In Search of Market Index Leaders: Evidence from World Financial Markets

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Abstract

This paper investigates the presence of Granger-causality amongst five world market indices: S&P 500, Dow Jones Industrial Average, Eurostoxx 50, Nikkei, FTSE 100, from January 2nd 1987 to October 17th 2008. Using daily market returns I performed a Granger-causality test, based on the Vector Autoregressive (VAR) model, in order to detect the causalities amongst indices. Different sub-samples were considered, which take into account the distinction between bearish and bullish phases of the markets. Results show that there is high Granger-causality amongst stock returns in every phase of financial markets, but that a real market index leader does not exist, except for Nikkei and Eurostoxx in the thirst quartile.

Keywords: Granger-causality, Asian stock markets, market indices, VAR.

1 Introduction

Is there a market index which reacts faster than others to market events and whose reactions are followed by other indices? In other words, is there a market index leader? This question has always been of remarkable interest amongst market traders, investors and portfolio managers, who aim to detect market trends to increase their trade's gains.

Finance journalism has always implicitly recognise the existence of a linkage amongst the performances of world stock markets and believes that some stock exchange (e.g. Wall Street) are more influencing than others in tracing the market trends[1]. But in spite of this common feeling regarding the existence of a linkage amongst indexes, the empirical evidence in this field of research is still very poor. One of the obstructing motivations which generates this scarcity is due to the difficulty in defining a causality model. Of course, the pioneering works by Granger (1969), Engle & Granger (1987), and Granger & Hallman (1991) represent the base on which establishing a research programme on this

[1] Just to mention two examples, one may read "Asian shares follow Wall Street lower", from the Financial Times' web site, 22nd October 2008; "Nikkei's 6.8% Fall Leads Asia Lower", from the Wall Street Journal's web site, 22nd October 2008.

topic. Nevertheless, the concept of "Granger-causality"[2] has not been fully understood yet, and it is often a source of misunderstandings.

Granger himself wrote that the G-causality (and the statistic test which measures it) does not capture a true causality amongst series (e.g.

series x_t is the cause of series y_t) but it measures the ability of a series to predict another series (e.g. series x_t predicts series y_t). Furthermore, Granger supposed that if x_t is the Granger-cause of y_t, then x_t must come before y_t (Hamilton, 1994), as causes happen before effects. Of course, this definition of causality from a temporal point of view seems to be very helpful to answer our initial questions, since we are looking for an approach which enables us to understand what happens to an index when another one moves in a certain direction, regardless of why this happens. Therefore, the problem is even more simple than that addressed in other disciplines (i.e. Labour Econometrics) where the goal is to fully understand why things happen. Investors can be totally outside the economic theories, but they simply desire to predict the future of their invested money.

In this paper I introduce the definition of market index leader, defining it as that index which Granger-causes other indices but it is not Granger-caused by any other index. I perform a time-series analysis to detect the existence of possible market index leaders in World financial markets. This study aims to investigate the Granger-causality under different market conditions in order to detect whether this type of causality always exist or if it is more related to certain conditions. Furthermore I aim to discover if market leaders does and if they are the same in all the quartiles analysed.

2 Methodology and Data

The candidate indexes used in the analysis are the following:

1. The **Standard & Poor's 500**
2. The **Dow Jones Industrial Average**
3. The **Eurostoxx 50**
4. The **Nikkei**
5. The **FTSE 100**

Performance of the stocks were measured by cumulative returns, calculated as

[2] Sometimes the term "Granger-causality" is substituted by the term "Granger-Wiener causality", since it is based on the concept of causality expressed by the mathematician Norbert Wiener (1956).

$$CR = \ln(P_{it}) - \ln(P_{it-1})$$

$i = 1, ..., n$

where P_{it} represents the trading day's closing price of index i.

The time period runs from January 2nd, 1987, to October 17th, 2008. Data source is Bloomberg database.

I divided the entire sample into four quantiles, in order to have a distinction between bullish and bearish markets. The first two quartiles represt the bearish phase of the market, whilst the third and the fourth the bullish. I want to test the hypothesis that there exists a leader index amongst Asian financial markets.

