Journal of International Business and Economics
September 2014, Vol. 2, No. 3, pp. 95-123
ISSN: 2374-2208 (Print), 2374-2194 (Online)
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Published by American Research Institute for Policy Development
DOI: 10.15640/jibe.v2n3a5
URL: http://dx.doi.org/10.15640/jibe.v2n3a5

Regime Switches in the Tangency Portfolio of NAFTA Markets During the Financial Crisis

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Abstract

We study the composition of a Conditional Tangency Portfolio built with the Mexican Stock Exchange Index, the Canadian Stock Exchange Index, and the US Stock Exchange Index using a Multivariate GARCH-VCC model to compute conditional volatilities and correlations for the period March 9, 2007 to March 9, 2012. As macroeconomic stability and a more mature stock market have attracted an increasing volume of foreign portfolio investments into Mexico's Stock Exchange, we document the impact of the recent Financial Crisis (2007-2009) on these flows. We compare the evolution of the Mexican market weights in the theoretically built Conditional Tangency Portfolio to the actual Foreign Portfolio Investment flows, and find that there were significant deviations which may be explained either by a "home bias" effect or by irrational behavior motivated by investors' fears.

Keywords: Global financial integration, tangency portfolio, Multivariate GARCH, Markov switching

JEL: F30, F36, F65, G11, G15

1. Introduction

Financial globalizationbrought along increased correlations across national stock markets' returns. Correlation matrices show increased positive association over time while, simultaneously, negative correlations tend to fade away.

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This process has been characterized by a faster transmission of shocks from one country to others, by co-movements and by contagion effects. As a result ofincreased correlations across markets, a reduction of cross-border capital flow regulations and the immediate distribution of relevant news, the advantages of international portfolio diversification have significantly diluted[Gilmore and McManus (2004); Aggarawal and Kyaw(2005); Darrat and Zhong(2005)].

In the case of emerging markets, the overwhelming influence of larger and more mature markets has resulted in an exacerbated sensitivity to the changes ofinternational capital flows; since volatility is driven by the fickleness of international investors, international capital flows have createddomestic risks, which are linked to international financial instability conditions (Ahmed and Zlate, 2013).

The recent creation of international free-trade agreements and multi-country economic blocks has also contributed to increasingly similar capital market returnsacross participating countries (e.g., due to increased return correlations, portfolio diversification gains have diminished since the creation of international free trade agreements like NAFTA, as reported by Phengpis and Swanson (2007)). Similarly, benefits of international diversification among countries that form economic blocks might even disappear when markets are declining (see, for example, the case of the ASEAN countries during the 1997 turbulence period in Ibrahim(2006)).

International economic crises and cross-country financial turbulence periods have also been drivers of stock markets integration and regime switches have influenced the decisions of investors who seek to hold an optimal portfolio diversification.[4]

This work claims that foreign portfolio investmentinflows to the Mexican Stock Marketduring the 2007-2009 Financial Crisis were not consistent with an optimal NAFTA portfolio strategy, (i.e., with a NAFTA “Tangency Portfolio” investment strategy[5]).

[4] This succinct characterization and definition of financial integration is supported with different measurements and methodologies by several financial studies revised in the next section.
[5]See, for example, Grinblatt and Titman (2002), pp. 141-142.

To support our a claim, we: 1) test whether the weights of the theoretical Tangency Portfolios differed from the actual foreign flows into the Mexican stock market; 2) test if those flows can be explained by their theoretical counterparts in the presence of regime switches. The findings will, we expect, contribute to better understand the impact of periods of international financial turbulence on the behavior of foreign portfolio investors into the Mexican market.

The methodological approach includes the utilization of a Multivariate GARCH model with Varying Conditional Correlations (MGARCH VCC) to obtainthe conditional volatilities of the NAFTA countries stock markets' returns and their corresponding conditional correlations. To estimate the weights of an optimal Tangency Portfolio, theinput variable used for the risk free asset was the U.S. one month T-Bill. The database also includes the Morgan Stanley Capital Indices for Canada, Mexico and the United States sincethe beginning of March 2007,upon consideration thatthe first signals of the subprime crisis became evident during that month[6], and through July 30, 2010. Previous research on this topic is practically inexistent, although some studies have dealt with the impact of the financial crisis on Latin American financial markets before (Dufrénot, Mignon, and Péguin-Fessole, 2011; Arouri, Lahiani, and Nguyen, 2013).

The paper is organized as follows. Section II presents a literature review on the subject of financial integration, emphasizing more recent works that deal with NAFTA stock markets integration and volatility. Section III presents a background review of the subprime crisis and its relation to the behavior of the NAFTA capital markets. Methodological issues are presented in Section IV. Section V reports the empirical evidence obtained and its interpretation. The last section contains concluding remarks.

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[6] Albeit, formally, the subprime crisis is generally (voxpopuli) acknowledged to have begun until August 2007, and was officially recognized until December of that same year

2. Financial Integration: Stylized Facts in the NAFTA Countries' Stock Markets

According to Berben and Jansen (2005), the growing economic importance of many national capital markets during the last thirty years was accompanied by greater "co-movements", as well as by recurring shocks transmitted across borders, likely explained by faster and more reliable electronic communications, liberalization of controls, and increasing worldwide economic integration.

A number of studies have addressed the relationships between the capital markets of NAFTA countries, and confirmed the existence of a process of financial integration between them (see, for example, Darrat and Zhong (2005), Aggarwal and Kyaw (2005); Ciner (2006); López-Herrera, Ortiz and Cabello (2007); and López-Herrera and Ortiz (2010)). Only recently, researchers have dealt with the volatility of returns among NAFTA markets. Relevant studies include the works by Ewing, Payne and Sowell (2001), and López-Herrera, Ortiz and Cabello (2009).

In a more recent work TéllezGaytán and López Sarabia (2010) used weekly returns to analyze the correlation between the Mexican stock exchange index (IPC) and the S&P and DJIA indices, as well as with the IBOVESPA from Brazil and the MERVAL from Argentina. Using wavelet analysis, for the period 1999-2000, they found that the correlation between the Mexican stock exchange and the other markets was not intense and only in a few cases correlations exceeded 0.7. This evidence questions whether or not the real co-movement is as intense as proposed by other studies. It should be noted that, the correlation levels estimated by TéllezGaytán and López Sarabia between Mexico and the United States tend to remain low during short periods but there is a tendency to increase in long time horizons. These results contrast in two important aspects with evidence presented by López-Herrera, Ortiz and Cabello (2009); first, correlations reported by the latter are lower, and second, overall, the mean correlation tends to increase through time reflecting the impact of the NAFTA implementation. Correlations for the period before the signature of the agreement, from the signature to the date of its formal enforcement, and for the period that followed were 0.15, 0.28, and 0.50, respectively. Similar results are present for the association between then Mexican and Canadian stock markets; for the same periods, the correlation between these two markets were 0.1638, 0.14.91, and 0.4470.

