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Financial Integration of the European, North America, Asiatic and Japanese stock markets from 2003 to present times

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Abstract We apply an integration/segmentation analysis between the European (EU) market and the North America stock market (US and Canada), the Asian Stock Market (AS) and the Japanese (JP) market. The analysis is carried out from 2003 until the present time. We apply the Jorion and Schwartz (1986) methodology and extend the work of Brooks et al. (2009) using a simpler Capital Asset Price Model (CAPM) and the Market return downloaded from the Fama French website for the time period analysed. Our results in this empirical study show integration between the European portfolios and the US stock market and the Asian Portfolios and the US stock market in the full time period analysed. Although the methods applied in this paper have been already introduced in the literature, this is the first time that they are applied systematically to compare the integration and segmentation between different economies and a given portfolio set. This systematic approach helps to establish the conclusiveness of their forecasts.

Keywords: integration, segmentation

JEL Classifications: F40, N10, O11

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I. Introduction

In recent times, China has started to rival the US financial and global hegemony. Asia with its undiscussed primate in population and the emerging strength of its youth majority is rivalling the cultural and strategic leadership of the old Europe (Bergsten, 2021). This new world frameset together with the rise of globalisation and financial market liberalisation increases the interest for developing a methodology that can show the integration and segmentation of different global economies.

CAPM has been the prevalent method for analysing economies integration. As noted by Brooks et al. (2009), a world market portfolio that is mean variance efficient in a global integrated market should show that assets of different geographic areas with the same sensitivities to

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the world market portfolio will be traded at similar prices, irrespective of their physical location (Solnik, 1977; Stulz, 1984; Jorion and Schwartz, 1986).

In this work, we use the North American, European, Asian and Japanese Fama French market returns published on the Fama website for running a CAPM integration and segmentation analysis according to the work of Jorion and Schwartz (1986) and Brooks et al. (2009).

First, we use six EU portfolios grouped on size and book to market to perform a multiple equation non-linear regression against the North America, Asian Pacific, and Japanese market factors. Then, given the importance of the US economy in the international financial market, we perform the non-linear regression of European, Asian and Japanese of six size and book to market portfolios against the North America market factors. Finally, we also use the European economy as global market, and we run the regression of North America, Asian and Japanese of six size and book to market portfolios against the European market factors.

For verifying the results, different techniques have been used (Maximum Likelihood Estimation (MLE), Non Linear Seemingly Unrelated Regression (NSUR) and the General Method of Moments (GMM)). Although different software packages (MATLAB, R, AMPL, Excel) were used to verify the results, all the calculations shown in this article were run in SAS.

The data downloaded from the Fama French website are all reported in US dollars, therefore there is no need for the currency conversion of the return to price the exchange rate risk (Glück and Hübel, 2020).

The reference work for this article is the paper of Jorion and Schwartz (1986), which shows a method to characterise stock markets on the basis of their integration or segmentation. Schwartz's article starts from the work of Stehle (1977), replacing the Fama McBeth time series cross sectional approach with maximum likelihood. Brooks et al. applied the Fama French (FF) three-factor model; the method described by Schwartz for the Capital Asset Price model (CAPM). We show the integration/segmentation methods applied to CAPM's equations. The extension to the three factor FF model is straightforward. In this paper, we:

1. Build two competing models for asset pricing: the integrated and the segmented model. This requires the orthogonalization of the local factors: orthogonal projections are taken when building the integrated model because the local factors can be some non-significant proportion of the international factors.
2. Use the Non-Linear Seemingly Unrelated Regression NSUR (Zellner, 1962) to estimate the parameters of the equations defined in the first step: if the errors are normally distributed the NSUR estimator is also a maximum likelihood estimator[1].
3. Use the Maximum Likelihood Estimation MLE (Wilks, 1938) to estimate the model parameters.

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1) The R package *systemfit* is able to fit a set of structural (non-)linear equations using Ordinary Least Squares (OLS), Seemingly Unrelated Regression (SUR), Two-Stage Least Squares (2SLS), Three-Stage Least Squares (3SLS), Non-Linear Seemingly Unrelated Regression (NSUR).

4. Apply the Generalised Method of Moments GMM (Mac Kinlay, 1991) to verify the integration or segmentation of the markets, relaxing the assumption of normalization of the assets returns.

II. Methodology

The methods described by Schwartz and further extended by Brooks help us to study the integration between the EU and the US, AS, and JP stock markets, using an extension of the Capital Asset Price model. Our model contains a set of linear equations which seem at first sight uncorrelated but their error terms are assumed to be correlated. Initially for the CAPM model, we test the integration/segmentation of the Market returns between the selected stock markets for the full time range 2003-2023. First, we test if the local EU market is integrated or segmented with all the other markets. In a further step we repeat this analysis, using global portfolio against the US Market. In this case we obtain the most interesting results, therefore, we run the same analysis using two different time periods (the range 2003-2023 is split in two equal subranges). The split into two equal periods was chosen without any special criteria but with the expectation to find a higher integration in the second period, due to the general increase of the world globalisation in the last decade.

Notation: the equation refers to the CAPM integration model between the EU (local market) and US (global market), the extension to the three factor model and to the other markets is straightforward and not shown in this article.

Geographic market type: Europe (EU), the local market; North America (US), Asia (AS) and Japan (JP), the global markets. For this example, we use US as the Global market and EU as the Local market.

i = 1…6 number of the local portfolios, in this example we used six EU portfolios built by Fama and French using the size (Market Capitalization) and the value (Book to Market) as group criteria.

RF_t = risk free rate at time t: the US zero coupon bond rate time series given by Fama French

$R^*_{i,t}$ = random return of the local portfolio i at time t

$R_{i,t}$ = excess random return of the local portfolio i at time t, i.e. $R_{i,t} = R^*_{i,t} - RF_t$

$E(R_{i,t})$ = expected excess return of the of the local portfolio i at time t

$R^*_{US,t}$ = US Global market return at time t

$R_{US,t}$ = US excess Global market return at time t, i.e. $R_{US,t} = R^*_{US,t} - RF_t$

$R^*_{EU,t}$ = EU Local market return at time t

$R_{EU,t}$ = EU excess Local market return at time t, i.e. $R_{EU,t} = R^*_{EU,t} - RF_t$

β_i^{US}= the integration factor related to the US Global Market returns for portfolio i

λ_{US} = US Global Market risk premium in the integration model

λ_{EU} = EU Local Market risk premium in the integration model

μ_{it} = the integration model estimation error for the excess returns of the local portfolio i time t

α_i^{EU}= the segmentation factor related to the EU Local Market returns for portfolio i

δ_{EU} = EU Local Market risk premium in the segmentation model

δ_{US} = US Global Market risk premium in the segmentation model

ϵ_{it} = the segmentation model estimation error for the excess returns of the local portfolio i time t

The capital asset price equation model can be written for a portfolio i and a reference market m as:

$$E(R_{i,t}) = b_i \, [E(R_{m,t})]$$

Its empirical counterpart is generally used for testing:

$$R_{i,t} = a_i + b_i R_{m,t} + \mu_{it}$$

Step 1: Build two competing models for asset pricing.

We show two similar approaches both based on the Capital Asset Price Model: Brooks et al. (2009) and Jorion and Schwartz (1986).