2.1 Leader Indexes

I define an index as a *leader index* if it causes another index and it is not caused by any other index. For example, let us take two indexes, say M and N. Index M is said to be a leader index if it Granger-causes (and it is not Granger-caused by) index N. The term "leader" should be read as a synonimous of "first mover", whose trend is followed by the other indexes. This definition respects the true meaning of Granger causality, which should not be read as "M causes N" but as "if M occurs, then also does N, regardless of whether M is the actual cause of N".

More formally, let us write the two time series $M = \{m_t, t, \text{real}\}$ and $N = \{n_t, t, \text{real}\}$; furthermore, let us introduce a "break-up" time, say t, and $M_t = \{m_{t-s}, s \geq 0\}$, $N_t = \{n_{t-s}, s \geq 0\}$ the two entire series up to the break-up time. Denote also Γ_t the information set accumulated at t and suppose that

$$M_s \subseteq \Gamma_t \Longleftrightarrow s \leq t$$

$$N_s \subseteq \Gamma_t \Longleftrightarrow s \leq t$$

If we are better able to predict m_t, using Γ_t than we are using $\Gamma_{t-1} \not/ N_{t-1}$, then N causes M. If we are better able to "predict" m_t, using $\Gamma_{t-1} \cup n_t$ than we are using Γ_{t-1}, then N causes M instantaneously. Appendix 1 illustrates more in details the concept of causality.

3 Results

Tables 1-5 show overall statistics for the first differences of the natural logarithms of prices for the overall sample and for the quartiles. It is interesting to note that, in table 1, means are around zero for every index but that the level of risk, roughly measured by the standard deviation is slightly higher for the Eurostoxx and Nikkei indexes. Table 1 shows that the return mean values on the overall sample are positive, except for Nikkei Index, i.e. -0.003\%. Dow Jones Industrial Average shows the highest return (0.03%). Eurostoxx also shows high level of risk (1.36%), whilst S&P 500 also shows high mean returns (0.026%) Results of the Granger-causality tests are reported in tables 5-10. Table 5 reveals that, during the overall period, there is no a market index leader, since there is no an index which causes the others without not being caused by any other index.

3.1 Leaders in Bearish Markets

Table 2 shows the mean values for the first quartile. Nikkei is still the more risky index (standard deviation equal to 1.57%) with one of the lowest mean returns (-1.1%). Otherwise, FTSE 100 is the least risky (standard deviation equal to 1.15%) whilst the two US indexes have the highest mean returns (-0.99% for the S&P 500 and –0.97% for the Dow Jones Industrial Average. Table 3 shows the mean values for the second quartile. There Nikkei reveals to be both the more risky and the least rewarding index (standard deviation equal to 1.01% and mean return equal to -0.27%).

Cointegration does exist in both the first and second quartile. I summarise the main results in the following scheme:

- Dow Jones G-causes S&P 500 and the Eurostoxx at the 5% of the confidence interval and FTSE 100 at the 1% in the first quartile, and G-causes Eurostoxx, Nikkei and Ftse 100 at the 5% in the second;
- Eurostoxx 50 G-causes Nikkei at the 10% of the confidence interval and FTSE 100 at the 1% of the confidence interval in the first quartile, and S&P500 and Dow Jones Industrial Average at the 5% in the second;
- Nikkei G-causes FTSE 100 at the 10% of the confidence interval in the first quartile.
- FTSE 100 G-causes S&P 500, Dow Jones Industrial Average, Eurostoxx at the 1% of the confidence interval in the first quartile, and S&P 500 at the 1%, Dow Jones Industrial Average at the 5% and Nikkei at the 10% in the second;
- S&P 500 G-causes Eurostoxx and FTSE 100 at the 1% of the confidence interval, Dow Jones Industrial Average at the 5% and Nikkei at 10% in the first quartile, and Dow Jones Industrial Average, Eurosoxx and Nikkei at the 1% and FTSE 100 at the 5% in the second.

Table 6 and Table 7 reveal again that, during the overall period, there is no a market index leader, since there is no an index which causes the others without not being caused by any other index.

