ARE AMERICAN AND FRENCH STOCK MARKETS INTEGRATED?

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ABSTRACT

Within a nonlinear framework, this article studies the market integration hypothesis between the French and American stock markets, on a short- and long-term basis. We use two nonlinear Error Correction Models (ECM): the Exponential Switching Transition ECM (ESTECM) and the nonlinear ECM-Rational Polynomial (NECM-RP). Our results provide strong evidence of integration between French and American stock markets. They show that the stock market integration process is non-linear and time-varying and that it has strengthened over time.

JEL: C22, G15

INTRODUCTION

Stock market integration has been studied in several papers (Jeon and Chiang, 1991; Richards, 1995; Bekaert and Harvey, 1995; Heimonen, 2002; Carrieri *et al.,* 2006). Overall, stock market integration can be assimilated to a situation in which the assets in different countries display the same expected risk-adjusted returns. Two stock markets are perfectly integrated if investors can pass from one market to the other without paying any additional costs and if there are possibilities of arbitration which ensure the equivalence of stock prices on both markets. These studies have focused on several questions: Are stock markets integrated? What are the factors of this financial integration? What is the financial integration dynamics? Is the integration process continuous or discontinuous? The answer to these questions is important because it helps understand the degree of interdependence and correlation between stock markets and helps apprehend the international investors' strategies. More interesting, the recent increases in the number of international investors and the recent development of stock markets and financial liberalization have alimented these studies and interrogations.

Exploration of the literature on stock market integration shows that most of the previous studies either examined the integration hypothesis only in a linear framework or used the usual correlation tools, thus limiting the convergence between stock markets to be symmetric and linear. However, the stock market integration dynamics should be nonlinear and asymmetric. The nonlinearity and asymmetry can be justified in different ways through the presence of heterogeneous transaction costs (Dumas, 1992 and Anderson, 1997), the coexistence of different shareholders (De Grauwe and Grimaldi, 2006), information asymmetry and through mimetic behavior (Jawadi, 2008), which can induce discontinuities, persistence and inertia effects in the financial integration dynamic. We use two kinds of Nonlinear Error Correction Models (NECM): the NECM-RP and the ESTECM. The first model considers several potential sources of nonlinearities, due to the abrupt changes in adjustment speeds, can be taken into account and adjustment may be differed according to stock price misalignment, etc. The second model helps to reproduce the asymmetry characterizing the financial integration process and stock price deviations.

The main idea of this paper is thus to check the integration hypothesis between the French and American stock markets in the short and long run, using recent nonlinear econometric modeling. The contribution of this study is twofold. On the one hand, the approach used helps to understand the interdependence, contagion and integration between the French and American stock markets. These questions are of crucial importance with regard to decisions related to international portfolio diversification. On the other hand,

using two different NECM would specify a more appropriate convergence process between these stock markets than the one induced by the linear cointegration tools used in previous studies.

The motivation of this paper is twofold. First, it is clear that the fusion between the Euronext group, a merger of Paris', Brussels', Amsterdam's and Lisbon's stock markets, and the NYSE, has affected Paris' and New York's quotations. It has also profited professionals and stimulated the convergence process between the French and American stock markets. Secondly, many stylized facts show significant independencies between these stock markets, notably in periods of crises, scandals and stock crashes. For example, after a prosperous period in 1999, the CAC40 lost 15% in about four months in September 2000 as a result of the first signs of a slowing of American growth. In 2001 and 2002, the CAC40 lost respectively 21.97% and 33.75% because of the American decrease, the fall of new technology markets and the fear of an American recession. The Internet Bubble also showed that both stock markets are strongly correlated and that investors are imitating each others. Indeed, while the NASDAQ recorded a fall of 75% in October 2002, the IT CAC40 fell by 90% between March 20, 2000 and October 8, 2002 (Jawadi, 2008).

More recently, due to a recession risk in the United States and after Georges Bush's declaration on January 18th 2008 concerning his plan to raise the American economy and suppress the "subprime" crisis, the CAC40 lost 6.83% on January 21st 2008, its most important fall since September 2001. The DAX also lost 7.6%, the Eurostoxx50 7.31%, the FTSE 5.48% and the BEL20 5.48%. But two days after the Fed reaction to the decrease of the interest rate by 75 points, a reaction which aimed at damming up the crisis and at restoring the investors' confidence, the CAC40 increased by 2.2%. This indicates that the American conjuncture leads world conjunctures. It also implies that the French and American Stock markets and economies seem to be strongly correlated. This interrelationship was justified differently in the finance literature: the decrease of transaction costs, the convergence of risk premium, the synchronization between markets, the internationalization of companies and investors, the ongoing liberalization process, etc. This article investigates the financial aspect of this interdependence. More precisely, we shall check whether the French and American stock markets are integrated and examine their convergence dynamic. The plan of the article is as follows. Section 2 presents a quick literature review on stock market integration. The NECM's are presented in the third section. Section 4 discusses the empirical results. Section 5 concludes the paper.

