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Exchange Markets and Stock Markets Integration in Latin-America

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Abstract

We analyze the relationship between the exchange markets and the integration process of the Latin American stock markets (MILA), focusing the analysis on two points. First, we evaluate the existence and nature of exchange risk premium and its relationship with the uncovered interest parity (UIP) bias. Second, we analyze the effect of MILA on Latin American foreign exchange markets. We use monthly time series between January 1997 and December 2021 for the exchange markets of Brazil, Chile, Colombia, Mexico and Peru. The econometric analysis was based on OLS, GARCH-in-Mean and DCC-MGARCH regressions. Our results indicate that UIP is does not meet. Even the GARCH-in-Mean models results indicates that there is no individual risk premium that corrects UIP bias. However, the results of the DCC-MGARCH model show that there is a risk premium generated simultaneously by the correlation between markets. Finally, MILA increased the dynamic correlations of exchange returns and risk premiums, mainly among the MILA markets. These results have relevant implications for policymakers and investors due to the impacts on exchange markets dependence and international investment decision-making.
JEL Classification: F31, F36, G15.

Keywords: exchange returns, risk premium, market integration, GARCH, DCC-MGARCH.

Sobre la prelación de las restricciones al crecimiento económico: abogando por la perspectiva basada en la huella ecológica

Resumen

Analizamos la relación entre los mercados cambiarios y el proceso de integración de los mercados bursátiles de América Latina (MILA), centrando el análisis en dos puntos. Primero, evaluamos la existencia y la naturaleza de un premio por riesgo cambiario y su relación con el sesgo de la paridad descubierta de interés (UIP). Segundo, analizamos el efecto de MILA en los mercados cambiarios latinoamericanos. Utilizamos series de tiempo mensuales entre enero de 1997 y diciembre de 2021 para los mercados cambiarios de Brasil, Chile, Colombia, México y Perú. El análisis econométrico se basa en regresiones OLS, GARCH-in-mean y DCC-MGARCH. Nuestros resultados indican que la UIP no se cumple. Incluso los resultados de los modelos GARCH-in-mean indican que no hay un premio por riesgo individual que corrija el sesgo de la UIP. Sin embargo, los resultados del modelo DCC-MGARCH muestran que existe una prima por riesgo generada simultáneamente por la correlación entre mercados. MILA incrementó las correlaciones dinámicas de los retornos cambiarios y de los premios por riesgo, principalmente entre los mercados MILA. Estos resultados tienen implicancias para inversores y policymakers.
Clasificación JEL: F31, F36, G15.

Palabras clave: retornos cambiarios, prima de riesgo, integración de mercados, GARCH, DCC-MGARCH.

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1. Introduction

The last decades have been marked by exchange markets development and various stock markets integration processes around the world. These facts have meant important benefits for investors in terms risk value and assets pricing. At academic level, these events have attracted the researchers interest to study new lines of analysis based on relationship between both events.

Exchange market and exchange rates pricing have been widely investigated in recent decades. Based on short-term equilibrium conditions such as Uncovered Interest Parity (hereinafter UIP), a vast empirical literature has shown that exchange market is not equilibrium because interest rate differential would not fully explain currencies values (Froot, 1990; Froot and Thaler, 1990). Even most of this evidence argues that the interest rate differential less predicts the subsequent direction of exchange rate, fact known as forward discount bias or forward premium puzzle (Lewis, 1995; Engel, 1996; Isard, 2006; Choudhry, 2013). In this way, diverse researches have formulated that UIP deviations are explained by a risk premium, constant or time-varying, but without a clear consensus (Domowitz and Hakkio, 1985; Baillie and Bollerslev, 1990a, 1990b; Chinn and Meredith, 2004).

In addition, the recent regional stock markets integrations could have significant effects on foreign exchange markets and risk premium dynamics. Theses integrations would promote higher capital movements and changes on risk pricing by investors (Glick and Rose, 1999; Beine, 2004). The co-movements between the exchange markets and the possible effects of the regional stock markets integration, would cause a regional risk assessment. So, the regional stock markets integration would affect the exchange market behavior and the UIP validity.

The events described previously are relevant for Latin American markets and constitute a little explored research area. On May 2011, Integrated Market of Latin America (hereinafter MILA) began to operate through a virtual integration process between Chile, Colombia and Peru, which would later be incorporated into Mexico. Each stock market has continued to operate independently despite the integration. Due to this process, MILA has become the second largest stock market in the region, second only to the Brazilian stock exchange. Although the MILA effects on liquidity and stock market activity have been favorable, its impacts on risk diversification have been limited (Castro and Marín, 2014). This could be explained by lower segmentation degree that characterizes Latin American markets and which would lead investors to assess risk regionally (De Jong and De Roon, 2005; Abid, Kaabia and Guesmi, 2014; Berggrun, Lizarzaburu and Cardona, 2016). This point would have two relevant aspects for Latin American exchange markets and that are still unanswered questions. If there was a risk premium, *would it be valued individually in each market*? or *regionally through the co-movements between the exchange markets*?; and if MILA has affected the behavior of exchange markets then, *the co-movements between these markets would be different after MILA*?.

Therefore, the aim of our research is to determine the possible risk premium nature for Latin American exchange markets and the effect of MILA on exchange returns and risk premium. Our work contributes to empirical evidence in three points. First, we evaluate the risk premium presence and its capability to correct the UIP bias. Second, we analyze the possible regional nature of risk premium explained by interaction between markets. Finally, we evaluate the MILA effect on exchange returns, risk premium and their co-movements.

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To achieve this goal, we use monthly time series between January 1997 and December 2021 for Brazil, Chile, Colombia, Mexico and Peru markets. The data was extracted from Bloomberg database. The OLS and GARCH-in-Mean regressions results show that there is not risk premium that corrects UIP deviations. Only the Chilean market was the time-varying risk premium presence evidenced. However, through DCC-MGARCH models, a time-varying risk premium was observed in all exchange markets. This result shows that risk premium in the Latin American exchange markets is valued regionally and not individually. Even the risk premium correlates positively and significantly between markets, mainly among MILA markets. Finally, the MILA implementation intensified the dynamic correlation of exchange returns and risk premium between MILA markets, despite the effects of the Covid-19 pandemic.

This article is structured as follows. After this introduction, section 2 presents the theoretical and empirical evidence about exchange market through the UIP, its relationship with risk premium and how the exchange markets have interacted with stock markets integration processes. This section also indicates the research hypotheses. Section 3 presents the data and analysis methodologies. Section 4 shows the results obtained. Finally, section 5 groups the conclusions and implications.

2. Theoretical framework and hypothesis

2.1. A quick review about Exchange rate and UIP

Exchange market has been an analysis focus for many researchers. An important part of the researches has centered the study in the exchange market equilibrium, mainly through UIP. The UIP indicates that the exchange rate expected depreciation $[E(e_{t+k})-e_t]/e_t$ is adjusted according to differential between the local i_t and foreign i_t^* interest rate, where $E(e_{t+k})$ is the expected exchange rate and e_t is the spot exchange rate. This relationship has been tested empirically through this regression:

$$\frac{E\left(e_{t+k} - e_t\right)}{e_t} = a + b_1\left(i_t - i_t^*\right) + e_t \quad (1)$$

Under this specification, short-term exchange market equilibrium will be fulfilled if the interest rate differential fully explains the exchange rate return. That is, $\alpha=0$, $\beta_1=1$ and ε_t is a non-autocorrelated residue. Empirical researches have shown a persistent lack of consensus and most of them have demonstrated contrary results for UIP. This literature has indicated that UIP prediction is biased, so that the interest rate differential only explains a fraction of the exchange rate return (Frenkel, 1981; Mussa, 1984). Indeed, most studies have found that $\alpha=0$, although often $\beta_1<0$, fact that reveals that the interest rate differential less predicts the subsequent direction of the exchange rate. Froot and Thaler (1990) summarized 75 empirical studies and found very few cases where $\beta_1>0$. Most studies showed $\beta_1<0$ with -0.88 average. In this sense, diverse studies have supported this empirical finding, called *forward premium puzzle* or *forward discount bias*, and which would be common in developed countries foreign exchange markets (Fama, 1984; Mussa, 1984; Hodrick, 1987; Froot, 1990; Lewis, 1995; Engel, 1996; Olmo and Pilbeam, 2011; Bhatti, 2014). Even other studies that analyzed periods prior to Bretton Woods, characterized by lower exchange rate volatility, found results similar to forward premium puzzle (McFarland, McMahon and Ngama, 1994; Phillips, McFarland and McMahon, 1996; Choudhry, 2013).

