Nonlinear Stock Market Integration in Emerging Countries

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Abstract

This article investigates the stock market integration hypothesis of two emerging countries (the Philippines and Mexico) into the world capital market over the last three decades. To check this hypothesis in the short and long run, we use the nonlinear cointegration techniques. Our results show that both stock markets are nonlinearly integrated into the world market, although the degree of integration is higher for Mexico. Furthermore, we show that the stock market integration process is nonlinear, asymmetric and time-varying.

Keywords: Nonlinear Cointegration, Stock Market Integration and Emerging Markets

JEL Classification: C22, F37, G15.

1. Introduction

Since the 1980s, emerging stock markets have been widely seen as the most exciting and promising area for investment, especially because they are expected to generate high returns and to offer good portfolio diversification opportunities. Consequently, these markets have known a considerable expansion. Indeed, financial liberalization has been largely implemented in several emerging countries through on-going structural adjustment programs. As a prerequisite to the financial liberalization processes, stabilization policies have been designed to ensure macroeconomic stability, low inflation and reduced budget deficits. As a result, emerging market capitalization has grown from 4% of world market capitalization in 1987 to 13% in 1996 and was around 20% in 2000.

Overall, economic stability and good perspectives have been key assets for the development of emerging markets. Theses changes have stimulated the integration process of emerging markets into the world market and increased their co-movements with developed stock markets. However, emerging markets are not homogeneous and their financial integration dynamics are significantly different [Bekaert and Harvey (1995)]. In other words, the nature and speed of the financial integration process both depend on internal and external factors: international, regional and specific economic, financial and political variables.

In order to better understand the emerging stock market integration dynamics, this article focuses on two emerging countries, namely the Philippines and Mexico. The choice of these countries can be justified differently. On the one hand, the Philippines and Mexico are both among the biggest emerging stock markets in Asia and Latin America. On the other hand, both countries have three similar features: an over-valued exchange rate, a fragile banking system and an insufficient level of reserves brought back to the monetary mass [Sachs *et al.* (1996)], which makes the comparison of these countries relevant. Moreover, our choice allows us to compare the financial integration dynamics for emerging markets from two different regions: Asia and Latin America.

Compared to previous works on emerging stock markets integration, the approach we propose in this article allows us to check whether the integration dynamics are symmetric or asymmetric, complete or partial, continuous or discontinuous, constant or variable and linear or nonlinear. It is clear that answering these questions is important because it helps us understand the dynamics of interdependencies and correlations between emerging and developed stock markets and it also facilitate decision-making concerning international portfolio diversification.

As we know, most previous studies on the financial integration of emerging stock markets used linear modeling tools. Unfortunately, this framework limits the financial integration dynamic to be linear and continuous and its speed to be constant over time [De Santis and Imrohoroglu (1997), Gérard *et al.* (2003), Phylaktis and Ravazzolo (2004) and Bekaert *et al*. (2005)]. However, the recent increase in the number of international investors, market liberalization and the financial crisis may have induced some persistence, asymmetry, irregularity and nonlinearity in the stock markets integration process, rejecting the linear framework. Thus, the main contribution of this article is to use new non-linear econometric techniques in investigating emerging stock markets integration.

This article will develop according to the following outline: the second section will present the justifications for financial integration; we shall then discuss a literature review on stock market integration in the third section. In the fourth section, the non-linear models we use will be briefly presented before discussing the empirical results in the fifth section and we will finally draw our conclusions in the last section.

2. Are Emerging Stock Markets Integrated?

In this section, we shall discuss briefly the factors that may have stimulated the integration of the Philippines and Mexico into the world market. Overall, the emerging stock market integration process depends on interactions between international, regional and local economic and political variables [Adler and Qi (2003) and Carrieri *et al.* (2006)].

Let's start with Mexico. All Latin American market capitalizations have increased over the recent years. Indeed, in 1990, Latin American stock markets represented 14,6% of emerging markets capitalization and 1% of world capitalization. In 2000, Latin American markets represent 30% of emerging markets capitalization and more than 3,7% of world capitalization. This increase stems both from internal and external factors: the debt reduction introduced by Brady Plane, bank system reforms in Argentina, Brazil, Mexico and Venezuela, the economic recession in developed countries in 1990, American monetary politics, the increase of nominal interest rates in Latin America and the introduction of the American Depository Receipts (ADR).

Several other domestic factors may account for the high level of financial integration of the Mexican stock market into the world market: improved economic and social stability, institutional economic reforms, liberal policies that implied a commercial and financial deregulation of the economic activity, as well as privatization. Therefore, the Mexican stock market has been made particularly outstanding by the strong growth of its capitalization. In fact, the later increased by 23% in 2005, and 44% of the securities were in the hands of foreign investors. Moreover, Mexico's exports reached a record of 250 billions US $ in 2006 and 85% of these exports were destined to the USA. This performance is mainly due to the North-American Free Trade Agreement (NAFTA).

