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Asymmetric Volatility Spillovers between Stock Market and Real Activity: Evidence from the UK and the US

Summary: This paper examines the short-run dynamic relationships between stock market and real activity, within a country, for the UK and the US. The Cross Correlation Function testing procedure is applied to test for causality in mean and in variance between the stock market and the real economic sector. Besides variance causation, volatility spillover effects are examined through the multivariate specification form of the Exponential GARCH model. There is evidence of significant reciprocal volatility spillovers between the two sectors within a country, implying stronger interdependencies in the UK rather than in the US and asymmetric behavior only in the case of the UK.

Key words: Stock market, Real activity, Volatility spillovers, UK, US.

JEL: C32, E44, G12.

The relationship between the financial system and economic growth is captured by a large amount of theoretical and empirical works.[1] From a theoretical point of view, Joseph A. Schumpeter (1912) argues that banks can spur technological innovation and economic growth by funding productive innovations. However, there are theoretical papers arguing that the relationship between financial institutions and economic growth is not significant. For example, Joan Robinson (1952) states that financial institutions follow the developments in the real economic sector. Similarly, Robert Lucas (1988) supports the view that the role of the financial system has been 'badly over-stressed'. However, most of the subsequent theoretical papers have shown that there is a positive relationship between the financial sector and the real economic sector. In a comprehensive review of the literature, Ross Levine (1997) mentions that the financial institutions may affect economic growth through two channels: (i) capital accumulation and (ii) technological innovation. Levine (1991) shows that stock markets decrease liquidity risk and increase the incentives to investing in long-duration investment projects. Furthermore, Michael B. Devereux and Gregor W. Smith (1994) and Maurice Obstfeld (1994) show that financial institutions that ease risk diversification provoke portfolio shifts toward investments with high expected return.

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[1] For an analytical review of the literature, see Levine (1997).

Turning to the empirical part of the literature, there is a plethora of empirical works dealing with this issue, especially for developed countries. For the US, Stanley Fischer and Robert C. Merton (1984), Robert J. Barro (1990), Eugene F. Fama (1990), and William G. Schwert (1990) find that real stock returns can lead changes in real activity. Furthermore, Christis Hassapis and Sarantis Kalyvitis (2002), using Granger causality in a Vector Autoregressive (VAR) framework, and Jongmoo J. Choi, Shmuel Hauser, and Kenneth J. Kopecky (1999), using the bivariate out-of-sample prediction test of Richard Ashley, Clive W. J. Granger, and Richard Schmalensee (1980) (AGS) also find evidence of causality from US stock returns to US industrial production growth. Under the framework of a VAR analysis, Bong-Soo Lee (1992) and David E. Rapach (2001) find a significant positive relation between stock returns and real activity in US. On the contrary, Nikiforos T. Laopodis (2006) finds no supportive evidence that stock returns signal changes in future real activity in US. Alireza Nasseh and Jack Strauss (2000), using a Vector Error Correction (VEC) model, find significant long-run relationships between stock prices and industrial production in five European countries, including the UK. In addition, Paolo Mauro (2003) states that stock market developments should be taken into account in forecasting output in both developed and developing countries.

However, all these studies have not tested if volatility in one sector can be imported to the other. Most importantly, they have not taken into account any possible asymmetries in the volatility transmission mechanism between stock market and real economic activity. Dale L. Domian and David A. Louton (1997) find evidence of asymmetry in the predictability of industrial production growth by stock returns for the case of US. Negative shocks in the stock market affect industrial production growth more than positive shocks. Although this study introduces the asymmetric nature of dependences between the series, the asymmetric nature of the volatility transmission mechanism has not been investigated.

In this work, we examine the short-run dynamic relationships between stock market and real activity for the UK and the US. Specifically, we investigate whether volatility causation and transmission (volatility spillover) characterize the relation between the two sectors. To capture this kind of relationship we employ two similar empirical methodologies. Specifically, to examine causality in both the mean and the variance between real stock returns and real growth rates, we apply the two-stage Cross Correlation Function (CCF) testing procedure, developed by Yin-Wong Cheung and Lilian K. Ng (1996). Moreover, we look for potential asymmetries in the volatility transmission mechanism between the two sectors, within an economy. We explicitly test whether a negative shock in one sector (for example, stock market) has exactly the same impact on the other sector (for example, real economic sector) with a positive shock. To capture this kind of asymmetry, we employ a bivariate exponential GARCH (EGARCH) model, which was originally presented by Daniel B. Nelson (1991). There are an adequate number of empirical studies which find that conditional volatility responds asymmetrically to innovations (good or bad news). Fischer Black (1976) was the first who observed that stock prices respond asymmetrically to new information due to the leverage effect. In the context of volatility transmission, Gregory Koutmos and Geoffrey G. Booth (1995), Koutmos (1996), and Angelos Ka-

nas (1998) find significant asymmetric volatility spillovers among international stock markets.[2]