Other researches have found favorable results to UIP under very specific conditions such as the use of long-term interest rates or high interest rate differentials (Chinn and Meredith, 2004, 2005; Chaboud and Wright, 2005; Lambelet and Mihailov, 2005; Sarno, Valente and Leon, 2006; Baillie and Kilic, 2006; Bekaert, Wei and Xing, 2007; Lothian and Wu, 2011; Lothian, Pownall and Koedijk, 2013; Lothian, 2016). Under these conditions, the empirical evidence show that the bias would be lower in emerging markets, while *forward discount bias* would be concentrated in developed markets (Bansal and Dahlquist, 2000; Frankel and Poonawala, 2010).

2.2. Exchange risk premium in the foreign exchange market

Various theories have explained the persistent UIP deviation; being one of them the risk premium existence. Frankel (1982) indicates that the risk premium is a function of prediction error variance and exchange rate movements. Fact supported by Froot and Frankel (1989) and Mark and Wu (1998). In this line, Domowitz and Hakkio (1985) elaborated a model for UIP that extends the Lucas (1982) and Hodrick and Srivastava (1984) models, and that incorporates a time-varying risk premium associated to exchange rate volatility σ_t. Following Engle (1982), Engle, Lilien and Robins (1987) and Bollerslev (1990), this relationship has been tested empirically through GARCH models for:

$$\frac{E\left(e_{t+k} - e_t\right)}{e_t} = a + b_1\left(i_t - i_t^*\right) + b_2 s_t + e_t \tag{2}$$

Under this specification, short-term equilibrium for exchange rate will be fulfilled if the interest rate differential fully explains the exchange rate return and there is no risk premium. That is, $\alpha=0$, $\beta_1=1$, $\beta_2=0$ and ε_t is a non-autocorrelated residue. If there is a risk premium, Frankel and Chinn (1993) and Cavaglia, Verschoor and Wolff (1994) point out that risk premium would have the capacity to correct the UIP deviation. That is, $\alpha=0$ and $\beta_1=1$. Empirically, the existence, nature, and capability of risk premium to correct the UIP deviation has been the focus of debate.

Various studies argue that the risk premium existence does not correct the UIP deviation. Domowitz and Hakkio (1985), analyzing the currencies of Germany, France, Japan, Switzerland, and United Kingdom through ARCH-in-Mean models, finding evidence that support the time-varying risk premium existence for Japan and United Kingdom markets. However, the UIP bias was only partially reduced. Tai (2001) finds similar evidence for Asian markets, ruling out UIP compliance. Despite the advantages of GARCH models for modeling exchange rate volatility, other studies have showed similar results (Baillie and Bollerslev, 1990a, 1990b; Forsberg and Bollerslev, 2002; Olmo and Pilbeam, 2011; Aysun and Lee, 2014; Engel, 2016). Another relatively minor part of empirical evidence has found that risk premium inclusion corrects the UIP deviation. Aggarwal (2013), in an empirical study for Japan, Australia and United States foreign exchange markets found favorable evidence for UIP. The author argues that the individual risk premium of each market is attributable to high interest rate differentials episodes. Li, Ghoshray and Morley (2012) corroborate this view and add that the risk premium adjustment would be more evident in emerging markets, where interest rate differentials are greater than developed markets. According to Yung (2017), the risk premium of each exchange market, would explain more than half of the exchange rate changes. The Latin American markets have these qualities and for this reason we formulate this hypothesis:

H1: The exchange risk premium in each market corrects the UIP bias.

The exchange risk premium could not only have each market characteristics, but also regional. The greater international trade between same region countries, common financial development policies and the greater interdependence degree among the countries would favor the regional valuation for exchange risk premium (He, 2017). Bollerslev (1990), in an empirical analysis for the German mark, Italian lira, Swiss franc, French franc and pound sterling showed that the monetary unification increased the exchange returns correlations. This fact increased the risk premium for all these markets due to higher co-movements between exchange markets. Even crises periods increased the foreign exchange markets dependence (Yang, Kolari and Min, 2003; Assidenou, 2011). The Latin American markets are characterized by low segmentation degree and have similar idiosyncratic qualities that make it difficult, on the one hand, the diversification possibilities in the region for investors, and on the other, they force them to value financial assets through a regional vision (Mellado and Escobari, 2015). Mellado and García (2014) argue that in Latin American markets these qualities would be supported by high correlations between markets. When risk premium is valued regionally, the UIP itself would not be valid because those co-movements between markets would explain the exchange rate return, in addition to interest rate differentials. The literature for Latin American markets is almost nonexistent in this matter, and for that reason we formulate this hypothesis:

H2: The exchange risk premium is valued regionally in the Latin American foreign exchange markets.

2.3. Effect of MILA on Latin-American exchange markets

The economic or financial integration processes developed by different countries would have significant effects on macroeconomic and financial system, mainly on markets financial liberalization (Francis, Hasan and Hunter, 2002; Seerattan and Birchwood, 2004). Several empirical studies have evaluated the effects of these processes. Fratzscher (2002) states that the economic and financial integration process developed in Europe helped to mitigate the markets uncertainty and positioned them better in relation to the United States. For Asian markets, Shin and Sohn (2006) argue that, although the integration degree of the region is lower than that European markets, the main effects of regional integration are visible in larger price movements.

The stock and exchange markets relationship is narrow. However, the empirical evidence that has investigated the effects of stock markets integration on foreign exchange markets is still scarce. Glick and Rose (1999) affirm that capital flows movements, inherent to these integration processes, could affect the foreign currency portfolios investors' positions. This fact, according to Beine (2004) and Tai (2007), would increase the financial contagion probability due to the higher exchange markets dependence. Conclusion that is also supported by Syllignakis and Kouretas (2011) and Celik (2012). Bollerslev (1990) analyzed the effect of these processes on exchange markets of Europe. Their results indicated that the monetary unification increased the exchange returns correlations. Along the same lines, Fratzscher (2002) argues that the equity markets integration deepened the effect of economic integration in Europe, generating a significant reduction of exchange volatility. Similar results were found by De Brouwer (1997) and Janor, Ali and Shaharudin (2007) for the Asian markets. These authors add that the exchange rate parity would be closely related to the countries financial openness. More recently, other studies reveal that both economic and financial integration processes deepen dependence on foreign exchange markets in both developed (Reboredo et al., 2021) and emerging (Aftab et al., 2020) markets. This would be seen in higher levels of correlation and spillover effects. Even Malik and Umar (2019) warn that this interdependence could be affected by the interaction between the foreign exchange, stock and commodity markets.

In Latin America, MILA began its operations in May 2011 through virtual financial integration between Chilean, Colombian and Peruvian markets, to which Mexico would later join. Despite integration, each stock markets continues to operate independently. Currently, MILA has become the second largest stock market in the region, second only to the Brazilian stock market. Some studies have argued that MILA has reported benefits in terms of stock market activity, liquidity, and depth (Castro and Marín, 2014; Lizarzaburu, Burneo, Galindo and Berggrun, 2015; Cardona, Gutiérrez and Agudelo, 2017). Even other research has shown that MILA implementation has generated support for economic activity during crisis periods (Asness, Israelov and Liew, 2011).

Despite of the above, its effects on exchange markets of the region have been scarcely investigated. Mellado and García (2014), in an empirical work carried out for MILA initial markets (Chile, Colombia and Peru) found that the exchange returns are significantly and dynamically correlated to their long-term average. This, according to Heston, Geert and Wessels (1995), reflects the greater dependence between these markets. In any case, Mellado y García (2014) indicate that MILA implementation did not have major effects on exchange returns dynamic correlations, except for co-movements between Chilean and Peruvian markets, where MILA generated a reduction. According to these authors, this reduction would allow to diversify the exchange risk in these markets. But this research did not analyze the MILA effect on exchange risk premium.

Thus, the higher dependence between Latin American markets observed by Chen, Firth and Meng (2002), added to its scant segmentation degree that mitigates the potential diversification benefit, would mean that the exchange returns, and risk premium of the region's exchange markets would experience co-movements. Given that MILA has strengthened the financial market integration in the region, it would be expected that such co-movements will be accentuated in the exchange markets, mainly among the MILA' markets. In this area, the evidence is scarce and motivates us to formulate this hypothesis:

H3: MILA positively affects the correlations between the exchange returns of Latin American markets.

H4: MILA positively affects the correlations between the exchange risk premiums of Latin American markets.

3. Data and methods

3.1. Sample data

The research data were extracted from Bloomberg database. The information corresponds to monthly time series between January 1997 and December 2021 for Brazil, Chile, Colombia, Mexico and Peru markets. Each time series contains 300 observations. We use monthly time series to attenuate the effects of volatility on the parametric convergence of the multivariate models. Table 1 shows the variables.

