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Further evidence on the determinants of regional stock market integration in Latin America

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Abstract

This paper employs a conditional version of the International Capital Asset Pricing Model (ICAPM) to investigate the determinants of regional integration of stock markets in the Latin America over the period 1996-2008. This model allows for three sources of time-varying risks: common regional market risk, exchange rate risk and local market risk. In particular, exchange rate risk exposure is not only measured by bilateral exchange rates against the US dollar as in previous studies, but also by the real effective exchange rate index. At the empirical level, we make use of the asymmetric multivariate DCC-GARCH of Engle and Sheppard (2006) process to simultaneously estimate the ICAPM for four major Latin American emerging countries (Argentina, Brazil, Chile and Mexico). Our findings show that the degrees of trade openness and stock market development are among the most important drivers of regional integration in the Latin America context whatever the measure of the exchange rate risk.

JEL classification: F36; C32; G15

Keywords: Multivariate GARCH, regional integration, ICAPM

1. Introduction

Latin American countries have established a key economic region over the past twenty years. The regional economic dynamics is substantially driven by Brazil as the sixth largest economy in the world overtaking the United Kingdom and Italy as well as by Mexico as the second largest economy of the region and the 14th largest economy in the world (August 2012). For their parts, Argentina and Chile are ranked 27th and 41st largest economies respectively. With a combined GDP of nearly 4,400 billion, this group of four fastest-growing economies in the Latin American region is located between Germany (3,600 billion) and Japan (5,800 billion). A number of studies have been devoted to these countries given their important role in world's international trade and economic growth, but the main focus was extensively on the issue of trade integration. Indeed, while Mexico is part of the North American Free Trade Agreement (NAFTA), Argentina, Brazil, and Chile (associate member) are the source of inspiration behind the creation MERCOSUR, another free trade area.

The issue of financial integration of these countries is seldom addressed, even though stock markets in Sao Paulo, Mexico City, Buenos Aires and Santiago have recently gained much attention from individual and professional investors, especially after respective governments undertook a series of structural economic and financial reforms to improve the transparency and attractiveness of their financial markets (Bekaert, 1995). In addition, existing attempts on Latin American market integration such as Bekaert and Harvey (1995, 1997), Adler and Qi (2003), and Hardouvelis et al., 2006) arbitrarily chose several financial and macroeconomic variables to model

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the dynamics of market integration without formally testing their economic relevance. For instance, Bekaert and Harvey (1995) propose a model allowing for time-varying world market integration of individual markets and find that increasing integration affects negatively and significantly the cost of equity. More recently, Bekaert and Harvey (2000) introduce changes in dividend yields to measure changes in the cost of equity and document that changes in dividend yields have an insignificant effect on the cost of equity. Carrieri et al. (2007) also use some arbitrary variables to model the dynamics of market integration measure which is then related to a number of factors that may explain the changes in the level of financial integration. Several studies have examined the issue of market linkages and integration outside the asset pricing frameworks. Using Geweke (1982)'s measures of feedback for different pairs of nine national equity markets, Bracker et al. (1999) show significant impacts of macroeconomic variables on the bilateral lead-lag market linkages. Chinn and Forbes (2004) find that direct trade with large economies is the only important factor explaining cross-market links whereas trade competition, bank lending and foreign investment have no significant effect. There is also evidence to suggest a weak role of macroeconomic fundamentals in explaining long-run cointegration of stock returns (Cheung and Lai, 1999).

Although past studies have permitted a better understanding of Latin American equity market integration as well as its determinants, they mainly rely on the concept of market correlation that is not directly related to the true patterns of evolving market integration. As noted by Carrieri et al. (2007), correlations are informative for portfolio allocation and management, but they do not constitute an accurate measure of diversification benefits or overall integration. In particular, Pukthuanthong and Roll (2009) show the inappropriateness of correlation as a proper measure of integration and they argue that two highly integrated markets may have a low correlation. Indeed, if returns on the two markets are affected by the same common factors but do not have the same sensitivities to all of them, the two markets are highly integrated but only weakly correlated. Adler and Dumas (1983) also point out that the correlation between markets depends very much on their level of international trade. As a result, market co-movement reflects only sector linkages instead of market integration. Therefore, tests for market integration need to be built on asset pricing model frameworks which impose the similarity of systematic risks (Bekaert and Harvey, 1995; Bhattacharya and Daouk, 2002).

This study contributes to the extant literature by exploring the determinants of regional market integration for emerging markets in Latin America. Given the exploratory nature of the empirical investigation, we attempt to encompass as much explanatory variables as possible. We consider a complete list of potential determinants from the past empirical literature on market integration. A partially segmented International Capital Asset Pricing Model (PS-ICAPM) in the spirit of Bekaert and Harvey (1995) is used to model the dynamics of expected returns. The model allows not only for the time-varying market integration but also for time-varying covariance risks. It considers the real exchange rates as a common source of systematic risk, in addition to the local and regional systematic risks. We adopt the Capiello et al. (2006)'s multivariate asymmetric DCC-GARCH process to accommodate the conditional variances and covariances of stock returns.

Using monthly data from four largest markets in the Emerging Latin America over the period 1996-2008, we find that the number and nature of driving factors for regional integration are very sensitive to the exchange rate risk measures. In the meanwhile, the trade openness and local stock market development play a common and significant role in explaining the dynamics of regional market integration.

The remainder of the article is organized as follows. Section 2 presents the empirical model. Section 3 describes the data. Section 4 discusses the obtained results. Section 5 concludes the article.