However, Mexico underwent of strong crisis during the 1990s. In December 1994, Mexico lost 5 billions US $ in only 5 days and the Mexican market capitalization fell by 43% in 1994. Nevertheless, Mexico managed to overcome this disequilibrium thanks to its commercial integration to North-America. Indeed, after the crisis, Mexico carried out vast adjustments to restore the confidence of investors by opening up its economy to international trade and by encouraging the free circulation of capital. Consequently, Mexico has known a fast rebound of its growth after the recession of 1995. On average, the Gross Domestic Product (GDP) increased of 6% between 1996 and 1997 and Mexican exports went from 13% of the GDP in 1993 to 26% in 1999, benefiting from its regional integration within the NAFTA. Moreover, Mexico's ties with the USA explain the increase of foreign direct investments which reached more than 11 billion US $ in 2000 against 4,4 billion US $ in 1993. Finally, several enterprises (i.e. Danone, Eads, Accord, Suez, Schneider Electric, etc.) have chosen Mexico to extend their activities into the United States.

Our attention shall now be drawn towards our second emerging market: the Philippines. A large number of Asian emerging markets have launched a series of reforms in the last few years, including the modernization and liberalization of their markets. As a result of these developments and of the important consequences of financial liberalization on international capital budgeting and investment, the integration of the Asian stock market has emerged as an important body of literature [Bekaert and Harvey (1995), Gérard *et al.* (2003) and Carrieri *et al.* (2006)]. However, the intensity and efficiency of these reforms differ from one country to another.

For cultural and historical reasons, the Philippines are probably the most welcoming country of the Asian region for the western businessman. The Philippines' trade openness ratio reached an average of 119% over the last decade. This is essentially due to the good functioning of the ASEAN (Association of South-East Asian Nations) created in 1965 by five countries (Indonesia, Malaysia, the Philippines, Singapore and Thailand). However, the Philippine stock market is less developed than the Mexican one and the proportion of securities held by foreign investors is smaller.

In order to promote its integration into other international stock markets, the Philippine market has recently undergone several reforms: liberalization and privatization (since 1985), introduction of ADR and country funds (1989). Therefore, the Philippine stock market is expected to be better integrated during the post-liberalization period than it was during the period prior to the opening of its market.

3. Literature Review

Emerging stock markets integration has naturally constituted a privileged field for international financial research. Markets are said to be integrated if they share a common trend, that is to say, if they move together. Papers such as Errunza and Losq (1985), De Santis and Imrohoroglu (1997), Gérard *et al.* (2003), Tai (2004), Phylaktis and Ravazzolo (2004) and Bekaert *et al.* (2005) tested the integration hypothesis within the Capital Asset Pricing Model framework (CAPM). The effects of global and local risk factors on returns are then considered. In this framework, the markets are perfectly integrated if only global factors are priced. They are strictly segmented if only local factors are significant. The markets are partially integrated if both global and local risk factors are priced. The results of these papers are hybrid. In particular, the models used in these studies are static and the integration degrees of the studied markets are constrained to be time invariant. However, financial integration is naturally an on-going process which evolves according to the economic and operational spheres.

Bekaert and Harvey (1995) allowed the degree of market integration to vary over time. They used a conditional regime-switching CAPM to account for periods when national markets were segmented from world capital markets and when they became later integrated into the sample. They show that the degrees of integration in emerging markets are time-varying and that several emerging markets have become more integrated at the end of the sample. Adler and Qi (2003) studied the integration of the Mexican market into the North-American market during the period January 1991 - February 2002. They generalized the model of Bekaert and Harvey (1995) in order to take the exchange risk into account. Their results show that the Mexican market is partially integrated into the North-American market: the prices of the common (world market and currency risk) and specific (local market) sources of risk are significant and time-varying. The degree of integration varies between 40% and 55% during the period 1991-1994, which corresponds to the period of Mexican market reforms. During the Mexican crisis, the degree of integration quickly decreased and varied between 10% and 20%, whereas it increased during the last years of the sample, reaching 58% in March 2000.

These results have been confirmed by numerous other studies. For example, Bekaert and Harvey (1997) and Carrieri *et al.* (2006) studied Asian and Latin American emerging markets (the Philippines, Mexico and other emerging countries) using a time-varying partially integrated CAPM. The main conclusions of these works are that the majority of emerging markets are partially integrated in the world market (*i.e.* returns in these markets depend on the effects of both local and global risk factors) and that their degrees of integration are time varying. However, the results of these studies are very sensitive to the validity of the CAPM and it is widely acknowledged that the tests of the domestic and international versions of this model are unfortunately inconclusive.