A. Brooks et al.

(a) The integrated model. If the European and US markets are integrated, the only priced factor for an EU stock is the US market return. Hence, the returns on an EU stock-based portfolio i are determined by the empirical CAPM equation below:

$$R_{i,t} = E(R_{i,t}) + \beta_i^{US} R_{US,t} + \mu_{it} \tag{1 a}$$

where $R_{i,t}$ is the excess random return of the local (EU) portfolio i, $E(R_{i,t})$ is its expected value and the other parameters are:

- R_{US_t}, the US excess Global Market returns[2)]
- β_i^{US}, the unknown betas *market* parameters that we wish to estimate for each portfolio i.
- μ_{it}, the respective random error

Assuming no arbitrage opportunities and some additional conditions (Connor, 1984), the expected return on portfolio i can be written as:

$$E(R_{i,t}) = \lambda_0 + \lambda_{US}\,\beta_i^{US} \qquad (1\ b)$$

A non-zero λ_0 implies that the expected return on the zero-beta portfolio is the riskless rate plus a constant. Equation (1 b) is also called the beta representation of the asset price (Cochrane, 2000, page 99). In this equation the systematic risk, β_i^{EU} relative to the European portfolio, $R_{i,}$, does not contribute to the pricing of assets. On the other hand, Stehle exposed how integration cannot be tested by directly running a univariate regression on β_i^{EU}, being the returns on the European and Global market positively correlated (Bruner, 2008). For testing the integration of two competing models we build the enhanced model using the local and the global factors.

The collinearity issue between the EU and US market makes a multiple regression on the two factors inadequate as well. Instead, we build the orthogonal projections of the local and global market returns using the Graham - Schmidt process (Apostol, 1969).

Given two vectors u, v, we define below the projection operator $p_u(v)$ that projects the vector v orthogonally into the line traversed by vector u:

$$p_{\boldsymbol{u}}(\boldsymbol{v}) = \frac{\langle \boldsymbol{u}, \boldsymbol{v} \rangle}{\langle \boldsymbol{u}, \boldsymbol{u} \rangle}\,\boldsymbol{u}$$

where $\langle \boldsymbol{u}, \boldsymbol{v} \rangle$ is the inner product of the vectors. Then:

$$\boldsymbol{v}_{ort} = \boldsymbol{v} - p_{\boldsymbol{u}}(\boldsymbol{v}) \text{ and } \boldsymbol{u}_{ort} = \boldsymbol{u} - p_v(\boldsymbol{u})$$

Replacing u with R_{US_t} and v with R_{EU_t}, we define $R'_{EU,t}$ as the orthogonal local vector,

2) The US excess Global market return factor is downloaded from the Fama French website.

the fitted values obtained from the projections of $R_{EU,t}$ into the line crossed by the vector $R_{US,t}$, and we use it as a measure of the local factors, in the enhanced integration model:

$$E(R_{i,t}) = \lambda_0 + \lambda_{US}\ \beta_i^{US} + \lambda_{EU}\ \beta_i^{EU\perp US} \qquad (2)$$

where λ_{US} is the risk premia related to the global US market return , λ_{EU} is the risk premia related to the local EU market return and λ_0 is the intercept. Now, we can write the empirical CAPM equation for the integrated model:

$$R_{i,t} = E(R_{i,t}) + \beta_i^{US} R_{US,t} + \beta_i^{EU\perp US} R'_{EU,t} + \mu_{it} \qquad (3)$$

Replacing equation (2) in equation (3) we obtain the integrated version of the CAPM model:

$$R_{i,t} = \lambda_0 + \beta_i^{US}(R_{US,t} + \lambda_{US}) + \beta_i^{EU\perp US}(R'_{EU,t} + \lambda_{EU}) + \mu_{it} \qquad (4)$$

In order to prove the complete integration hypothesis, the domestic market risk premiums λ_{EU} should be significantly equal to zero, while the global factor λ_{US} should be different from zero for partial integration.

(b) The segmented model is built in a similar way and we get the following equation:

$$R_{i,t} = \delta_0 + \alpha_i^{EU}\ (R_{EU,t} + \delta_{EU}) + \alpha_i^{US\perp EU}\ (R'_{US,t} + \delta_{US}) + \epsilon_{it} \qquad (5)$$

In order to prove the complete segmentation hypothesis, the global market risk premiums δ_{US} should be significantly equal to zero, while the local factor δ_{EU} should be different from zero for partial segmentation.

B. Jorion and schwartz

For this model, we can write equation (1 a) as:

$$R_{i,t} = E(R_{i,t}) + \beta_i^{EU}(R_{US,t} - E(R_{US,t})) + \mu_{it} \qquad (1^* \text{ a})$$

Equation (3) can then be written as:

$$R_{i,t} = E(R_{i,t}) + \beta_i^{US}(R_{US,t} - E(R_{US,t})) + \beta_i^{EU\perp US} R'_{EU_t} + \mu_{it} \qquad (3^*)$$

Replacing equation (2) in equation (3) we obtain the integrated version of the CAPM model:

$$R_{i,t} = \lambda_0 + \beta_i^{US}(R_{US,t} - E(R_{US,t}) + \lambda_{US}) + \beta_i^{EU\perp US}(R'_{EU_t} + \lambda_{EU}) + \mu_{it} \quad (4^* \text{ a})$$

We note that the CAPM implies the restriction, λ_{US} = E($R_{US,t}$) - λ_0 and write

$$R_{i,t} = \lambda_0(1 - \beta_i^{US}) + \beta_i^{US} R_{US,t} + \beta_i^{EU\perp US}(R'_{EU_t} + \lambda_{EU}) + \mu_{it} \quad (4^* \text{ b})$$

The segmented model is built in a similar way and we get the following equation:

$$R_{i,t} = \delta_0(1 - \alpha_i^{EU}) + \alpha_i^{EU} R_{EU,t} + \alpha_i^{US\perp EU}(R'_{US_t} + \delta_{US}) + \epsilon_{it} \quad (5^*)$$

Step 2: parameters estimation is run using different methods: NSUR, MLE and GMM

a) the non-linear seemingly unrelated regression (NSUR) is used to estimate the parameter vector in equation (4).

We run the R package *systemfit* method NSUR (*nlsystemfit*) for the estimation and the SAS procedure model/sur. The NSUR regression uses the so called Feasible Generalized Least Squares (FGLS) method for the estimation. This class of estimator (GLS) has better properties than OLS with Non spherical errors (ϵ), i.e. with Heteroscedasticity:

$$E(\epsilon\epsilon') = \sigma^2(\Omega) \neq \sigma^2 I$$

Where Ω is a matrix, whose main diagonal elements are the scaled variances of errors and all other elements are the scaled covariances of errors. In case of homoscedastic (constant variance), the diagonal elements of Ω are 1, i.e., ω_{ii} = 1 for all i. While if the errors are uncorrelated, all non-diagonal elements of Ω are 0. Hence, for homoscedastic, uncorrelated errors, the covariance matrix is I.

b) the Maximum Likelihood Estimation (MLE) is used to estimate the model parameter of equations (3) and (4). For a linear model with Gaussian errors MLE and OLS are identical. However MLE requires that the distribution of the dependent variable will be specified (for example the Gaussian normal distribution). Provided that the distribution specification is correct, the MLE parameters estimated are consistent.

The following steps have been run in excel and in R. Equations are shown for the Brooks et al. model but can easily be extended to the Jorion and Schwartz one:

1. set arbitrary initial value of the parameters
2. calculate the likelihood from January 2003 to December 2022 (N=240):

$$likelihood = \prod_{t=1}^{N} f(R_{i,t})$$

using the Probability Density Function (PDF) of the normal distribution

$$f(R_{i,t}) = \frac{1}{s_i\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{m_{i,t}}{s_i}\right)^2}$$

Where for the integration model, the sample error ($m_{i,t}$) and the sample standard deviation (s_i) are defined below:

$$m_{i,t} = R_{i,t} - \left(\lambda_0 + \beta_i^{US}(R_{US,t} + \lambda_{US}) + \beta_i^{EU\perp US}\left(R'_{EU,t} + \lambda_{EU}\right)\right)$$

$$s_i = \sqrt{\frac{\sum (R_{i,t} - E(R_{i,t}))^2}{(n-1)}}$$

3. calculate the negative logarithmic of the likelihood (NLL= -log(likelihood))
4. use the solver to find the parameter that minimise the sum of the -log(likelihood)

c) the generalised method of moments (GMM) is used to verify the integration or segmentation of the markets.