The exchange return (EXRET), measured by exchange rate monthly percentage change, is the dependent variable. The exchange rate quantifies the US dollar value in terms local currency. This measure is widely used by several international studies (Fama, 1984; Domowitz and Hakkio, 1985; Baillie and Bollerslev, 1990a; Lewis, 1995). While that, interest rate differential (DIF) is measured as the difference between the 30-day interbank rate of country *i* and the United States rate. Both variables are used to specify the UIP, theory that will be used for valuing exchange rates in the short-term.

The foreign exchange risk premium (PREM) is measured by the conditional standard deviation of foreign exchange returns. This measurement is based on prediction obtained from a GARCH-in-Mean(1,1) model where the conditional mean equation corresponds to ARMA(1,1) specification for exchange returns. To control systematic factors associated with economic and financial crises we define three dummy variables, which adopt the value 1 for the Asian (ASIA), Subprime (SUB) crises periods, and the Covid-19 pandemic respectively; and 0 otherwise.
Finally, we define the MILA variable as a dummy variable that adopts value 1 since May 2011, the date on which MILA started to operate.

Table 1. Variables

Variables		Description
EXRET	Monthly exchange return	Monthly percentage change of the nominal exchange rate
DIF	Interest rate differential	Difference between 30-day interbank interest rate of country *i* and the United States
PREM	Exchange risk premium	Exchange volatility measured by the conditional standard deviation estimated by the GARCH-in-Mean model (1,1)
MILA	MILA stock integration	Dummy equal to 1 since May 2011 and 0 otherwise
ASIA	Dummy Asia	Dummy equal to 1 between January 1997 and June 1998, and 0 otherwise
SUB	Dummy Subprime	Dummy equal to 1 between September 2008 and August 2009, and 0 otherwise
COVID	Covid-19 pandemic	Dummy equal to 1 since the month of the first case detected in the country and 0 otherwise

Source: Own elaboration.

3.2. Econometric methodology

In this section we present the econometric models used in this research. For a UIP preliminary analysis, we estimate the following regression by OLS:

$$EXRET_t = \alpha + \beta_1 DIF_t + \varepsilon_t \tag{3}$$

Where $EXRET_t$ is the exchange return in period t, which is controlled on interest rates differential (DIF_t). Moreover, ε_t is a random disturbance. According to (1) and (3) the exchange market will be in equilibrium if $\alpha=0$ and $\beta_1=1$.

As the first analysis model, we used the GARCH-in-Mean(1,1) model proposed by Engle, Lilien and Robins (1987) on UIP condition. The purpose is to determine the particular risk premium presence to each exchange market. The conditional mean equation is:

$$EXRET_t = \alpha + \beta_1 DIF_t + \beta_2 \sigma_t + \varepsilon_t \tag{4}$$

Where $EXRET_t$ is the exchange return in period t, which is controlled on interest rates differential (DIF_t) and conditional standard deviation of exchange returns (σ_t). This last regressor is the GARCH-in-Mean component, while ε_t is a random disturbance. According to (4), the exchange market will be in short-term equilibrium if $\alpha=0$, $\beta_1=1$ and $\beta_2=0$. That is, there is no risk premium ($\alpha=0$ and $\beta_2=0$) and that the interest rates differential fully explains the exchange return ($\beta_1=1$). Note that if $\alpha\neq0$ the risk premium is constant, whereas if $\beta_2\neq0$ the risk premium is time-varying. Both facts would support the risk premium existence in the exchange market. Additionally, the equation for conditional variance of exchange returns is:

$$\sigma_t^2 = \gamma_0 + \gamma_1 \sigma_{t-1}^2 + \gamma_2 \varepsilon_{t-1}^2 + u_t \tag{5}$$

Where σ^2_{t-1} is the GARCH(1) component represented by lag of the conditional variance in $t-1$, while ε^2_{t-1} is the ARCH(1) component measured by quadratic residue in $t-1$. Note that the coefficients γ_0, γ_1 and γ_2 are non-negative. If γ_1 and γ_2 were not significant, then the conditional variance of exchange returns would be homoscedastic and equal to γ_0. In addition, the variance persistence coefficient is equivalent to ($\gamma_1 + \gamma_2$), a factor that the closer it is to 1, more persistent are the variance temporal moves.

Second, we estimate a multivariate GARCH model with dynamic conditional correlation (DCC-MGARCH) proposed by Engle (2002) and Tse and Tsui (2002). The purpose is to determine if exchange risk premium is valued regionally. The model is:

$$EXRET_t = A_0 + B_1 DIF_t + \Theta_1 PREM_t + \varepsilon_t \tag{6}$$

The model (6) is the UIP multivariate representation, where the dependent variable is the exchange return ($EXRET_t$) at time t. Moreover, A_0 is the constants vector, B_1 is the coefficients matrix for interest rate differentials (DIF_t) in period t and Θ_1 is the coefficients matrix associated with risk premiums ($PREM_t$). Finally, ε_t is the errors vector. The advantage of model (6) over (4) is that it allows evaluating whether the risk premium affects the exchange rate return when co-movements between exchange markets are included. If Θ_1 is significant, then risk premium would be valued regionally in Latin American markets.

Thirdly, to estimates and predict the dynamics correlation for exchange risk premiums, we estimated a DCC-MGARCH(1,1) model:

$$PREM_t = \Phi_0 + \Phi_1 PREM_{t-1} + \varepsilon_t \tag{7}$$

The model (7) is a VAR(1) process for exchange risk premium. Where $PREM_t$ is the risk premium matrix for period t and $PREM_{t-1}$ is the risk premium matrix lagged in $t-1$. In addition, Φ_0 and Φ_1 are matrices that group the constants and lags coefficients of the VAR(1) process, respectively. Finally, ε_t is the errors vector.

For multivariate (6) and (7) models, we define σ_{ijt} as the conditional covariance between exchange markets i and j in period t, which is modeled by a GARCH(1,1) process:

$$\sigma_{ijt} = \delta_{ij} + \lambda_1 \varepsilon_{it-1} \varepsilon_{jt-1} + \lambda_2 \sigma_{ijt-1} \tag{8}$$

Where ε_{it} is the residue of the market i in period t and σ_{ijt-1} is the conditional covariance between exchange markets i and j in period $t-1$. Note that when $i=j$ the conditional variance is modeled. The parameters λ_1 and λ_2 are coefficients to be estimated and represent the correlations dynamic adjustment, such that $0<(\lambda_1+\lambda_2)<1$. So, we can rewrite (8) in its multivariate form MGARCH(1,1):

$$\Sigma_t = \Delta + \Lambda_1 E_{t-1} E'_{t-1} + \Lambda_2 \Sigma_{t-1} \tag{9}$$

Where Σ_t the conditional variances and covariances matrix, and E_{t-1} is the vector of lagged residuals in $t-1$. The conditional dynamic correlation model proposed by Engle (2002) spectrally decomposes the matrix Σ_t as follow:

$$\Sigma_t = D_t \Gamma_t D_t \tag{10}$$

Where D_t is the standard deviation matrix such as $D_t D_t'$=diag(Σ_t) and Γ_t the correlation matrix whose approximation we will denote by quasi-correlations matrix Q_t. Thus, dynamic quasi-correlations can follow this process:

$$Q_t = \Omega + \Lambda_1 \xi_{t-1} \xi'_{t-1} + \Lambda_2 Q_{t-1} \tag{11}$$

Being ξ_t the standardized residuals vector, and $\xi_t = \varepsilon_{it}/\sigma_{it}$. Note that Λ_1 and Λ_2 are the dynamic quasi-correlations adjustment parameters to their long-term averages. If Λ_1 and Λ_2 are non-significant parameters, then these correlations will be constants.

Finally, we estimate the following AR(1) process for determine the MILA effects on exchange markets:

$$y_t = f_0 + f_1 y_{t-1} + w_{MILA} MILA + e_t \tag{12}$$

Where y_t is the dependent variable measured by exchange returns, risk premiums and their dynamic correlations. These dynamic correlations were predicted from (6) model for exchange returns and from (7) model for risk premium. MILA is a dummy variable that adopts value 1 since May 2011 and 0 otherwise, and therefore ω_{MILA} measures the effect of this financial integration process on y_t. Moreover, we use a t-test to evaluate the means differences for these variables before and after MILA. All estimations include dummy variables for Asian, Subprime and Covid-19 periods. These variables allow us to control the effects of the crisis periods and the Covid-19 pandemic on exchange returns, exchange volatilities, and dynamic correlations.