2. The partially segmented ICAPM

Under the assumption of purchasing power parity (PPP) and perfect integration, the international version of the CAPM of Sharpe (1964) and Lintner (1965) predicts that excess expected return on a security is priced with respect to the world market risk factor, usually represented by the stochastic fluctuations of a world market portfolio. When the regional integration is examined, the world market portfolio can be replaced by a regional market portfolio. In this article, we extend the well-known one-factor ICAPM to the case of partial integration with three sources of systematic risk that reflect changes in regional stock market, domestic stock market and real exchange rate. Formally, expected returns are priced according to the degree of regional market integration as follows

$$E(R_{i,t}|\psi_{t-1}) = \Omega_{t-1}^{i}\left[\lambda_{t-1}^{r}Cov(R_{i,t}, R_{r,t}|\psi_{t-1}) + \sum_{k=1}^{l}\lambda_{t-1}^{k}Cov(R_{i,t}, R_{k,t}|\psi_{t-1})\right] + (1-\Omega_{t-1}^{i})\lambda_{i,t-1}^{d}Var(R_{i,t}|\psi_{t-1}) \quad (1)$$

where $R_{i,t}$, $R_{r,t}$ and $R_{k,t}$ represent respectively expected excess returns on the local market portfolio in the country *i*, the regional market portfolio and the exchange rate of currency *k* against the currency of the country under consideration. Returns on local and regional market portfolios are expressed in the currency of the considered country. λ_{t-1}^{r}, $\lambda_{i,t-1}^{d}$ and λ_{t-1}^{k} are the expected prices of a unit of risk, related to the regional market, the local market and the exchange rate, respectively. *k* denotes the currencies of the four countries that we consider in the Latin America: Argentina, Brazil, Chile, and Mexico. Ω_{t-1}^{i} refers to a conditional measure of financial integration degree of market *i* with the regional market, which falls within the interval [0,1]. If $\Omega_{t-1}^{i} = 1$, only the covariance risks are priced and the strict segmentation hypothesis is rejected. Inversely, the model is reduced to the domestic CAPM when $\Omega_{t-1}^{i} = 0$ as only the national systematic risk is relevant for pricing financial securities.

At the empirical stage, we estimate the following system of equations:

$$\begin{cases} \tilde{r}_t = \lambda_0^i + \Omega_{i,t-1}\left(\lambda_{t-1}^{reg} h_t^{i,reg} + \lambda_{t-1}^{A} h_t^{i,A} + \lambda_{t-1}^{B} h_t^{iB} + \lambda_{t-1}^{C} h_t^{iC} + \lambda_{t-1}^{M} h_t^{iM}\right) + \left(1-\Omega_{i,t-1}\right)\lambda_{t-1}^{i} h_t^{ii} + \varepsilon_{i,t} \\ \varepsilon_t = \left(\varepsilon_{reg,t}, \varepsilon_{A,t}^f, \varepsilon_{B,t}^f, \varepsilon_{C,t}^f, \varepsilon_{M,t}^f, \varepsilon_{A,t}, \varepsilon_{B,t}, \varepsilon_{C,t}, \varepsilon_{M,t}\right)' \left|\psi_{t-1} \to N(0, H_t)\right. \\ \Omega_{i,t-1} = Exp\left(-\left|\alpha_i' X_{i,t-1}\right|\right), i = A \text{(Argentina)}, B \text{(Brazil)}, C \text{(Chile), and } M \text{ (Mexico)} \end{cases} \quad (2)$$

where $r_{it}^f = \left(r_{regt}^f, r_{At}^f, r_{Ct}^f, r_{Mt}^f, r_{Bt}^f, \tilde{r}_{At}^f, \tilde{r}_{Ct}^f, \tilde{r}_{Mt}^f, \tilde{r}_{Bt}^f\right)'$ refers to the (9×1) vector of excess returns on the regional market, the four emerging markets and the four bilateral exchange rates, respectively. All the return series are assumed to be normally distributed. $X_{i,t-1}$ is the vector of information variables available at time *t*-1 that are likely to drive the integration degree of the market *i*. Expected prices of risk related to the regional market, to the four bilateral exchange rates and to the local market are allowed to vary through time. They reflect the risk aversion aggregated over all investors and should thus be positive (Adler and Dumas, 1983). H_t is the conditional variance-covariance matrix of returns at time *t* with h_t^{ii} being the conditional variance of the market *i*, and $h_t^{i,j}$ the covariance between two markets *i* and *j*. Following Hardouvelis and al. (2006) and Guesmi and Nguyen (2011), we model the time-varying prices of regional and local market risks as well as the time-varying price of exchange rate risks by a linear function of a set of regional and local information variables ($X_{reg,t-1}$ and $Z_{i,t-1}$), observable and available up to time *t*-1, such as[4]

$$\begin{aligned} \lambda_{reg,t-1} &= Exp(\delta_{reg}' X_{reg,t-1}) \\ \lambda_{i,t-1} &= Exp(\gamma_i' Z_{i,t-1}) \\ \lambda_{c,t-1} &= Exp(\delta_c' X_{reg,t-1}) \end{aligned} \quad (3)$$

The conditional variance-covariance matrix of returns, H_t, is assumed to follows a multivariate DCC-GARCH model as

$$H_t = G_t R_t G_t' \quad (4)$$

[4] The selected modeling approach helps satisfy the asset pricing constraint and solve a technical problem during the estimation. Effectively, both the logistic and exponential functions can be used to model the integration path between segmentation regime (0) and integration regime (1), and to ensure the positivity of market risk premium. However, when the logistic function is used, the optimization problem does not converge for almost all the empirical specifications. In this regard, it is worth noting that this numerical convergence problem is not unusual in the financial economics literature. Past studies, including for example Cooper and Kaplanis (2000), Hardouvelis (2006), De Santis and al. (2003), Carrieri and al. (2007), and Tai (2007) also find that the exponential function is suitable for capturing the evolution of market integration.