These results clearly suggest that Mexico´s stock market integration with the other two NAFTA markets increased through time, in particular with the U.S. market; additionally it must be pointed out that López-Herrera, Ortiz y Cabello show that correlations between the NAFTA capital markets may reach higher levels during periods in which there are strong market pressures (e.g., cracks or financial panics).

Bucio and Ortiz (2013a; 2013b) dealt with the association among the Mexican Stock Exchange (MSE), the U.S. and the Canadian stock markets. Bucio and Ortiz (2013a) use daily returns, copula modeling and a t-student distribution to find more precise estimates than the conventional Kendall and Pearson parameters for the period 1992-2009. The correlation between S&P 500 and S&P TSX was 0.6426; between S&P TSX and IPC 0.422; and the correlation between the Mexican IPC and the S&P 500 was 0.5502. And, more recently, Bucio and Ortiz (2013b) use the S&P 500, the S&P TSX, and the IPC daily returns for the period 1993-2012, partitioned in one year sub periods to show association patterns that increase over time, but alternating ups and downs throughout the years. According to these authors findings, the data reveals a persistent Granger causality from the U.S, market towards the Mexican and Canadian markets, particularly towards the latter one. Surprisingly and probably explained by its remarkable growth in recent years, the Canadian market exhibited Granger causality towards both, the U.S. and the Mexican capital markets. The Mexican market presents infrequent causality towards the other two NAFTA markets. Nonetheless, during periods of crisis, causality relationships are reciprocal among all NAFTA markets.

Although emerging stock markets are characterized by high volatility, research dealing with this issue is scarce. In an early study Bekaert, Harvey and (2000) found that liberalization of capital markets often increase the correlation between local market returns and the world market but do not raise local volatility. Similarly, Maharaj, Galagedera and Dark (2011) examined the volatility of daily returns in a sample of developed and emerging equity markets at different time scales through wavelet decomposition, but found no evidence that the return dynamics of developed and emerging markets are different. Additionally, while emerging markets generally exhibit higher volatility levels, the relative contribution of each time scale is quite similar to that of mature markets.

There are several studies that have rejected the hypothesis of constant correlations among national capital markets; e.g., Longin and Solnik (2001), Engle and Sheppard (2001), Cappielo, Engle and Sheppard (2002), Goetzmann, Li and Rouwenhorst (2002), Suleimann (2003), Wong and Vlaar (2003), Bekaert, Harvey and Ng (2003), Bekaert, Hodrick and Zhang (2005), Wang and Moore (2008), Machado, Duarte and Duarte (2010), Antonakakis and Filis (2013), and Arouri and Nguyen (2010).

However, the literature dealing with time-varying correlations among emerging markets (Latin American capital markets in particular) and among emerging markets and more developed markets is still limited, although there is a great interest and recent research by local scholars is promising. In what follows, some of the most recent works in this area will be reviewed.

Arouri, Bellalah, and Nguyen (2008) explore the time-variations of conditional correlations among selected Latin American emerging markets and between them and the World stock market to shed some light on capital market integration and portfolio diversification. The cross-market correlations are empirically estimated applying a DCC-GARCH model and structural break analysis to test the changing nature of stock market co-movements. Their evidence signals that the degree of cross-market co-movements changes over time and has significantly increased since 1994 and beyond.

Yiu, Wai-Yip, and Li. (2010) investigate the spillover of financial crises by focusing on the dynamics of correlation between eleven Asian and six Latin American stock markets vis-à-vis the U.S. stock market, and they find that there was a regional factor that drives common movements of stock markets in each region. Next, they estimate the time-varying volatility correlation between the regional factor and the US stock market by an asymmetric dynamic conditional correlation model, and their results indicate that there is a significant rise in the estimated time-varying correlation from August 2007 to March 2009, which suggests evidence of contagion effects from the U.S. stock market to the markets in the two regions, during the global financial turmoil. The magnitude of the contagion effect to both regions is very similar, their different economic, political and institutional characteristics notwithstanding.

Naoui, Liouane, andBrahim (2010) use a dynamic conditional correlation model to examine financial contagion after the Subprime Crisis.

Their data set includes the stock indices of six developed markets (S&P 500, CAC 40, DAX, AEX, FTSE 100 and MIB 30)) and ten emerging markets (India's BSE 30, Hong Kong's Hang Seng, Malaysia's KLSE, Korea's KS11, China's Shang comp, Singapore's STI, Brazil's IBOVESPA, Mexico's IPC, Argentina's MerVal and Tunisia's Tunindex). The period of analysis comprises daily data from January 3rd 2006 to February 26th 2010. The evidence suggests an intensification of dynamic conditional correlations during the crisis period. In the case of emerging markets, conditional correlations divide these countries into three groups. The first group, including Brazil, Mexico and Argentina is characterized by a high dynamic conditional correlation with the U.S. market. The second group, composed of India, Malaysia and Singapore, presents correlations varying in time, which do not exceed 50%. The third group, composed by China, Hong Kong, Korea and Tunisia, registered weak dynamic conditional correlations with the U.S. market and was almostunaffected by the subprime crisis.

Finally, a recent paper byLahrech and Kevin (2011) explores the extent to which Latin American equity markets, including Argentina, Brazil, Chile and Mexico, have become more integrated with the U.S. equity market. Their observation period goes from December 30th, 1988 to March 26th, 2004.Integration is measured with the dynamic conditional correlation (DCC) between each market and the U.S. using a DCC multivariate GARCH model. Changes in correlations over time are analyzed with a smooth transition model which not only shows when greater integration first occurred but also how long it took for those correlations to transit to their new levels. Results show an increase in the degree of co-movement between the sample countries' returns and the U.S. returns, although the magnitude and speed of the increases varies greatly.

To sum up, evidence from recent financial literature concerning both developed and emerging markets suggests that financial integration during the last few decades can be characterized as an increasing but time-varying process.

3. The NAFTA Stock Exchanges and the Financial Crisis

The Subprime Mortgages Crisis caused the stock market's decline between 2007 and 2009, although it is fair to recognize that financial markets played a major role in magnifying the disruptive consequences and spreading their effects.