We run the parameter vector estimation using the excel solver and the SAS procedure model gmm. We used the two steps GMM method. We show below the main steps of the algorithm for the case of the integration model.

We consider the random return of the local portfolio $R_{i,t}^*$ to be a weakly stationary ergodic stochastic process. A number of moment conditions should be specified for the model. These moment conditions are functions of the model parameters and the data, that is a vector function:

$$m(\theta) = g(R_{i,t}, \theta)$$

The moment condition expectation (E[ ]) is zero at the true parameter values, which are marked with $^{-}$ in the equation below:

$$E\left[m(\overline{\theta})\right] = \mathrm{E}[\mathrm{g}(R_{i,t},\overline{\theta})] = 0 \tag{6}$$

Furthermore the vector function $m(\theta)$ should not be zero for $\theta \neq \overline{\theta}$ otherwise the vector parameter θ is non-identifiable. The parameter vector is defined as:

$$\theta = \left(\lambda_0,\ \beta_i^{US},\ \beta_i^{EU\perp US},\ \lambda_{US}, \lambda_{EU}\right)$$

A natural choice for the moment conditions of the CAPM enhanced model is the error term of equation 3, which we can rewrite in the form of equation (7):

$$M_{i,t}(\overline{\theta}) = R_{i,t} - \left(\lambda_0 + \beta_i^{US}(R_{US,t} + \lambda_{US}) + \beta_i^{EU\perp US}(R'_{EU,t} + \lambda_{EU}\right) \tag{7}$$

Equation 7 defines the initial moments (of the model, while, the unit vector , the Global market return and the Local orthogonal factor, are the instruments, that we introduce as we have fifteen parameters and only six initial moments. The total number of moments is then composed of eighteen vectors $m_{k,t}\ with\ k = 1 \ldots 18$: given by the Hadamard product (identified by the symbol) between the vectors defined by equation 7 and the instruments (1_t, $R_{US,t}, R'_{EU,t}$): $M_{i,t}$, $M_{i,t} \circ R_{US,t}$, $M_{i,t} \circ R'_{EU,t}$

For each of the moments we calculate the expected value over t $[m_k]$; we replace the expected value with the empirical sample average $\widehat{m}_k$.

The GMM method minimizes a certain distance of the sample averages of the moment conditions; it can be seen as a special case of the minimum-distance estimation.

The properties of the subsequent estimator depend on the choice of the norm function: the GMM theory considers an entire family of norms, defined as:

$$\left\|\widehat{m}(\theta)\right\|_W^2 = \widehat{m}_k{}^T(\theta)\ \mathrm{W}^{-1}\widehat{m}_k(\theta)$$

with $\widehat{m}_k{}^T$ the transpose of $\widehat{m}_k$ and where W is a positive definite weighting matrix.

Finally, we define the estimator of the objective function as:

$$\hat{\theta} = \underset{\theta\epsilon\Theta}{\operatorname{argmin}}\ \widehat{m}_k{}^T(\theta)\, W^{-1}\ \widehat{m}_k\ (\theta)$$

In our case, in the first step we use the identity matrix I (18x18) as the initial weighting matrix to define the objective function Z as:

$$\text{Minimize } Z(\theta) \;=\; \widehat{m}_k{}^T(\theta)\; I\widehat{m}_k(\theta)$$

It means that all the moments will have the same weight in the first step.

We minimise the objective and calculate the equation parameters estimator vector $\hat{\theta}$ = $\left(\lambda_0,\ \beta_i^{US},\ \beta_i^{EU\perp US},\ \lambda_{US}, \lambda_{EU}\right)$. We use the vector $\hat{\theta}=1$ (2i+3) as the initial value of the parameters.

In the second step we used the so called Martingale Difference Sequence (MDS) method (Hamilton, Time Series Analysis, 1994) to improve our weighting matrix calculation. The weight matrix is now computed using the matrix product of the eighteen moments calculated using the parameters of step 1, $m_{k,t}\left(\hat{\theta}'\right)$ where $'$ denotes the first step.

$$W = \text{covarianceMDS} = \frac{m_{k,t}\left(\hat{\theta}'\right)^T \; m_{k,t}\left(\hat{\theta}'\right)}{N}$$

The second step objective function is now defined as:

$$\text{Minimize } Z(\theta) = \widehat{m}_k{}^T(\theta)\;\; W^{-1}\; \widehat{m}_k(\theta)$$

The second step parameters estimator $\hat{\theta}''$ of our models minimises this non-linear optimisation problem with the chosen GMM step tolerance (10^{-7}).

III. Empirical Findings of CAPM

A. Integration and segmentation (Full range 2003-2022)

For the test of market integration/segmentation, we used a set of six EU portfolios as dependent variables ($R_{i,t}$): with i=1…6 and t= 1…N (N=240). The EU portfolios returns were built using the size (Market Capitalization) and the value (Book to Market) as group criteria and were found in the Fama and French website. We refer to the original Fama French 2014 article for the details of the portfolio construction.

The independent variables of the integration model are the excess US "market" return time series ($R_{US,t}$) found in the Fama French website and the corresponding orthogonalized domestic return ($R'_{EU,t}$, calculated in R): equation 4. For the segmentation model, the independent variables are the excess EU market return time series ($R_{EU,t}$) and the corresponding orthogonalized North American return ($R'_{US,t}$, calculated in R): equation 5.

The main correlation tests were run for the time series and their results can be found in Appendix A. The difference in the results between the White and the Breusch-Pagan test is explained because, the Breusch-Pagan test only checks for the linear form of heteroskedasticity, $E(\epsilon\epsilon') = \sigma^2(\Omega) \neq \sigma^2 I$, while the White Test is more generic but it can be less efficient when the number of regressors increase. From the low P value for some portfolio, we can conclude that we have heteroskedasticity and it is worth using the NSUR and GMM methods over OLS.

Finally, the following definitions are provided to compare the results for the Brooks et al. model and the Jorion, Schwartz one:

Brooks et al.

- Total integration (also named complete integration in the article): the domestic market risk premium λ_{Local} should be significantly ($p<0.05$) equal to zero ($\lambda_{Local} \leq = 0.1$), while the global risk premium λ_{Global} should be significantly ($p<0.05$) different from zero ($\lambda_{Global}>0.1$)
- Partial integration: the global risk premium λ_{Global} should be significantly ($p<0.05$) different from zero ($\lambda_{Global}>0.1$)
- Total segmentation (also named complete segmentation in the article): the global market risk premium δ_{Global} should be significantly ($p<0.05$) equal to zero ($\delta_{Global} \leq = 0.1$), while the local risk premium δ_{Local} should be significantly ($p<0.05$) different from zero ($\delta_{Local}<0.1$)
- Partial segmentation: the local risk premium δ_{Local} should be significantly ($p<0.05$) different from zero ($\delta_{Local}>0.1$)

Our results show that partial integration and partial segmentation can be reported simultaneously as our model is not able to provide a cut off value for partial integration nor for partial segmentation. Thus, when these results are reported simultaneously, no conclusion can be withdrawn.

Jorion and Schwartz

- Total integration: the domestic market risk premium λ_{Local} should be significantly ($p<0.05$) equal to zero ($\lambda_{Local} \leq = 0.1$)
- Total segmentation (also named complete segmentation in the article): the global market risk premium δ_{Global} should be significantly ($p<0.05$) equal to zero ($\delta_{Global} \leq = 0.1$)

1. Results between EU portfolios and global markets

The calculations were done in SAS using: NSUR, MLE and GMM procedures.