LITERATURE REVIEW

The main idea of this section is to present the literature review on stock market integration while explaining and answering two questions: i) How did the previous studies justify financial integration? ii) Which econometric tools have been used to check the financial integration hypothesis?

Stock market integration has been studied by several authors (Gourinchas and Gurgand, 1990; Jeon and Chiang, 1991; Richards, 1995; Bekaert and Harvey, 1995; Heimonen, 2002; and Hardouvelis *et al.,* 2006). According to these studies, there is some evidence of interdependence and convergence between stock markets. Overall, this interdependence seems to be due to fewer cross-country restrictions on stock investment and foreign ownership (Bekaert, 1995), to the contagion effect (Roll, 1988; and Bekaert *et al,.* 2005), to the strong economic ties and policy coordination among countries (Engle and Susmel, 1993), to the global cooperation under technological and financial innovation (Chen *et al.,* 2002), and to the internationalization of companies and institutional investors (Lin *et al.,* 1998).

In practice, stock market integration was checked using different techniques and several results were proposed, either confirming or rejecting the perfect integration hypothesis, for instance, linear cointegration tests. According to the mixed results of previous studies, stock markets come off as very ambiguous: Cho *et al.* (1986) and Wheatley (1988) showed that stock markets are integrated whereas Ko

and Lee (1991) suggested that they are segmented. Chan *et al.* (1997) obtained mixed results across different periods. Other studies focusing on return correlations adopted a short-term approach. Their results were also mixed (Campbell and Hamao, 1992; and Ammer and Mei, 1996). Nevertheless, we have noted two remarks. First, these studies retained several definitions of integration and the results vary among these definitions (Heimonen, 2002). Second, most of the previous studies evaluated the integration within a linear framework.

However, linear tests cannot show whether stock markets have become more integrated and whether their integration process is gradual. In other words, the usual linear cointegration cannot detect the partial integration of the stock market because it does not take into account the fact that integration is a gradual and on-going process (Canarella *et al.,* 1990). To remedy these limits, other studies focused on nonlinear modeling. Bekaert and Harvey (1995) showed that the stock market integration degree is time-varying. The authors studied integration using a regime-switching framework. They assumed that stock markets are segmented in a part of the sample and become integrated in another part. Okunev and Wilson (1997) also used nonlinear tests to examine the integration between real estate and stock markets. Recently, Li (2006) has allowed for the risk premium function to be nonlinear as the cause of nonlinear linkages among international stock markets. Overall, these studies justified the nonlinearity and the persistence through the smoothness characterizing the stock market integration, liberalization and barrier removal between countries.

Few studies focus exclusively on the integration between American and French stock markets. Indeed, our exploration of the empirical literature identified only the study of Gourinchas and Gurgand (1990). The authors focused on the CAC40 and Dow Jones over the period September 1987-March 1990. They suggested that the French market is correlated with the American market variations and that there is a transmission effect from Wall Street toward Paris. However, Wall Street can only amplify, reduce, initiate movements and delay the tendencies of the French market; it cannot determine them. Thus, both stock markets are neither completely integrated nor segmented: they are partially integrated. In fact, Gourinchas and Gurgand (1990) established that both indexes have parallel movements and similar tendencies but the French stock market does not systematically nor exactly reflect the American one. They justified this result by the presence of information and transaction costs and currency risk.

However, these results are henceforth questionable because the reduction of transaction costs over the last few years can justify a progressive integration between these markets. Furthermore, the use of new information and communication technologies and the recent fusion of NYSE and Euronext supports the hypothesis of financial integration between American and French markets. To check this hypothesis, we focused on the study of the integration between these markets within a nonlinear framework. The nonlinearity is useful to reproduce the persistence characterizing stock market convergence and the integration dynamic. The next section presents our framework.

NONLINEAR ERROR CORRECTION MODELS

This section presents the nonlinear tools that we used to check the integration hypothesis between the American and French stock markets. First, we present the definition of the NECM as given by the theorem of Escribano and Mira (1998). Second, we describe the nonlinear modeling of these models.

