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Measuring the Impact of the GFC on European Equity Markets

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Abstract

I investigate the impact of the Global Financial Crisis (GFC) on the returns and volatilities of eleven major European share markets, and test the proposition that the GFC developed over two stages: a subprime mortgage crisis (pre-Lehman), and a more severe global liquidity shortage phase (post-Lehman). Significant structural breaks are found in the returns and volatilities associated with the two stages of the crisis. However, while there is strong statistical evidence suggesting that Phase 2 of the GFC experienced higher volatility levels than Phase 1, we are unable to reject the null that the impact on the returns was equal across the two stages. Further, it appears that the mean of the return series over the post-GFC period has returned to its pre-crisis level for all markets, whereas post-GFC volatilities remain statistically higher than their pre-crisis averages for ten of the eleven markets studied.

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1. Introduction

Financial contagion is a term used to describe the transmission of shocks between financial assets or markets associated with periods of severe bear markets and heightened market turbulence. These events are usually followed by deterioration of real economic activity, unemployment, deflation, and in worst cases civil unrest. The recent Global Financial Crisis (GFC), now widely regarded as the worst global economic downturn since the Great depression of the 1930's, spread across the globe with incredible speed and severity in the late 2007. Following the onset of the GFC studies such as McAndrews, Sarkar and Wang (2008), and Frank and Hesse (2009a) aimed to address important policy issues pertinent at the time. This literature has grown rapidly to include further papers on the effectiveness of the implemented policies (Ait-Sahalia et al., 2010; Taylor and Williams 2009; Taylor, 2009), linkages between housing and macroeconomic trends prior and during the crisis (Faruqee et al., 2009; Swagel, 2009), financial spillovers to emerging markets (Frank and Hesse, 2009b), and historical comparisons with other major financial crises (Reinhart and Rogoff, 2008, 2009), to name a few.

Contribution of this paper is twofold. First, I investigate the impact of the GFC on the returns and volatilities of eleven major European stock markets. As the chairman of the UK Financial Services Authority Lord Turner (2009) noted one of the main distinguishing features of the GFC was that severe financial problems emerged simultaneously in many different countries. Given that much of the existing literature focuses on the US case, this study's contribution is in providing new international evidence on the impact of the crisis across Europe. The eleven national stock markets included in the study are the UK, France, Germany, Italy, Austria, Belgium, Ireland, the Netherlands, Norway, Sweden, and Switzerland. Second, I test a hypothesis proposed in several papers such as Ait-Sahalia et al. (2010), and Taylor (2009), that the GFC developed in two stages: Phase 1, corresponding to the subprime mortgage crisis that originated in the US, and the more severe Phase 2 associated with the post-Lehman financial meltdown.

The empirical approach undertaken here consists of several steps. Given a data set covering the period July 17, 2003 – September 16, 2010, four time intervals are defined: a pre-GFC period (July 17, 2003 – August 19, 2007), Phase 1 of the GFC (August 20, 2007 – September 14, 2007), Phase 2 of the GFC (September 15, 2007 – March 31, 2009), and a post-GFC period (April 1, 2009 – September 16, 2010). These periods are chosen on two grounds. First, empirical evidence presented in the literature is used as a guide to partitioning the sample. For example, Ait-Sahalia et al. (2010) places the beginning of Phase 1 of the GFC around June 1, 2007, but Taylor (2009) and Swagel (2009) date it a little later to August 2007. The period surrounding the collapse of Lehman Brothers on September 15, 2008 is viewed as the start of Phase 2 of the crisis in Ait-Sahalia et al. (2010), Swagel (2009), Claessens, et al. (2010), and Taylor (2009), while the end of the crisis is generally regarded to be between March and April 2009. In order to confirm the plausibility of the above defined time intervals they are related to changes in the TED spread, which measures the level of credit risk of the economy. Three indicator functions are then created to correspond with the two phases of the crisis, and the post-GFC period.

