WHO DRIVES WHOM? INVESTIGATING THE RELATIONSHIP BETWEEN THE MAJOR STOCK MARKETS

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Abstract

In this paper we examine the relationships between the major stock markets including the U.S., the U.K, Japan, Germany and France covering a long period from July 1987 to December 2015 and employing Carrion-i-Silvestre et al. (2009) unit root tests and Maki (2012) cointegration test, both of which considering structural breaks. Additionally, we estimate the long-run elasticities of the co-integrating relationships by applying dynamic ordinary least squares algorithm of Stock and Watson (1993). And lastly, we investigate short-run linkages among stock markets using the Granger causality test across the subsamples determined according to the breakpoints. Our results indicate that these markets are mostly co-integrated. Among them only the Japanese market is mildly segmented proving a diversification benefit. Additionally, we observe a gradually decrease in the short-run relationship between these markets.

Keywords: Stock Market, Diversification, Cointegration, Structural Breaks, Financial Crisis

JEL Classification: G11, G14, G15

1. Introduction

Although, the long and short-run relationships between the stock markets in the world are one of the most common research topics, it doesn't lose its popularity in finance literature. There are many factors make the researchers still studying on this issue: First and the most important is the development of the econometric

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techniques using to measure the cointegration and causality between the stock markets day by day. The researchers need to apply these new techniques into their analysis in order to overcome the shortcoming of the old ones and achieve more trustable results. Second is that since the most recent studies cover an extended time period for stock market, their results on long-run tests are more reliable than the old studies with a shorter period. Third, since the most of the current studies include the 2007-08 financial crises period, researchers have got the change to examine its impact on the relationships between the stock markets. The impact of these turbulences on the integration of stock markets is always a big question for both the academicians and practitioners.

The liberalization and deregulation of financial markets, globalization of the world economy and the development of technology and computerized systems increased the international capital flows and the integration among the financial markets. Aside the positive effects of international capital flow, the strong integration between the stock markets reduce the benefits of international diversification. On the other hand, there are still opportunities for the arbitrageurs. There might be a high integration between the two stock markets, but it doesn't mean that the markets move in the same direction every day. The spread between the prices are mean-reverting in the long-run. Therefore, it is possible to observe arbitrage opportunities in the short-run for investors. We can also link the concept of cointegration with Efficient Market Theory of finance. If the markets are co-integrated, it will be possible to predict the movements in one market by using the movements in another market which is contradict to the weak form of efficient market hypothesis.

The aim of this paper is to find out whether there are diversification benefits for the international investors and portfolio managers preferring to keep their funds in developed markets which might be considered as more secured. We try to answer whether the international investors can reap profits and reduce risk by investing into the big markets. Our data consist of the major stock markets covering the U.S., the U.K, Japan, Germany and France. Our data period is from July 1987 to December 2015 covering a long period. Since our data period includes all financial turbulences, there is no way out to consider the structural breaks into our analysis. Therefore, we employ Carrion-i-Silvestre et al. (2009) unit root tests and Maki (2012) cointegration test, both of which considering up to five structural breaks. We further estimate the long-run elasticities of the cointegrating relationships by applying dynamic ordinary least squares algorithm of Stock and Watson (1993). Additionally, we investigate the short-run linkages among stock markets using the Granger (1969) causality test across the subsamples determined by the breakpoints which are detected by the cointegration test.

This paper improves the previous studies in four ways. First, most of the previous studies on cointegration use some latent techniques ignoring the structural breaks such as unit root tests proposed by Dickey and Fuller (1979), and Kwiatkowski et al.(1992) and cointegration tests proposed by Engle and Granger (1987), Johansen and Juselius (1990) and Johansen (1991). However, since these techniques do not take account the structural breaks, they might drive the researchers to unreliable results. To overcome this problem most of the recent studies have begun to use more developed techniques considering the structural breaks in testing integration such as Zivot and Andrews (1992) and Lumsdaine and Papell (1997) and cointegration such as Gregory and Hansen (1996). Although the techniques considering the structural breaks provide more trustable results, they include some shortcomings in such a way that Zivot and Andrews (1992) allows for only one and Lumsdaine and Papell (1997) allows for only two structural breaks. This paper improves the existing literature by employing the most recent and powerful techniques in testing unit root by using Carrion-i-Silvestre et al. (2009) allowing up to five structural breaks and Maki (2012) cointegration test with unknown structural breaks.