In the regression, we use six European portfolios' returns grouped by size and book to market and the European, North America, Asian and Japanese Market factors. We use the following notation in the field "Area": "Global Market"_"Local Market/Local-Portfolio".

For example US_EU means a regression using as independent variables the US as global market and the EU as local market and as dependent variable the EU as local portfolio.

Table 1. *EU portfolios - global markets Integration Results: PI = Partial Integration; TI = Total Integration*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
US_EU	*NSUR*	λ_{US}	-1.955	0.0011	***	Significant and different from zero, which shows partial integration	PI
US_EU	*NSUR*	λ_{EU}	0.733	0.1539		It is not close to zero, nor it is significant to determine total integration	
US_EU	NSUR, JS	λ_{EU}	0.098	<.0001	***	It is close to zero and it is significant to determine total integration	TI
US_EU	MLE	λ_{US}	*-1.963*	*0.001*	***	Results match NSUR, partial integration	PI
US_EU	MLE	λ_{EU}	0.736	0.1908		Results match NSUR, there is no total integration	
US_EU	GMM	λ_{US}	-2.102	0.0015	***	Results match NSUR, partial integration	PI
US_EU	GMM	λ_{EU}	0.805	0.1214		Results match NSUR, there is no total integration	
AS_EU	NSUR	λ_{AS}	0.303	0.7844		However different from zero, it is not significant to determine partial integration	
AS_EU	NSUR	λ_{EU}	-1.20	0.0488	**	However significant, it is not close to zero to determine total integration	
AS_EU	NSUR, JS	λ_{EU}	-0.201	0.0277	**	However significant, it is not close to zero to determine total integration	
AS_EU	MLE	λ_{AS}	0.317	0.7797		Results match NSUR	
AS_EU	MLE	λ_{EU}	-1.223	0.0561		It is not close to zero, nor it is significant to determine total integration	
AS_EU	GMM	λ_{AS}	-1.758	0.0037	***	Significant and different from zero, which shows partial integration	PI
AS_EU	GMM	λ_{EU}	0.0327	0.89		It is not close to zero, nor it is significant to determine total integration	
JP_EU	NSUR	λ_{JP}	1.935	0.367		However different from zero, it is not significant to determine partial integration	
JP_EU	NSUR	λ_{EU}	-3.025	0.105		It is not close to zero, nor it is significant to determine total integration	
JP_EU	NSUR, JS	λ_{EU}	-0.176	0.028	**	However significant, it is not close to zero to determine total integration	

Table 1. *Continued*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
JP_EU	MLE	λ_{JP}	*2.014*	*0.362*		Results match NSUR	
JP_EU	MLE	λ_{EU}	-3.112	0.098		Results match NSUR	
JP_EU	GMM	λ_{JP}	-0.698	0.063		However different from zero, it is not significant to determine partial integration	
JP_EU	GMM	λ_{EU}	-0.7044	0.051		It is not close to zero, nor it is significant to determine total integration	

JS = Jorion Schwartz regression, otherwise Brooks et al.

In the Brooks et al. regression, partial integration can be inferred between EU and US with all the three methods employed. While GMM is showing partial integration for EU and Asia (non-normality might be the reason of GMM different results from MLE and NSUR).

In the Jorion, Schwartz regression, in order to prove the complete integration hypothesis, the domestic market risk premiums λ_{EU} should be significantly equal to zero. Total integration can only be inferred between EU and US. Regional market integration does not imply industry integration, as pointed out by Carrieri, Errunza, Sarkissian, 2004 article using their model of partial industry integration.

Table 2. *EU Portfolios - global markets Segmentation Results: PS = Partial Segmentation; TS = Total Segmentation*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
US_EU	NSUR	δ_{EU}	-1.30612	0.0137	***	Significant and different from zero, which shows partial segmentation	PS
US_EU	NSUR	δ_{US}	-0.99015	0.0364	**	However significant , it is not close to zero to determine total segmentation	
US_EU	NSUR, JS	δ_{US}	-2.53804	0.0023	***	However significant , it is not close to zero to determine segmentation	
US_EU	MLE	δ_{EU}	-1.31215	0.0171	***	Results match NSUR, partial segmentation	PS
US_EU	MLE	δ_{US}	-0.99509	0.0499	**	Results match NSUR, there is no total segmentation	
US_EU	GMM	δ_{EU}	-1.38766	0.0147	***	Results match NSUR, partial segmentation	PS
US_EU	GMM	δ_{US}	-1.07771	0.0275	**	Results match NSUR, there is no total segmentation	
AS_EU	NSUR	δ_{EU}	-0.95126	0.1119		However different from zero, it is not significant to determine partial segmentation	
AS_EU	NSUR	δ_{AS}	1.179854	0.1324		It is not close to zero, nor it is significant to determine total segmentation	
AS_EU	NSUR, JS	δ_{AS}	4.771625	0.026	**	However significant, it is not close to zero to determine segmentation	

Table 2. *Continued*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
AS_EU	MLE	δ_{EU}	-0.96213	0.1125		Results match NSUR	
AS_EU	MLE	δ_{AS}	1.204319	0.1408		Results match NSUR	
AS_EU	GMM	δ_{EU}	-1.41504	0.0151	**	Significant and different from zero, which shows partial segmentation	PS
AS_EU	GMM	δ_{AS}	-0.45286	0.0638		It is not close to zero, nor it is significant to determine total segmentation	
JP_EU	NSUR	δ_{EU}	-1.39745	0.0389	**	Significant and different from zero, which shows partial segmentation	PS
JP_EU	NSUR	δ_{JP}	2.705618	0.2083		It is not close to zero, nor it is significant to determine total segmentation	
JP_EU	NSUR, JS	δ_{JP}	35.90094	0.658		It is not close to zero, nor it is significant to determine segmentation	
JP_EU	MLE	δ_{EU}	-1.41824	0.0604		However different from zero, it is not significant	
JP_EU	MLE	δ_{JP}	2.790915	0.1999		Results match NSUR	
JP_EU	GMM	δ_{EU}	-1.29099	0.0147	***	Significant and different from zero, which shows partial segmentation	PS
JP_EU	GMM	δ_{JP}	0.00877	0.9719		It is not close to zero, nor it is significant to determine total segmentation	

JS = Jorion Schwartz regression, otherwise Brooks et al.

In the Brooks et al. regression, in order to prove the complete segmentation hypothesis, the global market risk premiums δ_{US} should be significantly equal to zero, while the local factor δ_{EU} should be different from zero for partial segmentation. From the NSUR, we can infer partial segmentation for the EU and US and the EU and Japan markets. While MLE shows partial segmentation only for the EU and US markets. Finally GMM shows partial segmentation for the three markets.

In the Jorion, Schwartz regression, in order to prove the complete segmentation hypothesis, the global market risk premiums δ_{US} should be significantly equal to zero. We cannot infer segmentation for any market of the analysis.

2. Results between global portfolios and US market

In the regression, we use six European, Asian and Japanese portfolios' returns divided by size and book to market and the North America Market factors: all data were downloaded from the Fama French website.