4. Empirical results

4.1. Data description

Table 2 shows the statistical summary. The exchange returns oscillate on average between 0% and 1%. However, Colombia and Mexico stand out with slightly higher exchange returns than the rest of countries, being Peru the lower.

Interest rate differentials and risk premium series have similar behavior across countries. Brazil, Mexico and Colombia markets have the highest interest rate differentials in relation to the United States, with averages of 14.27%, 9.05% and 7.17%, respectively. Moreover, these same markets exhibit the highest risk premiums. While Chile and Peru markets have lower interest rate differentials and risk premiums. The highest record of exchange volatility occurred during the Subprime crisis and the Covid-19 pandemic.

Table 2 show that the Augmented Dickey-Fuller tests are significant at 1%. So, exchange returns, interest rate differentials and risk premiums are stationary processes. The results of the KPSS test confirm the stationary behavior of the time series. The time series of exchange returns, and exchange risk premium have ARCH structure that it justifies the use of GARCH models. In addition, the correlations between interest rate differentials and risk premium show a possible relationship with exchange returns. We observe that interest rate differentials are positively correlated with the exchange returns, except for Mexico. In addition, the risk premium would be positively associated with exchange rate returns of the Brazilian and Peruvian markets (except the Chilean market).

Table 2. Statistical summary.

Variables	***Statistical summary by country***				
	Brazil	**Chile**	**Colombia**	**Mexico**	**Peru**
Exchange returns (%)					
Mean	0.27	0.59	0.78	0.69	0.23
Standard deviation	4.15	3.96	5.32	4.08	2.64
ADF test	-13.28***	-9.57***	-16.97***	-20.35***	-13.19***
KPSS test	0.09	0.10	0.17	0.04	0.19
ARCH test	32.27***	18.26***	21.33***	8.99***	10.08***
Interest rates differentials (%)					
Mean	14.27	3.34	7.17	9.05	5.64
Standard deviation	7.36	4.17	7.99	8.04	5.08
ADF test	-7.03***	-5.58**	-6.92***	-5.26***	-3.93***
KPSS test	0.11	0.09	0.18	0.17	0.20
Correlation with EXRET	0.11*	0.16**	0.26***	0.09	0.21***
Exchange risk premium (%)					
Mean	4.36	3.84	4.69	5.17	2.95
Standard deviation	2.18	1.29	2.62	1.91	1.08
ADF test	-8.10***	-6.24***	-4.97***	-14.31***	-10.39***
KPSS test	0.03	0.14	0.06	0.07	0.05
ARCH test	54.81***	41.11***	49.03***	32.18***	17.68***
Correlation with EXRET	0.07*	-0.09*	0.08	0.04	0.07*

Notes: ADF test correspond to Augmented Dickey-Fuller test. This test includes random walk and drift. For the KPSS tests, the critical value at 1% of significance is 0.216 and it considers 15 lags. ARCH is a chi-squared test for autoregressive conditional heteroskedasticity structure. Superscripts ***, **, * indicate statistical significance at 1%, 5%, and 10%, respectively.

Source: Own elaboration.

4.2. Testing the presence and nature of exchange risk premium

In this section we analyze the potential risk premium presence on Latin American exchange markets. Table 3 presents the UIP results, where panel A shows the model (3) results and panel B presents model (4) estimation.

Panel A of Table 3 shows the UIP results through OLS estimations. We observe that constant $\alpha=0$, which rules out the constant risk premium presence in each exchange markets. Additionally, the coefficient β_1 is not significant, so the interest rate differential (DIF) does not explain the exchange return (EXRET). The UIP1 test that under the null hypothesis indicates the short-term equilibrium for exchange market (H_0: $\alpha=0$ and $\beta_1=1$), is rejected at 1% significance. Even, the Wald test shows that OLS estimation is not significance. So, UIP is not fulfilled, and each exchange market is not at its short-term equilibrium. The UIP non-compliance is supported by several international studies (Fama, 1984; Mussa, 1984; Froot, 1990; Engel, 1996; Choudhry, 2013). But the observed bias is clearly lower than that exhibited in developed markets, which also be in accordance with international evidence (Bansal and Dahlquist, 2000; Lothian, 2016).

Panel B shows the model (4) results estimated through GARCH-in-mean specification. The purpose of this UIP specification is to include a time-varying risk premium that potentially corrects the UIP bias. This premium would be generated individually in each exchange markets and would be independent among them. The results do not differ from panel A. The UIP2 test, which under the null hypothesis indicates α=0, β_1=1 and β_2=0, is rejected at 1% for all markets. Even, the risk premium existence and short-term equilibrium are discarded for Latin American exchange markets. Despite of that the Chilean market has a time-varying negative risk premium and Brazil market presents favorable evidence for forward discount bias. This result goes against hypothesis H1, so the risk premium presence in each market capable to correct the UIP bias is discarded (Domowitz and Hakkio, 1985; Frankel and Chinn, 1993; Cavaglia, Verschoor and Wolff, 1994; Tai, 2001; Forsberg and Bollerslev, 2002; Olmo and Pilbeam, 2011).

Table 3. OLS and GARCH in Mean (1,1) estimators for UIP in Latin-American countries.

Explanatory variables	***Dependent variable: Monthly exchange returns***				
	Brazil	**Chile**	**Colombia**	**Mexico**	**Peru**
A. OLS estimation					
Const.	0.0137	-0.0113	0.0038	0.0102	0.0023
	(1.26)	(-1.26)	(0.62)	(1.58)	(0.47)
DIF	0.0789	-0.0731	0.0349	-0.0099	0.0461
	(0.64)	(-1.49)	(0.97)	(-0.81)	(1.60)
Dummy Asia	Yes	Yes	Yes	Yes	Yes
Dummy Subprime	Yes	Yes	Yes	Yes	Yes
Dummy Covid-19	Yes	Yes	Yes	Yes	Yes
Variance robust	Yes	Yes	Yes	Yes	Yes
Sample	300	300	300	300	300
Wald	2.36	1.59	2.17	3.25	2.74
Test UIP1	1071.39***	374.07***	619.25***	862.68***	951.47***
ARCH LM test	40.26***	17.33***	29.74***	20.93***	15.29***
B. GARCH-in-Mean (1,1) estimation					
Mean equation					
Const.	0.0079	0.0143**	-0.0054	0.0098	-0.0017
	(0.26)	(2.31)	(-0.77)	(0.89)	(-0.57)
DIF	-0.0956***	-0.0009	0.0241	0.0106	0.0256
	(-3.18)	(-0.45)	(1.19)	(0.64)	(1.26)
PREM	1.4582	-6.9563***	1.8576	-0.2753	-1.8692
	(1.37)	(-2.62)	(0.68)	(-0.35)	(-0.90)
Variance equation					
Const.	0.0007***	0.0003**	0.0008**	0.0009***	0.0009***
	(4.01)	(2.04)	(2.48)	(4.16)	(4.03)

ARCH(1)	0.7147***	0.2196***	0.3067***	0.4203***	0.6851***
	(3.54)	(2.91)	(3.19)	(3.35)	(3.22)
GARCH(1)	0.1496***	0.7348***	0.6625***	0.2759***	0.2596***
	(2.65)	(8.41)	(7.36)	(2.88)	(3.02)
Variance persistence	0.86	0.95	0.97	0.70	0.94
Dummy Asia	Yes	Yes	Yes	Yes	Yes
Dummy Subprime	Yes	Yes	Yes	Yes	Yes
Dummy Covid-19	Yes	Yes	Yes	Yes	Yes
Sample	300	300	300	300	300
Wald	29.43**	31.09***	26.85***	30.02***	24.82***
Test UIP2	5574.48***	385.06***	2309.58***	2085.17***	3869.94***

Notes: Superscripts ***, **, * indicate statistical significance at 1%, 5%, and 10%, respectively.
Source: Own elaboration.

The previous results, although they reveal that there is no individual risk premium in each market (except Chile), do not conclude if this risk premium is regionally valued for Latin American markets. Investors assess risk regionally when markets have a low segmentation and diversification degree, as Latin America (De Jong and De Roon, 2005; Abid, Kaabia and Guesmi, 2014; Berggrun, Lizarzaburu and Cardona, 2016). To evaluate the regionally valued risk premium existence, the model (6) was estimated by DCC-MGARCH specification. Table 4 shows its results. This UIP specification considers that the exchange returns are explained by interest differential (DIF), risk premium (PREM) and co-movements between exchange returns. The model includes dummy variables to control the effects of the Asian, Subprime crises, and Covid-19 pandemic.