Second, we again consider financial breaking points in examining both long-run elasticities and short-run relationships between the stock markets. We obtain long-run elasticities in the presence of structural breaks in order to check whether the link between cointegrating relationships are perfect and/or changing over time. In addition to that we employ novel and powerful Granger causality across subsamples determined by the structural breaks detected by the cointegration method in analyzing short-run interactions.

Third, we extend the previous studies by using the monthly data for a longer period beginning from July 1987 up to December 2015. Since the cointegration tests measures the long-term relationship, extended period data is essential to achieve more realistic results.

Fourth, different from the previous studies before the last recent 2007/08 financial crises, this paper contributes to the literature by covering the crises period into its analysis and examine its impact on stock market integration.

The reminder of this paper is organized as follows: In Section 2 we present the existing literature, in Section 3 we explain the methodology. Then in Section 4, we present the data and empirical results. And last, we conclude the paper in Section 5.

2. Literature Review

As is known, there exists a plenty of studies examining the long- and short-run relationships among the stock markets. Since in this paper, we focus on the major stock markets, we have just unfolded briefly the common points that previous studies on the issue have shared.

Among these studies Taylor and Tonks (1989) examine the cointegration of the U.K. with the major stock markets by using the two-step Engle and Granger (1987) cointegration technique with monthly data covering the period from 1973 to mid-1986 and they show that the abandonment of the U.K. exchange rate controls in 1979 increases long-run integration of the U.K. market with those of the U.S., Japan, the Netherlands and West Germany.

Kasa (1992) examines the long-run relationship between the stock markets of Canada, Germany, Japan, the U.K and the U.S. by using monthly and the quarterly data covering the period from January 1974 to August 1990. He employs the Johansen (1991) cointegration test and identifies one common stochastic trend for these markets and gives the strongest rejection of no cointegration hypothesis. His estimates of the factor loadings indicate that this trend is most important in the Japanese market and least important in the Canadian market.

Similarly, Corhay, Rad and Urban (1993) examine the cointegration between the largest stock markets of Europe including France, Germany, Italy, Netherland and the U.K. for the period from March 1975 to September 1991. They employ the Johansen (1991) cointegration test with weekly data and find the evidence of cointegration between these markets. They argue that while a long-run relationship seems to hold among European stock prices, Italian stock prices do not seem to influence this long-run relationship. On the other hand, Arshanapalli and Dokukas (1993) examine the integration between the stock markets of the U.S., France, Germany, Japan and the U.K. before and after the 1987 stock market crash. They find that while the Japanese stock market is integrated with the U.S. market before and after the crash, the stock markets of France, Germany and the U.K are only integrated with the U.S. after the crises. Similarly, Meric and Meric (1997) employ the factor analysis to examine long-term co-movements of 12 European and the U.S. equity markets before and after the stock market crash of October 1987 and find that co-movements of the markets became more harmonious after the stock market crash.

In contrast, Richards (1995) analysis the cointegration between sixteen markets covering Australia, Austria, Canada, Denmark, France, Germany, Hong Kong, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the U.K, and the U.S. He employs the Johansen (1991) and Engle and Granger (1987) cointegration tests by using quarterly data from end-December1969 to end-December 1994. He finds a little empirical evidence for the proposition that the stock return indices of different countries are co-integrated. He argues that while national stock return indices are correlated around a common world component, in the long-run they are not co-integrated around a common component since the country-specific factors affect the long-term stock performance. The mean-reverting tendencies of the return and price series of the national stock markets indicate market efficiency. And according to him, the existence of permanent country specific component in return series of national stock markets implies that there will be a long-run risk reduction benefits from international investments. Gallagher (1995) examine the relationship between the Irish stock market with those of the Germany and the U.K by using weekly data from mid-Jan 1983 to mid-Feb 1993. He employs Phillips and Ouliaris (1990) test and Granger causality test. According to him, long-run relationship does not exist but there exists a short run relationship after the 1987 stock market crash. Similarly, Kanas (1998) employs the multivariate trace statistic, the Johansen method, and the Bierens (1997) nonparametric approach to test for pairwise cointegration between the U.S. and each of the six largest European equity markets, namely those of the U.K., Germany, France, Switzerland, Italy, and the Netherlands for the period from the beginning of January 1983 to end of November 1996. His findings indicate that the U.S. market is not pairwise co-integrated with any of the European markets. He argues that there exist potential long-run benefits in risk reduction from diversifying in U.S. stocks and stocks in any of the major European markets.