Table 3. *Global portfolios - US market Integration Results: PI = Partial Integration; TI = Total Integration*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
US_EU	*NSUR*	λ_{US}	-1.955	0.0011	***	Significant and different from zero, which shows partial integration	PI
US_EU	*NSUR*	λ_{EU}	0.733	0.1539		It is not close to zero, nor it is significant to determine total integration	
US_EU	NSUR, JS	λ_{EU}	0.098	<.0001	***	It is close to zero and it is significant to determine total integration	TI
US_EU	MLE	λ_{US}	*-1.963*	*0.001*	***	Results match NSUR, partial integration	PI
US_EU	MLE	λ_{EU}	0.736	0.1908		Results match NSUR, there is no total integration	
US_EU	GMM	λ_{US}	-2.102	0.0015	***	Results match NSUR, partial integration	PI
US_EU	GMM	λ_{EU}	0.805	0.1214		Results match NSUR, there is no total integration	
US_AS	NSUR	λ_{US}	-2.96858	<.0001	***	Significant and different from zero, which shows partial integration	PI
US_AS	NSUR	λ_{AS}	-0.19399	0.6332		It is not close to zero, nor it is significant to determine total integration	
US_AS	NSUR, JS	λ_{AS}	0.090469	<.0001	***	It is close to zero and it is significant to determine total integration	TI
US_AS	MLE	λ_{US}	-2.99614	<.0001	***	Results match NSUR, partial integration	PI
US_AS	MLE	λ_{AS}	-0.04773	0.8569		Results match NSUR, there is no total integration	
US_AS	GMM	λ_{US}	-3.03854	<.0001	***	Results match NSUR, partial integration	PI
US_AS	GMM	λ_{AS}	0.333464	0.3289		Results match NSUR, there is no total integration	
US_JP	NSUR	λ_{US}	-2.25431	0.0004	***	Significant and different from zero, which shows partial integration	PI
US_JP	NSUR	λ_{JP}	0.936342	0.2475		It is not close to zero, nor it is significant to determine total integration	
US_JP	NSUR, JS	λ_{JP}	-0.61	0.017	**	However significant, It is not close to zero to determine total integration	
US_JP	MLE	λ_{US}	-2.25431	0.0005	***	Results match NSUR, partial integration	PI
US_JP	MLE	λ_{JP}	0.936342	0.2888		Results match NSUR, there is no total integration	
US_JP	GMM	λ_{US}	-2.26443	0.0004	***	Results match NSUR, partial integration	PI
US_JP	GMM	λ_{JP}	0.936024	0.2393		Results match NSUR, there is no total integration	

JS = Jorion Schwartz regression, otherwise Brooks et al.

In the Brooks et al. regression, in order to prove the complete integration hypothesis, the domestic market risk premiums λ_{EU}, λ_{AS}, λ_{JP} should be significantly equal to zero, while the global factor λ_{US} should be different from zero for partial integration. Partial integration can be inferred between US and all the other global markets with all the three methods employed.

In the Jorion, Schwartz regression, in order to prove the complete integration hypothesis, the domestic market risk premiums λ_{EU}, λ_{AS}, λ_{JP} should be significantly equal to zero. Total Integration can be inferred for the US and EU and the US and Asian markets.

Table 4. *Global Portfolios - US market Segmentation Results: PS = Partial Segmentation; TS = Total Segmentation*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
US_EU	NSUR	δ_{EU}	-1.30612	0.0137	**	Significant and different from zero, which shows partial segmentation	PS
US_EU	NSUR	δ_{US}	-0.99015	0.0364	**	However significant , it is not close to zero to determine total segmentation	
US_EU	NSUR, JS	δ_{US}	-2.53804	0.0023	***	However significant , it is not close to zero to determine segmentation	
US_EU	MLE	δ_{EU}	-1.31215	0.0171	**	Results match NSUR, partial segmentation	PS
US_EU	MLE	δ_{US}	-0.99509	0.0499	**	Results match NSUR, there is no total segmentation	
US_EU	GMM	δ_{EU}	-1.38766	0.0147	**	Results match NSUR, partial segmentation	PS
US_EU	GMM	δ_{US}	-1.07771	0.0275	**	Results match NSUR, there is no total segmentation	
US_AS	NSUR	δ_{AS}	-2.91192	0.0010	***	Significant and different from zero, which shows partial segmentation	PS
US_AS	NSUR	δ_{US}	-1.08018	0.0647		It is not close to zero, nor it is significant to determine total segmentation	
US_AS	NSUR, JS	δ_{US}	-0.81352	0.1376		It is not close to zero, nor it is significant to determine total segmentation	
US_AS	MLE	δ_{AS}	-2.91192	0.0006	***	Results match NSUR	PS
US_AS	MLE	δ_{US}	-1.08018	0.0555		Results match NSUR	
US_AS	GMM	δ_{AS}	-2.98724	0.0025	***	Results match NSUR	PS
US_AS	GMM	δ_{US}	-1.0608	0.0876		Results match NSUR	
US_JP	NSUR	δ_{JP}	-0.45074	0.5578		Not significant, nor close to zero to determine partial segmentation	
US_JP	NSUR	δ_{US}	-1.95238	0.0101	**	However significant, it is not close to zero to determine total segmentation	
US_JP	NSUR, JS	δ_{US}	-1.3964	0.0306	**	However significant, it is not close to zero to determine total segmentation	
US_JP	MLE	δ_{JP}	-0.45074	0.5978		Results match NSUR	
US_JP	MLE	δ_{US}	-1.95238	0.0138	**	Results match NSUR	
US_JP	GMM	δ_{EU}	-0.45717	0.5405		Results match NSUR	
US_JP	GMM	δ_{JP}	-1.95839	0.0098	**	Results match NSUR	

JS = Jorion Schwartz regression, otherwise Brooks et al.

In the Brooks et al. regression, in order to prove the complete segmentation hypothesis, the global market risk premiums δ_{US} should be significantly equal to zero, while the local factors δ_{EU}, δ_{AS}, δ_{JP} should be different from zero for partial segmentation. The methods show partial segmentation for the EU and US with 5% confidence level and for the AS and US with 1% confidence level.

In the Jorion, Schwartz regression, in order to prove the complete segmentation hypothesis, the global market risk premiums δ_{US} should be significantly equal to zero. We cannot infer segmentation for any market of the analysis.

3. Results between global portfolios and EU market

In the regression, we use six North America, Asian and Japanese portfolios' returns divided by size and book to market and the European Market factors: all data were downloaded from the Fama French website.

Table 5. *Global portfolios - EU market Integration Results: PI = Partial Integration; TI = Total Integration*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
EU_US	*NSUR*	λ_{EU}	-3.26721	0.0056	***	Significant and different from zero, which shows partial integration	PI
EU_US	*NSUR*	λ_{US}	0.847967	0.8497		It is not close to zero, nor it is significant to determine total integration	
EU_US	NSUR, JS	λ_{US}	-0.26823	0.0346	**	However it is significant, it is not close to zero to determine total integration	
EU_US	MLE	λ_{EU}	-3.26721	0.0161	**	Results match NSUR, partial integration	PI
EU_US	MLE	λ_{US}	0.847967	0.1266		Results match NSUR, there is no total integration	
EU_US	GMM	λ_{EU}	-3.23643	0.0028	***	Results match NSUR, partial integration	PI
EU_US	GMM	λ_{US}	0.823894	0.1198		Results match NSUR, there is no total integration	
EU_AS	NSUR	λ_{EU}	-4.1449	0.0028	***	Significant and different from zero, which shows partial integration	PI
EU_AS	NSUR	λ_{AS}	0.216003	0.7722		It is not close to zero, nor it is significant to determine total integration	
EU_AS	NSUR, JS	λ_{AS}	-0.63805	<.0001	***	However it is significant, it is not close to zero to determine total integration	
EU_AS	MLE	λ_{EU}	-4.1449	0.0027	***	Results match NSUR, partial integration	PI
EU_AS	MLE	λ_{AS}	0.216003	0.7598		Results match NSUR, there is no total integration	
EU_AS	GMM	λ_{EU}	-4.17079	0.0046	***	Results match NSUR, partial integration	PI

Table 5. *Continued*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
EU_AS	GMM	λ_{AS}	0.221576	0.7858		Results match NSUR, there is no total integration	
EU_JP	NSUR	λ_{EU}	-2.72435	0.0035	***	Significant and different from zero, which shows partial integration	PI
EU_JP	NSUR	λ_{JP}	0.459643	0.4599		It is not close to zero, nor it is significant to determine total integration	
EU_JP	NSUR, JS	λ_{JP}	-0.24368	0.0099	***	However significant, It is not close to zero to determine total integration	
EU_JP	MLE	λ_{EU}	-2.72435	0.0037	***	Results match NSUR, partial integration	PI
EU_JP	MLE	λ_{JP}	0.459643	0.4864		Results match NSUR, there is no total integration	
EU_JP	GMM	λ_{EU}	-2.77255	0.0040	***	Results match NSUR, partial integration	PI
EU_JP	GMM	λ_{JP}	0.501154	0.4375		Results match NSUR, there is no total integration	

JS = Jorion Schwartz regression, otherwise Brooks et al.