Another group of papers focused on examining stock market integration in developed and emerging countries, using either bivariate or multivariate cointegration techniques. Taylor and Tonks (1989) was the first study to use the bivariate cointegration technique of Engle and Granger (1987) in order to examine whether the UK stock market was integrated into the American, German, Dutch and Japanese stock markets. Kasa's study (1992) was the first to apply Johansen's multivariate cointegration method (1988) to five developed financial markets (the U.S., the U.K., Japan, Germany and Canada) in order to estimate the permanent and transitory components of stock price series and examine the existence of a single common stochastic trend as a driver of the cointegrated system. In this framework, if stock markets share a single common stochastic trend, then this means that these markets are perfectly integrated over long horizons. The absence of cointegration relations means financial segmentation. The results of these studies show that there is a long-run relationship between developed stock markets.

Using the same cointegration methods, Masih and Masih (1997) showed that the newly industrialized Asian countries of Honk Kong, Singapore, Taiwan and South Korea shared a long run relationship with the developed markets (the U.S., Japan, the U.K. and Germany). Masih and Masih (1999) applied the recent econometric methods including vector error-correction and level VAR models and found similar results. More recently, Masih and Masih (2001) have studied the dynamic causal linkages amongst international stock markets. They found significant interdependencies between the established OECD and the emerging Asian Markets. More particularly, their results highlighted the leadership of the U.S and U.K markets both in the short and long term, despite the global financial crash of October 1987. Lim *et al.* (2003) examined the linkages between stock markets in the Asian region over the period 1988-2002 using non-parametric cointegration techniques and they found that there is a common force which brings these markets together in the long run. Similar results were also found by Wang and Nguyen Thi (2007) and Iwatsubo and Inagaki (2007).

By contrast**,** Roca and Selvanathan (2001), using different recent econometric techniques, showed that there are no short-term and long-term linkages among the stock markets of Australia, Hong Kong, Singapore and Taiwan. Phylaktis and Ravazzolo (2000) studied the potential linkages between stock prices and exchange rate dynamics for a group of Pacific-Basin capital markets, and they identified a lack of comovement during the eighties for the free stock markets of Singapore and Hong Kong.

On the other hand, recent works using cointegration methods have confirmed the fact that the level to which markets are integrated or segmented is not fixed, but changes gradually over time. Liu and Pan (1997) found that the US market was more influential than the Japanese market in transmitting returns and volatilities to the Asian and Latin markets and that the observed spillover effects were unstable over time and had substantially increased after the October 1987 stock market crash. Bilson *et al.* (2000) showed that the regional integration among stock markets in South Korea, Taiwan, Thailand, the Philippines and Malaysia was faster than their integration within the international market. However, Barari (2003) compared the status of regional versus global integration of six Latin American equity markets over the period 1988-2001, using time-varying integration score. Empirical evidences show that integration is time-varying and suggests that, in recent years, global stock market integration has increased relative to regional stock market integration.

Ratanapakon and Sharma (2002) studied the short and long-term relationships in five regional stock indices of the pre-Asian crisis and of the crisis period. They found that the degree of linkage increased during and after the crisis period. However, more recently, Phylaktis and Ravazzolo (2004) have applied multivariate cointegration methods to investigate the stock market interactions amongst a group of Pacific-Basin countries and the industrialized countries of Japan and the US over the period 1980-1998. They show that although linkages have increased in recent years, there is room for long-term gains when investing in Pacific-Asian markets. In particular, their results show that the Asian crisis did not have a substantial effect on the degree of linkages of these markets.

To sum up, this literature review suggests dependencies between most emerging stock markets and those of developed countries. However, it also shows that it is not possible to decide between the two polar cases of strict segmentation and perfect integration. In fact, dynamic approaches show that the financial integration dynamic can be assimilated to a continuous process combining these two extreme cases as well as to an intermediate state continuum. Moreover, this is much more valid for emerging stock markets that are generally characterized by on-going liberalization processes. Nevertheless, the linear framework used in most previous works does not tell us much about the nature of the integration process: linear or nonlinear, symmetric or asymmetric, persistent or not persistent, regular or irregular.

In the remainder of this article, we will explore the short and long-run nature of the Philippine and Mexican stock markets integration process into the world market. More precisely, we propose a more original framework to check the emerging markets financial integration dynamics in a nonlinear setting in the short and long-run. We will apply the nonlinear cointegration methodology which will not only allow us to study integration in a more general setting, taking into account the asymmetry, persistence and nonlinearity characterizing the dynamics of stock price adjustment, but also to check and specify the degree of interdependence and integration in every regime and in the short and long-run. The next section presents the nonlinear framework.

4. Nonlinearity and Stock Market Integration

Stock market integration dynamics should be nonlinear and asymmetric. Nonlinearity and asymmetry can be justified differently by the presence of information barriers, asymmetries and other sources of market segmentation [Bekaert and Harvey (1995)], heterogeneous transaction costs [Anderson (1997)], the coexistence of different shareholders, and noise trading [De Grauwe and Grimaldi (2006)]. These factors can induce asymmetries, discontinuities and persistence in the financial integration processes and imply a nonlinear time-varying correcting mechanism. In order to reproduce these facts, we propose to use the nonlinear cointegration techniques. Using the nonlinear cointegration methodology is suitable for at least two reasons. On the one hand, most stock prices are not stationary, and using the cointegration techniques would therefore be useful to reproduce their dynamics in the long-run. On the other hand, the nonlinear methodology reproduces the nonlinearity and asymmetry which should characterize stock integration dynamics. We suggest using two Nonlinear Error Correction Models (NECM): the Exponential Switching Transition ECM (ESTECM) and the nonlinear ECM-Rational Polynomial (NECM-RP).