The Nonlinear Error Correction Model Representation: Theorem of Escribano and Mira (1998)

We develop this representation according to Escribano and Mira (1998) and Dufrénot and Mignon (2002). Consider two sets of I(1) variables: an endogenous variable y_t and a vector X_t of K explanatory variables. A NECM is written as follows:

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

Where: γ'_i and δ'_j are vectors of parameters, ρ is the adjustment term, z_t is the residual term of the linear cointegration relationship. It is assumed that: μ_t and ν_t are mixing processes with finite second-order moments and cross-moments; f is a nonlinear function that is continuously differentiable and that satisfies some regularity conditions: $-2 < \frac{\partial f(zt-1,\gamma)}{\partial z_{t-1}} < 0$, the roots of $\left|1 - \sum_{i=1}^{p} \delta'_j L^P\right| = 0$, all lie outside the unit circle. 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 $(1, -\beta')$. The NED assumption can be tested in the same way as the mixing hypothesis (Dufrénot and Mignon, 2002).

In order to check the integration in a nonlinear framework, we first test the mixing hypothesis. To do so, we use two tests: a nonparametric test given by the KPSS test and a parametric test defined by Lo (1991). Secondly, we reproduce the potential integration process using two particular classes of NECM's: the ESTECM (equation (2)) and the NECM-RP (equation (3)):

$$\Delta y_t = \alpha_0 + \rho_1 z_{t-1} + \sum_{i=0}^{q} \gamma_i \Delta x_{t-i} + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + (\rho_2 z_{t-1} + \sum_{i=0}^{q} \gamma'_i \Delta x_{t-i} + \sum_{j=1}^{p} \delta'_j \Delta y_{t-j}) \times \left[1 - \exp\left\{-\gamma (z_{t-1} - c)^2\right\}\right] + \mu_t \qquad (2)$$

Using NECM's helps study the integration hypothesis in the short- and long-term, while the ESTECM allows gradual reproduction and smooth changes in the integration process, during the successive periods of stock price under- and overvaluation. It also helps detect temporal paths governed by smooth changing regimes and accounts for a slow adjustment mechanism. This modeling was used in several empirical studies to model the asymmetries in the misalignment dynamics of the financial assets (a, b, c and d are the parameters of the rational polynomial function).

$$\Delta y_t = \alpha_0 + \rho_1 z_{t-1} + \sum_{i=0}^{q} \gamma_i \Delta x_{t-i} + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + (\rho_2 + \sum_{i=0}^{q} \gamma'_i \Delta x_{t-i} + \sum_{j=1}^{p} \delta'_j \Delta y_{t-j}) \times \frac{(z_{t-1} + a)^3 + b}{(z_{t-1} + c)^2 + d} + \mu_t \qquad (3)$$

The NECM-RP is more general because this modeling is a useful parametric approximation to unknown function forms. Indeed, as suggested by Chaouachi *et al.* (2004), this modeling 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-term attractors, etc.). In addition, the NECM-RP can highlight asymmetric dynamics between the overvaluation and undervaluation regimes and allows these asymmetric dynamics to be modeled in a more flexible way than with the ESTECM.

Nonlinear modeling for Stock Market Integration

We propose to check the integration between the American and French stock markets using NECM that not only allow us to test stock market integration while taking into account the persistence and the asymmetry characterizing stock price dynamics, but also to specify the integration process per regime. Furthermore, the comovements among various national stock markets may well take nonlinear forms, and a lot more evidence of stock market integration can emerge from nonlinear cointegration analysis than

from linear cointegration analysis. This empirical investigation will involve several tests. To begin with, we apply the usual unit root tests (Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests) to check the integration order of stock price series. Second, by applying two tests - the KPSS test and *R/S* test - on the residual term ($\hat{z}_t$), we check the mixing hypothesis in order to verify the nonlinear cointegration hypothesis. Third, accepting the mixing hypothesis implies that stock prices are nonlinearly mean-reverting and allows the NECM to be estimated by the Nonlinear Least Squares (NLS) method. These estimations are useful for reproducing the dynamics of the market integration process.

DATA AND EMPIRICAL RESULTS

Data and Preliminary Tests

Our empirical study concerns the daily American and French stock indexes (CAC40 and Dow Jones) over the period of January 1st 1988 – September 28th 2007. Using daily data provides us with enough observations for nonlinear modeling. Both indexes are expressed in US dollars so as to have homogenous data and to take currency risk into account. This stock price data was obtained from DATASTREAM while the exchange rate series were obtained from the Federal Reserve Bank of St. Louis. The indexes are transformed in logarithm.