However most of these empirical studies have failed to notice that the cointegration relationship may have a structural break during the sample period which implies significant changes on cointegration parameters. After the development of the cointegration techniques allowing for structural breaks, many finance researchers have begun to apply them for stock markets. Among these studies Huang et al. (2000) examine whether there is a long-run relationship between the stock markets of the U.S., Japan and South China triangle by applying the Gregory and Hansen (1996) approach and find that there is only a relationship between the Shanghai and Shenzhen stock markets. Narayan and Smyth (2004) analyzes stock market integration between Australia and G7 Economics by applying the same technique and finds some evidence of a pair-wise long-run relationship between Australian stock markets and the stock markets of Canada, Italy and Japan. Narayan and Smyth (2005) examine whether there is a long-run relationship between New Zealand stock markets and the stock markets of Australia and G7 economics. They find that New Zealand stock market is only not co-integrated with these markets other than the U.S after they employ the Gregory and Hansen (1996).

Yang, Khan and Pointer (2003) investigate the impact of 1987 stock market crash on the long-run integration between the U.S. and 14 developed countries. They employ the Johansen test for the period from 1970 to 2001 and do not find any cointegration between the countries. Additionally, they use a recursive cointegration analysis to examine the time-varying nature of long-run relationships. They find similar results indicating any cointegration. However, they find increasing integration between the U.S. and many smaller markets such as Belgium, Norway, Denmark and Sweden in the late 1990s. In contrast, Fraser and Oyefeso (2005) run a Johansen multivariate cointegration test between the U.S., the U.K., Germany, France, Italy, Germany, Belgium, Spain, Denmark and Sweden for the period from January 1974 to January 2001 and find that there is a single common stochastic trend to which all markets have a long-run relationship. The contrast findings might be the result of using real stock prices which are adjusted to the Consumer Price Index (CPI).

Baele (2005) employes a regime-switching shock spillover model to test the interactions from the U.S. to the European stock markets Austria, Belgium, France, Germany, Ireland, Italy, the Netherlands, and Spain Denmark, Sweden, Norway, and Switzerland. He uses weekly data for the period from January 1980 - August 2001 finds evidence of increased cross-market interactions from the U.S. to a number of European equity markets during periods of high world market volatility. On the other hand, Bekaert et al. (2005) employ a two-factor asset pricing model and define contagion as correlation among the model residuals. They examine the stock markets of 22 countries including both the developed and emerging markets for the period from Jan 1980 to Dec 1998. They find no contagion between the U.S. and countries in Europe, Asia and Latin America during the Mexican Peso crisis. However, they find economically meaningful increases in residual correlation, especially in Asia, during the Asian crisis.

Lafuente and Ordonez (2007) investigate the dynamic nature of financial integration for Germany, France, Spain and Italy and the U.K. They test whether the degree of integration between these countries increased after European monetary union. They employ time varying correlation as a proxy of the degree of dynamic financial integration, a bivariate error correction DCC-MV-GARCH model is used to estimate conditional correlations between stock index returns during the sample period 1993-2004. They find that these markets are co-integrated after they allow for the structural changes.

Yunus (2013) analyze the dynamic relationship among ten major stock markets including the U.S., Australia, Japan, China, India, France, Germany, U.K., Brazil and Mexico covering the period beginning January 1993 and ending in December 2008. He employs the recursive cointegration technique and find that these markets are integrated and that the degree of integration among these markets has increased over time. A scrutiny of the various crisis periods reveals that a major financial crisis had an effect of increasing the level of convergence among these markets. Additionally, he finds that the U.S., Japan, India, China, U.K., and Germany lead the other markets with the U.S. contributing most heavily to the common trend.