3.2 Leaders in Bullish Markets

Table 4 shows the mean values for the third quartile. The most risky / best performer indexes are Nikkei and Eurostoxx with a standard deviation of 0.95\% for Nikkei and 0.66% for Eurostoxx and a mean return equal to 0.32% for the

Nikkei and 0.27% for Eurostoxx. Finally, table 5 shows the mean values for the fourth quartile. Nikkei and Eurostoxx reveal again to have the highest level of risk, i.e. 1.49% for Nikkei and 1.2% for Eurostoxx, whilst Eurostoxx is the best performer, with a mean return equal to 1.16%.

Cointegration does exist in both the third and fourth quartile.

- Dow Jones G-causes S&P 500 and the Eurostoxx at the 5% of the confidence interval and FTSE 100 at the 1% in the first quartile, and G-causes Eurostoxx, Nikkei and Ftse 100 at the 5% in the second;
- Eurostoxx 50 G-causes Nikkei at the 10% of the confidence interval and FTSE 100 at the 1% of the confidence interval in the first quartile, and S&P500 and Dow Jones Industrial Average at the 5% in the second;
- Nikkei G-causes FTSE 100 at the 10% of the confidence interval in the first quartile.
- FTSE 100 G-causes S&P 500, Dow Jones Industrial Average, Eurostoxx at the 1% of the confidence interval in the first quartile, and S&P 500 at the 1%, Dow Jones Industrial Average at the 5% and Nikkei at the 10% in the second;
- S&P 500 G-causes Eurostoxx and FTSE 100 at the 1% of the confidence interval, Dow Jones Industrial Average at the 5% and Nikkei at 10% in the first quartile, and Dow Jones Industrial Average, Eurosoxx and Nikkei at the 1% and FTSE 100 at the 5% in the second.

In this case we may argue that Eurostoxx and Nikkei could be candidates to be market index leaders in the third quartile, since they G-cause other indexes but are weakly caused by other indexes. Nevertheless, no market index leaders emerge in the fourth quartile.

4 Conclusions

In this paper I performed a time series analysis whose goal was to find market index leaders, those which lead other indices in different phases of the market. I found that even though an high level of G-causality amongst world market indexes is detectedt, we cannot say that a true market index leader exist. An exception is represented by the situation of the third quartile, where Nikkei and Eurostoxx can (weekly) be consider as index leaders.

5 Appendix 1

Suppose to have a space of possible outcomes C and two sets of restrictions $M, N \subset \mathsf{C}$ on these outcomes, with $(M \cap N) \subset \mathsf{C}$. x and y map C by probabilistic function $\Pr_x$ and $\Pr_y$. We write the set of the following 5 axioms which represents the steps to define the concept of causality.

- Axiom of *Causal Ordering from x to y*

$$C1 := \left(\Pr_y(M) = M\right) \cap \left(\Pr_x(M \cap N) = \Pr_x(M)\right) \Rightarrow (M, N) \subset \complement x \circlearrowleft y$$

- Axiom of *Acceptance of inputs by N*

$$\begin{aligned} C2 \quad : \quad &= \left(\overset{-1}{\Pr_x}\left(\Pr_x(M)\right) = M, \forall M \subset \complement\right) \\ \Longrightarrow \quad &\left(\left(\Pr_y(M) = M\right) \cap \left(\Pr_x(M \cap N) = \Pr_x(M)\right) \Rightarrow (M, N) \subset \complement x \circlearrowleft y\right) \end{aligned}$$

- Axiom of *Realilzability of N with M as input*

$$C3 := C2 \cap \left(\begin{array}{c} \Pr_{x_t}(M_1) = \Pr_{x_t}(M_2) \\ \Rightarrow \Pr_{y_s}\left(\Pr_{x_t}(M_1 \cap N) = \Pr_{x_t}(M_2 \cap N)\right), \\ \forall M_1, M_2 \subset \complement, \forall t \geq s \end{array} \right)$$

- Axiom of *Structurality of N with x as input*

$$C4 := C3 \cap \left(\begin{array}{c} \textit{any implemented } C \subseteq \complement \\ \Rightarrow \Pr_y\left(\Pr_x^{-1}(C) \cap B\right) = True \end{array} \right)$$