The Morgan Stanley Composite World Index reflects the turbulence experienced by the world financial markets.

Among the first symptomsof the crisis was an abrupt increase in the number of home foreclosures during the late months of 2006. By March 2007 the U.S. subprime-mortgages industry had collapsed and more than 25 subprime-lenders had declared bankruptcy, announced significant losses or put themselves up for sale. The shares of the country's largest lender, New Century Financial, plunged 84%, amid Justice Department investigations, and before filing for Chapter 11 on April 2, 2007 (Bianco, 2008). The liquidity crunch experienced by the Bear and Sterns Hedge Fund during June and July forewarned future climaxes of the crisis.The U.S. Economic growth slowed down and the recession was officially recognized in December 2007. By March 2008 Bear and Stearns was bailed-out by the U.S. government to avoid potentially disastrous systemic effects; but, by September 15 of that same year, Lehman Brothers declared bankruptcy, and that time there was no bail-out. As a result of the combined effects of the Subprime Mortgages financial crisis and itsexpansion waves, real U.S. GDP growth was negative for two consecutive years (-0.4 percent in 2008 and -3.1 percent in 2009). After 2009, the economic slowdown was followed by an unconvincing low economic growth of around 2.0 percent.

By March 2009 the DJIA reached a through of 5,209 points and finally recovered, reaching 10,465.94 points by the end of July 2010. Monetary policies carried out by the U.S. Federal Reserve Board undoubtedly aided to the stock market recovery.Beginning in September 2007, in a series of 10 moves, the federal funds target was reduced from 5.25% to a range of 0% to 0.25% on December 16, 2008 (Labonte 2013).In addition, the Federal Reserve Board cut interests rates to almost zero, provided unrestrained funds, and expanded swap lines with other central banks in order to augment liquidity in the U.S. dollar global market. Furthermore, it rescued various institutions whose bankrupt was considered to threaten the entire financial system (Brages 2009).

During 2004-2006, the Mexican Stock Exchange[7] (MSE) recorded extraordinary profits of more than 40% (compared to yields of less than 10% for other markets). Similar to the DJIA, during March and June 2007, the MSE was shaken by the U.S. subprime impact. Nonetheless the market reached a historical maximum of 32,836 units on October 17 of that year.

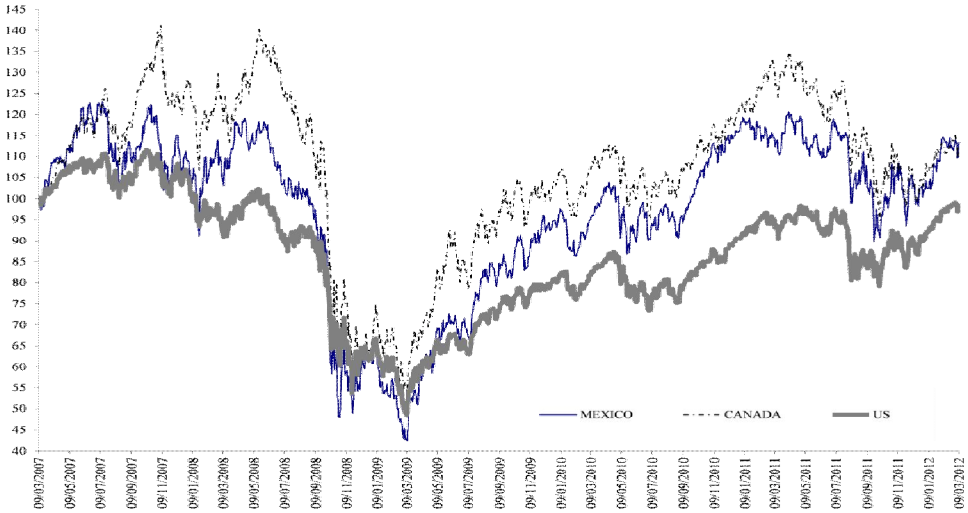
7 Information summarized from Annual Reports of the Mexican Stock Exchange, 2007-2011.

However, during the following months, the MSE declined hitting a minimum level of 16,868.66 points in 2008. Over all the MSE experienced an annual variation of -22.23% in pesos and -39.84% in dollars, more negative than the change recorded by the DJIA (-33.84%). Negative tendencies continued during 2009, but 2010 was a year of economic recovery for the global economy,and better performance of financial markets. The MSE index generated an annual return of 20.22% in pesos and a 36.83% points in dollars, partly due to the appreciation of the peso vis à vis the dollar. The Dow Jones annual return that year was of only 11.0%.

The subprime crisis also had harmful effects on the Canadian economy with real GDP growth of -2.8% in 2008. While economic performance improved during 2009 (GDP increased by 3.2%) in 2010, it slowed again to only 1.7% in 2012. The Canadian stock exchange also experienced bouncy changes as a result of the Subprime Crisis. reached12,923.66 units in January 2, 2007, and by February 26 scored 13,404.46 units. However, along with the evolutionobserved in the other NAFTA capital markets as a result of the first signals of the Subprime Crisis,it declined by mid March to 12,808.73; however, on June 18, 2008 the Toronto stock index reached a cyclical high of 15,073.13 points. But that remarkable growth was followed by a jumpy decay period ending May 9, 2009 to reach a record low of 7,566.94 points. Finally, a turbulent period of recovery took place. By July 30, 2010 the index reached 11,713.43 points, well below the initial and highest levels attained during the 2007-2010 period, used here to examine the changing correlations and tangency portfolio for the NAFTA stock exchanges. From the cyclical high to the lowest market level, losses in the Canadian markets reached -49.80%.

Figure 1 shows the performance NAFTA's stock markets between March and mid-July 2007; the crack affected the United States and the Mexican stock exchanges first but, roughly speaking, after the onset of the crisis the three markets followed very similar paths, descending steadily to their lowest values on the first week of March, 2009. Additionally, investors' expectations about the performance of the financial markets were worsened due to the economic recession that hit the United States beginning December, 2007. Obviously, although the subsequent recovery led to price levels comparable to those observed prior to the collapse, the magnitude of the fall caused severe losses to investors.