As can be observed from the studies, their results are conflict. This paper fills the gap in cointegration analysis by using the most improved and recent techniques covering a long period for the world major markets.

3. Methodology

3.1. Unit Root

The conventional unit root tests, such as Augmented Dickey-Fuller (1979) (ADF), lose their power and lead researchers to unreliable conclusions when there is a structural break in the deterministic trend. In order to reach accurate decisions in the presence of possible structural breaks due to financial crises, Carrion-i-Silvestre et al. (2009) (CKP) extends the methodology of Kim and Perron (2009) by allowing for an arbitrary number of changes up to five structural breaks in both the level and slope of the trend function. Basically, the structural break dates are estimated endogenously using an algorithm based on Bai and Perron (2003). CKP analyze *M*-class unit root tests in the literature and further improve the power and size properties of those tests. By doing so, CKP advocate that their unit root tests overcome many problems of previous methods widely employed in the literature. We estimate three test statistics proposed by CKP, namely $MZ_{\alpha}^{GLS}(\lambda)\ MZB^{GLS}(\lambda)\ MZ_{t}^{GLS}(\lambda)$[1].

3.2. Empirical Model

Maki (2012) develops cointegration test (MB*k*) under the assumption that unspecified number of breaks of the cointegrating vector is smaller than or equal to the maximum number of breaks set a priori. Maki (2012) advocates that MB*k* test performs even better than the previously developed cointegration tests of Gregory and Hansen (1996) and Hatemi-J's (2008) when the cointegration relationship has more than three breaks or persistent Markov switching shifts.

Maki (2012) proposes four regression models in order to test cointegration allowing for multiple structural breaks:

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' \mathbf{x}_t + \sum_{i=1}^{k} \beta_i' \mathbf{x}_t D_{i,t} + u_t \qquad 1)$$

where $t = 1, 2, ..., T$. y_t (dependent) and $x_t = (x_{1t}, ..., x_{mt})'$ (regressors) indicate observable integrated of order one (I(1)) variables, and u_t is the equilibrium error. $D_{i,t}$ takes value of 1 if

[1] *See Carrion-i-Silvestre, Kim, and Perron (2009) for detailed technical explanations for the procedures of the tests.*

$t > T_{Bi}$ $(i = 1,...,k)$ and of 0 otherwise, where k is the maximum number of breaks and T_{Bi} indicates the time period of break. The above model (1) accounts for structural breaks both in the level (μ) and regressors (x), called regime shift model. Following Maki (2012), we estimate the regime shift model in order to estimate the test statistic, MB*k*, with the null hypothesis of no cointegration against the alternative hypothesis of cointegration with *I* breaks (*i*≤*k*) [2].

3.3. Dynamic Ordinary Least Squares

We employ dynamic ordinary least squares (DOLS) developed by Stock and Watson (1993) in order to estimate the long-run equilibrium relationships among the cointegrated prices of the stock markets. We estimate the long-run relation between two stock markets with the following regression model:

$$y_t = \omega C_t' + \beta X_t' + \sum_{j=-q}^{r} \psi \Delta X_{t+j}' + \sum_{b=1}^{\eta_m} d_m DUM_{m,t} \qquad 2)$$

where X_t' represents the vector of long-run coefficients of x; $\lambda = (\omega', \beta')'$ is the least-square estimates of the above equation (5). q and r are the lags and leads of the differenced regressors, respectively and they are determined according to Akaike Information Criterion (AIC). η_b is the number of breaks in the cointegrating vector suggested by the cointegration test of Maki (2012), and $DUM_{m\ ,t}$ represent the dummy variables taking a value of 1 from each point of structural breaks in cointegrating vector onwards, 0 otherwise.