In the Brooks et al. regression, partial integration can be inferred between EU and all the other global markets with all the three methods employed.

In the Jorion, Schwartz regression, in order to prove the complete integration hypothesis, the domestic market risk premiums λ_{US}, λ_{AS}, λ_{JP} should be significantly equal to zero. The results are not significant.

Table 6. *Global portfolios - EU market Segmentation Results: PS = Partial Segmentation; TS = Total Segmentation*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
EU_US	NSUR	δ_{US}	-1.56449	0.0142	**	Significant and different from zero, which shows partial segmentation	PS
EU_US	NSUR	δ_{EU}	-1.63534	0.0357	**	However significant , it is not close to zero to determine total segmentation	
EU_US	NSUR, JS	δ_{EU}	-2.54458	0.0167	**	However significant , it is not close to zero to determine segmentation	
EU_US	MLE	δ_{US}	-1.56449	0.0342	**	Results match NSUR, partial segmentation	PS
EU_US	MLE	δ_{EU}	-1.63534	0.0475	**	Results match NSUR, there is no total segmentation	
EU_US	GMM	δ_{US}	-1.56581	0.0083	***	Results match NSUR, partial segmentation	PS
EU_US	GMM	δ_{EU}	-1.6033	0.0309	**	Results match NSUR, there is no total segmentation	

Table 6. *Continued*

Area	Method	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
EU_AS	NSUR	δ_{AS}	-3.60795	0.0003	***	Significant and different from zero, which shows partial segmentation	PS
EU_AS	NSUR	δ_{EU}	-1.17305	0.1748		It is not close to zero, nor it is significant to determine total segmentation	
EU_AS	NSUR, JS	δ_{AS}	-1.16304	0.1835		It is not close to zero, nor it is significant to determine total segmentation	
EU_AS	MLE	δ_{AS}	-3.60795	0.0002	***	Results match NSUR	PS
EU_AS	MLE	δ_{EU}	-1.17305	0.1620		Results match NSUR	
EU_AS	GMM	δ_{AS}	-3.62568	0.0009	***	Results match NSUR	PS
EU_AS	GMM	δ_{EU}	-1.1853	0.2009		Results match NSUR	
EU_JP	NSUR	δ_{JP}	-1.03136	0.1198		Not significant, nor close to zero to determine partial segmentation	
EU_JP	NSUR	δ_{EU}	-1.85612	0.0264	**	However significant, it is not close to zero to determine total segmentation	
EU_JP	NSUR, JS	δ_{JP}	-1.59095	0.0460	**	However significant, it is not close to zero to determine total segmentation	
EU_JP	MLE	δ_{JP}	-1.03136	0.1530		Results match NSUR	
EU_JP	MLE	δ_{EU}	-1.85612	0.0280	**	Results match NSUR	
EU_JP	GMM	δ_{JP}	-1.01628	0.1245		Results match NSUR	
EU_JP	GMM	δ_{EU}	-1.91771	0.0297	**	Results match NSUR	

JS = Jorion Schwartz regression, otherwise Brooks et al.

In the Brooks et al. regression, the methods show partial segmentation for the US and EU with 5% confidence level and for the AS and EU with 1% confidence level.

In the Jorion, Schwartz regression, in order to prove the complete segmentation hypothesis, the global market risk premiums δ_{EU} should be significantly equal to zero. We cannot infer segmentation for any market of the analysis.

B. Time period analysis using US as global market

The integration results are similar for both the full time period analysis and the partial time period analysis for EU portfolios and the US market, and the AS portfolios and US market. The expectation to find a higher integration in the second period, due to the general increase of the world globalisation in the last decade, is met for Asia portfolio and the US market.

Table 7. *Global portfolios - US market Time Period Integration Results: PI = Partial Integration; TI = Total Integration*

Area	Period	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
US_EU	03-12	λ_{US}	-2.437	0.048	**	Significant and different from zero, which shows partial integration	PI
US_EU	03-12	λ_{EU}	2.526	0.11		It is not close to zero, nor it is significant to determine total integration	
US_EU (JS)	03-12	λ_{EU}	0.08453	0.0004	***	It is close to zero and it is significant to determine total integration	TI
US_EU	13-22	λ_{US}	-1.77	0.028	**	Significant and different from zero, which shows partial integration	PI
US_EU	13-22	λ_{EU}	0.11	0.839		It is not close to zero, nor it is significant to determine total integration	
US_EU (JS)	13-22	λ_{EU}	0.097537	0.0046	***	It is close to zero and it is significant to determine total integration	TI
US_AS	03-12	λ_{US}	-5.04391	0.0146	**	Not Significant however different from zero	PI
US_AS	03-12	λ_{AS}	-0.25633	0.7229		It is not close to zero, nor it is significant to determine total integration	
US_AS (JS)	03-12	λ_{AS}	0.153502	0.0042	***	However significant, it is not close to zero to determine segmentation	
US_AS	13-22	λ_{US}	-2.30238	0.0003	***	Not Significant however different from zero	PI
US_AS	13-22	λ_{AS}	1.472129	0.0877		It is not close to zero, nor it is significant to determine total integration	
US_AS (JS)	13-22	λ_{AS}	0.061847	0.0071	***	It is close to zero and it is significant to determine total integration	TI
US_JP	03-12	λ_{US}	-3.68165	0.0050	***	Significant and different from zero, which shows partial integration	PI
US_JP	03-12	λ_{JP}	1.801053	0.2350		It is not close to zero, nor it is significant to determine total integration	
US_JP (JS)	03-12	λ_{JP}	-1.20715	0.0007	***	However significant, it is not close to zero to determine segmentation	
US_JP	13-22	λ_{US}	-1.18331	0.2792		Not Significant however different from zero	
US_JP	13-22	λ_{JP}	-1.32509	0.3752		It is not close to zero, nor it is significant to determine total integration	
US_JP (JS)	13-22	λ_{JP}	-0.07333	0.6934		However It is close to zero, it is not significant	

Table 8. *Global Portfolios - US market Time Period Segmentation Results: PS = Partial Segmentation; TS = Total Segmentation*

Area	Period	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
US_EU	03-12	δ_{EU}	-0.015	0.988		Not Significant nor different from zero	