In the second step the stock market return series are regressed on the crisis indicator variables, and statistical tests are performed in order to assess the impact of the GFC. An ARMA filter is also used in each regression to eliminate any autocorrelation that may exist in the data, while a lagged US return variable is added to control for the impact of the US market. The following hypotheses are then tested i) mean equity returns corresponding to the GFC Phase 1 and GFC Phase 2 periods are lower than those associated with the pre-GFC period, ii) mean returns over GFC Phase 2 is lower than the mean return over the GFC Phase 1 time interval, and iii) post-GFC mean return is equal to the pre-GFC average. Lastly, a GARCH (Generalized Conditional Heteroskedasticity) model is fitted to each series with the purpose of assessing the impact of the GFC on the volatility of the stock markets. Conditional variances are specified as EGARCH models (Nelson, 1991) augmented with the GFC indicator variables and a lagged US squared return variable in order to account for possible breaks in the conditional variances. EGARCH models specify the natural logarithm of the conditional variance, thus eliminating the possibility of negative variance estimates when additional explanatory variables are included in GARCH equations. Three null hypotheses are specified regarding the conditional variance series postulating that i) the two GFC phases exhibit higher volatility than the rest of the sample, ii) volatility is greater during Phase 2 of the GFC than during Phase 1, and iii) average volatilities are equal over the pre-GFC and post-GFC periods.

In the rest of the paper I discuss the econometric methodology in Section 2; in Section 3 I describe the dataset and present some summary statistics. Section 4 provides empirical results, while Section 5 summarizes the findings and concludes.

2. Econometric Methodology

In order to test for possible structural breaks in the return process for the eleven national stock indices I estimate the following ARMAX model for each index

$$\Phi(L)y_{i,t} = c_i + a_i r_{US,t-1} + \theta(L)\varepsilon_{i,t}$$

$$+\delta_{1,i} I(GFC\ Phase\ 1) + \delta_{2,i} I(GFC\ Phase\ 2) + \delta_{3,i} I(post\ GFC) \qquad (1)$$

where $y_{i,t}$'s (i = 1,...,11; t = 1,...,T) are the stock market return series, $c_i, \delta_{1,i}, \delta_{2,i}$ and $\delta_{3,i}$ represent the intercept and structural break parameters, while $\Phi(L) = 1 \quad - \phi_1 L - \cdots - \phi_p L^p$ is the AR lag polynomial and $\theta(L) = 1 - \theta_1 L - \cdots - \theta_q L^q$ is the MA lag polynomial. The ARMA(p, q) component of the model serves the purpose of filtering out any autocorrelation that may exist in the returns. The correct ARMA order is selected using the Schwarz Information Criterion for each return series; $r_{US,t-1}$ is a lagged return on the US S&P500 share market index used to control for the impact of structural changes in the US equities over the period of the crisis. The indicator functions are defined as follows:

$$I(GFC\ Phase\ 1) = \begin{cases} 1 & \text{if August 19, 2007} \leq \text{time} < \text{September 15, 2008} \\ 0 & \text{otherwise} \end{cases}$$
$$I(GFC\ Phase\ 2) = \begin{cases} 1 & \text{if September 15, 2008} \leq \text{time} < \text{March 31, 2009} \\ 0 & \text{otherwise} \end{cases} \qquad (2)$$
$$I(post\ GFC) = \begin{cases} 1 & \text{if April 1, 2009} \leq \text{time} \leq \text{September 16, 2010} \\ 0 & \text{otherwise} \end{cases}$$

These periods are selected from the existing literature as explained in Section 1. In order to test for possible structural breaks in the returns associated with GFC Phase 1, GFC Phase 2 and post-GFC periods the following hypotheses are specified:

1.a) $H_0: \delta_{1,i} = 0;\ H_1: \delta_{1,i} < 0$ i.e. negative returns over GFC Phase 1 period

1.b) $H_0: \delta_{2,i} = 0;\ H_1: \delta_{2,i} < 0$ i.e. negative returns over GFC Phase 2 period

1.c) $H_0: \delta_{2,i} = \delta_{1,i};\ H_1: \delta_{2,i} < \delta_{1,i}$ i.e. Phase 2 return lower than Phase 1 return

1.d) $H_0: \delta_{3,i} = 0;\ H_1: \delta_{3,i} \neq 0$ i.e. post-GFC return is back to pre-GFC level.