where G_t is a (9×9) diagonal matrix of conditional standard deviations for each of the return series, defined as $G_t = diag\left\{\sqrt{h_t^{ii}}\right\}$, with h_t^{ii} being the conditional variance of each variable in the system. h_t^{ii} is modeled by a standard univariate GARCH(1,1) process such as

$$h_t^{ii} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{t-1}^{ii} \quad (5)$$

The DCC-GARCH model specifies the conditional covariances as the product of the conditional standard deviations and the conditional correlations between the two markets *i* and *j* such that

$$h_t^{ij} = \rho_t^{ij} \sqrt{h_t^{ii} h_t^{jj}} \quad (6)$$

R_t represents the (9×9) symmetric matrix of conditional correlation coefficients $\rho_{ij,t}$ and is defined as

$$R_t = (diag(Q_t))^{-1/2} Q_t (diag(Q_t))^{-1/2} \quad (7)$$

In Eq. (7), Q_t is a (9×9) variance-covariance matrix of standardized residuals ($z_t = G_t^{-1}\varepsilon_t$) and $Q_t = (1-\theta_1-\theta_2)\overline{Q} + \theta_1 u_{t-1}u'_{t-1} + \theta_2 Q_{t-1}$, with $\overline{Q}_t = E(u_t, u'_t)$ referring to a (9×9) symmetric positively-defined matrix of the unconditional variance-covariance of standardized residuals. θ_1 and θ_2 are the unknown parameters to be estimated. The sum of these coefficients must be less than one in order to insure positivity of the matrix Q_t.

The time-varying correlation coefficients between two markets, *i* and *j*, is given by

$$\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ii,t}q_{jj,t}}} \text{ with } q_{ij,t} = (1-a-b)\overline{\rho}_{ij} + az_{i,t-1}z_{j,t-1} + bq_{ij,t-1} \quad (8)$$

As indicated by Eq. (8), the time-varying correlation coefficients are determined by two components. The first component refers to the unconditional expectation of the cross product $z_{it}z_{jt}$ or the unconditional correlation coefficient, and the second component, $az_{i,t-1}z_{j,t-1} + bq_{ij,t-1}$, shows the conditional time-varying covariance.

All in all, the DCC-GARCH model of Engle (2002) is more advantageous than the CCC-GARCH model of Bollerslev (1990) in that it allows to estimate the cross-market comovement conditionally on all information available until time *t*-1. However, this model does not account for the impact of asymmetries (positive versus negative shocks) on both dynamic conditional correlations and volatilities. That is the reason why we resort to the asymmetric version of DCC-GARCH model, proposed by Cappiello et al. (2006), where asymmetric effects of news are directly introduced into the variance-covariance matrix of standardized residuals such as

$$Q_t = (\overline{Q} - A'\overline{Q}A - B'\overline{Q}B - D'\,\overline{N}D) + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'Q_{t-1}B + D'\,n_{t-1}n'_{t-1}D \qquad (9)$$

where *A*, *B* and *D* are diagonal matrices of parameters, $n_t = I[\varepsilon_t \prec 0] \otimes \varepsilon_t$ with $\otimes$ indicating the Hadamard product, and $\overline{N} = E[n_t n'_t]$. For $\overline{Q}$ and $\overline{N}$, the expectations of these matrices are infeasible and they are replaced by sample analogues, $T^{-1}\sum_{t=1}^{T}\varepsilon_t\varepsilon'_t$ and $T^{-1}\sum_{t=1}^{T}n_t n'_t$, respectively. $Q_t^* = [q_{ii,t}^*] = [\sqrt{q_{ii,t}}]$ refers to a diagonal matrix with the square root of the i^{th} diagonal element of Q_t.

Following Bekaert and Harvey (1995) and Bhattacharya and Daouk (2002), we adopt a 2-stage procedure to estimate the system of equations (2) since the simultaneous estimation of the full model is not feasible owing to a large number of unknown parameters. As in Engle et al. (1987), we employ the quasi-maximum likelihood (QML) estimation method in order to obtain robust estimates even in case of non-normality. The log-likelihood function to be maximized can be expressed as

$$\ln L(\theta) = -\frac{TN}{2}\ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\ln\left|H_t(\theta)\right| - \frac{1}{2}\sum_{t=1}^{T}\varepsilon_t'(\theta)H_t^{-1}(\theta)\varepsilon_t(\theta) \qquad (10)$$

where θ is the vector of unknown parameters to be estimated. In the first stage, we estimate the system (2) for the returns on regional stock market and four real exchange rates, and store their conditional covariances as well as the prices of the regional market and exchange rate risks. In the second stage, we use estimate the full model by imposing the estimators obtained from the first stage and by introducing the candidate factors of market integration one by one. This procedure guarantees the identical prices of regional market and exchange rate risks across the four individual emerging markets and allows us to identify the determinants of regional financial integration for each individual markets. Once the relevant factors of regional market integration factors have been identified from the above procedure, the full system with nine equations can be estimated to explore the evolution of regional integration as well as risk premiums.

3. Data

We use monthly data over the period from January 1996 through December 2008. The recent period covering the global financial crisis is excluded in order to avoid its harmful impacts on the estimation of the model parameters. The dataset includes returns series, real exchange rates, and various variables that are likely to affect the degree of financial market integration and equity risk premiums. We give more details about our dataset in what follows.