- Axiom of *Causality*

$$C5 := C3 \Rightarrow C4$$

6 Appendix 2

The standard multi-variate Granger causality test adopts an OLS approach of the following system of equations

$$
\begin{aligned}
Y_t &= \mu_0 + \mu_1 Y_{t-1} + ... + \mu_k Y_{t-k} + \\
&+ \sum_{p=1}^{P} \left(\gamma_1^p X_{t-1}^p + ... + \gamma_k^p X_{t-k}^p \right) + u_t \\
X_t^1 &= \mu_0 + \mu_1 X_{t-1}^1 + ... + \mu_k X_{t-k}^1 + \gamma_1^1 Y_{t-1}^1 + ... + \gamma_k^1 Y_{t-k}^1 + \\
&+ \sum_{p=2}^{P} \left(\gamma_1^p X_{t-1}^p + ... + \gamma_k^p X_{t-k}^p \right) + u_t \\
&\vdots \\
X_t^p &= \mu_0 + \mu_1 X_{t-1}^p + ... + \mu_k X_{t-k}^p + \gamma_1^1 Y_{t-1}^1 + ... + \gamma_k^1 Y_{t-k}^1 + \\
&+ \sum_{p=1}^{P-1} \left(\gamma_1^p X_{t-1}^p + ... + \gamma_k^p X_{t-k}^p \right) + u_t
\end{aligned}
$$

under the joint hypothesis

$$H_0 : \gamma_1^1 = ... = \gamma_{t-p}^1 \wedge ... \wedge \gamma_1^P = ... = \gamma_{t-p}^P = 0$$

which is tested by the meaning of a Wald test that the coefficients on the lags of the "excluded" variables are zero in the equation for the (assumed) dependent variable. Selection criteria, such as the Bayesian Information Criteria (BIC, Schwartz, 1978)) or the Akaike Information Criteria (AIC, (Akaike, 1974)), can be used to determine the appropriate number of lags.

The multivariate case of the Granger causality test produces more reliable results than repeated pairwise analyses. Let us take the example 1 in Figure 1; a pairwise analysis would not be able to disambiguate the two connectivity patterns between the yellow, the blue and the red circle. A multivariate approach is able to detect the causality nexus where the red circle is both caused by the blue and the yellow circles. The example 2 of the same figure shows another danger which a multivariate test is able to avoid. Suppose that the blue circle drives two outputs (red and yellow) with different time delays. Pairwise analyses would falsely infer a causal connection from the red circle to the yellow circle, whilst a multivariate Granger test would not detect this result.

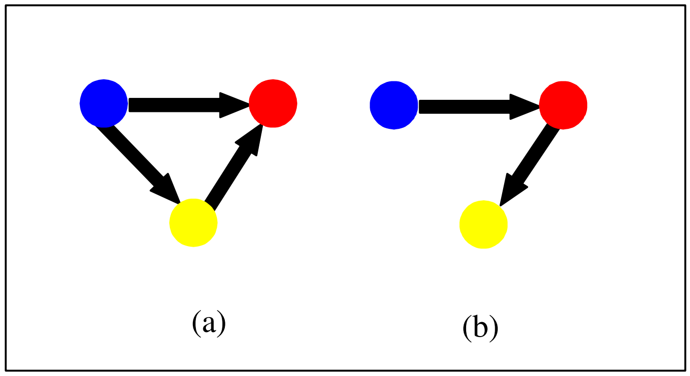

Figure 1: Two relations which cannot be disentangled by a pairwise analysis.