For all cases, the correlations between exchange returns are significant, which indicate the higher integration degree between these markets. We observe that the returns correlations between MILA markets -Chile, Colombia, Mexico and Peru- are positive, while the correlations between these markets and Brazil are negative and not significant in general. This result shows a diversification possibility between Brazilian and MILA exchange markets, while among the MILA markets diversification benefit is more limited. About these correlations, we note that the quasicorrelations adjustment parameters, λ_1 and λ_2, are significant. So, the exchange returns correlations between Latin American markets are dynamically adjusted, which validate the DCC-MGARCH model. The LR test that evaluates the significance for λ_1 and λ_2 also supports this conclusion.

Table 4. DCC-MGARCH model for exchange returns.

Variables	***Dependent Variable: Monthly exchange returns***				
	Brazil	**Chile**	**Colombia**	**Mexico**	**Peru**
Conditional mean equation					
Const.	-0.0185**	0.0175***	-0.0106	0.0258**	0.0091
	(-2.09)	(2.67)	(-0.92)	(2.19)	(0.49)
DIF	0.0693	-0.0298	0.0072	0.0027	0.0326
	(1.06)	(-0.30)	(0.11)	(0.84)	(1.17)
PREM	2.0937***	-1.6822***	2.3867***	-2.9841***	-2.0572***
	(2.91)	(-3.18)	(4.10)	(-3.28)	(-3.51)

Conditional variance equation					
Const.	0.0008***	0.0001	0.0003**	0.0004***	0.0002***
	(3.74)	(1.33)	(2.47)	(3.96)	(4.11)
ARCH(1)	0.4176***	0.2365***	0.3179***	0.3168***	0.5875***
	(3.66)	(2.90)	(3.11)	(3.39)	(3.60)
GARCH(1)	0.4868***	0.7384***	0.6168***	0.2973***	0.2987***
	(2.76)	(9.62)	(6.15)	(2.79)	(3.01)
Variance persistence	0.90	0.97	0.93	0.61	0.89
Dynamic quasi-correlations					
Brazil	1.00				
Chile	-0.11	1.00			
Colombia	-0.16*	0.44***	1.00		
Mexico	-0.07	0.47***	0.61***	1.00	
Peru	-0.03	0.31***	0.49***	0.40***	1.00
Dynamic adjustment parameters					
λ_1					0.3289***
					(27.64)
λ_2					0.6471***
					(44.36)
Sample					300
Wald test					75.53***
Dummy Asia	Yes	Yes	Yes	Yes	Yes
Dummy Subprime	Yes	Yes	Yes	Yes	Yes
Dummy Covid-19	Yes	Yes	Yes	Yes	Yes
LR test					39.02***

Notes: Superscripts ***, **, * indicate statistical significance at 1%, 5%, and 10%, respectively.
Source: Own elaboration.

Table 5. DCC-MGARCH model for exchange risk premium.

Variables	***Dependent Variable: Monthly exchange risk premium***				
	Brazil	**Chile**	**Colombia**	**Mexico**	**Peru**
A. Conditional mean equation VAR(1)					
Const.	0.0195***	0.0226***	0.0271***	0.0401***	0.0127***
	(4.10)	(4.58)	(5.92)	(6.14)	(3.41)
$PREM(BRAZIL)_{t-1}$	0.4028***	0.0482	0.0003	0.0038	0.0229
	(4.39)	(1.50)	(0.01)	(0.26)	(1.51)
$PREM(CHILE)_{t-1}$	-0.1648*	0.3174***	0.0184	0.0157**	-0.0017
	(-1.69)	(3.86)	(1.15)	(2.10)	(-0.12)
$PREM(COLOMBIA)_{t-1}$	0.1048	0.0291	0.3327***	-0.3016***	0.2547***
	(1.03)	(0.90)	(3.28)	(-2.97)	(2.60)
$PREM(MEXICO)_{t-1}$	0.1682*	0.1477**	-0.0094	0.2850***	0.0035
	(1.71)	(2.03)	(0.87)	(3.74)	(0.46)

PREM(PERU)$_{t-1}$	0.0026	-0.1943***	0.1759**	-0.0682**	0.5648***
	(0.49)	(-3.17)	(2.30)	(-1.98)	(4.73)
B. Conditional variance equation					
Const.	0.0001***	0.0002***	0.0001***	0.0001***	0.0002***
	(10.27)	(8.74)	(4.13)	(3.56)	(11.95)
ARCH(1)	0.6947***	0.5992***	0.7025***	0.4860***	0.4763***
	(3.12)	(4.01)	(4.28)	(3.09)	(4.15)
GARCH(1)	0.2658***	0.3027***	0.2290***	0.4451***	0.3801***
	(3.77)	(2.86)	(3.33)	(4.42)	(2.90)
Variance persistence	0.96	0.90	0.93	0.93	0.86
C. Dynamic quasi-correlations					
Brazil	1.00				
Chile	0.09**	1.00			
Colombia	0.18***	-0.07*	1.00		
Mexico	0.17***	-0.02	0.21***	1.00	
Peru	0.33***	-0.05	0.19***	0.28***	1.00
D. Dynamic adjustment parameters					
λ_1					0.1842***
					(6.08)
λ_2					0.4801***
					(4.22)
Sample					300
Wald test					150.39***
Dummy Asia	Yes	Yes	Yes	Yes	Yes
Dummy Subprime	Yes	Yes	Yes	Yes	Yes
Dummy Covid-19	Yes	Yes	Yes	Yes	Yes
LR test					104.26***

Notes: Superscripts ***, **, * indicate statistical significance at 1%, 5%, and 10%, respectively.
Source: Own elaboration.

The conditional mean equation results show that UIP condition is not met for these exchange markets. However, we observed that there is a significant time-varying risk premium valued regionally in Latin American markets. This fact supports hypothesis H2. Even Table 5 that shows the model (7) results, also support this conclusion. We add that risk premium correlates significantly between the Latin American markets. The VAR(1) component for conditional mean equation indicates also the temporal dependence between risk premiums. These results confirm hypothesis H2 from another perspective, which also agrees with Mellado and García (2014).

4.3. Effect of MILA on foreign exchange markets

In this section we analyze the effects of MILA on Latin American exchange markets. Table 6 shows the t-test that quantifies the mean difference significance through MILA implementation and model (12) results. It should be noted that the dynamic correlations for exchange returns and risk premiums were predicted from the DCC-MGARCH models (6) and (7), respectively. In addition, the idea of analyzing the exchange markets of Latin America through Brazil, which does not belong to MILA; and Chile, Colombia, Mexico and Peru, which do belong, is to visualize the potential complementary effect (positive co-movements) or substitute (negative co-movements) of exchange returns and risk between these markets.

Table 6. AR(1) regression and *t*-test for mean difference across MILA process.

Variables	Before MILA	After MILA -Before Covid-19	*t-statistics*	After MILA -with Covid-19	*t-statistics*	*ω_{MILA} coefficient from model (12)*
A. Exchange returns						
Brazil	-0.12	-0.64	-1.16	-0.81	-1.57	-0.0075
Chile	0.09	0.32	0.70	0.37	1.18	0.0031
Colombia	0.39	0.62	0.45	0.65	0.98	0.0034
Mexico	0.25	0.61	0.83	0.82	1.25	0.0049
Peru	0.06	0.17	0.56	0.20	0.31	0.0019
B. Interest rate differential						
Brazil	14.05	10.36	-7.06***	11.71	-9.17***	-0.0201***
Chile	1.41	3.55	10.16***	4.26	8.35***	0.0243***
Colombia	8.06	4.45	-5.74***	4.81	-6.23***	-0.0298***
Mexico	8.73	4.38	-8.61***	5.39	-5.60***	-0.0312***
Peru	4.65	3.60	-3.50***	4.00	-4.01***	-0.0053***
C. Exchange risk premium						
Brazil	3.69	3.41	-1.22	4.83	3.89***	0.0141***
Chile	2.57	2.18	-4.87***	3.73	6.27***	0.0108***
Colombia	3.44	4.02	3.03**	5.45	4.19***	0.0182***
Mexico	3.03	3.17	1.98**	4.07	3.10***	0.0115***
Peru	1.71	1.75	0.14	2.26	2.60***	-0.0096***
D. Dynamics correlations for Exchange returns						
Brazil v/s Chile	-0.017	-0.081	-10.13***	-0.055	-5.37***	-0.0346***
Brazil v/s Colombia	-0.025	-0.098	-8.27***	-0.071	-7.05***	-0.0461***
Brazil v/s Mexico	0.006	-0.045	-9.74***	-0.030	-9.16***	-0.0257***
Brazil v/s Peru	0.003	-0.017	-7.13***	-0.012	-4.77***	-0.0163***
Chile v/s Colombia	0.262	0.318	8.70***	0.376	11.46***	0.1086***