The residuals from Eq.(1) are assumed to be conditionally normally distributed $\varepsilon_{i,t}|\Omega_{t-1} \sim N(0, h_{i,t})$, where the information set Ω_{t-1} is a filtration generated by the innovations $\varepsilon_{i,t-1}, \varepsilon_{i,t-2} \ldots\ldots$, and $h_{i,t}$ is a time varying conditional variance. The conditional variances $h_{i,t}$ are specified as augmented EGARCH(1, 1, 1) models

$$log(h_{i,t}) = \omega_i + \alpha_i \left|\frac{\varepsilon_{i,t-1}}{h_{i,t-1}}\right| + \gamma_i \frac{\varepsilon_{i,t-1}}{h_{i,t-1}} + \beta_i log(h_{i,t-1}) + b_i r_{US,t-1}^2$$

$$+\theta_{i,1} I(GFC\ Phase\ 1) + \theta_{i,2} I(GFC\ Phase\ 2) + \theta_{i,3} I(post\ GFC) \qquad (3)$$

One important advantage of the EGARCH specification is that it avoids the problem of imposing non-negativity constraints on parameter estimates by modeling the natural logarithm of the conditional variance. In the above equation γ accounts for the asymmetric volatility effect, a tendency of volatility to increase more during bear markets than during bull markets, while $\theta_{i,1}, \theta_{i,2}$ and $\theta_{i,3}$ are parameters designed to capture possible structural breaks in the volatility due to the GFC. Indicator functions appearing in the second row of the above equation are constructed as in Eq. (2); $r_{US,t-1}^2$ is a squared lagged US market return added to the equations in order to control for changes in the US volatility.

I test four hypotheses related to the impact of the GFC on the stock market volatilities

3.a) $H_0: \theta_{1,i} = 0, H_1: \theta_{1,i} > 0$ i.e. Phase 1 GFC period exhibits heightened volatility

3.b) $H_0: \theta_{2,i} = 0, H_1: \theta_{2,i} > 0$ i.e. Phase 2 GFC period exhibits heightened volatility

3.c) $H_0: \theta_{2,i} = \theta_{1,i}, H_1: \theta_{2,i} > \theta_{1,i}$ i.e. Phase 2 exhibits higher volatility than Phase 1

3.d) $H_0: \theta_{3,i} = 0, H_1: \theta_{3,i} \neq 0$ i.e. post-GFC volatility returns to pre-GFC level.

Eq. (1) and Eq. (3) are estimated jointly in one step using the method of maximum likelihood using the Berndt, Hall, Hall, and Hausman (BHHH, 1974) optimization algorithm.

3. Description of Data and Summary Statistics

I use daily observations on a set of eleven major European share markets that consists of the following indices: FTSE All Share index (UK), CAC40 (France), DAX30 (Germany), COMIT30 (Italy), ATX (Austria), BEL20 (Belgium), ISEQ (Ireland), AEX (the Netherlands), OBX (Norway), OMX30 (Sweden), and SSMI (Switzerland). All indices are expressed in Euros and obtained from Datastream International. S&P 500 denominated in the euro is used as the US stock market index. Daily returns are calculated as log differences of the closing prices over the time period July 17, 2003 – September 16, 2010, a total of 1,871 observations.

Table 1 reports descriptive statistics for the eleven index return series. As illustrated in the table Norway and Sweden exhibit the highest average annualized returns with 11.16% and 8.88%, respectively, while Italy and Ireland record the lowest returns of -2.50% and -6.30%, respectively.

Table 1: Descriptive Statistics for Daily Return Series

	FTSE (UK)	DAX30 (Germany)	CAC40 (France)	COMIT30 (Italy)	ATX (Austria)	BEL20 (Belgium)	SMI (Switzerland)	ISEQ (Ireland)	AEX (Netherlands)	OBX (Norway)	OMX30 (Sweden)	S&P 500 (US)
Mean	2.40	8.18	2.28	-2.50	8.29	3.62	5.53	-6.30	1.10	11.16	8.88	-0.43
Std. Dev.	21.18	22.00	22.55	21.46	26.79	20.33	16.79	25.90	22.75	32.54	26.79	22.48
Skew	-0.22	0.13	0.12	-0.02	-0.32	-0.21	0.04	-0.63	-0.18	-0.56	0.12	-0.11
Kurtosis	11.52	11.43	12.00	12.68	10.10	11.33	10.63	10.94	12.63	9.19	8.12	11.12
JB. prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