3.1 Stock returns and exchange rates

We use monthly stock returns in excess of the 1-month Eurodollar deposit rate which is considered as the risk-free rate in our study. Stock market returns are calculated from stock market indices with dividends reinvested by taking the difference in the natural logarithm of two successive index prices. The return on regional stock market is calculated as the average of the returns series of the four sample markets, weighted by their market capitalization. Market index data are obtained from Thomson Datastream International. Real exchange rates represent the value of local currencies against the U.S. dollar and come from the IMF's International Financial Statistics (IFS) and the U.S. Federal Reserve databases (US Fed databases). The real effective exchange rate index refers to the geometric average of bilateral real exchange rates of a particular country against the currencies of the remaining sample countries. Logarithmic changes of real exchange rates are used in our empirical estimation.

3.2 Global, regional and local instrumental variables

Global and regional instrumental variables are used to capture the dynamics of regional market and exchange rate risk premiums. They include the first lag of the world market dividend yield in excess of the 1–month Eurodollar deposit rate (WDY), the first lag of the US term spread or default spread (USSPR) and the first lag of the regional market portfolio returns in excess of the 1–month Eurodollar deposit rate (RRETURN).[5] The local variables comprise the first lag of local market equity returns in excess of the 1–month Eurodollar deposit rate (LRETURN), the local dividend yields (LDY) and the first lag of inflation rate (LINF). These data are extracted from Datastream International.

3.3 Potential factors of financial integration

We consider a set of potential factors of market integration that have been considered by various studies in the related literature and summarize their measurements in Table 1. These factors are expected to provide information about the evolving degree of market integration through time. For example, stock market returns in Latin America may react significantly to changes in the US term structure of interest rate, owing to the leading role of the US market in international capital mobility. To the extent that the term spread (i.e., the differential of returns between the US 10-year Treasury bond and the US risk-free 30-day rate) reflects capital market conditions (normal versus downturn) in the United States, its upward (downward) trend may increase (decrease) capital flows into Latin American markets. It is finally worth noting that we use the linear interpolation method to

[5] The US term spread is measured by the difference in the yields between the US 10-year Treasury bond and the US 1-month Treasury bills.

transform the annual GDP into monthly variable before the economic growth rate is calculated.

Table 1. Potential factors of market integration

Variables	Measurement	Data sources	Previous works
Trade openness	Total trade with the world to GDP ratio	Datastream	Bekaert and Harvey (1997, 2000), Rajan et Zingales (2001), Bhattacharya et Daouk (2002), Carrieri et al. (2007) and Guesmi and Nguyen (2011)
Stock market development	Market capitalization to GDP ratio	Datastream	Levine and Zervos (1996), Bekaert et Harvey (1995,1997), Bekaert et al. (2002), Carrieri et al. (2007)
Industrial production	Industrial production in logarithm	Datastream	King et Levine (1992, 1993), Savides (1995) et Odedokun (1996), Honig (2008)
Inflation rate	Arithmetic changes in consumer price index	Datastream	Boyd et al. (2001)
US term spread	Natural logarithm of US 10-year Treasury bond in excess of US risk-free 30-day rate	Datastream	Harvey(1995), Hardouvelis and al. (2006)
Dividend yield differential	Differential of dividend yields on country's *i* market index and world market index or Dividend to price ratio	Datastream	Ferson and Harvey (1993, 1994, 1998), Bekaert and Harvey (1995, 2000), Chari et Henry (2004), Hardouvelis and al. (2006)
Exchange rate volatility	GARCH-based conditional volatility. Exchange rate represents the value of domestic currency per unit of US dollar	IFS and US Fed databases	Jorion (1991), De Santis and Gerard (1998), Bollerslev et al. (1992), Ng (2004)
Economic growth rate	Logarithmic changes in Gross Domestic Product	IFS and US Fed databases	King et Levine (1992, 1993), Savides (1995), Odedokun (1996), Honig (2008)
Current account deficit	Natural logarithm of the difference between total export and total import	IFS	Guesmi (2012)
Market returns	Difference in natural logarithm of two successive prices	Datastream	Bekaert and Harvey (1997, 2000), Guesmi and Nguyen (2011)
Interest rate	Natural logarithm of short-term interest rate, T-bills rate or interbank rate	Datastream	Desroches and Francis (2007), Carrieri et al. (2007)
Difference in industrial production	Difference in industrial production between country *i* and G7 countries	Datastream	Gurley et Shaw (1967), King et Levine (1993)

4. Results

4.1 Statistical properties of the data

Table 2 presents the descriptive statistics of sample data. Average excess stock returns are all positive and comprised between 0.203% and 0.587% on a monthly basis. The unconditional volatility, as measured by standard deviations, ranges from 5.080% (Chile) to 11.250% (Brazil). The skewness coefficients are positive for Argentina and Mexico, while they are negative for Brazil and Chile. These values suggest that the probability of realizing positive returns by investing in Argentina and Mexico is higher than that of a corresponding normal distribution. On the other hand, the kurtosis coefficients are above three in all cases. As to the exchange rate returns, they are all positive and range from 0.197 (Argentina) to 0.371 (Chile). Their unconditional volatility is relatively lower than that of stock market returns. The skewness coefficients for exchange rate returns are negative in all cases, except for Argentina, and the kurtosis coefficients are all above three. Taken together, these statistics show that both stock and exchange rate returns are asymmetrically distributed and exhibit leptokurtic behavior.