Chile v/s Mexico	0.274	0.321	9.94***	0.425	9.89***	0.1325***
Chile v/s Peru	0.195	0.248	8.19***	0.278	10.57***	0.0756***
Colombia v/s Mexico	0.423	0.511	10.91***	0.558	8.68***	0.1649***
Colombia v/s Peru	0.390	0.460	12.47***	0.663	9.24***	0.2541***
Mexico v/s Peru	0.366	0.414	10.36***	0.524	13.46***	0.1946***
E. Dynamics correlations for Exchange risk premiums						
Brazil v/s Chile	0.017	0.031	3.93***	0.042	6.16***	0.0190***
Brazil v/s Colombia	0.055	0.065	6.17***	0.106	8.04***	0.0454***
Brazil v/s Mexico	0.175	0.223	10.12***	0.276	7.21***	0.0895***
Brazil v/s Peru	0.164	0.155	-2.79***	0.182	4.33***	0.0138***
Chile v/s Colombia	-0.070	-0.086	-9.26***	-0.132	-12.07***	-0.0728***
Chile v/s Mexico	-0.041	-0.047	-0.52	-0.055	-3.18***	-0.0203***
Chile v/s Peru	-0.067	-0.118	-3.15***	-0.136	-6.72***	-0.0562***
Colombia v/s Mexico	0.168	0.220	15.90***	0.298	13.07***	0.1745***
Colombia v/s Peru	0.161	0.215	14.39***	0.286	15.29***	0.1126***
Mexico v/s Peru	0.180	0.231	9.58***	0.279	14.84***	0.1248***

Notes: Superscripts ***, **, * indicate statistical significance at 1%, 5%, and 10%, respectively. Model (12) includes a dummy variable for the periods of Asian and Subprime crises, and Covid-19 pandemic.

Source: Own elaboration.

The results indicate that MILA did not has significant effects on exchange returns of Brazil, Chile, Colombia, Mexico and Peru markets. However, MILA had significant effects on dynamic correlations of exchange returns between these markets. At this point, we observe two interesting results. First, the dynamic correlations of exchange returns between the markets that belong to MILA increased significantly. This result shows that exchange markets integration degree has increased due to MILA. This fact supports hypothesis H3 and the view of the various authors regarding the effects of these integration processes on price moves (Bollerslev, 1990; Shin and Sohn, 2006). However, this finding shows that the exchange diversification opportunities within MILA markets are more limited. For these reasons, it is considered that Latin American markets have low segmentation degree and investors would value their risk regionally. Second, the dynamics correlations of exchange returns between each MILA market and Brazil were significantly reduced.

This fact contradicts hypothesis H3. In general, these correlations were negatives, and as a MILA's result, these correlations became little more negative. This result indicates that the Brazilian market is a relevant diversification source for international investors in Latin America. The Covid-19 pandemic increased the dynamic correlations, but it did not affect the previous results.

Regarding risk premium, the results are mixed after MILA and before Covid-19. On one hand, the MILA implementation significantly increased the exchange risk premium for Colombia (0.58%) and Mexico (0.14%), while in Chile it reduced it by 0.39%. In Brazil and Peru it did not have significant effects. Including the Covid-19 period, all exchange risk premium figures increased. On the other hand, the MILA's effects on dynamic correlations of exchange risk premium between each market were significant. The increase on dynamic correlations between the exchange risk premium of Brazil and the MILA markets stands out (except for Peru market). We observe a similar situation between Colombia, Mexico and Peru markets. These facts corroborate that exchange risk premium has regional qualities in Latin America. So, the increase on dynamic correlations of risk premium between these markets supports the hypothesis H4. However, the dynamic correlations of risk premium between Chile and the MILA markets are negative and due to MILA they decreased a little (except for Mexico). Fact that is against hypothesis H4. From a regional perspective, any risk increase in Latin America would generates capital flows movements to Chile, a country characterized by low risk. In fact, these movements generate a lower exchange rate return, consistent with the negative individual risk premium in this market and the Chilean peso strengthening. A similar pattern was observed when it included the Covid-19 period.

We observe that the interest rate differentials decreased significantly, except for Chilean market. However, they increased after Covid-19 period due to the inflationary pressures. In general, these results are conditioned by monetary policy direction implemented for these countries in the last two decades because inflation and economic crisis scenarios.

5. Conclusions and discussion

At the present, the exchange markets analysis can hardly be dissociated from financial development policies adopted by countries. The interaction between exchange markets and stock markets has intensified in recent decades. The integration processes that many countries have developed among their stock exchanges have facilitated the interaction between these markets and international capital flows movements. This fact has a relevant effect on investor's mechanisms to value the exchange rate and risk, and of which Latin America has not been exempt.

Our research focuses on this relationship for the main Latin American markets. Combining the classic valuation fundamentals of exchange rates through UIP, risk premium and stock market integration processes, we provide evidence on risk premium presence and nature in the region's exchange markets and how MILA has influenced them.

Our results are summarizing in three points. First, in Brazil, Chile, Colombia, Mexico and Peru exchange markets, the exchange rates are not in equilibrium. According to a vast empirical literature, our estimates show that the exchange returns of these markets persistently deviate from UIP fundamentals, and the interest rate differential does not fully explain the exchange rate subsequent direction. Additionally, in the Latin American exchange markets, as in most of the emerging countries, the UIP bias is lower than that indicated in developed countries. This fact does not constitute any novelty and supports the previous researches findings. In an attempt to evaluate the risk premium existence, we estimate the UIP through GARCH-in-Mean models. Our results reveal that there is no time-varying risk premium, except for Chilean market where was found a negative time-varying risk premium that promotes the Chilean peso appreciation. These results indicate that the Latin American exchange markets have not a risk premium that is valued individually.

Second, the DCC-MGARCH models indicate that in the Latin American markets there is risk premium regionally valued. This result has two implications based on significant co-movements between these exchange markets. On one hand, the exchange returns are significantly correlated, which facilitates the financial contagion possibilities in the region. On the other hand, the exchange risk premium is also correlated between these markets, a fact that corroborate the regional valuation of risk premium in Latin America. So, the investors would value regionally these markets because they are characterized by low segmentation degree and make it difficult diversification strategies.

Finally, the MILA start had significant effects on regional exchange markets behavior. Although MILA did not have significant effects on exchange returns, its impacts on dynamic correlations show an increasing integration degree between these markets, mainly within MILA markets. This result corroborates that these exchange markets have become less segmented, hinder the international diversification strategies and facilitate the financial shocks transmission. However, due to this stock markets integration process, the dynamic correlations between Brazilian foreign exchange market and MILA markets became little more negative. This result shows that investors seeking to diversify risk in the region outside MILA can use the Brazilian foreign exchange market for this purpose. MILA also had relevant effects on risk premium, mainly on its regional co-movements. The dynamic correlations of risk premium between each market were significant, which confirms our previous results regarding the regional value of risk. Due to MILA, there was a significant increase in the risk premium co-movements between Brazilian exchange market and MILA markets. A result that was also observed between Colombia, Mexico and Peru markets. However, the risk premium from the Chilean exchange market correlates negatively with the other Latin American markets; correlations that decreased after MILA. This fact positions Chile as a countercyclical market over foreign exchange risk, which favors the fly to quality in the region and would state it as a partial exception in the regional risk assessment. In general, the Covid-19 increased the exchange risk premium and the dynamic correlations of the exchange returns and risk premium, but it does not affect the previous results.

Our results provide relevant implications for investors and researchers. To the firsts, these results will allow them to adapt their strategies and positions in currencies of Latin American markets by identifying their risk patterns and co-movements among them. For the seconds, it provides an empirical explanation about relationship between exchange markets and capital markets development in this region. From this point, we can continue towards future research that address the analysis of co-movements between exchange markets in relation to productive sectors that make up the stock markets of the region. This is a way of linking exchange markets behavior with economic activity that is more frequently related to international business operations.

Future research could focus on spillover effects between foreign exchange markets. This would make it possible to quantify not only the dependence between exchange markets but also to measure which ones are transmitters or receivers of shocks and their temporal dynamics. This would contribute to a better understanding of the links between foreign exchange markets and their potential effects on foreign exchange investment decisions.