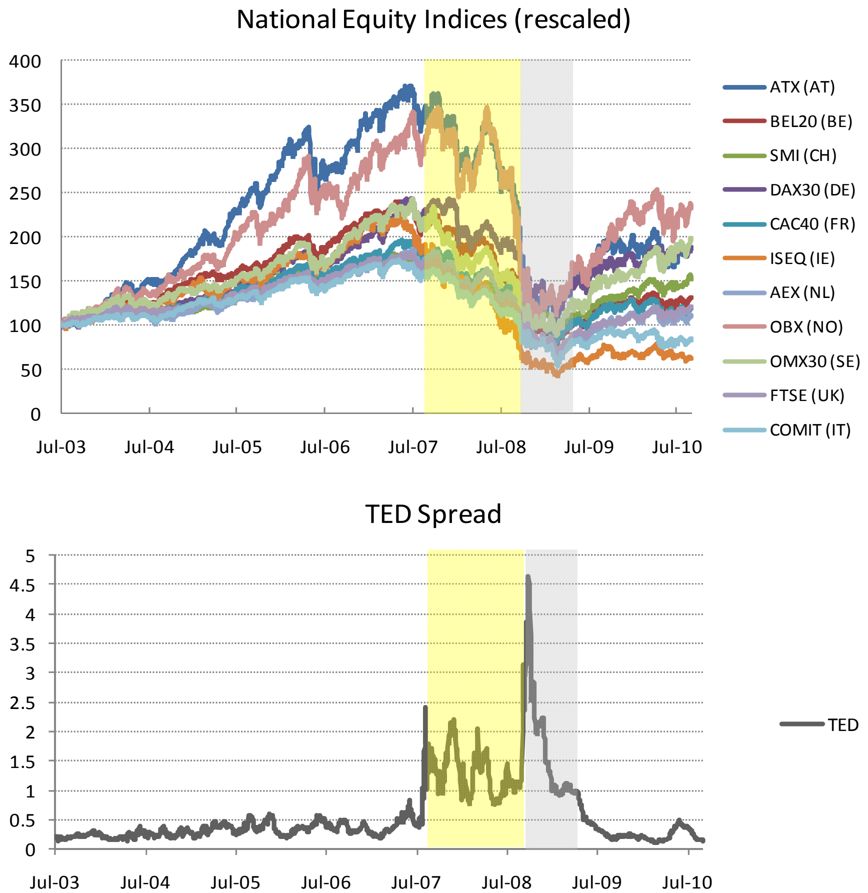
Note: Mean and Standard Deviation figures represent annualized statistics for the sample August 17, 2003 – November 18, 2010. *JB. prob*. refers to the Jarque-Bera Normality test *p*-value.

In terms of risk, as measured by the standard deviation, most markets rank about the same, with the notable exceptions of Switzerland, with annual volatility of only 16.79% p.a., and Norway with the highest level of risk at 32.54% p.a. Daily skewness figures are close to zero, but most markets exhibit significant excess kurtosis, with the Jarque-Bera tests clearly rejecting the null of normality for all eleven return series.

Figure 1 depicts the national stock market indices, together with the TED spread[1], which is often used as an indicator of the overall credit risk in the economy.

[1] The TED spread is the spread between the Libor rate and the short-term risk-free US government debt.

Figure 1: National stock market indices and the TED spread



Note: The share market indices are rebased to 100 at the start of the sample. Areas shaded in yellow correspond to GFC Phase 1 period, areas shaded in grey correspond to GFC Phase 2 period.

A visual inspection of the TED spread confirms the accuracy of the time intervals chosen to represent the GFC Phase 1 and Phase 2 periods. On August 20, 2007 the TED spread increased almost fivefold heralding the onset of the crisis. The period between August 20, 2007 and September 14, 2008 exhibits a heightened level of credit risk, and is associated with a downward trend in the European share markets. The collapse of Lehman Brothers on September 15, 2008 is characterised by a further sharp increase in the TED spread and a very steep decline in equities. Following the end of the period shaded in grey in Figure 1 (April 1, 2009), we observe the TED spread returning to its pre-GFC levels, and the European share markets commencing an upward trend.

Before proceeding further, I conduct Augmented Dickey-Fuller (1979) and Kwaitkowski-Phillips-Schmidt-Shin (1992) unit root tests on the natural logarithms of the share market indices. All eleven markets are found to contain a unit root in log-levels, but not in the first differences of the log, i.e. log returns, at the 5% level[2].

[2] Unit root test results are available upon request.

4. Empirical Results

Estimates of the structural break parameters discussed in Section 2 are given below in Table 2, which presents the relevant mean equation parameters, and Table 3 that provides coefficients for the conditional variance specifications.