Figure 1. Morgan Stanley NAFTA Stock Markets Indexes Daily Closing Levels (March 9, 2007- March 9, 2012)



4. Methodological Issues

4.1 Tangency Portfolio

To estimate a TP that combines the NAFTA countries largest stock markets,[8] during the Financial Crisis, the input variables were the Morgan Stanley Capital Indices series for Canada, Mexico and the United States. We follow a three step procedure: a) we estimate a Multivariate GARCH model allowing varying conditional correlations (MGARCH-VCC), as originally proposed by Tse and Tsui (2002); b) then, employ an MGARCH-VCC that allows not only for heteroscedasticity in market returns but that also accommodates a time varying correlation process; and c) we used the MGARCH VCC output to estimate the portfolio weights (w_i's) that solve the following non-linear optimization problem:

[8] These series are also employed to estimate the conditional volatilities and covariances among NAFTA countries' markets, as detailed in the empirical section.

$$\max \frac{E(r_{TP}) - r_f}{\left[\sum_{i=1}^{n} w_i^2\,\sigma_i^2 + 2\sum_{i=1}^{n-1}\ \sum_{j=i+1}^{n} w_i\,w_j\sigma_{ij}\right]^{1/2}}$$

$$\textit{subject to:}\quad \sum_{i=1}^{n} w_i = 1$$

$$\textit{and}\quad -1 < w_i < 1$$

Where the last constraint is introduced in order to limit the spectrum of possibilities that are allowable to the investors, including the two extreme cases: a) when investors allocate all their funds to a single market, or b) when investors fully short-sell their position in one market, but limited to 100% of their wealth.[9]

4.2. Modeling Time-Varying Conditional Volatility and Conditional Correlation

The inputs needed to find the TP weights are the risk free rate, the mean, and the time changing (conditional) variance and covariance of individual assets' returns. To get a more precise understanding of time-changing volatility of financial assets' returns some authors propose the use of ARCH models (Bollerslev, Chou and Kroner 1992; Corhay and Rad 1994); others propose the use of GARCH (Bollerslev 1986) and still others recommend different variations of ARCH (Bollerslev, 2008). In this study, as previously mentioned, we follow the Tse and Tsui (2002) methodology to estimate a Multivariate GARCH with Varying Conditional Correlations (MGARCH VCC), expressed as follows:

$$r_t = \mu + \varepsilon_t$$

$$\varepsilon_t = H_t^{1/2} \upsilon_t$$

$$H_t = D_t^{1/2} R_t D_t^{1/2}$$

$$R_t = \left(1 - \lambda_1 - \lambda_2\right) R + \lambda_1 \Psi_{t-1} + \lambda_2 R_{t-1},$$

9A natural way to construct the short position depicted in our TP problem is to take a short position in a suitable futures market. In the context of our inquiry, a negative position implies that the "more" negative is the weight suggested by the TP, the less favorable its performance expectations are, so it is optimal to short-sell it.

where:

r_t is an *m* x 1 vector that contains the different markets returns as elements;
$H_t^{1/2}$ is the factor that results from performing Cholesky's decomposition of H_t, the time-changing conditional variances matrix;
D_t is a diagonal matrix with conditional variances:

$$D_t = \begin{pmatrix} \sigma_{1,t}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{2,t}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_{m,t}^2 \end{pmatrix}$$

where $s_{i,t}^2$ evolves in time according to a process similar to the univariate GARCH:

$$\sigma_{i,t}^2 = \omega_i + \sum_{j=1}^{q_i} \alpha_j \epsilon_{i,t-j}^2 + \sum_{j=1}^{p_i} \beta_j \sigma_{i,t-j}^2,$$

ω_i, $a_j and \beta_j$ are the parameters to be estimated;

R is a matrix of mean correlations to which the process of conditionally changing correlations converges:

$$\begin{pmatrix} 1 & \rho_{12,t} & \cdots & \rho_{1m,t} \\ \rho_{21,t} & 1 & \cdots & \rho_{2m,t} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{m1,t} & \rho_{m2,t} & \cdots & 1 \end{pmatrix}$$

ψ_t is the rolling estimator of the correlations of ε_t; and $\lambda_1 \; and \; \lambda_2$ are the parameters that govern the dynamics followed by the conditional correlations.

To maintain the stability of the model, it is required that the changing correlations fulfill the restrictions $\lambda_1 > 0, \lambda_2 > 0, 0 \geq \lambda_1 + \lambda_2 < 1.$

The likelihood logarithmic function based on the Multivariate Normal Distribution of observation *t* is:

$$l_t = \frac{1}{2} m \log(2\pi) - \frac{1}{2} \log\{\det(R_t)\} - \log\left\{\det\left(D_t^{\frac{1}{2}}\right)\right\} - \frac{1}{2} \varepsilon_t R_t^{-1} \varepsilon_t'.$$

So, if one has the observations for t = 1, 2,...,T, the estimation of the model's parameters can be made using the Maximum Likelihood method to optimize the following function:

$$Max \sum_{t=1}^{T} l_t .$$

4.3Markov-Switching Regression

A number of authors have developed models to examine the dynamic behavior of non linear economic and financial time series. Among them, the Markov switching model, also known as a regime switching model, has been employed extensively to capture dependency and volatility clusters exhibiting distinct dynamic patterns. Succintly, this model involves multiple structures (equations) that can characterize the time series behavior for different regimes. By allowing switching between these structures, the model is able to capture more complex dynamic patterns. One of its' important features is that the swithching mechanism is controlled by an unobservable state variable which follows a first-order Markov chain sequence.The Markovian property regulates that the current value of the state variable depends on its immediate previous value. Thus, a structure may prevail for a random length of time,and be replaced by another structure when switching takes place (Kuan, 2002).

Following Cosslett and Lee (1985) and as an extension of Goldfeld and Quandt (1973) and Neftci (1984), Hamilton (1989) introduced the Markov Switching Model, for the study of the business cycle.