First, both ADF and PP tests show that the CAC40 and Dow Jones are I(1). Second, we estimated a static regression modeling the CAC40 on a constant before estimating the Dow Jones and applying usual linear cointegration tests (ADF). Table 1 shows the results.

By comparing the linear cointegration statistic with the critical value of Engle and Yoo (1987), we rejected the hypothesis of linear cointegration. This implies that the American and French stock markets are segmented. However, it is important to be careful when analyzing this result as the rejection of linear cointegration hypothesis can be explained differently: misspecification, low power of linear cointegration tests, etc. In order to remedy these limits, we proposed to check the cointegration hypothesis within a nonlinear framework using "mixing" tests. Accepting the nonlinear cointegration hypothesis implies that the CAC40 is nonlinearly mean-reverting toward the Dow Jones and that both stock markets are nonlinearly integrated.

Table 1: Linear Cointegration and Mixing Tests

		Coefficients (t-statistic)
Constant		1.12 (37.87)
Dow Jones		0.79 (235.3)
$\overline{R}^2$		0.91
Linear Cointegration test: ADF		-2.32
Mixing Tests		
KPSS		**R/S**
l_4	l_{12}	**Andrews**
0.44	**0.26**	2.4*

This table presents the estimation results of the long-run relationship and those of the linear cointegration tests. It also gives the results of the nonlinear cointegration tests. The values between brackets are the t-ratio. (*) denotes the rejection of the null hypothesis at the 5% significance level.

Third, we applied, two "mixing" tests: the KPSS test and the *R/S* test. The first one is a nonparametric test, which tests the null hypothesis of "mixing" against its "non-mixing" alternative. The second one is a parametric test that tests the null hypothesis of null or short-range dependence (mixing) against its "non-mixing" or long-range dependence alternative. As far as the KPSS is concerned, we empirically retained

the values recommended 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 (Int [.] denotes the interior part). Concerning the choice of q for the *R/S* test, we used the value of Andrews (1991) corresponding 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.

Our mixing tests did not show the same conclusion insofar as the mixing hypothesis is rejected according to the test of Lo (1991), whereas the KPSS test accepted this hypothesis. In what follows, we retained the mixing hypothesis and preferred the KPSS test because it is a nonparametric one which is more powerful than the *R/S* test (parametric test). To check this mixing hypothesis and assess whether French and American stock prices are nonlinearly mean-reverting, two NECM - the ESTECM and the NECM-RP - will be examined in the next step.

ESTIMATION RESULTS OF NECM

The estimation of the NECM is done through the NLS method and the use of a nonlinear optimization program. We need to define initial values in order to start the nonlinear estimation. We proceed in many steps according to the methodology proposed by Escribano and Mira (1998) and developed by Van Dijk *et al.* (2002) to estimate the NECM. The results are presented in Table 2.

Several conclusions may be drawn from Table 2. First, for both models, the US parameters are statistically significant in the two regimes, showing the statistical dependence of the French stock market toward the American one. The AR parameters for the CAC40 are more significant in the first regime, indicating that the CAC40 depends on its past tendencies while it becomes more correlated to the actual and previous American stock price variations in the second regime.

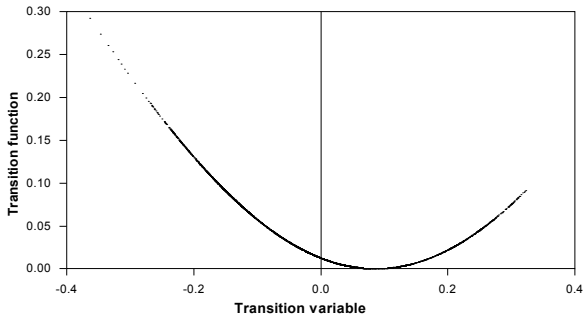
Second, for the ESTECM, γ and c are also statistically significant validating the choice of this nonlinear representation. The estimated value for γ is low, thus confirming the slowness in the transition between regimes. More interestingly, the estimation of the nonlinear adjustment terms (ρ_1 and ρ_2) shows an important result and feature which had also been pointed out by several previous empirical studies (Michael *et al.,* 1997; Peel and Taylor, 2000). Indeed, ρ_1 is negative but non significant and ρ_2 is negative and statistically significant at 5%. In addition, the sum ($\rho_1 + \rho_2$) is negative, implying a significant nonlinear error correction adjustment dynamic for the French index and showing a nonlinear integration process between the Paris and New York stock markets. This also indicates that in the first regime, while the French deviations are small, the CAC40 cannot follow the Dow Jones fluctuations and both markets are rather segmented. By contrast, in the second regime, while French stock price deviations are large, a nonlinear integration process will be active and its convergence speed will increase with the stock price deviation size, as it is shown in Figure 1. This figure also shows that the estimated function did not exceed 30%, reflecting the persistence, asymmetry and smoothness associated with the stock price adjustment dynamic. Applying the misspecification tests, we showed that the residuals of ESTECM are mixing and stationary.