We refer to Escribano and Mira (1998) and Van Dijk *et al.* (2002) to briefly discuss these NECM.(Note 1) The first authors propose a generalization of the theorem of Granger (1981) to develop the nonlinear cointegration framework and define the NECM, whereas the second adopt this methodology to the threshold models, thus defining a particular kind of threshold cointegration models for which the adjustment is rather smooth and asymmetric.

Following the theorem of Escribano and Mira (1998), a NECM is defined as follows:

$$\begin{aligned} &\Delta y_t = \alpha_0 + \rho\ z_{t-1} + f(z_{t-1},\theta) + \sum_{i=1}^{q} \gamma'_i\, \Delta X_{t-i} + \sum_{j=1}^{p} \delta'_j\, \Delta y_{t-j} + \mu_t \\ &\Delta X_t = \nu_t \\ &z_t = y_t - \beta' X_t \end{aligned} \tag{1}$$

where: y_t is the endogenous variable and X_t is a vector of *K* explanatory variables that are I(1). γ'_i and δ'_j are vectors of parameters, ρ is the adjustment terms, z_t is the residual term of the linear cointegration relationship and *f(.)* is a nonlinear function.

According to the authors, the following conditions have to be satisfied in order to validate a nonlinear cointegration relationship:

i) μ_t *and* ν_t *are mixing processes with finite second-order moments and cross-moments;*

ii) f(.) is a nonlinear function that is continuously differentiable and that satisfies some regularity conditions: $-2 < \dfrac{\partial f(zt-1,\gamma)}{\partial z_{t-1}} < 0$,

iii) the roots of $\left|1 - \sum_{i=1}^{p} \delta'_j L^P\right| = 0$, *all lie outside the unit circle.*

iv) μ_t *is a martingale difference process with zero mean and constant variance. Under these assumptions,* z_t *is NED (Near Epoch Dependent) and* y_t *and* X_t *are cointegrated with cointegrating vector* $(1,-\beta')$.

Escribano and Mira (1998) also showed that for the nonlinear cointegration hypothesis to be checked, it is necessary to test the null hypothesis of linear adjustment H_0: $f(z_{t-1},\theta) = 0$ against its nonlinear cointegration alternative H_1: $f(z_{t-1},\theta) \neq 0$. Rejecting H_0 concludes in favor of nonlinear cointegration. However, as the function $f(z_{t-1},\theta)$ is seldom specified under the null hypothesis, this test (using a Wald test, a Lagrange Multiplier test or a log-likelihood ratio test) is then sometimes difficult to apply, particularly when $f(z_{t-1},\theta)$ is not identified under H_0. Moreover, as suggested by Dufrénot and Mignon (2002), under H_1, it is not sufficient that $f(z_{t-1},\theta) \neq 0$, but this function must also characterize an error-correction mechanism (hence the importance of the stability conditions on *f(.)*).

In other words, these conditions have to be satisfied to ensure the consistence of this nonlinear modeling. However, since this is sometimes difficult to check and often requires some simulation studies, notably when nothing can be said about the nonlinearity that enters in $f(z_{t-1},\theta)$, it would be difficult to apply this test. Thus, Escribano (1997) proposes to use the nonlinear function that satisfies the above stability conditions such as: the rational polynomial function, the cubic function or the smoothing functions [Dufrénot and Mignon (2002)]. Thus, many types of NECM depending on the definition of the nonlinear function *f(.)* may be identified in the literature. In this paper, we propose to use two particular kinds of NECM: the NECM-RP and the ESTECM.

Consequently, in order to check the market integration hypothesis, we first need to test the mixing hypothesis using parametric and nonparametric tests (Note 2). To do this, we use two mixing tests: the KPSS test (nonparametric test) and the parametric test of Lo (1991): the *R/S* test. In a second step, we estimate the potential integration process using two particular classes of NECM: the ESTECM (equation (2)) and the NECM-RP (equation (3)) that are derived from the theorem of Escribano and Mira (1998). The identification of two adjustment terms in the NECM helps to check the nonlinear cointegration more parsimoniously than with the above conditions.

$$\Delta y_t = \alpha_0 + \rho_1 z_{t-1} + \sum_{i=0}^{q} \beta_i\, \Delta x_{t-i} + \sum_{j=1}^{p} \delta_j\, \Delta y_{t-j} + \rho_2 z_{t-1} \times \left[1 - \exp\left\{-\gamma (z_{t-1} - c)^2\right\}\right] + \varepsilon_t \tag{2}$$

One of the advantages of the ESTECM is that it allows the financial integration process to be smooth and gradual. It also helps us capture temporal paths governed by smooth changing regimes and account for a slow adjustment mechanism.