Table 2: Mean Equation Parameter Estimates

	GFC Phase 1 $\delta_{1,i}$	GFC Phase 2 $\delta_{2,i}$	Post-GFC $\delta_{3,i}$	$H_0: \delta_{2,i} = \delta_{1,i}$ $H_1: \delta_{2,i} < \delta_{1,i}$	ARMA(p, q)
FTSE (UK)	-0.15 [-2.37]**	-0.32 [-1.75]*	0.04 [0.86]	[-0.92]	(1, 1)
DAX30 (Germany)	-0.10 [-1.64]*	-0.33 [-1.69]*	-0.03 [-0.44]	[-1.18]	(1, 0)
CAC40 (France)	-0.13 [-2.17]*	-0.28 [-1.66]*	-0.00 [-0.05]	[-0.82]	(1, 1)
COMIT30 (Italy)	-0.15 [-2.56]**	-0.45 [-2.08]*	-0.02 [-0.35]	[-1.36]	(0, 1)
ATX (Austria)	-0.20 [-2.26]*	-0.38 [-1.35]	-0.06 [-0.67]	[-0.61]	(0, 0)
BEL20 (Belgium)	-0.18 [-2.77]**	-0.37 [-2.07]*	-0.03 [-0.59]	[-1.00]	(1, 0)
SMI (Switzerland)	-0.10 [-1.81]*	-0.27 [-1.84]*	0.04 [0.93]	[-1.14]	(0, 1)
ISEQ (Ireland)	-0.33 [-3.25]**	-0.42 [-1.78]*	-0.07 [-0.84]	[-0.35]	(1, 0)
AEX (Netherlands)	-0.10 [-1.56]	-0.39 [-1.70]*	0.01 [0.24]	[-1.25]	(1, 0)
OBX (Norway)	-0.10 [-0.96]	-0.41 [-1.11]	-0.09 [-0.82]	[-0.81]	(0, 0)
OMX30 (Sweden)	-0.22 [-2.54]**	-0.33 [-1.34]	0.01 [0.15]	[-0.42]	(0, 1)

Note: The estimates presented in the above table correspond to Eq. (1), which is reproduced here for convenience $\Phi(L)y_{i,t} = c_i + a_i r_{US,t-1} + \delta_{1,i} I(GFC\ Phase\ 1) + \delta_{2,i} I(GFC\ Phase\ 2) + \delta_{3,i} I(post\ GFC) + \theta(L)\varepsilon_{i,t}$. Given in square brackets are *t*-ratios calculated using Bollerslev-Wooldridge (1992) HAC standard errors. 5% critical values for one-sided left tail test is -1.64; 1% critical value is -2.36. The 5% critical value for the two-sided test is 1.96; 1% critical value is 2.58. * denotes rejection of a relevant null at 5%, ** denote rejection of a relevant null at 1%.

Considering the first and second columns of the above table, which present coefficient estimates of the structural break parameters $\delta_{1,i}$ and $\delta_{2,i}$, we observe that the impact of the two stages of the GFC is reflected in negative point estimates in all cases. The null hypotheses that the GFC Phase 1 and Phase 2 periods are not associated with a change in the mean of the return series is rejected in favour of its one-sided alternative (returns decline over the two GFC time intervals) in most cases, at either 1% or 5% significance level. The notable exceptions for the GFC Phase 1 period are the Netherlands and Norway, and for Phase 2 stage Austria, Norway and Sweden. Although, the estimates of $\delta_{2,i}$ are in all cases smaller (more negative) than those for $\delta_{1,i}$, which is consistent with the proposition that Phase 2 was more severe than Phase 1, this hypothesis cannot be verified on a statistical basis. As the second-last column of Table 2 illustrates, the null that the impact of the two stages of the GFC was equal cannot be rejected for any of the eleven markets. Lastly, judging by the magnitudes of the estimated parameters $\delta_{3,i}$ and their t-ratios, the average returns across all eleven markets appear to have returned to their pre-crisis levels.

The impact of the GFC on the stock markets volatilities differs in two important aspects from that described above for the return series, as illustrated in Table 3 below.