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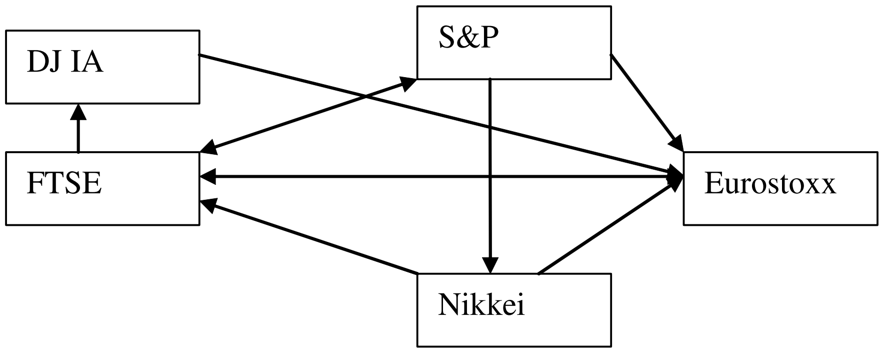

Chart 1 - G-causality amongst indexes - Entire sample

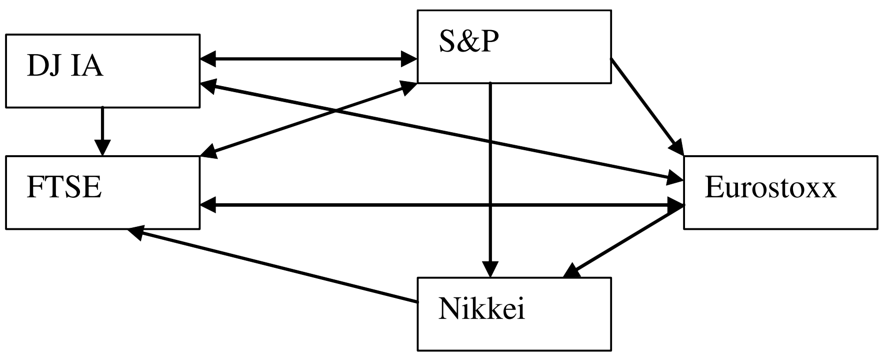

Chart 2 - G-causality amongst indexes - First Quartile

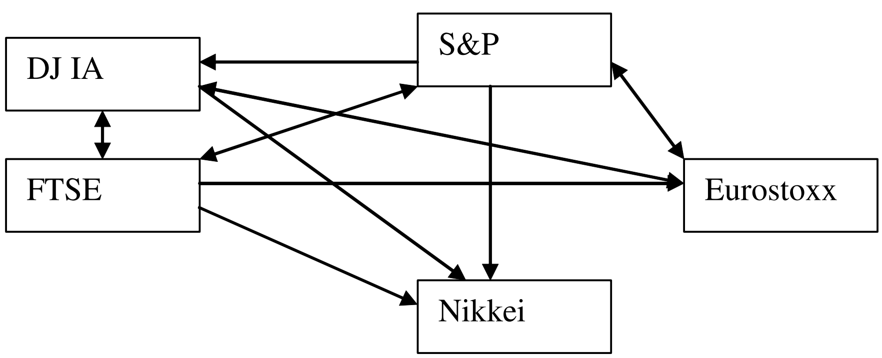

Chart 3 - G-causality amongst indexes - Second Quartile

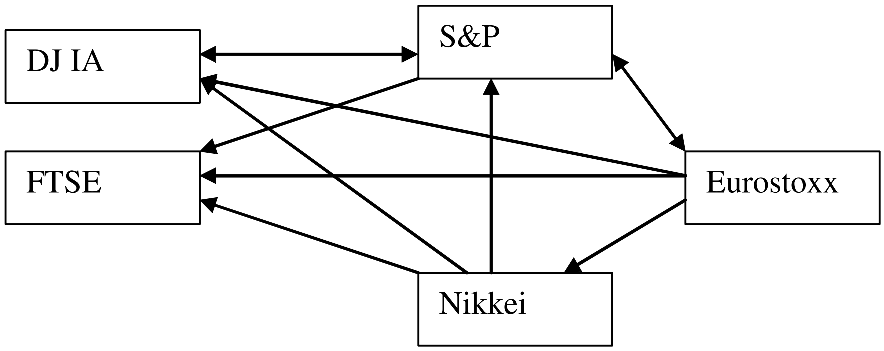

Chart 4 - G-causality amongst indexes - Third Quartile

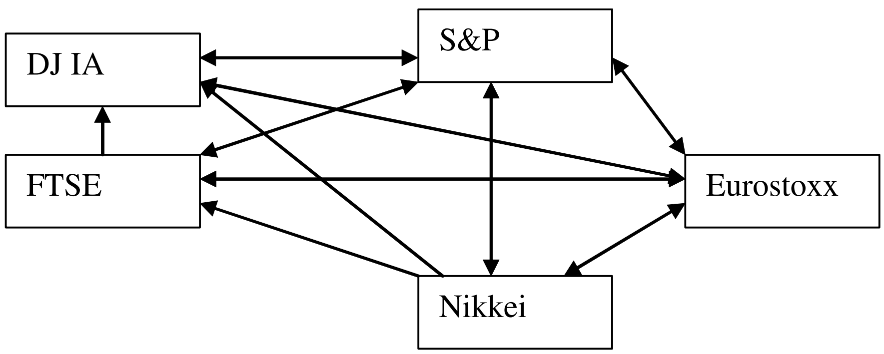

Chart 5 - G-causality amongst indexes - Fourth Quartile

	Obs	Mean	Std. Dev.	Min	Max
S&P 500	5117	0.00026	0.01158	-0.22900	0.10424
Dow Jones IA	5117	0.00030	0.01161	-0.25632	0.09689
Eurostoxx 50	5117	0.00020	0.01326	-0.08262	0.12951
Nikkei	5116	-0.00015	0.01503	-0.16135	0.13235
Ftse 100	5117	0.00017	0.01147	-0.13029	0.11113
Mean	5116	0.00016	0.00936	-0.14130	0.11482

Table 1 – Summary Statistics for the Indexes' Return in Natural Logs – Entire Sample; Source: Processed data

	Obs	Mean	Std. Dev.	Min	Max
S&P 500	1279	-0.00998	0.01320	-0.22900	0.05195
Dow Jones IA	1279	-0.00977	0.01351	-0.25632	0.05715
Eurostoxx 50	1279	-0.01222	0.01324	-0.08262	0.01723
Nikkei	1279	-0.01104	0.01576	-0.16135	0.07222
Ftse 100	1279	-0.01042	0.01159	-0.13029	0.01673