3.4. Granger Causality

We apply the novel Granger (1969) causality test in order to check whether the stock markets are interrelated in short-term. We estimate the following pairwise regression models across the subsamples determined by the break points in the cointegration vector:

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[2] *See also Maki (2012) for detailed explanations of the estimation steps for the test statistic, MBk.*

$$y_t = \omega_0 + \alpha_1 y_{t-1} + \dots + \alpha_k y_{t-k} + \beta_1 x_{t-1} + ... + \beta_k x_{t-k} + \varepsilon_t$$
$$x_t = \omega_0 + \alpha_1 x_{t-1} + ... + \alpha_k x_{t-k} + \beta_1 y_{t-1} + ... + \beta_k y_{t-k} + \upsilon_t \quad 3)$$

where *y* and *x* represent the stock market price pairs; ε_t and υ_t are error terms and *k* is the length of lag selected according to the AIC. The null hypothesis of *x* (*y*) does not Granger cause *y* (*x*) for the first (second) regression can be written as follows:

$$H_0 : \beta_1 = \beta_2 = ... = \beta_k = 0 \quad 4)$$

If the *F*-statistic (Wald Statistic) for the null hypothesis is found to be statistically significant, then we can reject joint null hypothesis.

4. Data and Empirical Results

All stock market data are monthly from July 1987 to December 2015 for a total of 342 observations. We obtain the data for the S&P500 (SPX), the FTSE100 (UKX), Nikkei225 (NKY), DAX30 (DAX), and CAC40 (FRA) indices from the Bloomberg. We analyze the natural logarithm of the stock price indices.

Table 1

Unit Root Test Results

Index	$MZ_{\alpha}^{GLS}(\lambda)$	$MZB^{GLS}(\lambda)$	$MZ_{t}^{GLS}(\lambda)$	**BP 1**	**BP 2**	**BP 3**	**BP 4**	**BP 5**
SPX	-22.450	0.149	-3.350	Oct-90	Dec-94	Mar-98	Jan-01	May-08
UKX	-17.756	0.167	-2.970	Dec-99	Mar-03	Apr-06	Feb-09	Feb-12
NKY	-19.002	0.162	-3.073	Sep-90	Apr-95	Sep-98	Apr-03	Oct-07
DAX	-22.301	0.149	-3.327	Jul-90	Jul-98	Mar-03	Dec-07	May-12
CAC	-24.474	0.143	-3.498	Jul-90	Jan-95	Mar-98	Jan-01	May-08

Note: BP stands for break point. $MZ_{\alpha}^{GLS}(\lambda)$ $MZB^{GLS}(\lambda)$ $MZ_{t}^{GLS}(\lambda)$ *are the test statistics.*

Source: Carrion-i-Silvestre et al. (2009)

Table 1 presents Carrion-i-Silvestre et al. (2009) unit root tests results. The estimation results suggest that the null hypothesis of unit root cannot be rejected for all the price indices, indicating that they are integrated of order one (1). The unit root test procedure detects several structural breaks which are concentrated around significant economic and political events.

The break points in 1990 for all country indices except U.K. might be the result of the Iraq's invasion of Kuwait on August 2, 1990. Then the Gulf War began and the International Coalition intervened in the conflict. The second half of the 1990s was a period of crises. The break points at the end of 1994 and the beginning of 1995 in SPX and CAC indices respectively might result from the ramifications of the crisis in Mexico. It is highly probable that the Asian and Russian crisis in 1998 inflicted all but UKX. The break points on January 2001 for SPX and CAC poses parallels with the presidential election in the U.S. at the end of which George W. Bush was elected. The break points in March and April 2003 seem correlated with the outbreak of the Second Gulf War against Iraq under now defunct Saddam regime, that started with the U.S. aerial attacks on the Iraqi capital on March 20. Lastly, it is very likely that the global financial turbulence that took its start in the middle of 2007 culminated in the break points observed in the years of 2007 and 2008 which was derived from the developments in the subprime mortgage markets in the U.S. The breakpoints cumulated in the beginning of 2010s might quite likely be related to the debt crisis in some European economies, especially in Greece and to ongoing economic fluctuations in the whole Euro-zone.