Table 2. Descriptive statistics and stochastic properties of the data

	Mean (%)	Std. dev. (%)	Skewness	Kurtosis	J.B	Q(12)	ARCH(6)
Panel A: Excess returns on stock market indices							
Argentina	0.203	9.011	0.501	7.183	25.047^{+++}	84.22^{+++}	45.197^{+++}
Brazil	0.306	11.250	-0.300	5.083	28.047^{+++}	84.22^{+++}	57.284^{+++}
Mexico	0.442	6.778	1.105	7.327	140.72^{+++}	83.93^{+++}	61.917^{++}
Chile	0.587	5.080	-1.071	5.761	68.313^{+++}	70.077^{+++}	75.126^{++}
Panel B: Real exchange rate returns							
Argentina	0.323	4.331	0.331	7.120	111.15^{+++}	82.15^{+++}	50.145^{++}
Brazil	0.197	4.362	-1.700	11.728	119.869^{+++}	62.78^{+++}	55.114^{+++}
Mexico	0.247	1.977	-0.788	4.544	28.745^{+++}	148.15^{+++}	23.191^{+++}
Chile	0.371	2.111	-1.382	6.470	47.43^{+++}	56.89^{+++}	37.894^{+++}

Notes: JB, Q(12), and ARCH(6) are the empirical statistics of the Jarque-Bera test for normality, the Ljung-Box test for serial correlation of order 1, and the Engle (1982)'s test for conditional heteroscedasticity. $^{+}$, $^{++}$, *and* $^{+++}$ *indicate that the null hypothesis of normality and autocorrelation is rejected at the 10%, 5% and 1% levels respectively.*

We also perform some commonly-used test statistics to further investigate the stochastic properties of stock and exchange rates returns. We see that all return series depart from the normality, are serially correlated and display ARCH effects in their conditional dynamics, as indicated by the Jarque-Bera, Ljung-Box and ARCH tests for normality, autocorrelation, and conditional heteroscedasticity, respectively. These findings justify our decision to model the conditional volatility of returns by GARCH-type processes and to use the QML estimation method.

4.2 Time-varying prices of risk

Table 3 reports the expected prices of regional market and exchange rate risks that we obtain from estimating the system (2) for regional market and exchange rate returns. We see that the global information variables significantly affect changes in the market prices of exchange risk as the estimates associated with lagged values of the world market dividend yield (WDY), the regional market returns (RRETURN), and the US term spread (USSPR) are highly significant. The impact is found to be positive and negative respectively for regional market's dividend yield and returns, whatever the country we consider. The US term spread has a negative impact on expected price of exchange risk in Argentina and Brazil, but positive impact in Chile and Mexico. As to the expected price of regional market risk, it is determined by three instrumental variables considered. The regional market price of risk is positively linked to the WDY and RRETURN variables, but negatively linked to the USSPR variable.

Table 3. Estimated price of risk

	Constant	**WDY**	**RRETURN**	**USSPR**
Panel A: Expected price of exchange rate risks				
Argentina	0.222^{***}	0.003^{***}	-0.002^{***}	-0.011^{***}
	(0.001)	(0.000)	(0.000)	(0.001)
Brazil	0.234^{***}	0.004^{***}	-0.005^{***}	-0.012^{***}
	(0.021)	(0.001)	(0.000)	(0.001)
Chile	1.337^{***}	0.001^{***}	-0.012^{***}	0.011^{***}
	(0.020)	(0.000)	(0.000)	(0.003)
Mexico	0.650^{***}	0.001^{***}	-0.005^{***}	0.007^{***}
	(0.015)	(0.000)	(0.000)	(0.000)
Panel B: Expected price of regional market risk				
	0.165^{***}	0.004^{***}	0.008^{***}	-0.011^{***}
	(0.009)	(0.000)	(0.000)	(0.001)

Note: This table presents the results of the estimation of the model (2) for regional market and exchange rate returns. The QML robust standard errors of the estimates are reported in parenthesis. The *** indicates significance at the 1% level.

Table 4. Specification tests for the relevance of prices of regional market and exchange rate risks

Null hypotheses	χ^2	p-value
Is the price of regional market risk null? H_0: $\lambda^r = 0$	113.332	0.000
Is the price of regional market risk constant? H_0: $\lambda^r = 1$	125.321	0.000
Is the price of exchange rate risk in Argentina zero? H_0: $\lambda^A = 0$	143.607	0.000
Is the price of exchange rate risk in Argentina constant? H_0: $\lambda^A = 1$	129.883	0.000
Is the price of exchange rate risk in Brazil zero? H_0: $\lambda^B = 0$	89.321	0.000
Is the price of exchange rate risk in Brazil constant? H_0: $\lambda^B = 1$	81.841	0.000
Is the price of exchange rate risk in Chile zero? H_0: $\lambda^C = 0$	91.568	0.000
Is the price of exchange rate risk in Chile constant? H_0: $\lambda^C = 1$	72.234	0.000
Is the price of exchange rate risk in Mexico? H_0: $\lambda^M = 0$	96.122	0.000
Is the price of exchange rate risk in Mexico constant? H_0: $\lambda^M = 1$	86.443	0.000
Are the prices of the exchange rate risks jointly null? H_0: $\lambda^i = 0$	94.322	0.000
Are the prices of the exchange rate risks jointly constant? H_0: $\lambda^i = 1$	119.311	0.000

Notes: χ^2 is the empirical statistics of the Wald test examining the null hypotheses of nullity and constancy of parameters. $^{+}$, $^{++}$and $^{+++}$ indicate rejection of the null hypotheses at the 10%, 5% and 1% levels, respectively.