$$\Delta y_t = \alpha_0 + \rho_1 z_{t-1} + \sum_{i=0}^{q} \beta_i\, \Delta x_{t-i} + \sum_{j=1}^{p} \delta_j\, \Delta y_{t-j} + \rho_2 \times \frac{(z_{t-1} + a)^3 + b}{(z_{t-1} + c)^2 + d} + \mu_t \tag{3}$$

As suggested by Chaouachi *et al.* (2004), the NECM-RP is a more general nonlinear model which can take into account many potential sources of nonlinearities (*i.e.* abrupt changes in adjustment speeds, effects of negative and positive shocks on stock price adjustment, multiple long-run attractors, etc.). It can also reproduce asymmetric dynamics between the overvaluation and undervaluation regimes.

In equations (2) and (3), y_t denotes the emerging stock market index and X_t the MSCI world market index. (Note 3) Thus, our approach enables us to examine the integration process of our two emerging markets (Mexico and the Philippines) into the world capital market and to specify the nature per regime of the financial integration process. More precisely, our empirical investigation will be carried out in several steps. Firstly, we will apply the usual unit root tests (Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests) to check the integration order of the stock price series. Secondly, we will check the mixing hypothesis applying KPSS and *R/S* tests on the residual term ($\hat{z}_t$) in order to test the nonlinear cointegration hypothesis. Thirdly, accepting the mixing hypothesis suggests that stock prices are nonlinearly mean-reverting and allows our NECM to be estimated through the Nonlinear Least Squares (NLS) method.

5. Empirical Results

5.1 Preliminary Analysis

We examined the monthly stock market indices of two emerging countries (the Philippines and Mexico) plus the world market over the period December 1988 – December 2008. All the indices were obtained from Morgan Stanley Capital International (MSCI) and are expressed in US dollar so as to get a homogenous data and to take currency risk into account.

Both ADF and PP tests showed that all indices are not stationary in level but stationary in the first difference, meaning that the three MSCI indices are I(1). (Note 41) In addition, we computed the bilateral correlation between both emerging countries and the world market returns, taking into account the Tequila effect. (Note 5) The results, presented in Table 1, show two important features. On the one hand, the bilateral correlations of the Mexican and Philippine stock markets with the world market are higher after the Mexican crisis, indicating that these stock markets have became more integrated in recent years. On the other hand, the financial integration degree of the Mexican market into the world market is more important, even though the bilateral correlation between the Mexican and Philippine stock markets has risen after 1994.

We also present some descriptive statistics of our series in Table 2. These statistics show that the normality hypothesis is rejected for all markets. In addition, the stock return dynamics seem to be asymmetric and leptokurtic since the Skewness and Kurtosis coefficients are statistically significant. The negativity of the Skewness is seen as a sign of nonlinearity in the dynamics of stock markets.

5.2 Linear and Nonlinear Cointegration Tests

We estimate first the long-run relationship which is a static regression of the Mexican (respectively the Philippine) stock index on a constant and of the MSCI world index. Then, we apply the usual linear cointegration tests (ADF) on the static relation residuals. The results are presented in Table 3.

By comparing the linear cointegration statistic to the critical value of Engle and Yoo (1987), we reject the hypothesis of linear cointegration for both emerging market indices. This may imply that neither of the emerging stock markets under study is integrated into the World market and that they are segmented.

However, these results have to be carefully analysed. Indeed, the rejection of linear cointegration hypotheses can be explained differently: misspecification, low power of linear cointegration tests, etc. Furthermore, as shown by previous works and by our correlation analysis, the financial integration degree is time-varying. Nevertheless, these features can escape the usual linear modeling. In order to remedy these limits, we check the cointegration hypothesis in a nonlinear framework using "mixing" tests which are more powerful and robust than linear cointegration tests. To accept the mixing and nonlinear cointegration hypotheses implies that the Mexican and Philippine stock indices are rather nonlinearly mean-reverting toward the world market index, which suggests that the Philippine and Mexican markets are *a priori* nonlinearly integrated into the world market.

Thus, we apply two "mixing" tests: the KPSS and the *R/S* tests. Both tests check the null hypothesis of "mixing" against its "no-mixing" alternative. Empirically, for the KPSS, we retain the values suggested by Schwert (1989) for the truncation parameter: $l_4 = \text{int}\left[4\left(\frac{T}{100}\right)^{\frac{1}{4}}\right]$ and $l_{12} = \text{int}\left[12\left(\frac{T}{100}\right)^{\frac{1}{4}}\right]$ where T is the number of observations(Note 6), while we retain the value of Andrews (1991) concerning the choice of q for the *R/S* test which corresponds to the following formula: $q_t = [K_T]$, where $K_T = \left(\frac{3T}{2}\right)^{\frac{1}{3}} \left(\frac{2\hat{\rho}}{1-\hat{\rho}^2}\right)^{\frac{2}{3}}$, $[K_T] = \text{int}(K_T)$ and $\hat{\rho}$ is the first-order autocorrelation coefficient. The results of the mixing tests are summarized in Table 4.