Table 8. *Continued*

Area	Period	Parameter	Estimate	Pr > |t|	Significant 5% ** 1% ***	Comments	Results
US_EU	03-12	δ_{US}	-2.425	0.08		It is not close to zero, nor it is significant to determine total segmentation	
US_EU (JS)	03-12	δ_{US}	-7.66114	0.1946		It is not close to zero, nor it is significant to determine total segmentation	
US_EU	13-22	δ_{EU}	-1.46	0.0629		Not Significant however different from zero	
US_EU	13-22	δ_{US}	-0.58	0.278		It is not close to zero, nor it is significant to determine total segmentation	
US_EU (JS)	13-22	δ_{US}	-0.13844	0.8007		It is not close to zero, nor it is significant to determine total segmentation	
US_AS	03-12	δ_{AS}	-5.43021	0.0031	***	Significant and different from zero, which shows partial segmentation	PS
US_AS	03-12	δ_{US}	-1.52825	0.1354		It is not close to zero, nor it is significant to determine total segmentation	
US_AS (JS)	03-12	δ_{US}	-1.75803	0.1058		It is not close to zero, nor it is significant to determine total segmentation	
US_AS	13-22	δ_{AS}	-0.88836	0.3265		Not Significant however different from zero	
US_AS	13-22	δ_{US}	-1.72687	0.0087	***	However significant, it is not close to zero to determine segmentation	
US_AS (JS)	13-22	δ_{AS}	-1.42996	0.0188	**	However significant, it is not close to zero to determine segmentation	
US_JP	03-12	δ_{US}	-1.43107	0.2521		Not Significant however different from zero	
US_JP	03-12	δ_{JP}	-2.43302	0.0123	**	However significant, it is not close to zero to determine segmentation	
US_JP (JS)	03-12	δ_{US}	-1.63221	0.0152	**	However significant, it is not close to zero to determine segmentation	
US_JP	13-22	δ_{US}	-0.09127	0.8664		Not Significant nor different from zero	
US_JP	13-22	δ_{JP}	-0.57524	0.5148		It is not close to zero, nor it is significant to determine total segmentation	
US_JP (JS)	13-22	δ_{US}	-1.53034	0.0858		It is not close to zero, nor it is significant to determine total segmentation	

The segmentation results are not significant for the time period analysis.

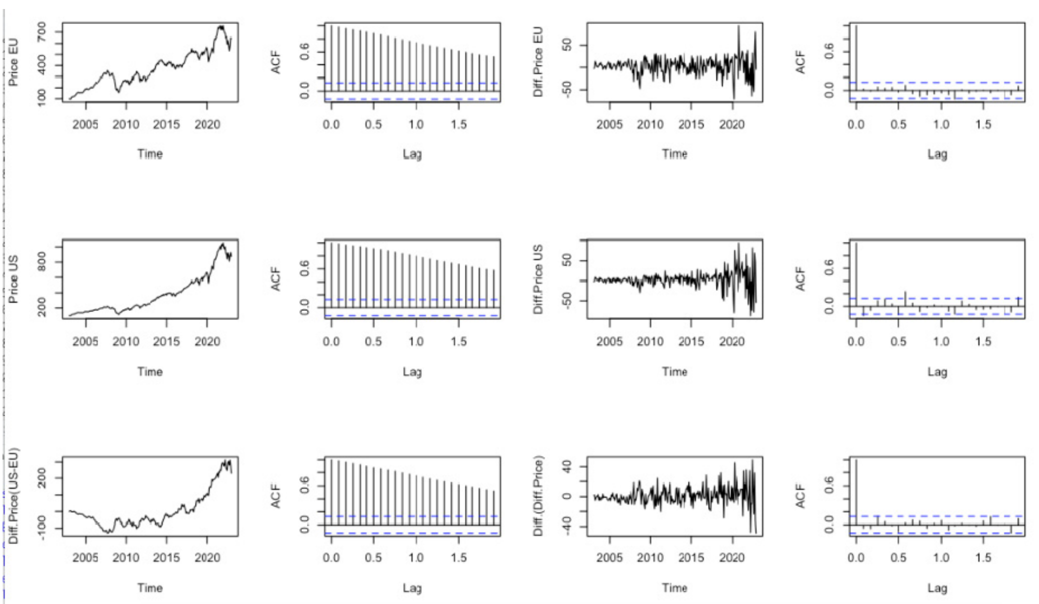
C. Cointegration analysis

We can think of the European and American stock markets as a pair trade, and check if we can use a mean reverting pair trade strategy to invest in them. A pair trade is generally responding in the same way to general market movements (for example the change of the interest rate), while specific circumstances that adversely affect only one market will be the driver for short-long trade which will become profitable as long as the specific circumstances change and equilibrium is reached again. For example, during the 2007-2008 Bank Crisis in the US it would have been wise to short the US market and be long with the EU market, while during the further EU debt crisis in 2011-2012 we should have reversed this position. In a future contribution we may consider extending to Asia, Europe and Japan the business cycle integration and segmentation model proposed for Australia and US by Ragunathan et al. 1999, and simultaneously applying a portfolio pair trade investment strategy.

The results of our integrated model between the European Market and the North American show total integration in the full time range. A pair trade mean reverting strategy of these two markets is a linear combination of the two assets. For the pair trade to be successful, we have to verify the cointegration of the time series components (Huck and Afawubo, 2015 and Granger, 1981). This is equivalent to check the stationarity of the asset strategy: the linear combination of the two assets has to be stationary.

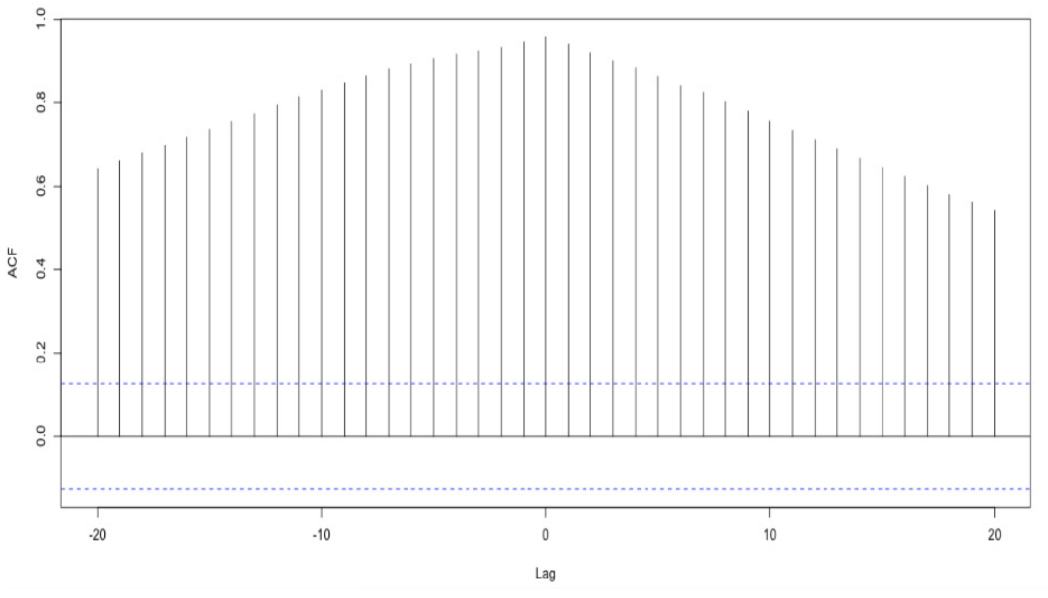
The individual stock market prices are non-stationary by nature which is shown in the autocorrelation (ACF) graph of the EU and US price time series and their difference's ACF, Figure 1 below.

Figure 1. Autocorrelation (ACF) graph of the EU and US price time series and their difference's ACF



The EU and US market prices are two non-stationary series of which the difference is stationary. First, we check for autocorrelation (ACF, shown in the second column), for non-stationary time series the autocorrelation decreases slowly while for stationary time series (the difference shown in the third column) it drops faster. We also notice that the correlation is high and persists during the time as shown in Figure 2 below where we compute the cross-correlation or cross-covariance of the two series. In addition, as already shown auto-correlation does not persist after differencing.