Nowadays, the Markov Switching model has become one of the most popular nonlinear time series models in the literature. The Markov-switching approach to modeling economic and financial time series as introduced by Hamilton (1989), is specified as:

$$y_t = \beta_{0,(s_t)} + \beta_{1,(s_t)} x_t + \varepsilon_t ,$$

where the possible realizations of the process are split into m different "states of the world" (or regimes), $s_t \in 1, 2, \ldots, m$, allowing for changes in the model's parameters as a consecuence of a switch from one regime to other, in accordance with an unobserved state-determining variable. In the case that the process moves within two regimes only, as in the estimation carried out below, we have:

$$\beta_{0,s_t} = \begin{cases} \beta_{0,1} & \text{if } s_t = 1 \\ \beta_{0,2} & \text{if } s_t = 2 \end{cases}$$

and

$$\beta_{1,s_t} = \begin{cases} \beta_{1,1} & \text{if } s_t = 1 \\ \beta_{1,2} & \text{if } s_t = 2 \end{cases}$$

Under the assumption that a first-order Markov process conducts the current regime, s_t depends only on the regime one period ago, s_{t-1}, and on the following time varying transition probabilities:

$p_{11,t} \equiv \text{Prob}(s_t = 1 \mid s_{t-1} = 1; z_{t-1})$, $p_{12,t} \equiv \text{Prob}(s_t = 2 \mid s_{t-1} = 1; z_{t-1})$,
$p_{22,t} \equiv \text{Prob}(s_t = 2 \mid s_{t-1} = 2; z_{t-1})$, $p_{21,t} \equiv \text{Prob}(s_t = 1 \mid s_{t-1} = 2; z_{t-1})$,
which satisfy: $p_{11,t} + p_{12,t} \equiv 1 \equiv p_{22,t} + p_{21,t}$, with $0 \le p_{ij,t} \le 1$ for all $i,j = 1, 2$; and z_{t-1} is a conditioning exogenous variable (which could be a vector).

Then, the log-likelihood is defined as:

$$l(\beta, \sigma, \delta) = \sum_{t=1}^{T} \log \left\{ \sum_{i=1}^{m} \frac{1}{\sigma} \Phi\left(\frac{y_t - x_t'\beta}{\sigma} \right) \cdot P(s_t = i \mid \Omega_{t-1}, \delta) \right\},$$

where□ is a vector containing the parameters of the regression model to be estimated, □ is the variance of the errors (it can be also dependent on the regime), □ is a vector of parameters determining the regime probabilities, $□_{t\text{-}1}$ is the information set in period *t*-1, and □(□) is the standard normal density function. The varying regime probabilities p_m can be estimated as a multinomial logit function of vectors of the exogenous variable(s) and the □ vector of parameters:

$$P\left(s_t = i \middle| \Omega_{t-1}, \delta\right) \equiv p_i\left(z_{t-1}, \delta\right) = \frac{\exp\left(z'_{t-1}\delta_i\right)}{\sum_{j=1}^{m} \exp\left(z'_{t-1}\delta_j\right)}$$

so, the likelihood function shown above can be maximized with respect to the parameters by means of iterative methods obtaining the one-step ahead prediction of the of the regime probabilities and, as by-products, the filtered and the smoothed regime probabilities.

5. Empirical Evidence

The conditional volatilityof and conditional covariances among NAFTA countries' markets were estimated using the Morgan Stanley Capital Indexes for Canada, Mexico and the United States closing prices,for a period that goes from March 3, 2007 through July 9, 2012, for a total of 1,306 daily observations. The three indexes are expressed in US dollars, eliminating any potential distortions introduced by the exchange rates fluctuations. Table 1 presents the estimation output of the MGARCH (1,1) VCC (1,1) model.

Table 1: The MGARCH (1,1) VCC (1,1) Model

Coefficient	*Mexico*	*Canada*	*US*
□	0.0603537	0.0527436	0.0371239
Standard error (robust)	0.0149009	0.0134157	0.007925
z-statistics	4.0503392	3.9314833	4.6844038
□	0.0888642	0.078989	0.1047957
Standard error (robust)	0.0109023	0.0105695	0.0116028
z-statistics	8.150959	7.4732958	9.0319319
□	0.8933415	0.9018628	0.8763321
Standard error (robust)	0.0122183	0.0126063	0.012042
z-statistics	73.11504	71.540642	72.77296

Correlations' Model

$□_1$	0.0096177
Standard error (robust)	0.0020529
z-statistics	4.68493351
$□_2$	0.9847595
Standard error (robust)	0.0039993
z-statistics	246.232966
Log-likelihood: -5,976.061	
AIC = 11,980.12; BIC = 12,052.56	

All the parameters estimated with the changing-variances model were highly significant and pertinently met the stability requisites. Also, the changing correlations model parameters were very significant, and their sum suggests a highly persistent correlation process.

Figure 3 presents the estimated conditional volatility obtained from the model reported in Table 1 for the three NAFTA countries' market indices. During the period of this analysis, the OECD reported different sub-periods of economic recession for each of the three NAFTA countries: Canada was in a recession from May 2007 through June 2009; Mexico entered a recession in June 2007 and exited in May 2009; finally, the United States was in a recession from December 2007 through May 2009. We highlighted with a discontinuous box frame the period, from May 2007 until June 2009, in which the three countries' recessions overlapped.

Conditional volatility rose in moderate waves since the end of July 2007, but declined in April 2008, returning to a level comparable with the period before to the crisis. However, by September 2008 volatility increased again, and reachedits highest points during October 2008 (36% for the Canadian Market, in October 30, 2008; 48% for the Mexican market, in October 14, 2008; and, 30% for the United States market, in October 16, 2008). During the following months the conditional variances receded, but not completely; during February 2009 there was a new escalation of volatility that faded away August of that year. Then again, two additional sup-periods of increasing volatility occurred between May and August 2010 and August and December 2011, which were likely related to the Greek government'sannouncementthat it would not be able to honor its sovereign debt compromises.

Through the whole period of analysis, except for a few observations, our estimations of conditional volatility for the Mexican market were higher than those for Canada and the United States, a fact that highlights greater sensitivity of the MSE to: a) the daily news reports on corporate and non-corporate financial news, most of them pessimistic; and b) announcements of new policy measures to face market turbulences implemented by governments (mainly by the United States' Federal Reserve and Treasury Department).

Conditional correlations marginally declined in 2007, but in 2008 had a drastic fall (Figure 4). As stock prices recovered, towards the end of April 2009, they returned to a level comparable with that observed in early March of 2008 and, according to our estimations, from that moment on remained stable, even when there was a raising trend that reached a new maximum during the first days of February 2012, associated a new liquidity crisis of the Greek government thatresultedin a second bailout by the EU, the IMF and the European Central Bank.