Table 2 – Summary Statistics for the Indexes' Return in Natural Logs, First Quartile; Source: Processed data

	Obs	Mean	Std. Dev.	Min	Max
S&P 500	1279	-0.00123	0.00564	-0.02304	0.03927
Dow Jones IA	1279	-0.00114	0.00563	-0.02476	0.03030
Eurostoxx 50	1279	-0.00139	0.00661	-0.04794	0.04437
Nikkei	1279	-0.00274	0.01016	-0.05242	0.04100
Ftse 100	1279	-0.00162	0.00596	-0.03268	0.02446

Table 3 – Summary Statistics for the Indexes' Return in Natural Logs, Second Quartile; Source: Processed data

	Obs	Mean	Std. Dev.	Min	Max
S&P 500	1279	0.00214	0.00538	-0.02739	0.02490
Dow Jones IA	1279	0.00216	0.00563	-0.02334	0.03211
Eurostoxx 50	1279	0.00278	0.00669	-0.03388	0.05834
Nikkei	1279	0.00328	0.00952	-0.03472	0.05991
Ftse 100	1279	0.00277	0.00605	-0.02446	0.02799

Table 4 – Summary Statistics for the Indexes' Return in Natural Logs, Third Quartile; Source: Processed data

	Obs	Mean	Std. Dev.	Min	Max
S&P 500	1279	0.01010	0.00970	-0.01563	0.10424
Dow Jones IA	1279	0.00993	0.00967	-0.01549	0.09689
Eurostoxx 50	1279	0.01164	0.01204	-0.02157	0.12951
Nikkei	1279	0.00990	0.01497	-0.05570	0.13235
Ftse 100	1279	0.00996	0.01010	-0.02118	0.11113

Table 5 – Summary Statistics for the Indexes' Return in Natural Logs, Fourth Quartile; Source: Processed data