Table 2: NECM Estimation Results

Coefficients	ESTECM (3,1)	NECM-RP
α_0	-0.0048 (-0.01)	-0.0009 (-0.42)
ρ_1	-0.0052 (-0.62)	-0.026 (-1.43)
ρ_2	-0.0024* (-2.27)	0.011 (1.25)
δ_1	0.0768* (2.72)	0.4973* (2.25)
δ_2	-0.0335 (-1.27)	-0.0624 (-0.30)
δ_3	0.0779* (2.88)	-0.3131 (-1.51)
γ_0	0.3604* (8.48)	1.372* (4.67)
γ_1	0.3746* (9.95)	1.507* (4.73)
α'_0	0.0003 (0.34)	0.0021 (0.27)
δ'_1	-0.0513 (-1.36)	0.1961** (1.77)
δ'_2	-0.0041 (-0.12)	0.0140 (0.13)
δ'_3	0.0619** (1.76)	0.139 (1.33)
γ'_0	0.2363* (4.75)	-0.436* (-2.94)
γ'_1	0.0658 (1.27)	-0.5505* (-3.43)
γ	1.707* (1.98)	-
C	0.0856* (5.94)	-
ADF^{GLS}	-50.64	-35.13

This table reproduces the estimation results of the two NECM. The second column presents the estimation results of the ESTECM whereas the estimation results of the NECM-RP are given in the third column. The values in brackets are the t-statistic of nonlinear estimators. (*) and (**) denote significance respectively at 5% and 10%.

Figure 1: Exponential Transition Function

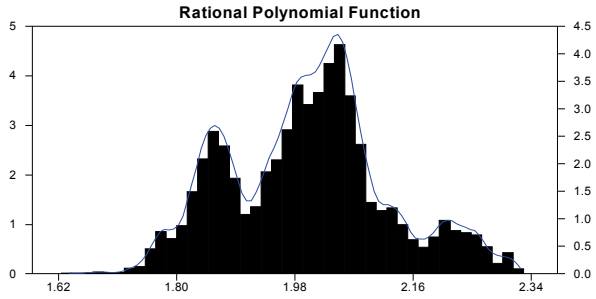


This figure reproduces the graph of the exponential transition function which describes the transition between the central and upper regimes.

Third, in order to simplify convergence of the algorithm, we estimated the NECM-RP under the following restrictions: a = c = d =1 and b = 0 as in [Chaouachi *et al.* (2004)]. The estimation results show a significant correlation between American and French indexes. The analysis of the histogram of the rational polynomial function (figure 2) which is plotted in function of the estimated misalignment values ($\hat{z}_{t-1}$) shows that the NECM-RP has captured the asymmetry in the integration process between American and French stock markets. Indeed, it shows a bimodal density with two modes of unequal heights. The coexistence of these unequal modes reflects the important and extreme stock price deviations between the regimes of segmentation and integration. This asymmetry in the distribution of

the rational polynomial function shows the persistence and the smoothness in the integration process between the Paris and New York stock markets. It also indicates the presence of an integration process which is activated by regime, varying over time and increasing, particularly if integration was observed in the preceding phase.

Figure 2: Histogram of the Rational Polynomial Function



This figure reproduces the graph of the rational polynomial function that characterizes the NECM-RP.

CONCLUSION

The main contribution of this article is to study the stock market integration between France and the United States of America within a nonlinear framework and to specify the integration dynamic process using nonlinear cointegration tools. The estimation results indicated a nonlinear financial integration between Paris and NYSE and established that the CAC40 and Dow Jones are nonlinearly mean-reverting. They also showed that the ESTECM and NECM-RP could respectively reproduce the slow convergence in the integration process and capture the asymmetry and the persistence associated with the nonlinear dynamic integration between France and the United States of America. However, this study was limited to two developed countries: France and the United States, and limited to two kinds of nonlinearity. Therefore, one possible extension would be to check the integration process for other markets belonging to the group of the G8 countries, and also check the integration hypothesis for emerging stock markets. It would also be interesting to test the integration hypothesis between stock markets while looking for other kinds of nonlinearity and modeling. Alternatively, our methodology may be used to check for nonlinear integration using microeconomic data from smaller sectors and firms.

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