Table 2

Cointegration Test Results

Dependent	MB*k*	# of Break	BP 1	BP 2	BP 3	BP 4	BP 5
	Panel A. Independent: SPX						
UKX	**-6.640**	5	Apr-99	Apr-01	Aug-03	Sep-08	Feb-13
NKY	-5.530	5	Aug-90	Dec-96	Mar-00	Dec-12	Jul-14
DAX	**-6.341**	5	Nov-89	Jan-00	Jun-02	May-07	Dec-11
CAC	**-6.933**	5	Oct-89	Mar-02	Feb-06	Oct-10	Apr-12
	Panel B. Independent: UKX						
SPX	-5.222	2	Dec-99	Oct-05	-	-	-
NKY	-5.593	3	Feb-98	Nov-08	Mar-13	-	-
DAX	**-6.158**	5	Feb-94	Apr-98	Dec-02	Mar-07	Dec-08
CAC	**-7.191**	5	Jul-96	Apr-98	Jan-00	Jun-07	Jun-11
	Panel C. Independent: NKY						
UKX	-5.307	5	Mar-92	Apr-96	Nov-97	Apr-06	Oct-08
SPX	**-6.435**	4	Mar-92	Mar-95	Nov-97	Sep-11	-

DAX	-5.454	5	Nov-91	Dec-95	Apr-98	Jun-03	Sep-10
CAC	-5.788	5	Nov-89	Aug-96	Apr-98	Apr-02	Oct-10
	Panel D. Independent: DAX						
NKY	-5.622	5	Aug-90	Mar-00	May-08	Oct-09	Mar-13
UKX	**-6.365**	5	Feb-93	Mar-97	Jan-02	May-04	Apr-12
SPX	-5.979	5	Aug-98	May-02	Nov-03	May-10	May-12
CAC	**-6.549**	5	Dec-88	Jun-01	Nov-02	May-08	Apr-10
	Panel E. Independent: CAC						
DAX	-4.579	4	Aug-95	Apr-97	Mar-99	Feb-02	-
NKY	**-6.467**	5	Aug-90	Jun-96	Aug-00	Nov-07	Apr-14
UKX	-4.875	5	Jun-91	Aug-95	Apr-97	Jan-00	Jun-11
SPX	-5.281	4	Dec-94	Mar-97	Dec-06	Apr-12	-

Note: BP stands for break point. MBk is the test statistic.
Source: Maki (2012)

Table 2 presents the results Maki (2012) cointegration test considering the structural breaks. Additionally, before that we implement Engle and Granger (1987) cointegration test which doesn't consider the structural breaks in order to compare their results. We observe that while the results of the Engle and Granger test indicate any long-run relationship between indices except UKX-CAC pair only when CAC is used independent variable, Maki test suggests no cointegration between UKX-CAC pair[3].

After we consider structural breaks, we find significant long-run relationship between most of the stock markets other than two pairs namely UKX – NKY and DAX – NKY regardless of which is used as dependent or independent variable. This offers a diversification opportunity in the long-run for the investors and portfolio managers trading in both European and Japanese markets even after taking the structural breaks into account.

Table 3 presents the results of the DOLS estimations with dummy variables representing the subsamples. Our results indicate that the long-run relationships between the co-integrated stock markets are statistically significant albeit the relationships between them are not perfect[4]). In addition to that degrees of relationships are

[3] *We do not document the Engle and Granger (1987) test results in order to conserve space.*
[4] *We tested H_0: $\beta=1$ for all, however do not report the results to conserve space.*

changing over time. This might indicate that the market movements especially in the short run are separating from time to time, but eventually they converge to equilibrium in the long-run.