Table 5. Analysis of residuals

	Skewness	Kurtosis	J.B	Q(12)	ARCH(6)
Argentina	1.012	2.579	66.803^{+++}	6.983	0.327
Brazil	0.391	3.094	6.712^{++}	7.347	0.209
Chile	0.982	2.202	55.001^{+++}	3.472	0.634
Mexico	0.222	8.399	9.546^{+++}	7.664	0.285
Regional market	0.178	4.192	15.797^{+++}	5.901	0.957

Notes: J.B, Q(12), and ARCH(6) are the empirical statistics of the Jarque-Bera test for normality, the Ljung-Box test for serial correlation of order 12, and the Engle (1982) test for conditional heteroscedasticity. $^{++}$ and $^{+++}$ indicate that the null hypothesis of normality, no autocorrelation and no ARCH effect is rejected at the 5% and 1% levels respectively.

The economic significance of the model's risk factors as well as their time-varying feature can be examined by testing the null hypotheses that the corresponding expected prices of risk are zero and constant, respectively. The results from the Wald tests, reported in Table 4, indicate the rejection of these null hypotheses at the 1% level for all the markets considered. These findings suggest that the estimated prices of risk are economically significant and time-varying. They are thus consistent with those of previous studies including, among others, Adler and Dumas (1983), Hardouvelis et al. (2006), and Carrieri et al. (2007).

Table 5 presents a detailed analysis of the model's residuals. The results show that normality condition is still rejected for all markets studied, even though the J.B statistics for residual series are smaller than those for return series. In addition, the Ljung-Box test does not reject the hypothesis of no autocorrelation and the Engle (1982) test indicates that ARCH effects no longer exist for all the residual series. These results thus reveal the suitability and usefulness of the multivariate GARCH modeling approach. Our empirical model is therefore appropriate to model the time-variations of stock market returns in selected markets.

4.2 Financial integration factors

We now turn to identify the determinants of regional financial integration by estimating the full system (2) for each integration factor at a time. Following Bhattacharya and Daouk (2002), we impose the same coefficients in the equation specifying the degree of market integration for all markets. This assumption permits us to account for the impact of each candidate factor on the integration of each individual market into the regional market. Recall that the set of considered factors includes the local, regional and global variables that may influence the degree of regional financial integration.

When the bilateral exchange rates against the US dollar are used, the results in Table 6 show that the level of regional market integration in Latin American countries is positively linked to the degree of trade openness, local stock market development, national industrial production, interest rate spread, regional market returns, and world interest rate. Differently, economic growth rate and dividend yield on local market index negatively affect the degree of market integration. Bhattacharya and Daouk (2002), and Carrieri et al. (2006) find that financial integration is positively related to trade openness and local stock market development.

Similar to most prior empirical work, we use, in the previous estimations, the US dollar as the reference currency (Bekaert and Harvey, 1997; Griffin, 2001; Karolyi and Stulz, 2002; Dumas et al., 2003; Barr and Priestley, 2004; Carrieri et al., 2007). We now test the sensitivity of our results when bilateral exchange rates are replaced by a real effective exchange rate index.[6] The latter is simply the geometric average of bilateral real exchange rates of the countries under consideration. Accordingly, our model incorporates two common risk premiums for all markets: the regional market risk premium and the exchange risk premium. The results in the last column of Table 4 show that, in addition to the degree of trade openness and the level of local market development, world industrial production, inflation rate, exchange rate volatility, dividend yield on world market index, short-term interest rate, world market returns, and regional market returns significantly explain the evolution of regional financial integration.

[6] Adler and Qi (2003) also adopt this approach in their study.

Table 6. Potential factors of financial integration

	Bilateral exchange rates against the US dollar		Real effective exchange rate index	
	α_0	α_1	α_0	α_1
Degree of trade openness	0.065*** (0.003)	0.987*** (0.004)	0.540*** (0.038)	0.140*** (0.052)
Degree of stock market development	0.342*** (0.053)	0.453*** (0.068)	0.240*** (0.030)	0.703*** (0.049)
National industrial production	0.656*** (0.033)	0.500*** (0.030)	0.285 (0.762)	0.214 (0.384)
World industrial production	0.112 (0.125)	-0.125 (0.322)	-0.243*** (0.067)	-0.005*** (0.002)
Differences in industrial production growth rates	-0.111 (0.123)	0.0358 (0.675)	-0.383 (0.525)	0.155 0.749
Inflation rate	1.819* (1.085)	1.280 (1.01)	0.063 (0.353)	0.010*** (0.000)
Exchange rate volatility	-1.978 (2.233)	-0.262 (0.119)	-0.143 (0.132)	0.020*** (0.000)
Economic growth rate	0.234*** (0.043)	-0.660*** (0.031)	0.130 (0.020)	-0.163 (0.345)
Dividend yield on the local market index	0.292 (0.264)	-5.800*** (0.305)	0.807 (0.953)	-1.732*** (0.619)
Dividend yield on the regional market index	0.240 (0.44)	0.019 (0.575)	0.213 (0.343)	-0.023 (0.364)
Dividend yield on the world market index	-0.207 (0.163)	0.559 (0.300)	0.569 (0.730)	-4.050*** (0.987)
Differences in dividend yield	-0.003 (0.004)	0.605 (0.426)	1.060 (1.230)	0.0030 (0.000)
Short-term interest rate	-0.161 (0.098)	0.121 (0.175)	0.307 (0.253)	-0.597*** (0.092)
Long-term interest rate	-0.000 (0.000)	0.0004 (0.002)	0.1583 (0.471)	-0.254 (0.162)
Interest rate spread (long-term minus short-term)	0.902* (0.601)	0.900* (0.646)	-0.383 (0.524)	0.1657 (0.647)
Current account deficit	-0.120*** (0.182)	-0.333 (0.574)	-0.0426 (0.501)	-0.214 (0.243)
Local market returns	0.290 (1.10)	-0.800 (0.710)	0.0783 (0.184)	0.137 (0.755)
Regional market returns	-2.736*** (0.353)	1.546*** (0.289)	0.285 (0.762)	-1.214*** (0.384)
World market returns	0.020 (0.033)	0.920 (0.598)	-0.243*** (0.0673)	-0.005*** (0.002)
World interest rate	-0.030 (0.027)	0.132*** (0.090)	-0.211 (0.315)	0.215 (0.341)