Equation	Excluded	chi2	df	Prob>chi2
S&P 500	**Dow Jones IA**	**39.025**	**20**	**0.007(*)**
	Eurostoxx 50	26.585	20	0.147
	Nikkei	17.943	20	0.591
	Ftse 100	**31.973**	**20**	**0.044(**)**
	All	175.25	80	0(*)
Dow Jones IA	S&P 500	36.139	20	0.015(**)
	Eurostoxx 50	23.851	20	0.249
	Nikkei	17.75	20	0.604
	Ftse 100	**30.188**	**20**	**0.067(*)**
	All	166.14	80	0(*)
Eurostoxx 50	**S&P 500**	**131.3**	**20**	**0(*)**
	Dow Jones IA	**34.432**	**20**	**0.023(**)**
	Nikkei	**54.019**	**20**	**0(*)**
	Ftse 100	**32.798**	**20**	**0.036(*)**
	All	912.11	80	0(*)
Nikkei	**S&P 500**	**93.489**	**20**	**0(*)**
	Dow Jones IA	27.175	20	0.13
	Eurostoxx 50	28.057	20	0.108
	Ftse 100	25.884	20	0.17
	All	969.64	80	0(*)
Ftse 100	**S&P 500**	**130.78**	**20**	**0(*)**
	Dow Jones IA	24.417	20	0.225
	Eurostoxx 50	**70.917**	**20**	**0(*)**
	Nikkei	**73.091**	**20**	**0(*)**
	All	910.16	80	0(*)

Table 6 – Granger causality Wald tests, Entire Sample; (*) significant at the 1% of the C.I.; (**) significant at the 5% of the C.I.; (***) significant at the 10% of the C.I.

Equation	Excluded	chi2	df	Prob>chi2
S&P 500	**Dow Jones IA**	**31.965**	**20**	**0.044(**)**
	Eurostoxx 50	15.564	20	0.743
	Nikkei	22.99	20	0.289
	Ftse 100	**41.589**	**20**	**0.003(*)**
	All	139.71	80	0(*)
Dow Jones IA	**S&P 500**	**34.124**	**20**	**0.025(**)**
	Eurostoxx 50	18.65	20	0.545
	Nikkei	19.847	20	0.468
	Ftse 100	**40.133**	**20**	**0.005(*)**
	All	145.53	80	0(*)
Eurostoxx 50	**S&P 500**	**45.885**	**20**	**0.001(*)**
	Dow Jones IA	**36.038**	**20**	**0.015(**)**
	Nikkei	26.944	20	0.137
	Ftse 100	**37.515**	**20**	**0.01(*)**
	All	320.06	80	0(*)
Nikkei	**S&P 500**	**29.34**	**20**	**0.081(***)**
	Dow Jones IA	23.599	20	0.26
	Eurostoxx 50	**29.705**	**20**	**0.075(***)**
	Ftse 100	27.516	20	0.121
	All	425.24	80	0(*)
Ftse 100	**S&P 500**	**67.14**	**20**	**0(*)**
	Dow Jones IA	**43.349**	**20**	**0.002(*)**
	Eurostoxx 50	**52.657**	**20**	**0(*)**
	Nikkei	**28.524**	**20**	**0.098(***)**
	All	434.73	80	0(*)

Table 7 – Granger causality Wald tests, First Quartile; (*) significant at the 1% of the C.I.; (**) significant at the 5% of the C.I.; (***) significant at the 10% of the C.I.

Equation	Excluded	chi2	df	Prob>chi2
S&P 500	Dow Jones IA	24.769	20	0.21
	Eurostoxx 50	**35.91**	**20**	**0.016(**)**
	Nikkei	25.58	20	0.18
	Ftse 100	**47.65**	**20**	**0(*)**
	All	138.88	80	0(*)
Dow Jones IA	**S&P 500**	**59.889**	**20**	**0(*)**
	Eurostoxx 50	**33.737**	**20**	**0.028(**)**
	Nikkei	24.914	20	0.205
	Ftse 100	**34.076**	**20**	**0.026(**)**
	All	151.67	80	0(*)
Eurostoxx 50	**S&P 500**	**40.003**	**20**	**0.005(*)**
	Dow Jones IA	**31.431**	**20**	**0.05(**)**
	Nikkei	24.146	20	0.236
	Ftse 100	23.103	20	0.284
	All	204.54	80	0(*)
Nikkei	**S&P 500**	**39.232**	**20**	**0.006(*)**
	Dow Jones IA	**35.682**	**20**	**0.017(**)**
	Eurostoxx 50	23.537	20	0.263
	Ftse 100	**31.161**	**20**	**0.053(***)**
	All	165.45	80	0
Ftse 100	**S&P 500**	**33.687**	**20**	**0.028(**)**
	Dow Jones IA	**32.631**	**20**	**0.037(**)**
	Eurostoxx 50	16.79	20	0.667
	Nikkei	21.256	20	0.382
	All	118.25	80	0.004(*)