Table 3

Dynamic OLS Results

Dependent	*β*	*ω*	d1	*d* 2	*d* 3	*d* 4	*d* 5	*r*	*q*
Panel A. Independent: SPX Index									
UKX Index	**0.7629**	**0.8186**	**0.1687**	**0.2552**	**0.0524**	**0.1499**	**0.2292**	16	0
	0.000	*0.000*	*0.000*	*0.000*	*0.006*	*0.000*	*0.000*		
DAX Index	**0.8834**	**2.1759**	**0.1377**	**0.1292**	**0.1590**	**0.6498**	**0.5013**	0	16
	0.000	*0.000*	*0.000*	*0.006*	*0.000*	*0.000*	*0.000*		
CAC Index	**0.6028**	**4.0151**	**0.0922**	**0.1730**	**0.4082**	**0.1894**	**0.1010**	16	16
	0.000	*0.000*	*.006*	*0.000*	*0.000*	*0.000*	*0.017*		
Panel B. Independent: UKX Index									
DAX Index	**1.2626**	**-2.9694**	**0.1034**	**0.0730**	**0.1188**	**0.3200**	**0.6225**	6	2
	0.000	*0.000*	*0.000*	*0.005*	*0.000*	*0.000*	*0.000*		
CAC Index	**1.1025**	**1.5701**	**0.2363**	**0.1271**	**0.0657**	**0.1556**	**0.0400**	0	0
	0.000	*0.000*	*0.000*	*0.000*	*0.001*	*0.000*	*0.083*		
Panel C. Independent: NKY Index									
SPX Index	**0.2568**	**4.3840**	**0.4348**	**0.7530**	**1.4676**	**1.7696**		13	0
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*			
Panel D. Independent: DAX Index									
UKX Index	**0.4618**	**4.8076**	**0.0577**	**0.3027**	**0.2548**	**0.1784**	**0.0852**	0	16
	0.000	*0.000*	*0.007*	*0.000*	*0.000*	*0.000*	*0.093*		
CAC Index	**0.6834**	**2.3439**	**0.1479**	**0.1779**	**0.3135**	**0.1022**	**-0.0995**	16	0
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.003*	*0.008*		
Panel E. Independent: CAC Index									
NKY Index	**0.4549**	**2.0086**	**-0.3631**	**-0.7855**	**-1.2024**	**-1.1240**	**-0.8913**	0	0
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*		

Note: β is the slope coefficient, ω is the constant. d(.) are the dummy variables representing the subsamples. q and r are the lengths of lags and leads, respectively.

Table 4

Granger Causality Results across Subsamples

Dependent	$\beta_{1\text{-}BP1}$	$\beta_{BP1\text{-}BP2}$	$\beta_{BP2\text{-}BP3}$	$\beta_{BP3\text{-}BP4}$	$\beta_{BP4\text{-}BP5}$	$\beta_{BP5\text{-}T}$
Panel A. Independent: SPX						
UKX	**0.2143**	**-0.2553**	**0.5376**	0.2972	**0.2184**	0.0889
	0.000	*0.089*	*0.033*	*0.163*	*0.065*	*0.205*
NKY	-0.0600	0.0587	0.0797	-0.0086	0.1338	0.1680
	0.505	*0.237*	*0.115*	*0.894*	*0.289*	*0.674*
DAX	**0.5157**	**0.1625**	-0.0122	0.8103	0.2581	0.0082
	0.002	*0.007*	*0.963*	*0.216*	*0.284*	*0.932*
CAC	0.0042	**0.1047**	0.3269	0.0199	-0.0660	-0.0244
	0.990	*0.001*	*0.233*	*0.934*	*0.841*	*0.729*
Panel B. Independent: UKX						
SPX	-0.0289	**0.1259**	-0.0348	-	-	-
	0.660	*0.072*	*0.253*			
NKY	**-0.0951**	0.0492	**0.2432**	-0.0939	-	-
	0.001	*0.356*	*0.083*	*0.371*		
DAX	-0.0256	**0.3181**	**0.4205**	0.0158	**0.7465**	0.0214
	0.817	*0.094*	*0.002*	*0.964*	*0.000*	*0.932*
CAC	-0.0141	**0.6683**	0.3056	0.3336	**0.4244**	0.2051
	0.858	*0.000*	*0.470*	*0.205*	*0.071*	*0.471*
Panel C. Independent: NKY						
UKX	-0.0453	0.0080	-0.0811	0.0288	**0.4751**	0.0636
	0.454	*0.853*	*0.298*	*0.383*	*0.035*	*0.455*
SPX	0.0048	0.0142	-0.0790	**0.0734**	0.0109	-
	0.922	*0.684*	*0.268*	*0.003*	*0.932*	
DAX	0.0811	0.0497	-0.1589	**0.1638**	0.0872	0.0903
	0.271	*0.327*	*0.256*	*0.011*	*0.278*	*0.418*
CAC	**0.3224**	-0.0229	-0.1411	**0.1892**	**0.1661**	0.0565
	0.097	*0.538*	*0.209*	*0.000*	*0.079*	*0.470*
Panel D. Independent: DAX						
NKY	-0.0750	-0.0236	**0.0724**	-0.1288	**0.1634**	-0.0228
	0.240	*0.253*	*0.058*	*0.780*	*0.031*	*0.802*
UKX	0.1184	0.1071	**-0.1482**	-0.0136	**-0.0478**	0.0807
	0.143	*0.208*	*0.017*	*0.951*	*0.028*	*0.535*
SPX	-0.0186	0.0213	**-0.4659**	-0.0257	-0.1133	0.0320
	0.636	*0.873*	*0.033*	*0.212*	*0.200*	*0.628*
CAC	-0.4054	**0.0615**	-0.9165	-0.0003	0.5438	0.1008
	0.206	*0.068*	*0.185*	*0.998*	*0.357*	*0.276*
Panel E. Independent: CAC						
DAX	0.0779	-0.1154	0.1078	0.2695	-0.0186	-
	0.379	*0.599*	*0.796*	*0.294*	*0.542*	
NKY	-0.0338	0.0025	0.0019	**0.1871**	**-0.0688**	-0.1382
	0.593	*0.985*	*0.966*	*0.001*	*0.089*	*0.326*
UKX	**0.1964**	-0.0652	-0.1104	-0.0241	-0.0334	-0.0386
	0.013	*0.624*	*0.307*	*0.802*	*0.722*	*0.788*
SPX	0.0381	-0.0491	0.0438	-0.0573	0.0411	-
	0.568	*0.623*	*0.186*	*0.134*	*0.476*	