For Mexico, the mixing hypothesis is accepted according to KPSS and R/S tests implying a cointegration relationship between Mexican and world stock indexes. Concerning the Philippines, the null hypothesis of mixing is retained only at 10% according to the R/S test. According to the KPSS test, it is also accepted but only for the second value of the truncation parameter (l_{12}). Despite our preference for the results of the nonparametric test (KPSS test) which is more powerful than the *R/S* test (parametric test), we also retain the mixing hypothesis and accept the nonlinear cointegration for the Philippines.

Finally, after checking this mixing hypothesis and testing whether the Mexican and Philippine stock markets are nonlinearly mean-reverting, we estimate two NECM: the ESTECM and the NECM-RP.

5.3 Estimation of NECM

We estimate the NECM through the NLS method. We use a nonlinear optimization program and estimate the models according to the steps proposed by Escribano and Mira (1998) and Van Dijk *et al.* (2002). The number of lags (p) for the NECM is specified using the information criterias, the autocorrelation functions and the Ljung-Box tests. The results retained, p=0 for Mexico and p=1 for the Philippines, suggest local time dependence for the Philippines. Concerning the estimation, different initial values are tested with the NECM parameters, and the results retained (Table 5 for Mexico and Table 6 for the Philippines) are those for which the maximum is absolute.

The empirical results suggest several conclusions about the integration of our two emerging stock markets. Firstly, for both markets, the current MSCI world index parameter is statistically significant, suggesting the presence of statistical dependence of the Mexican and Philippine stock markets on the world market. The first AR parameter is only significant for the Philippines, which suggests that its index depends on its past tendencies.

Our results show that ESTECM is not appropriate to the Philippines. Neither the exponential function parameters nor the nonlinear adjustment terms are statistically significant and the residuals of the estimated model are not mixing. We reject this nonlinear representation for the Philippines.

However, this model offers important and interesting results in the Mexican case. Indeed, γ and *c* are statistically significant, validating the choice of this nonlinear representation for Mexico. The estimated value for γ is not very low, suggesting that the transition between regimes is not always slow. More interestingly, the estimation of the nonlinear adjustment terms (ρ_1 and ρ_2) offers an important result in terms of financial integration. We have found that ρ_1 is positive and significant and ρ_2 is negative and statistically significant at 5%. This indicates that in the first regime, the Mexican stock price can deviate from the world market, its deviations might be uncorrected, can be characterized as random walk and the market would be segmented; but for a large disequilibrium, its dynamic should converge toward the equilibrium allowing for the market integration.

Furthermore, the sum ($\rho_1 + \rho_2$) is negative implying a significant nonlinear error correction adjustment dynamic for the Mexican index and showing a nonlinear integration process of Mexico into the world stock market. In other words, in the first regime (before the Mexican crisis) (Note 7), when the Mexican deviations are small, the Mexican index cannot follow the MSCI world index and Mexico is rather segmented, while in the second regime, when its stock price deviations are large, a nonlinear integration process is active and its convergence speed increases with the stock price deviation size, as it is shown in figure 1.

Figure 1 shows two important features. Firstly, the ESTECM captures the asymmetry characterizing the Mexican financial integration dynamic which is largely justified in section 2 of this article. Secondly, the figure clearly shows the important degree of persistence inherent to the Mexican financial mechanism, particularly after 1994. Indeed, as shown in figure 2, the transition function reaches the upper bound for a long time, confirming the results of Adler and Qi (2003) for whom Mexican stock market integration has strongly increased in the recent years. This increasing integration can certainly be explained through the different arguments discussed in section 2. Finally, applying the misspecification tests, we show that the residuals of ESTECM are mixing and stationary, which validates this representation for Mexico.

Besides, the persistence, asymmetry and smoothness associated with the Mexican and Philippine stock price adjustment dynamic are also captured by the NECM-RP (Figures 3 and 4). Empirically, we estimate the NECM-RP under the following restrictions: a = c = d =1 and b = 0, as in [Chaouachi *et al.* (2004)], in order to simplify the algorithm convergence. The estimation results show a significant correlation between both emerging markets and the world market, but this correlation is more important for Mexico.

Moreover, the analysis of the histogram of the rational polynomial function (figures 3 and 4) that is plotted in function of the estimated misalignment values ($\hat{z}_{t-1}$) confirms the rejection of normality for both stock indices. The NECM-RP has captured the asymmetry in the integration process between both emerging markets and the world market. Indeed, the figures show a bimodal density (in fact, several modes for the Philippines) with two modes of unequal heights. The histograms are not similar for both indices, confirming the difference in the skewness and, consequently, in the degree of asymmetry. Nonetheless, the presence of these unequal modes suggests important and extreme stock price deviations between the regimes of segmentation and integration. This asymmetry in the distribution of the rational polynomial function also shows the persistence and the smoothness in the integration process of these emerging stock markets into the world market. These features can also be seen as an indicator of the presence of an integration process continuum that is activated by the regime and which varies over time, notably increasing when integration is observed in the previous period.