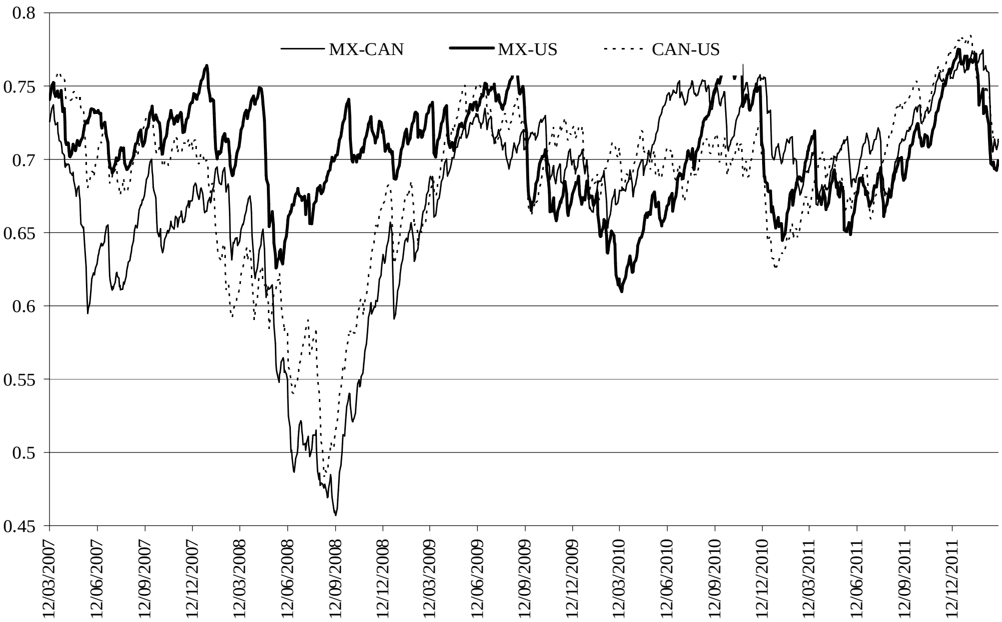
The changing trend in conditional correlations confirms 'that integration between the NAFTA equity markets is a time varying process, affected deeply by prevailing financial conditions and the economy. However, it is worth noting that during the onset of the crisis the correlations between the Mexican and Canadian markets and between the Canadian and U.S. markets exhibited a propensity to decline sharply; this result contradicts previous research which has documented notorious increments in correlations as a consequence of the financial crisis.

The correlation between the U.S. and the Mexican market remained at more than 0.60 at the peak of the crisis, and for the remaining period conditional correlations followed similar patterns, fluctuating around the higher levels observed for all the sample observations.

Our estimated conditional correlations between the Canadian and the Mexican markets, as well as for the Mexican and the United States markets were higher than what López *et al*. (2009) reported using a different period of observations (from August 23, 1984 through December 22, 2005). There was also, as explained before, a somewhat different behavior in the conditional correlations observed between the Mexican and the United States markets, compared to the pattern followed by the correlations between the Canadian and the Mexican markets. In our sample one observes that the conditional correlations between the Mexican and the United States markets followed a lateral trajectory fitted in a range of approximately 0.70 to 0.75 during the first months of the analysis. However, during the period that goes from April 18 through May 20 of 2008, when the three markets were in free-fall, there was a noticeable reduction in their correlation, in sharp contrast with the stylized fact that higher levels of correlations are present during periods of crisis. After returning to the levels observed before August 21, 2009, the correlations fell again, in a tendency that concluded on March 16, 2010, when they reached their lowest estimated value during the whole period of analysis.

Alternatively, the conditional correlations for the Canadian and Mexican markets took a deep dive around the Lehman Brothers bankruptcy announcement, in mid-September 2008, reaching their lowest level around values close to 0.45. Finally, the conditional correlation between the Canadian and the United States markets also reached its nadir around mid-September (close to 0.50).

Figure 2. Conditional Correlations for the NAFTA Stock Exchange Markets



The estimated time-varying correlations among NAFTA markets confirm that financial integration is an ongoing process. While some sub-periods of stability and growth can be discerned,the subprime crisis clearly affected it, which is consistent with one of our initial two hypotheses.

To calculate the changing weights that correspond to a Tangency Portfolios (TP) including the three NAFTA markets indexes, the standard variance and correlation estimates were replaced with conditional volatilities and conditional correlations obtained from the previous analysis, and combined with the four-week U.S. Treasury Bill's rate[10], as the market proxy for the theoretical risk free rate.

[10]The United States Treasury Bills are the most representative regional risk free securities for the NAFTA region.

The theoretical weights assigned by the TP model to the Mexican indexwere highly volatile throughout the period of analysis, exceeding the range of variation of the other two NAFTA markets.[11] But there was a period of consistent low weights between February 2008 and October 2008. It is interesting to notice that while the TP weights were theoretically estimated, that period corresponds to the most turbulent phase of the global financial crisis. From an investor's point of view, the theoretical weights were consistent with the intuition of flight to quality, i.e., selling risky assets to find protection in more traditional asset alternatives.

One of the distinctive contributions of this work consists in contrasting the evolution of foreign portfolio investments with respect to the optimal tangency portfolio weights obtained from our estimations. A perfect correlation between these two variables would mean that investors were able to optimize their investments in Mexico, modifying the composition of their NAFTA portfolios adjusting their portfolio weights according to the estimated TP weights obtained by using time varying variances and covariances. It is important to recall that employing improved estimations for the variance-covariance matrix of stock returns, allows the design of a tangency portfolio that overcomes the limitations of conventional mean variance estimates based on constant parameters (mean, variance and covariances) assumptions.

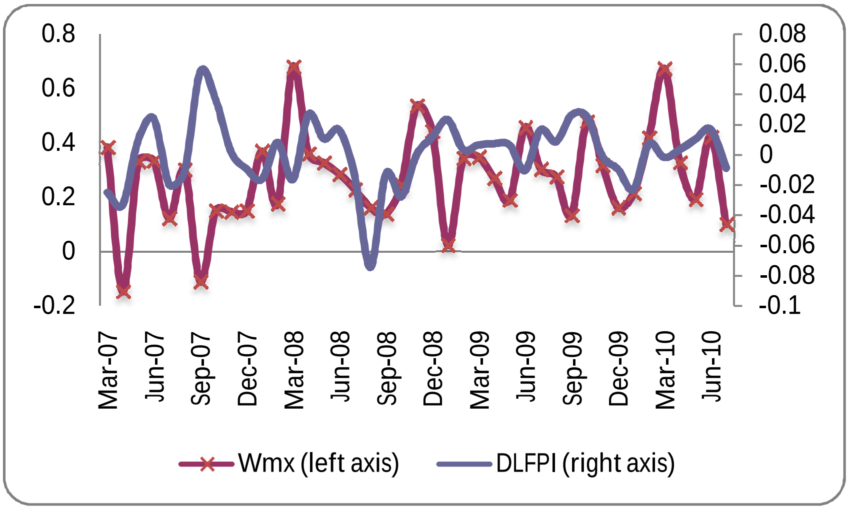
Figure 3, shows that the two variables had short periods of almost perfect symmetry, but there were periods of discrepancies, and sometimes of almost perfect opposition. We inferred that such a pattern could be explained by switching regimes, probably due to asymmetrical information and perceptions of value and risk prevailing in the market during turbulent times, i.e., in times of extreme volatility high risk investors may not adjust their portfolios following optimizing criteria, but may rely mainly on their instincts and experience. That is, for the valuation of assets high risk foreign investors, at least those who are experienced, and, more likely, large institutional investors, valued assets with a long term perspective, trying to find overvalued or undervalued assets to buyor sell at prices far different from the securities' intrinsic value.