References

[1] Abid, I., Kaabia, O., and Guesmi, K. (2014). Stock market integration and risk premium: Empirical evidence for emerging economies of South Asia. *Economic Modelling*, 37, 408–416. doi: 10.1016/j.econmod.2013.11.015

[2] Aftab, M., Ahmad, R., Ismail, I., and Phylaktis, K. (2020). Economic integration and the currency and equity markets nexus. *International Journal of Finance and Economics*, 26(4), 5278-5301. doi: 10.1002/ijfe.2065

[3] Aggarwal, S. (2013). The uncovered interest rate parity puzzle in the foreign exchange market, New York University, working paper. Retrieved from https://web-docs.stern.nyu.edu/old_web/economics/docs/workingpapers/2013/Aggarwal_ParityPuzzle_May2013.pdf

[4] Assidenou, K. (2011). Cointegration of major stock market indices during the 2008 global financial distress. *International Journal of Economics and Finance*, 3(2), 212–222. doi: 10.5539/ijef.v3n2p212

[5] Asness, C., Israelov, R., and Liew, J. (2011). International diversification works (Eventually). *Financial Analysts Journal*, 67(3), 24-38. doi: 10.2307/23032038

[6] Aysun, U., and Lee, S. (2014). Can time-varying risk premiums explain the excess returns in the interest rate parity condition?. *Emerging Markets Review*, 18, 78–100. doi: 10.1016/j.ememar.2014.01.002

[7] Bhatti, R. (2014). The existence of uncovered interest parity in the CIS countries. *Economic Modelling*, 40, 227–241. doi: 10.1016/j.econmod.2014.04.002

[8] Baillie, R., and Bollerslev, T. (1990a). Intra-day and inter-market volatility in foreign exchange rates. *Review of Economic Studies*, 58(3), 565-585. doi: 10.2307/2298012

[9] Baillie, R., and Bollerslev, T. (1990b). A multivariate generalized ARCH approach to modeling risk premia in forward foreign exchange rate markets. *Journal of International Money and Finance*, 9(3), 309-324. doi: 10.1016/0261-5606(90)90012-O

[10] Baillie, R., and Kilic, R. (2006). Do asymmetric and nonlinear adjustments explain the forward premium anomaly?. *Journal of International Money and Finance*, 25(1), 22–47. doi: 10.1016/j.jimonfin.2005.10.002.

[11] Bansal, R., and Dahlquist, M. (2000). The forward premium puzzle: different tales from developed and emerging economies. *Journal of International Economics*, 51(1), 115–144. doi: 10.1016/S0022-1996(99)00039-2.

[12] Beine, M. (2004). Conditional covariances and direct central bank interventions in the foreign exchange markets. *Journal of Banking and Finance*, 28(6), 1385–1411. doi: 10.1016/S0378-4266(03)00124-9.

[13] Bekaert, G., Wei, M., and Xing, Y. (2007). Uncovered interest rate parity and the term structure. *Journal of International Money and Finance*, 26(6), 1038-1069. doi: 10.1016/j.jimonfin.2007.05.004.

[14] Berggrun, L., Lizarzaburu, E., and Cardona, E. (2016). Idiosyncratic volatility and stock returns: Evidence from the MILA. *Research in International Business and Finance*, 37, 422–434. doi: 10.1016/j.ribaf.2016.01.011

[15] Bollerslev, T. (1990). Modelling the coherence in short-run nominal exchange rates: A multivariate generalized ARCH model. *The Review of Economics and Statistics*, 72(3), 498-505. doi: 10.2307/2109358

[16] Cardona, L., Gutiérrez, M., and Agudelo, D. (2017). Volatility transmission between US and Latin American Stock Markets: Testing the decoupling hypothesis. *Research in International Business and Finance*, 39(Part A), 115–127. doi: 10.1016/j.ribaf.2016.07.008

[17] Castro, C., and Marín, N. (2014). Stock return comovements and integration within the Latin American integrated market. Universidad de Rosario, working paper No. 154. Retrieved from https://www.researchgate.net/publication/275337142_Castro_C_Marin_N_J_2014_Stock_return_comovements_and_integration_within_the_Latin_American_integrated_market_No_011041_UNIVERSIDAD_DEL_ROSARIO

[18] Cavaglia, S., Verschoor, W., and Wolff, C. (1994). On the biasedness of forward foreign exchange rates: Irrationality or risk premia?. *The Journal of Business*, 67(3), 321-343. http://www.jstor.org/stable/2353131

[19] Celik, S. (2012). The more contagion effect on emerging markets: The evidence of DCC-GARCH model. *Economic Modelling*, 29(5), 1946–1959. doi: 10.1016/j.econmod.2012.06.011

[20] Chaboud, A., and Wright, J. (2005). Uncovered interest parity: it works, but not for long. *Journal of International Economics*, 66(2), 349–362. doi: 10.1016/j.jinteco.2004.07.004

[21] Chen, G., Firth, M., and Meng Rui, O. (2002). Stock market linkages: Evidence from Latin America. *Journal of Banking and Finance*, 26(6), 1113-1141. doi: 10.1016/S0378-4266(01)00160-1

[22] Chinn, M., and Meredith, G. (2004). Monetary policy and long-horizon uncovered interest parity. *IMF Staff Papers*, 51(3), 409–430. Retrieved from https://www.imf.org/External/Pubs/FT/staffp/2004/03/chinn.htm

[23] Chinn, M., and Meredith, G. (2005). Testing uncovered interest parity at short and long horizons during the post-Bretton Woods era. *National Bureau of Economic Research*, Working Paper 11077. doi: 10.3386/w11077

[24] Choudhry, T. (2013). The long memory of the forward premium during the 1920s' float: Evidence from the European foreign exchange market. *The European Journal of Finance*, 19(10), 964–977. doi: 10.1080/1351847X.2012.703142

[25] De Brouwer, G. (1997). Interest parity conditions as indicators of financial integration in East Asia. *Australia–Japan Research Center*, Pacific Economic Papers No. 268. Retrieved from https://crawford.anu.edu.au/pdf/pep/pep-268.pdf

[26] De Jong, F., and De Roon, F. (2005). Time-varying market integration and expected returns in emerging markets. *Journal of Financial Economics*, 78(3), 583-613. doi: 10.1016/j.jfineco.2004.10.010

[27] Domowitz, I., and Hakkio, C. (1985). Conditional variance and the risk premium in the foreign exchange market. *Journal of International Economics*, 19(1-2), 47-66. doi: 10.1016/0022-1996(85)90018-2

[28] Engel, C. (1996). The forward discount anomaly and the risk premium: A survey of recent evidence. *Journal of Empirical Finance*, 3(2), 123–192. doi: 10.1016/0927-5398(95)00016-X.

[29] Engel, C. (2016). Exchange rates, interest rates, and the risk premium. *American Economic Review*, 106(2), 436–474. doi: 10.1257/aer.20121365.

[30] Engle, R. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica*, 50(4), 987-1007. http://www.jstor.org/stable/1912773

[31] Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroscedasticity models. *Journal of Business and Economic Statistics*, 20(3), 339–350. doi: 10.1198/073500102288618487

[32] Engle, R., Lilien, D., and Robins, R. (1987). Estimating time varying risk premia in the term structure: The ARCH-M model. *Econometrica*, 55(2), 391-407. doi: 10.2307/1913242

[33] Fama, E. (1984). Forward and spot exchange rates. *Journal of Monetary Economics*, 14(3), 319-338. doi: 10.1016/0304-3932(84)90046-1

[34] Forsberg, L., and Bollerslev, T. (2002). Bridging the gap between the distribution of realized (ECU) volatility and ARCH modelling (of the Euro): The GARCH-NIG model. *Journal of Applied Econometrics*, 17(5), 535-548. doi: 10.1002/jae.685

[35] Francis, B., Hasan, I. and Hunter, D. (2002). Emerging market liberalization and the impact on uncovered interest rate parity. *Journal of International Money and Finance*, 21(6), 931–956. doi: 10.1016/S0261-5606(02)00029-3

[36] Frankel, J. (1982). In search of the exchange risk premium: A six currency test assuming mean-variance optimization. *Journal of International Money and Finance*, 1(3), 255-274. doi: 10.1016/0261-5606(82)90019-5

[37] Frankel, J., and Chinn, M. (1993). Exchange rate expectations and the risk premium: Test for a cross section of 17 currencies. *Review of International Economics*, 1(2), 136-144. doi: 10.1111/j.1467-9396.1993.tb00011.x

[38] Frankel, J., and Poonawala, J. (2010). The forward market in emerging currencies: Less biased than in major currencies. *Journal of International Money and Finance*, 29(3), 585-598. doi: 10.1016/j.jimonfin.2009.11.004

[39] Fratzscher, M. (2002). Financial market integration in Europe: On the effects of EMU on stock markets. *International Journal of Finance and Economics*,.7(3), 165-193. doi: 10.1002/ijfe.187

[40] Frenkel, J. (1981). Flexible exchange rates, prices and the role of "news": Lessons from the 1970s. *Journal of Political Economy*, 89(4), 665-705. http://www.jstor.org/stable/1833030.