VI. Conclusion

The aim of this article was to explore the financial integration hypothesis for two emerging countries (the Philippines and Mexico) into the world stock market in a nonlinear framework. After discussing the main economic justifications for this financial integration and presenting a critical analysis of the previous studies, we proposed to use two new kinds of nonlinear models. More precisely, we studied the market integration dynamics using nonlinear cointegration tools. The econometric techniques we used have enabled us to reproduce the extreme cases of financial integration (perfect integration and strict segmentation) as well as a continuum of intermediate states relative to partial integration that characterizes most emerging stock markets.

Our results validate a nonlinear financial integration of the two emerging countries studied into the world stock market. However, they show that this integration relationship is significantly more important for Mexico and that it has been powerfully stimulated after 1994. The approach we used in this article can naturally be extended to other emerging and developed stock markets to compare their financial integration dynamics.

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Notes

Note 1. For a more detailed presentation of nonlinear cointegration, see Dufrénot and Mignon (2002).

Note 2. The mixing hypothesis for nonlinear cointegration is equivalent to the stationary hypothesis of the residuals in the linear framework.

Note 3. All of the stock market indices that we used are in log.

Note 4. Results are available from authors upon request.

Note 5. The stock return structures of our markets have not been significantly affected by the Asian crisis.

Note 6. Int [.] denotes the interior part.

Note 7. The threshold parameter approximately corresponds to the Mexican deviation price of May 1993.

Appendices

Table 1. Matrix of bilateral correlations

Series	RPHI	RMEX	RMSCI
Before Mexican Crisis : January 1988– November 1994			
RPHI	1.0000		
RMEX	0.0967	1.0000	
RMSCI	0.3277	0.2643	1.0000
After Mexican Crisis : December 1994, January 2008			
RPHI	1.0000		
RMEX	0.3982	1.0000	
RMSCI	0.4374	0.5988	1.0000
All the period : January 1988- January 2008			
RPHI	1.0000		
RMEX	0.3107	1.0000	
RMSCI	0.3947	0.4745	1.0000

Note: RMSCI, RPHI and RMEX are respectively the stock returns of the World, Philippine and Mexican stock markets.

Table 2. Descriptive statistics and normality test

Series	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis	Jarque-Bera (Probability)
Mexico	0.0169	0.0935	0.2540	-0.4195	-0.9425	6.1437	134.92 (0.0)
Philippines	0.0050	0.0927	0.3601	-0.3465	-0.0727	4.8155	33.31 (0.0)
MSCI World Index	0.0053	0.0398	0.1055	-0.1444	-0.5733	3.8673	20.75 (0.0)

Table 3. Linear Cointegration Tests

Series	Constant	LMSCI	R^2	ADF (p, model)
Mexico	-4.71 (-7.88)*	1.76 (19.85)*	0.62	-2.02 (1, a)
Philippines	6.04 (9.24)*	-0.093 (-0.95)	0.003	-1.81 (1, a)

Note: The values between brackets are the t-ratio.(*) and (a) designate respectively the significance at 5% and a model without constant and linear trend.

Table 4. Mixing Tests

KPSS		R/S
Mexico		
l_4	l_{12}	Andrews
0.45	0.12	1.1
Philippines		
l_4	l_{12}	Andrews
0.72*	0.29	1.6*

Note: (*) denotes the rejection of the null hypothesis at the 5% significance level.

Table 5. NECM Estimation Results for Mexico

Coefficients	ESTECM (0,1)	NECM-RP
α_0	0.0045 (1.04)	0.0094 (1.36)
ρ_1	0.0994* (2.36)	-0.032 (-1.11)
ρ_2	-0.1315* (-3.05)	0.0054 (0.36)
β_0	1.105* (8.52)	1.11* (8.38)
γ	26.06* (2.04)	-
$\gamma \times \sigma_{z_{t-d}}$	7.64	-
c	0.6268* (16.979)	-
ADF^{GLS}	-9.83	-9.79
R/S	1.4	1.5
$\sigma_{NECM} / \sigma_{LECM}$	0.73	0.88

Note: The values in brackets are the t-statistic of nonlinear estimators. (*) denotes the significance at 5% .

Table 6. NECM Estimation Results for the Philippines

Coefficients	ESTECM (1,1)	NECM-RP
α_0	-0.0021 (-0.37)	0.0009 (0.90)
ρ_1	-0.1815 (-1.02)	-0.0086 (-0.81)
ρ_2	0.1624 (0.91)	-0.0053 (-0.329)
β_0	0.2177* (3.55)	0.2086* (3.59)
δ_1	0.9228* (6.82)	0.9224* (6.83)
γ	625.07 (0.49)	-
$\gamma \times \sigma_{z_{t-d}}$	219.53	-
C	-0.3319* (-16.36)	-
ADF^{GLS}	-15.85	-15.85
R/S	2.5*	1.5
$\sigma_{NECM} / \sigma_{LECM}$	0.99	0.95

Note: The values in brackets are the t-statistic of nonlinear estimators. (*) denotes the significance at 5%.