Table 8 – Granger causality Wald tests, Second Quartile; (*) significant at the 1% of the C.I.; (**) significant at the 5% of the C.I.; (***) significant at the 10% of the C.I.

Equation	Excluded	chi2	df	Prob>chi2
S&P 500	**Dow Jones IA**	**31.543**	**20**	**0.048(**)**
	Eurostoxx 50	**44.358**	**20**	**0.001(*)**
	Nikkei	**49.943**	**20**	**0(*)**
	Ftse 100	28.177	20	0.105
	All	158.47	80	0(*)
Dow Jones IA	**S&P 500**	**56.338**	**20**	**0(*)**
	Eurostoxx 50	**52.624**	**20**	**0(*)**
	Nikkei	**50.674**	**20**	**0(*)**
	Ftse 100	23.467	20	0.266
	All	191.66	80	0(*)
Eurostoxx 50	**S&P 500**	**31.041**	**20**	**0.055(***)**
	Dow Jones IA	24.226	20	0.233
	Nikkei	21.974	20	0.342
	Ftse 100	18.55	20	0.551
	All	174.31	80	0(*)
Nikkei	S&P 500	20.138	20	0.449
	Dow Jones IA	17.041	20	0.65
	Eurostoxx 50	**33.51**	**20**	**0.03(**)**
	Ftse 100	27.238	20	0.129
	All	183.93	80	0(*)
Ftse 100	**S&P 500**	**34.689**	**20**	**0.022(**)**
	Dow Jones IA	21.576	20	0.364
	Eurostoxx 50	**39.744**	**20**	**0.005(*)**
	Nikkei	**30.528**	**20**	**0.062(***)**
	All	161.81	80	0(*)

Table 9 – Granger causality Wald tests, Third Quartile; (*) significant at the 1% of the C.I.; (**) significant at the 5% of the C.I.; (***) significant at the 10% of the C.I.

Equation	Excluded	chi2	df	Prob>chi2
S&P 500	Dow Jones IA	39.506	20	0.006(*)
	Eurostoxx 50	42.946	20	0.002(*)
	Nikkei	31.435	20	0.05(*)
	Ftse 100	51.135	20	0(*)
	All	155.83	80	0(*)
Dow Jones IA	S&P 500	37.383	20	0.011(**)
	Eurostoxx 50	40.793	20	0.004(*)
	Nikkei	35.657	20	0.017(**)
	Ftse 100	53.079	20	0(*)
	All	166.52	80	0(*)
Eurostoxx 50	S&P 500	48.613	20	0(*)
	Dow Jones IA	38.268	20	0.008(*)
	Nikkei	34.689	20	0.022(**)
	Ftse 100	48.757	20	0(*)
	All	243.82	80	0(*)
Nikkei	S&P 500	35.998	20	0.015(**)
	Dow Jones IA	33.741	20	0.028(**)
	Eurostoxx 50	36.167	20	0.015(**)
	Ftse 100	18.837	20	0.532
	All	259.1	80	0(*)
Ftse 100	S&P 500	35.261	20	0.019(**)
	Dow Jones IA	22.344	20	0.322
	Eurostoxx 50	43.22	20	0.002(*)
	Nikkei	43.152	20	0.002(*)
	All	235.5	80	0(*)

Table 10 – Granger causality Wald tests, Fourth Quartile; (*) significant at the 1% of the C.I.; (**) significant at the 5% of the C.I.; (***) significant at the 10% of the C.I.