[41] Froot, K. (1990). Short rates and expected asset returns. *National Bureau of Economic Research*, Working paper No. 3247. Retrieved from https://www.nber.org/papers/w3247

[42] Froot, K., and Frankel, J. (1989). Forward discount bias: Is it an exchange risk premium?. *The Quarterly Journal of Economics*, 104(1), 139-161. doi: 10.2307/2937838

[43] Froot, K., and Thaler, R. (1990). Anomalies: Foreign exchange. *The Journal of Economic Perspectives*, 4(3), 179-192. doi: 10.1257/jep.4.3.179

[44] Glick, R., and Rose, A. (1999). Contagion and trade: Why are currency crises regional?. *Journal of International Money and Finance*, 18(4), 603–617. doi: 10.1016/S0261-5606(99)00023-6

[45] He, H. (2017). Regional currency and regional trade integration. *Journal of Global Economics*, 5(2), 1-8. doi: 10.4172/2375-4389.1000245

[46] Heston, S., Geert, K., and Wessels, R. (1995). The structure of international stock returns and the integration of capital markets. *Journal of Empirical Finance*, 2(3), 173-197. doi: 10.1016/0927-5398(95)00002-C

[47] Hodrick, R. (1987). The empirical evidence on the efficiency of forward and futures foreign exchange markets. Harwood Academic Publishers, Chur, Switzerland.

[48] Hodrick, R., and Srivastava, S. (1984). An investigation of risk and return in forward foreign exchange. *Journal of International Money and Finance*, 3(1), 5-29. doi: 10.1016/0261-5606(84)90027-5

[49] Isard, P. (2006). Uncovered interest parity. *International Monetary Fund*. IMF Working Paper WP/O6/96. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.453.7058&rep=rep1&type=pdf

[50] Janor, H., Ali, R., and Shaharudin, R. (2007). Financial integration through equity markets and the role of exchange rate: Evidence from Asean-5 countries. *Asian Academy of Management Journal of Accounting and Finance*, 3(1), 77-92.

[51] Lambelet, J., and Mihailov, A. (2005). The triple-parity law, unpublished working paper. Retrieved from http://www.audentia-gestion.fr/economie/PDF/TripleParity.pdf

[52] Lewis, K. (1995). Puzzles in international financial markets. In: Grossman, G., Rogoff, K. (Eds.), Handbook of International Economics vol. 3. Elsevier, 1913–1971.

[53] Li, D., Ghoshray, A., and Morley, B. (2012). Measuring the risk premium in uncovered interest parity using the component GARCH-M model. *International Review of Economics and Finance*, 24, 167–176. doi: 10.1016/j.iref.2012.02.001

[54] Lizarzaburu, E., Burneo, K., Galindo, H., and Berggrun, L. (2015). Emerging markets integration in Latin America (MILA) stock market indicators: Chile, Colombia, and Peru. *Journal of Economics, Finance and Administrative Science*, 20(39), 74-83. doi: 10.1016/j.jefas.2015.08.002

[55] Lothian, J. (2016). Uncovered interest parity: The long and the short of it. *Journal of Empirical Finance*, 36, 1–7. doi: 10.1016/j.jempfin.2015.12.001

[56] Lothian, J., Pownall, R., and Koedijk, K. (2013). I discovered the peso problem: Irving Fisher and the UIP puzzle. *Journal of International Money and Finance*, 38, 5-17. doi: 10.1016/j.jimonfin.2013.06.003

[57] Lothian, J., and Wu, L. (2011). Uncovered interest-rate parity over the past two centuries. *Journal of International Money and Finance*, 30(3), 448–473. doi: 10.1016/j.jimonfin.2011.01.005

[58] Lucas, R. (1982). Interest rates and currency prices in a two country world. *Journal of Monetary Economics*, 10(3), 335-359. doi: 10.1016/0304-3932(82)90032-0

[59] Malik, F., and Umar, Z. (2019). Dynamic connectedness of oil price shocks and exchange rates. Energy Economics, 84. doi: 10.1016/j.eneco.2019.104501

[60] Mark, N., and Wu, Y. (1998). Rethinking deviations from uncovered interest parity: The role of covariance risk and noise. *The Economic Journal*, 108(451), 1686-1706. doi: 10.1111/1468-0297.00367

[61] McFarland, J., McMahon, P., and Ngama, Y. (1994). Forward exchange rates and expectations during the 1920s: A re-examination of the evidence. *Journal of International Money and Finance*, 13(6), 627–636. doi: 10.1016/0261-5606(94)90035-3

[62] Mellado, C., and García, S. (2014). The effects of the Latin American integrated market (MILA) on the foreign exchange of Colombia, Peru and Chile. *American Journal of Economics*, 4(2A), 42-50. doi: 10.5923/s.economics.201401.04

[63] Mellado, C., and Escobari, D. (2015). Virtual integration of financial markets: A dynamic correlation analysis of the creation of the Latin American Integrated Market. *Applied Economics*, 47(19), 1956-1971. doi: 10.1080/00036846.2014.1002892

[64] Mussa, M. (1984). The theory of exchange rate determination, in Exchange Rate Theory and Practice, University of Chicago Press, pp. 13-58.

[65] Olmo, J., and Pilbeam, K. (2011). Uncovered interest parity and the efficiency of the foreign exchange market: A re-examination of the evidence. *International Journal of Finance and Economics*, 16(2), 189–204. doi: 10.1002/ijfe.429

[66] Phillips, P., McFarland, J., and McMahon, P. (1996). Robust tests of forward exchange market efficiency with empirical evidence from the 1920s. *Journal of Applied Econometrics*, 11(1), 1-22. doi: 10.1002/(SICI)1099-1255(199601)11:1<1::AID-JAE367>3.0.CO;2-Q

[67] Reboredo, J., Ugolini, A., and Arreola J. (2021). Dynamic spillovers and network structure among commodity, currency, and stock markets. *Energy Policy*, 74. doi:10.1016/j.resourpol.2021.102266

[68] Sarno, L., Valente, G., and Leon, H. (2006). Nonlinearity in deviations from uncovered interest parity: An explanation of the forward bias puzzle. *Review of Finance*, 10(3), 443–482. doi: 10.1007/s10679-006-9001-z

[69] Seerattan, D., and Birchwood, A. (2004). Financial market integration, arbitrage and interest rate parity in the Caribbean, Presented at: The inaugural International Conference on Business, Banking and Finance. Retrieved from https://sta.uwi.edu/conferences/financeconference/Conference%20Papers/Session%2022/Financial%20Market%20Integration,%20Arbitrage%20and%20Interest%20Rate%20Parity%20in%20the%20Caribbean.pdf

[70] Shin, K., and Sohn, C. (2006). Trade and financial integration in East Asia: Effects on co-movements. *The World Economy*, 29(12), 1649-1669. doi: 10.1111/j.1467-9701.2006.00862.x

[71] Syllignakis, M., and Kouretas, G. (2011). Dynamic correlation analysis of financial contagion: Evidence from the Central and Eastern European markets. *International Review of Economics and Finance*, 20(4), 717–732. doi: 10.1016/j.iref.2011.01.006

[72] Tai, C. (2001). A multivariate GARCH in mean approach to testing uncovered interest parity: Evidence from Asia-Pacific foreign exchange markets. *The Quarterly Review of Economics and Finance*, 41(4), 441-460. doi: 10.1016/S1062-9769(01)00105-3

[73] Tai, C. (2007). Market integration and contagion: Evidence from Asian emerging stock and foreign exchange markets. *Emerging Markets Review*, 8(4), 264-283. doi: 10.1016/j.ememar.2006.09.011

[74] Tse, Y., and Tsui, A. (2002). A multivariate GARCH model with time-varying correlations. *Journal of Business and Economic Statistics*, 20(3), 351–362. doi: 10.1198/073500102288618496

[75] Yang, J., Kolari, J., and Min, I. (2003). Stock market integration and financial crises: the case of Asia. *Applied Financial Economics*, 13(7), 477-486. doi: 10.1080/09603100210161965

[76] Yung, J. (2017). Can interest rate factors explain exchange rate fluctuations?. *Federal Reserve Bank of Dallas*, Globalization and Monetary Policy Institute Working Paper No. 207. Retrieved from https://www.dallasfed.org/~/media/documents/institute/wpapers/2014/0207.pdf