[11] One month investment horizons are assumed. Due to limited data availability, the analysis employs only monthly data for the periods March 2007 to December 2011. Monthly averages are based on daily weights calculated from the multivariate GARCH model; these averages are used to estimate the Markov Switching model.

However, it is worth mentioning that Fleisher, Mallerand Müller (2011)detect, with a high degree of reliability, significant changes (improvements) in information linkages across the three countries from the pre- to post-NAFTA period with a high degree of reliability.

Additionally, high volatility induced firms to offer higher compensations for risk encouraging some investors to disregard optimal portfolio allocations. However, it is also important to tress that the inability to hold the tangency portfolio might have also derived from weak and irrational decisions from investors. In any event, deliberate and irrational estrangements from the TP also explain the wavering routes in financial integration. Recognizing the evolution of correlations and rifts from the TP, we can characterize integration in the NAFTA bloc as growing but wavering, i.e. consistent with our hypothesis stated in the second section of this paper, crisis inhibits financial integration; additionally, this assertion was accentuated in the case of the NAFTA capital markets because it includes a sensitive and highly volatile emerging market, Mexico. Indeed, Pierdzioch andKyzis (2012) supports Mexico´s dithering integration and the inconsistent decisions of foreign investors.Those authors estimate a space-state model to decompose the stock market indices of the three member countries into fundamentals and speculative bubbles. Using co-integration techniques their evidence reveals that linkages between fundamentals is stronger than evidence of cointegration linkages between speculative bubbles.

Figure 3. Foreign Portfolio Investment Variations and Optimal Weight in a NAFTA Tangency Portfolio for the Mexican Market (March 2007-July 2010)



With the intention to verifytheexistence of stochastic regime switches at different points during the period of observations, we estimated a two-regime Markov-switching regression. Two regimes were assumed since the relationship between foreign portfolio investments and optimal weights for positions in the stock market follow similar patterns in some periods, while trends differ and are even opposite during some other periods as previously explained. Thedependent variable in the switching equation is the foreign portfolio investments;and the regressoris the previously estimated optimal portfolio weights of the Mexican market in the NAFTA Portfolio.

Dummy variables, common to both regimes were included in the specification to capture the effects of the occurrence of the events that triggered the crisis on the financial markets. In order to take into account the effects of the slowdown of the U.S. economy in the investor decisions, we conditioned the estimation of the regime probabilities with a suitable dummy as dated by NBER´s Business Cycle Dating Committee for the period covered by our estimation; in this fashion we were able to obtain time-varying regime probabilities. We also assume that there is a common error variance.

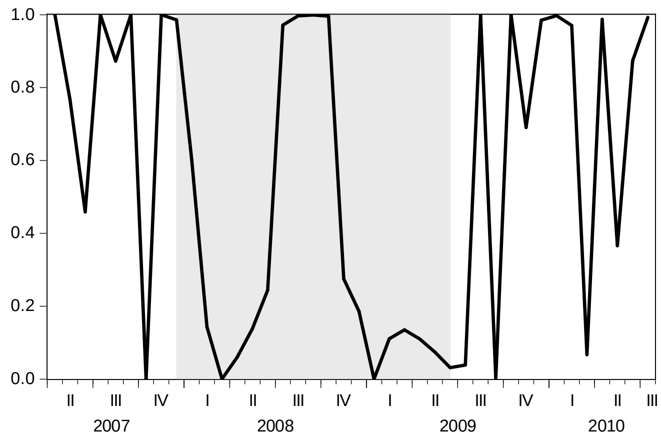
Table 2 presents the Markov-switching regression model estimated to further analyze the relationship between the foreign portfolio investment flows and the optimal weight predicted for the foreign portfolio investment (FPI) in the Mexican stock exchange by the Tangency NAFTA portfolio. All the estimated coefficients, specific or common to both, regimes are highly significant, even at the 1% level. It is worth noting that the coefficients associated to the optimal Mexican stock market weight for the NAFTA Tangency Portfolio switch their value and their sign. The estimated coefficient for regime (state) 1 was positive; so, this regime was identified as the one in which FPI arrived to the Mexican stock market in agreement with the direction suggested by the TP model. In the other regime, the negative sign may be interpreted as an inverse relationship between the direction of flows and the theoretical optimal weights, suggesting that the investors did not reacted according to the optimal behavior predicted by the TP model.

Table 2. FPI MS Regression on Mexican Optimal Weights in NAFTA Portfolio

	Coefficient	*Standard error*	*t*	*p-value*
$\square_{0,1}$	-0.022394	0.006582	-3.402406	< 0.01
$\square_{1,1}$	0.074565	0.027285	2.732832	< 0.01
$\square_{0,2}$	0.027661	0.006939	3.986388	< 0.01
$\square_{1,2}$	-0.054689	0.017786	-3.074760	< 0.01
D_2007M9	0.085571	0.015480	5.527861	< 0.01
D_2008M8	-0.064467	0.013005	-4.957012	< 0.01
ln□	-4.549746	0.151720	-29.98787	< 0.01
Log-likelihood	114.9870	SSR	0.009288	
Ljung-Box Q(1)	0.390	Jarque-Bera test 0.6324		

Figure 4 displays regime 1 smoothed state probabilities. Although a good deal of variation in the regime probabilities were present throughout the whole period, it seems obvious that the recession period (shaded area) influenced the probabilities of this state.