Note: BP stands for break point. Lag length for each equation is set to 1 based on AIC criterion. First and second rows are 1-lagged explanatory coefficients and p-

values associated with that lagged coefficients, respectively. Bold values indicate statistical significance at conventional levels. First dashes (–) in the rows indicate that there are less than five structural breaks and that the previous column is for the last subsample, from last breakpoint to end of sample.

Table 4 depicts the results of Granger Causality test across subsamples which are determined by the break points in the co-integrating vector of the Maki test. Our results indicate limited short-run diversification opportunities for the investors.

In the late 90s and early of 2000s, we observe short-run linkages between stock markets, however they are disappearing over time. Such that, we barely observe any short run interactions among them during the subsamples spanning from the last breakpoint to end of the sample.

It is important to assess that the U.S., as the predominant stock market in our sample, has no impact on the Japanese market in the short run as in long run. On the other hand, Japanese market has a significant effect on the U.S. market in the long run and there are limited short run linkages between these two markets in the subsamples. Moreover, French market do no cause the U.S. and the German markets in any subsamples.

5. Conclusions

In this paper, we try to examine the relationship between the major stock markets including the U.S., U.K., Japan, Germany and France for a long span of time from July 1987 to December 2015 including many important economic and political events. Our study differs from most of the previous ones in terms of its methodology. We implement Carrion-i-Silvestre et al. (2009) unit root and Maki (2012) cointegration tests considering the structural breaks. Additionally, we use the Granger causality test for subsamples determined according to the period between break points to point out the changes in the short-run relationship between these markets over time.

The bottom line is that structural breaks suggested by the cointegration methodology are empirically relevant. Most of these breaks are observed around significant economic and political events including the wars and financial crises. Our results indicate that most of these markets are co-integrated with the others but Japan stock market is not co-integrated with those of the U.K. and Germany indicating a limited diversification benefit.

While, in the long-run, most of the stock markets are significantly interconnected in the presence of structural breaks, we observe a gradually decrease in the short-run linkages between these stock markets. Even we observe any linkage between these markets in the last subsamples for all pairs indicating a short run diversification opportunity as of late.

As a result, after we consider structural breaks, we observe that the Japanese market is mildly segmented from the other countries providing limited diversification benefits for international investors and portfolio managers in both short and long run. This can be the result of divergence of its economic and financial policies from those of the other countries. For instance, while the FED and following the European Central Bank reduced the interest rates in order to invigorate the economy after the global financial crises in 1997-98, the Bank of Japan just reduced the interest rates during we are writing up this paper.

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