text{Var}\,(R_t)}} + \frac{\rho(Z_{jt}, R_t)\sqrt{\text{Var}\,(Z_{jt})}\sqrt{\text{Var}\,(R_t)}}{\sqrt{\text{Var}\,(R_{jt}^{USD})}\sqrt{\text{Var}\,(R_t)}} \\
&= \rho(R_{jt}^{LCD}, R_t)\sqrt{\frac{\text{Var}\,(R_{jt}^{LCD})}{\text{Var}\,(R_{jt}^{USD})}} + \rho(Z_{jt}, R_t)\sqrt{\frac{\text{Var}\,(Z_{jt})}{\text{Var}\,(R_{jt}^{USD})}}. \qquad \text{(A.2)}
\end{aligned}$$

The proportion of the correlation coefficient between the US and the local market returns that can be attributable to exchange rate fluctuations, Φ, is given by the second part of (A.2):

$$\Phi = \frac{\rho(Z_{jt}, R_t)\sqrt{\frac{\text{Var}\,(Z_{jt})}{\text{Var}\,(R_{jt}^{USD})}}}{\rho(R_{jt}^{LCD}, R_t)} = \frac{\rho(Z_{jt}, R_t)}{\rho(R_{jt}^{USD}, R_t)}\sqrt{\frac{\text{Var}\,(Z_{jt})}{\text{Var}\,(R_{jt}^{USD})}}. \tag{A.3}$$

References

[1] Bekaert, G. and Harvey, C. R. (1995). *Time-varying world market integration*, Journal of Finance, Vol.50, No.2, 403-444.

[2] Brooks, R., Edison, H., Kumar, M. and Slok, T. (2001). Exchange Rates and Capital Flows, IMF Working Paper No. 01/190, www.imf.org/external/pubind.htm.

[3] Campos, N. F. and Kinoshita, Y. (2008). Foreign Direct Investment and Structural Reforms: Evidence from Eastern Europe and Latin America, IMF Working Paper No. 08/26, www.imf.org/external/pubind.htm.

[4] Chiang, T. C. (1991). *International asset pricing and equity market risk*, Journal of International Money and Finance, Vol.10, No.3, 349-364.

[5] Dumas, B., and Solnik, B. (1995). *The world price of foreign exchange risk*, Journal of Finance, Vol.50, no.2, 445-479.

[6] Engle, R. (2002). *Dynamic conditional correlation-a simple class of multivariate GARCH models*, Journal of Business and Economic Statistics, Vol.20, No.3, 339-350.

[7] Errunza, V, Losq, E. and Padmanabhan, P. (1992). *Tests of integration, mild integration and segmentation hypotheses*, Journal of Banking and Finance, Vol.16, No.5, 949-972.

[8] Hau, H. and Rey, H. (2006). *Exchange rates, equity prices, and capital flows*, Review of Financial Studies, Vol.19, No.1, 273-317.

[9] IMF, (2007). World Economic Outlook Database for October 2007. www.imf.org/external/ns/cs.aspx?id=28.

[10] Jorion, P. (1991). *The pricing of exchange rate risk in the stock market*, Journal of Financial and Quantitative Analysis, Vol.26, No.3, 363376.

[11] Kasa, K. (1992). *Common stochastic trends in international stock markets*, Journal of Monetary Economics, Vol.29, No.1, 95-124.

[12] Koedijk, K. G., Kool, C. J. M., Schotman, P. C. and van Dijk, M. A. (2002). *The cost of capital in international financial markets: local or global*?, Journal of International Money and Finance, Vol.21, No.6, 905-929.

[13] Malliaropulos, D. (1998). *International stock return differentials and real exchange rate changes*, Journal of International Money and Finance, Vol.17, No.3, 493-511.

[14] Morley, B. and Pentecost E. J. (1998). *Asset pricing and foreign exchange risk: econometric evidence for the* G-7, Journal of International Money and Finance, Vol.17, No.2, 317-329.

[15] Mun, K. C. (2007). *Volatility and correlation in international stock markets and the role of exchange rate fluctuations*, Journal of International Financial Markets, Institutions and Money, Vol.17, No.1, 25-41.

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