Figure 2. Cross-correlation or cross-covariance of the EU and US market prices non-stationary time series



The Johansen cointegration test, Figure 3, will help us to calculate the coefficient of the stationary linear combination.

The eigenvector associated with the largest eigenvalues of the Johansen test is the best input to build the linear combination:

Trade Pair Strategy = 1* Market_Portfolio_EU-0.49*Market_Portfolio_US

However we have to note that the test values are below the 10% critical value, so the hypothesis of no cointegration cannot be discarded.

Figure 3. Johansen cointegration test

```
######################
# Johansen-Procedure #
######################

Test type: trace statistic , with linear trend

Eigenvalues (lambda):
[1] 0.049215259 0.003401813

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 1 |  0.81  6.50  8.18 11.65
r = 0  | 12.82 15.66 17.95 23.52

Eigenvectors, normalised to first column:
(These are the cointegration relations)

            P_EU.l2    P_US.l2
P_EU.l2  1.0000000  1.0000000
P_US.l2 -0.4958312 -0.9092751

Weights W:
(This is the loading matrix)

             P_EU.l2     P_US.l2
P_EU.d -0.045405043 -0.01160416
P_US.d  0.001591125 -0.01476529
```

In Figure 4 below, we run the Augmented Dick Fueller (ADF) cointegration test for the Trade Pair Strategy.

Figure 4. Augmented Dick Fueller (ADF) cointegration test

```
###############################################
# Augmented Dickey-Fuller Test Unit Root Test #
###############################################

Test regression trend


Call:
lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)

Residuals:
    Min      1Q  Median      3Q     Max
-31.340  -7.376  -0.255   7.691  48.787

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 10.28018    3.08160   3.336 0.000989 ***
z.lag.1     -0.06767    0.02099  -3.224 0.001443 **
tt           0.02522    0.01625   1.552 0.122099
z.diff.lag   0.14655    0.06481   2.261 0.024663 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


Residual standard error: 12.52 on 233 degrees of freedom
Multiple R-squared:  0.05918,	Adjusted R-squared:  0.04706
F-statistic: 4.885 on 3 and 233 DF,  p-value: 0.002592


Value of test-statistic is: -3.2243 3.9282 5.5797

Critical values for test statistics:
      1pct  5pct 10pct
tau3 -3.99 -3.43 -3.13
phi2  6.22  4.75  4.07
phi3  8.43  6.49  5.47
```

Random walks, which are non-stationary, are AR(1) processes with unit roots. In general, for stationarity all the roots of the model have to exceed the unit. The ADF zero hypothesis is that a unit-root exists, i.e. non stationarity. When the trade pair strategy below is tested:

Trade Pair Strategy = 1* Market_Portfolio_EU-0.49*Market_Portfolio_US

the p-value of the ADF cointegration test is lower than 0.005 so that we can reject the null hypothesis of a unit root. It means that the Price time series are cointegrated and the pair strategy will be stationary. Although integration and cointegration have different statistical formulations, the results of our data seem consistent.

IV. Summary, Conclusions, and the Way Forward

We have applied the integration and segmentation models proposed by Brooks et al and Jorion and Schwartz to excess return of global stock markets from North America, Asia and Japan, and regress against local European portfolio excess returns. Regarding the integration and segmentation model: there is a good correspondence in the parameters and objective values calculated with the different methods. The integration analysis of the EU portfolios and US market show significant results: in both methods proposed for the integration model, the global factor λ_{US} is significant at 1% level different from zero, which show integration; while for the segmentation model, the method from Brooks et al. shows partial segmentation between EU and US and EU and Japan at 5% confidence level. Finally, when we use North America as global market, our results show total integration between the EU portfolios and the US market and Asian Pacific portfolios and the US market, both at 1% confidence level.

Contributions and Further Works

The objective of this article is to employ multi-factor asset pricing models to explain average returns in the global stock markets and linked funds and compare the results of the national markets/funds with the international market/funds: our contribution will formulate a systematic approach to test the segmentation and integration of the different geographic zone economies. We were also interested in comparing the results of the integration/segmentation analysis in the different time frames.

The Maximum Likelihood and Seemingly Unrelated regression show similar results in the full time range and the split time periods, while the results of the General Methods of Moments are not consistent with the other regressions. The analysis of the different time periods show that the last decade is the most significant determining the partial integration of the North America and European Market.

To our knowledge, this is the first time that the Capital Asset Price model is applied systematically to compare the integration and segmentation between different economies and a given portfolio set. Our results show a good integration between the EU and US economies, which is also evident in the time split study and confirmed by a further cointegration analysis. A partial segmentation between EU and Japan is also shown from the full time period results. In conclusion, we hope that our systematic approach can corroborate the validity of the CAPM integrated and segmented model.

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Appendix A

The correlation matrix between variables is shown in the table together with the Pearson correlation test results. As discussed, a high correlation between the market returns is shown with a high confidence level (P below 1%).

	$R_{EU,t}$	$R_{US,t}$	$R_{AS,t}$	$R_{JP,t}$
$R_{EU,t}$	1.00000	0.87607 <.0001	0.86936 <.0001	0.67400 <.0001

This multicollinearity was the reason to use the orthogonal projection of the returns, which, as shown below in the correlation matrix with the projection, will fix the multicollinearity problem:

	$R_{EU,t}$	$R'_{US,t}$	$R'_{AS,t}$	$R'_{JP,t}$
$R_{EU,t}$	1.00000	-0.01785 0.7832	-0.00978 0.8802	-0.00478 0.9413

Autocorrelation was tried via the Durbin Watson test, below we report the result between the Big size and High Value Portfolio, the European market return and the EU/US market return projection. The ordinary least square (OLS) results are also reported:

Ordinary Least Square Estimates			
SSE	885.574602	DFE	237
MSE	3.73660	Root MSE	1.93303
SBC	1010.87588	AIC	1000.43396
MAE	1.39248538	AICC	1000.53566
MAPE	61.7741053	HQC	1004.64129
Durbin-Watson	1.9833	Total R-Square	0.9140

The Durbin Watson value in this case close enough to 2 (1.9833) and we can conclude that there is no statistical evidence that the error terms are positively autocorrelated.

We also tested for heteroscedasticity, which causes the OLS estimates to be inefficient as it assumes constant error variance, while NSUR and GMM considering the changing variance can make more efficient use of the data. Both White's test and the Breusch-Pagan based on the residuals of the fitted model were run. For systems of equations, these tests are computed separately for the residuals of each equation.

The results of the test are shown below for the European market return and EU/US market return projection model (equation (5)):

Heteroscedasticity Test				
Equation	Test	Statistic	DF	Pr > ChiSq
$R_{1,t}$ = *Size Small, Value High*	White's Test	48.12	5	<.0001
	Breusch-Pagan	6.42	2	0.0403
$R_{2,t}$ = *Size Small, Value Medium*	White's Test	43.21	5	<.0001
	Breusch-Pagan	3.54	2	0.1707
$R_{3,t}$ = *Size Small, Value Low*	White's Test	23.57	5	0.0003
	Breusch-Pagan	2.56	2	0.2787
$R_{4,t}$ = *Size Big, Value High*	White's Test	19.09	5	0.0019
	Breusch-Pagan	0.81	2	0.6669
$R_{5,t}$ = *Size Big, Value Medium*	White's Test	5.81	5	0.3255
	Breusch-Pagan	1.85	2	0.3969
$R_{6,t}$ = *Size Big, Value Low*	White's Test	10.76	5	0.0563
	Breusch-Pagan	2.13	2	0.3448