*Notes: We estimate the system (2) for all countries by imposing the same prices of exchange rate and regional market risks as well as conditional variances and covariances obtained during the first estimation stage. We consider one candidate factor for financial integration at a time. The estimation results are obtained respectively with the bilateral exchange rates against the US dollar and the real effective exchange rate index. The numbers in parenthesis are the associated standard deviations. *, **, and *** indicate significance at the 10%, 5% and 1% levels respectively.*

Overall, the key factors that drive regional financial integration change significantly when the real effective exchange index is considered. These findings help explain the result divergence among previous studies with regard to the number and nature of integration factors. Specifically, trade openness and stock market development are the common factors of regional market integration, regardless of the exchange rate risk proxies.

Table 7. Counterfactual experiment of the statistical association between market integration indices and their a priori determinants

	Correlation **($\Omega_{i,t-1}$, Trade Openness)**	***Correlation*** **($\Omega_{i,t-1}$, Market Development)**
Argentina	0.395^{***} (5.118) [0.000]	0.631^{***} (9.647) [0.000]
Brazil	0.407^{***} (5.274) [0.000]	0.541^{***} (7.617) [0.000]
Mexico	0.419^{***} (5.463) [0.000]	0.389^{***} (5.005) [0.000]
Chile	0.611^{***} (9.139) [0.000]	0.394^{***} (5.860) [0.000]

Notes: The numbers in parenthesis are the associated statistics of the t-Student tests examining the null hypothesis that the coefficient of correlation is equal to zero. The p-values are in brackets.

As a back-testing procedure for the selection of integration determinants, we re-estimate the whole empirical model while conditioning the market integration on the levels of trade openness and stock market development. Our estimation results show that the coefficients associated with the levels of trade openness and stock market development are statistically significant at the 1% level, meaning that they successfully explain the evolving regional integration process of the four Latin American markets we consider and thus confirming the relevance of our selection procedure of market integration drivers.[7] Similarly, we run a counterfactual analysis which consists of computing the statistical correlations between our integration measures and their *a priori* determinants, and find that these coefficients of correlation are highly significant (Table 7). Taken together, this finding leads us to conclude on the important role of economic linkages and financial development in promoting regional market integration. Finally, all the markets we consider are also found to be only partially and moderately integrated with the regional market since their integration indices averaged 0.527, 0.463, 0.474, and 0.490 for Argentina, Brazil, Chile, and Mexico, respectively. Argentina is the most integrated into regional market, while Brazil, Chile, and Mexico have relatively the same level of regional integration.

[7] The detailed results can be made entirely available upon request to the corresponding author.

Comparatively, our results are consistent with those of, among others, Bekaert and Harvey (1995), and Carrieri et al. (2007) in the sense that the financial integration process of these four Latin American markets is not completed. For example, Carrieri et al. (2007) analyze the integration process of eight emerging markets including ours and obtain an average level of market integration between 0.368 (Argentina) and 0.605 (Mexico) over the period 1977-2000. Moreover, they show that on average, the level of integration after 1992 is at least two times higher than the observed level before 1992. Note however that this comparison is very relative since Bekaert and Harvey (1995), and Carrieri et al. (2007) address the world integration of these markets.