Table 3:Conditional Variance Equation Parameter Estimates

	GFC Phase 1 $\theta_{1,i}$	GFC Phase 2 $\theta_{2,i}$	Post-GFC $\theta_{3,i}$	$H_0: \theta_{2,i} = \theta_{1,i}$ $H_1: \theta_{2,i} > \theta_{1,i}$
FTSE (UK)	0.09 [2.83]**	0.17 [2.91]**	0.07 [2.59]**	[2.10]*
DAX30 (Germany)	0.02 [1.42]	0.12 [3.31]**	0.04 [2.54]*	[2.90]**
CAC40 (France)	0.06 [3.04]**	0.13 [3.53]**	0.07 [3.54]**	[2.16]*
COMIT30 (Italy)	0.07 [2.92]**	0.18 [3.65]**	0.10 [3.74]**	[2.87]**
ATX (Austria)	0.06 [2.26]*	0.15 [2.76]**	0.07 [2.33]*	[2.23]*
BEL20 (Belgium)	0.11 [3.68]**	0.21 [3.78]**	0.10 [3.67]**	[2.29]*
SMI (Switzerland)	0.05 [2.46]**	0.10 [2.60]**	0.02 [1.61]	[1.67]*
ISEQ (Ireland)	0.13 [2.37]**	0.20 [2.39]**	0.11 [2.24]*	[1.56]
AEX (Netherlands)	0.04 [2.52]**	0.12 [3.59]**	0.04 [3.11]**	[2.84]**
OBX (Norway)	0.05 [2.71]**	0.17 [3.81]**	0.08 [3.47]**	[3.37]**
OMX30 (Sweden)	0.06 [2.83]**	0.14 [3.38]**	0.06 [3.26]**	[2.43]**

Note: The estimates presented in the above table correspond to Eq. (3) reproduced here for convenience $log(h_{i,t}) = \omega_i + \alpha_i \left|\frac{\varepsilon_{i,t-1}}{h_{i,t-1}}\right| + \gamma_i \frac{\varepsilon_{i,t-1}}{h_{i,t-1}} + \beta_i log(h_{i,t-1}) + b_i r^2_{US,t-1} + \theta_{i,1} I(GFC\ Phase\ 1) + \theta_{i,2} I(GFC\ Phase\ 2) + \theta_{i,3} I(post\ GFC)$. Given in square brackets are *t*-ratios calculated using Bollerslev-Wooldridge (1992) HAC standard errors. 5% critical values for one-sided right tail test is 1.64; 1% critical value is 2.36. The 5% critical value for the two-sided test is 1.96, 1% critical value is 2.58. * denotes rejection of the relevant null at 5%, ** denote rejection of the relevant null at 1%.

First, the null of equal impact on the volatility over the two stages of the GFC is clearly rejected in favour of the alternative that Phase 2 is associated with higher levels of volatility for all eleven cases. While this may be observed in the point estimates for $\theta_{1,i}$ and $\theta_{2,i}$, the last column of Table 3 provides statistical evidence for this claim showing that the null is rejected at either the 1% or 5% levels in ten instances. Ireland is the only case for which the two phases of the crisis appear to exhibit the same level of volatility. The second important difference from the mean equation estimates is that ten of the eleven volatility series do not return to their pre-GFC levels following the end of the crisis. According to the *t*-ratios presented in the second-last column of Table 3, Switzerland is the only market whose post-GFC volatility has returned to its pre-GFC level.

5. Conclusion

I analyze the impact of the GFC on eleven major European stock markets, and test the hypothesis that the GFC developed in two stages: Phase 1, a pre-Lehman subprime mortgage crisis, and Phase 2, a global liquidity shortage crisis.

Both of the GFC stages are associated with lower average returns relative to the pre-GFC period. However, although point estimates indicate that price declines were larger during the Phase 2 period, a statistical test is unable to reject the null hypothesis that the decreases recorded over the two periods were equal for any of the eleven markets. On the other hand, the impact of Phase 2 on the volatility in the markets appears to be greater than the effect of Phase 1 with statistical significance. Thus, while the statistical evidence gained from the volatility equations suggests that the crisis developed over two stages characterized by different volatility regimes, we are unable to draw a similar conclusion from the mean equations. However, the inability of the test to distinguish between the two periods of the crisis in the return series could be due to significant increases in the volatility. Lastly, while the means of the return series in the post-GFC period appears to revert to their pre-GCF levels in ten of the eleven markets investigated, the average volatility levels remain higher in all eleven instances.

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