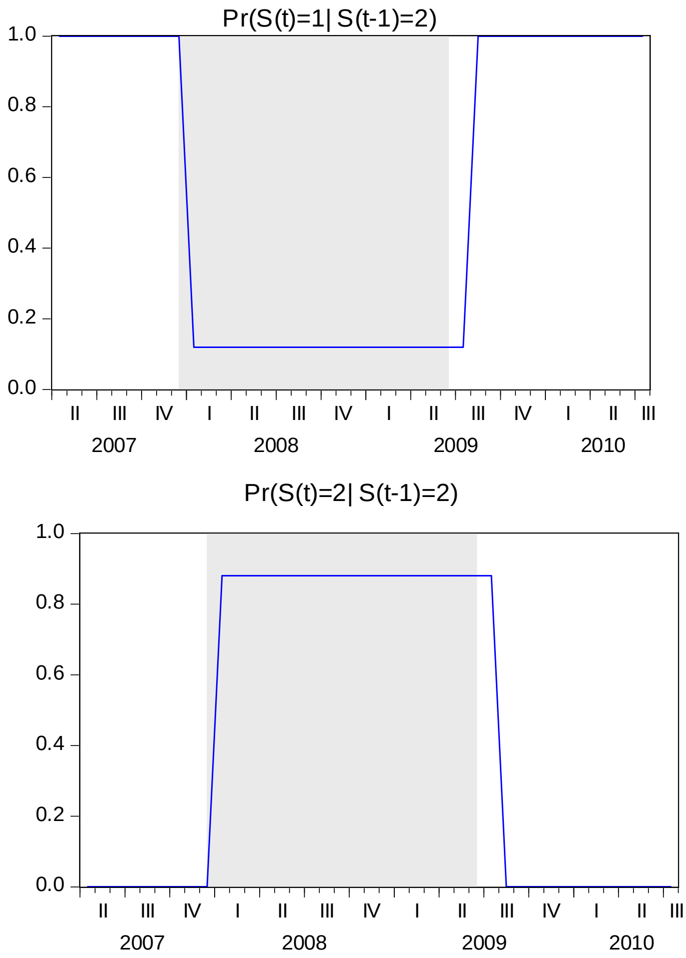
Figure 4. Smoothed Probabilities for Regime 1



The estimated time-varying transition probabilities are presented in Figure 5. The estimated probability to change from regime 2 to regime 1 decreased sharply during the recession period, from a value close to 1, to a level as low as 0.1197.

Obviously, this result implies that the estimated probability to stay in regime 2 rose in a dramatic way, from almost zero to 0.8803. Also the probability to stay at regime 1 increased but only marginally, from 0.6578 to 0.6634 and, as a consequence, the probability to switch to regime 2 coming from the regime 1 observed a mild descent to 0.3366 from its original level of 0.3422, the value estimated for the non recession period.

Figure 5. Time-Varying Transition Probabilities



The estimates of the time-varying transition probabilities could contribute to explain our previous analysis: amid the storm unleashed by the subprime crisis in all the world's financial markets, investors possibly preferred to built their portfolios purchasing and selling value stocks disregarding current prices and risk.

To conclude the analysis in the context of the Markov-switching regression estimation, it is worth noticing that the estimated duration, expressed in months, for regime 1, remained almost without changes, increasing marginally from 2.92 before the crisis to only 2.97 months during the crisis; but the estimation corresponding to regime 2 showed a very sharp increase from 1.0 month,during for the non crisis period, to as much as 8.34 months during the crisis.

The previous results emphasize the lack of consistency in the behavior of international investors All the above facts, increased volatility, changing correlations, and regime changes emphasize the lack of consistency of international investors building optimal portfolios which we also hypothesized as a likely circumstance within the dithering financial integration of Mexico's equity market with the share markets from Canada and United States.

6. Conclusions

This study examined the financial integration among NAFTA stock markets by looking at their time-varying correlations for the 2007-2012 period. Due to potential impacts from the subprime crisis, we also focused our attention on the implications of the 2007-2009 financial crisis on the NAFTA stock markets integration, as well as on the optimality of foreign portfolio investment flows estimated using time varying conditional variances and covariances. The empirical evidence obtained shows that during the recent crisis there were notorious increases in the volatility of the NAFTA region's stock exchanges. Noticeably, such increases took place during sub periods in which, according to the OECD, the economies of the three NAFTA countries were undergoing a recessive phase. In the case of the Mexican market it stands out the fact that when the financial crisis started, the negative impact resulting from the transmission of the complex events that took place in the United States markets was relatively mild, considering that not many Mexican financial firms possessed "toxic assets" in their balance sheets. Maximum risk levels were not immediately reached; they only occurred towards the end of the recessive phase. We found that there was a notable increasing but fluctuating degree of association of the three NAFTA marketsduringthe period of analysis, a fact that is particularly relevant considering that in previous studies there was evidence of negative correlation during certain periods, or else assumed integration as a smoothly growing path.

It is likely that the manifestations of the world financial crisis in this triad of countries and the increasing economic integration produced closer co-movements. Nevertheless, their integration cannot be characterized as a continuous growing process for it was affected by regime switches. Further, since correlations are still lower than the highest positive levels, it can be concluded that a mild segmentation still prevails among NAFTA countries' financial markets; (optimal) international portfolio diversification is still possible by investing in these three markets.

Nevertheless, analyzing foreign portfolio investment flows into the MSE we found that investors did not always behave according to the TP weights prescribed by the optimization model based on Tobin's Separation Theorem. Optimal weights were estimated using time varying conditional variances and correlations. The evidence shows that during the period of economic recession in the United States, non-optimal and contradictory decisions prevailed, suggesting that investors' decisions more likely responded to purchases and sales of value oriented assets. Involuntary estrangements from the TP might have also occurred due to asymmetrical information and weak decision making processes. Finally, the misallocation of funds might have taken place in some investors' segments due to erroneous asset diversification models. To reexamine at depth this problem we used a multivariate GARCH model to estimate the time-varying correlations and used them in our portfolio optimization models. We also explored the existence of switching regimes applying a two-regime Markov-switching regression in order to determine the relationship between foreign portfolio investment flows and estrangements from the tangency portfolio. The coefficients associated to the optimal Mexican stock market weight into the NAFTA Tangency Portfolio switch their value and their sign. The estimated coefficient for regime 1 was positive indicating entrance of foreign portfolio flows to the Mexican stock market in agreement with the direction suggested by the TP model. In the other regime, the negative sign indicates an inverse relationship between the direction of flows' and the theoretical optimal weights. This result suggests that the investors reacted contrary to the optimal behavior predicted by the optimal model namely because the speculative opportunities and risks, as well as due to possible asymmetries in information affecting the path of financial integration.

The findings presented shed light on the effects of the Subprime Mortgages Crisis on NAFTA financial markets integration and on the behavior of portfolio investors during that period. However, this explains only one part of a complex integration process between one emerging market and two fully developed markets.

Further research is needed to enhance our understanding of the role of stock markets on financial integration and international capital flows.

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