Figure 1. Time-varying regional market integration

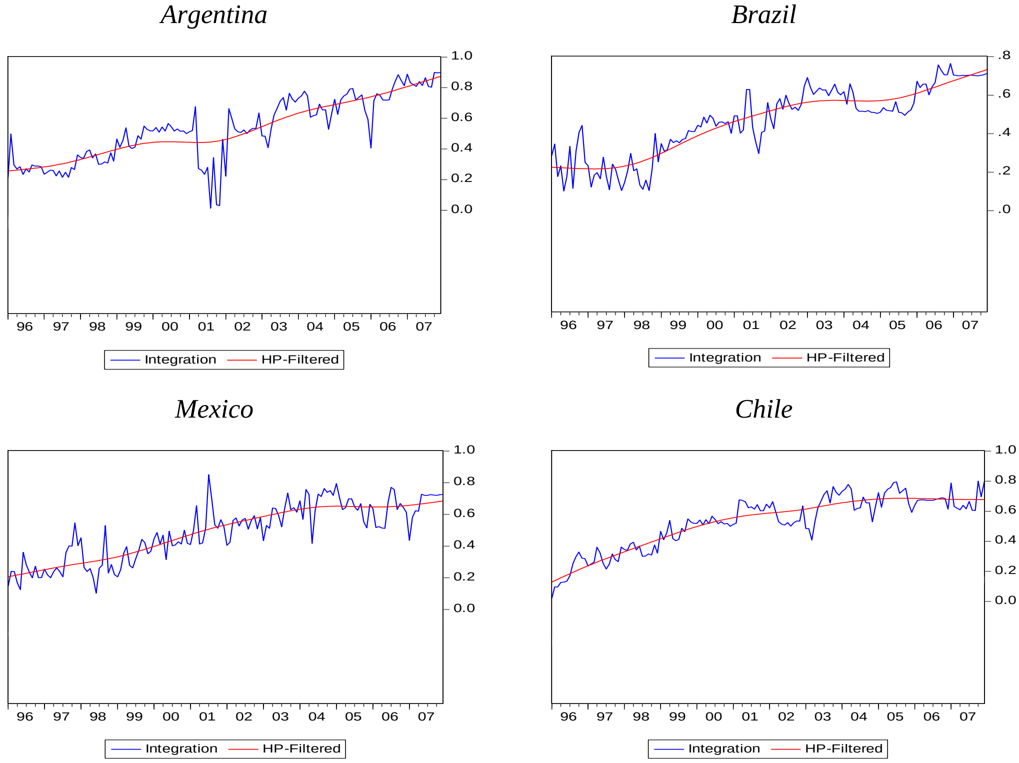

Figure 1 shows how our integration measures evolve through time. We can see that each of the sample markets exhibit a time-varying integration process towards the regional market. While there is a general tendency of market integration since 1996, the process of integration has sometimes been reverted under the effects of economic crisis and country-specific events (e.g., the Argentina crisis of 2001-2002, and the Brazil's energy crisis in 2001). For all the markets, the average level of regional market integration only exceeds 0.5 since 2003 onwards, suggesting that financial integration still remain a recent phenomenon. Even in 2010, the intra-regional exports as share of total exports of the Latin America are much lower than those for North America, Asia, and Europe.[8]

[8] International Trade Statistics 2011, World Trade Organization.

5. Conclusion

A conditional version of the International Capital Asset Pricing Model (ICAPM) has been implemented to investigate the determinants of regional integration of four important stock markets in the Latin America region. We find that our empirical results are very sensitive to exchange rate risk, which typically shows the divergence of previous results regarding the number and nature of integration factors. In the meanwhile, the degrees of trade openness and stock market development are identified as the most important drivers of regional financial integration in Latin America. Their relevance is confirmed by our back-testing procedure.

References

Adler M., Dumas B. (1983), 'International Portfolio Selection and Corporation Finance: A Synthesis', *Journal of Finance*, **38**, 925-984.

Adler M., Qi R. (2003), 'Mexico's Integration into the North American Capital Market', *Emerging Markets Review*, **4**, 91-120.

Barr D., Priestley R. (2004), 'Expected Returns, Risk and the Integration of International Bond Markets', *Journal of International Money and Finance*, **23**, 71-97.

Bhattacharya U., Daouk H. (2002), 'The World Price of Insider Trading', *Journal of Finance*, **57**, 75-108.

Bekaert G., Harvey C.R. (1995), 'Time-varying World Market Integration', *Journal of Finance*, **50**, 403-444.

Bekaert G., Harvey C.R. (1997), 'Emerging Equity Market Volatility', *Journal of Financial Economics*, **43**, 29-77.

Bekaert G., Harvey C.R. (2000), 'Foreign Speculators and Emerging Equity Markets', *Journal of Finance*, **55**, 565-613.

Bracker K. *et al.* (1999), 'Economic Determinant of Evolution in International Stock Market Integration', *Journal of Empirical Finance*, **6**, 1-27.

Carrieri F., Errunza V., Hogan K. (2007), 'Characterizing World Market Integration through Time', *Journal of Financial and Quantitative Analysis*, **42**, 915-940.

Cheung Y.W., Lai K.S. (1999), 'On the Purchasing Power Parity Puzzle', *Journal of International Economics*, **52**, 321–330.

Chinn M., Forbes K. (2003), 'A Decomposition of Global Linkages in Financial Markets over Time', *NBER Working Paper*, **9555**.

Dumas B., Harvey C., Ruiz P. (2003), 'Are Correlations of Stock Returns Justified by Subsequent Changes in National Outputs?', *Journal of International Money and Finance*, **22**, 777-811.

Engle R., Lilien D., Robins R. (1987), 'Estimating Time-varying Risk Premia in the Term Structure: The ARCH-M Model', *Econometrica*, **55**, 391–408.

Engle R. (2002), 'Dynamic Conditional Correlation: A Simple Class of Multivariate GARCH Models', *Journal of Business and Economic Statistics*, **20**, 339-350.

Geweke J. (1982), 'Measurement of Linear Dependence and Feedback between Multiple Time Series', *Journal of American Statistical Association*, **77**, 304-313.

Guesmi K. (2012), 'Characterizing Southeast Asian Stock market Integration through Time', *International Journal of Business*, **17**, 100-112.

Guesmi K., Nguyen D.K. (2011), 'How Strong is the Global Integration of Emerging Market Regions? An Empirical Assessment', *Economic Modelling*, **28**, 2517-2527.

Griffin J. (2001), 'Are the Fama and French Factors Global or Country-specific?', *Review of Financial Studies,* **15**, 783-803.

Hardouvelis G.A., Malliaropulos D., Priestley R. (2006), 'EMU and European Stock Market Integration', *Journal of Business*, **79**, 365-373.

Karolyi A., Stulz R. (2002), 'Are Financial Assets Priced Locally or Globally?', In G.M. Constantinides, M. Harris, and R.M. Stulz (ed.), *Handbook of the Economics of Finance*, Elsevier, North-Holland.

Levine R., Zervos S. (1998) 'Capital Control Liberalization and Stock Market Development', *World Development*, **26**, 1169-1183.

Lintner J. (1965), 'The Valuation of Risky Assets and the Selection of the Risky Investments in Stock Portfolios and Capital Budgets', *Reviews of Economics and Statistics,* **47**, 13-37.

Pukthuanthong K., Roll R. (2009), 'Global Market Integration: An Alternative Measure and its Application', *Journal of Financial Economics*, **94**, 214-232.

Sharpe W. (1964), 'Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk', *Journal of Finance*, **9**, 725-742.