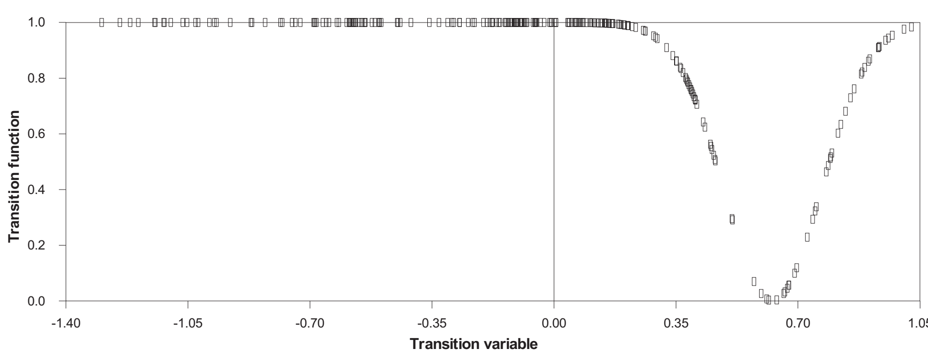

Figure 1. Exponential Transition Function

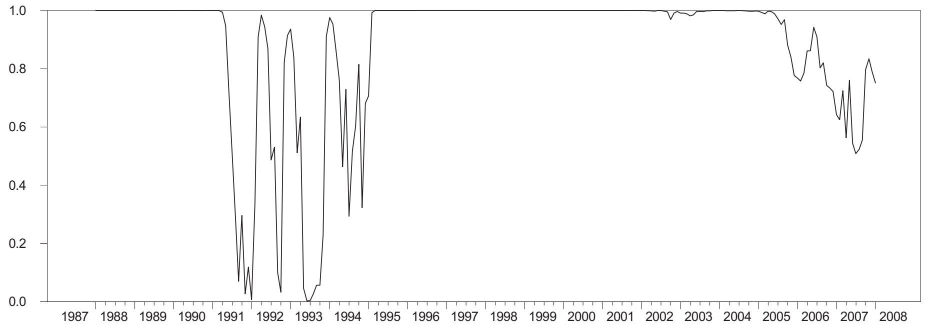

Figure 2. Evolution of the Exponential Transition Function

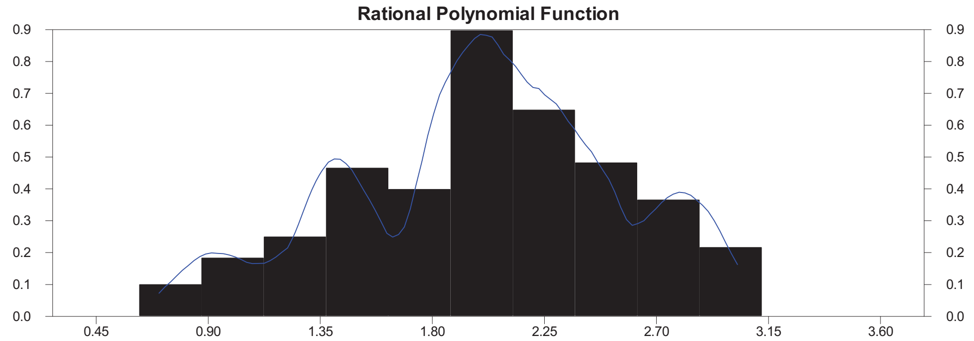

Figure 3. Histogram of the Rational Polynomial Function for Mexico

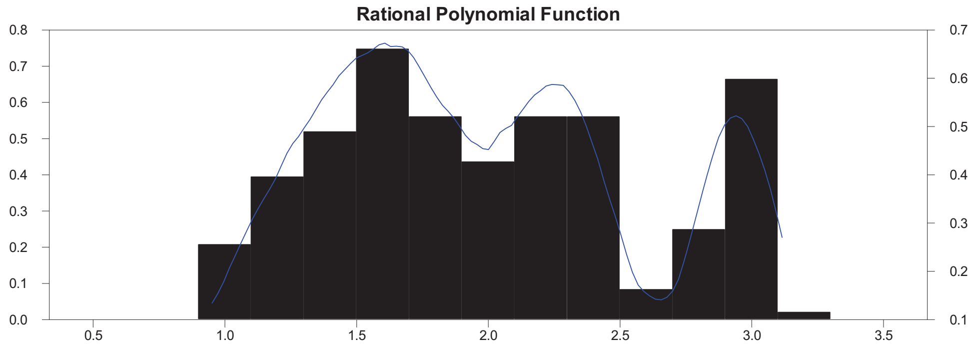

Figure 4. Histogram of the Rational Polynomial Function for the Philippines