To the best of our knowledge of the literature, this paper is the first that examines the asymmetric nature of the volatility transmission mechanism between the stock market and the real economic sector for the cases of the UK and the US. A new finding that arises from this analysis is that the short-run dynamic relationship between stock market and real activity is characterized by a bi-directional asymmetric behavior, especially for the case of the UK. In addition, this analysis entails important economic and policy implications. Given that price stability and financial stability are highly complementary objectives, the question for policy makers is whether they should be concerned about the stock market's volatility. Ben Bernanke and Mark Gertler (2000) argue that monetary authorities should be concerned about asset price volatility if this is caused by "nonfundamental" factors, such as the poor regulatory practice and the irrational investing behavior in stock markets. This is because "nonfundamental" financial instability can be seen as an independent source of real activity instability.

This is actually the case of the recent global financial crisis of 2008. Namely, "nonfundamental" factors, such as the high-risky investment policy of the financial institutions and the poor regulatory policy of the monetary authorities, are considered as main causes of this crisis. Hence, the origin of the recent financial crisis and the ongoing slowdown of the global economy indicate the linkage of this study with the recent global financial crisis. Specifically, the evidence in favor of asymmetric volatility spillover effects sheds light on the selection of the appropriate monetary policy that should be applied. For example, evidence of asymmetry would imply that bad news (falling stock returns) exports more volatility to the real activity sector than good news (increasing stock returns). This means that policy makers should apply a monetary policy framework suitable for protecting real economic activity from unexpected stock market shocks in periods of financial instability. To preview our results, we have found evidence of significant interdependencies between stock market and real activity, within an economy, implying stronger interdependencies in the UK rather than in the US. In addition, volatility spillovers from the stock market to the real sector are found to be symmetric only in the case of the US. This fact may be explained by the applied monetary policy in the US and by the good condition of the US balance sheets during the 1990s. Finally, this study provides lessons for policy makers, especially in developing countries with unstable financial markets. In periods of high financial instability, monetary authorities should adjust interest rates in a systematic way until the economy and the financial system are stabilized. An appropriate monetary policy framework is of the form of flexible inflation targeting, increasing interest rates when stock prices rise and reducing them when stock prices are falling.

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[2] The Exponential GARCH model has been applied to various fields of economic interest, such as the relation between US and Eurodollar interest rates (Yiuman Tse and Booth 1996), the dynamic relationship between stock returns and exchange rates (Kanas 2000), the relationship between interest rates and exchange rates (Raymond W. So 2001), the dynamic correlation in European bond market (Vasiliki D. Skintzi and Apostolos N. Refenes 2006) and volatility spillovers across swap markets (Francis In 2007).

The structure of the remaining paper is as follows. The next section describes the data used in this study and Section 2 presents our estimation output. A final section summarizes and provides policy implications for developing economies.

1. Data

The data set consists of monthly observations over the period January 1970–December 2002 for UK and US stock prices (s), UK and US industrial production, as well as UK and US producer price indices. Real industrial production (IP) is calculated by dividing the industrial production index by the producer price index, while its growth rate (y) is calculated as the first difference of real IP. Real stock prices (s) are calculated by dividing nominal stock prices by the price index, and real stock returns (r) are calculated as the first difference of real stock prices. All variables are presented in natural logarithms. Jargue-Bera statistics reveal that the hypothesis of normality is rejected for all variables. The distributions of stock returns and real IP growth are negatively skewed and leptokurtic relative to the normal distribution. The Ljung-Box statistics applied to the series and squared series using 12 lags imply evidence of significant linear and nonlinear dependencies. The ARCH test (Robert F. Engle 1982) for time-varying conditional heteroskedasticity confirms the evidence of volatility clustering in the distributions of the above series.

When it comes to the stationary nature of the variables, a variety of alternative unit root tests provides evidence of non-stationarity for the stock prices and the industrial production. Accordingly, real stock returns and real IP growth rate appear to be stationary. Johansen's trace test for cointegration between industrial production and stock prices, within a country, implies no evidence of long-run cointegrating relation. Given that real stock returns and the real IP growth rate are stationary, and that there is no cointegration, a VAR model for real stock returns and real IP growth rate should be used.[3]

2. Empirical Results

2.1 Results from the CCF Test

The empirical application of the CCF test entails a two-stage procedure. The first one involves the estimation of the univariate EGARCH (p,q) model for both series, whereas the second includes the construction of the standardized and squared standardized residuals. Then, the constructed residuals are used to calculate the CCF test statistics. For the real stock returns and the real IP growth, we estimate AR(2)-EGARCH (1,1) models of the following form

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[3] The employed unit root tests are the Augmented Dickey-Fuller (ADF) test, the Graham Elliot, Thomas J. Rothenberg, and James H. Stock (1996) and Elliot (1999) GLS-ADF, and the Serena Ng and Piere Perron (2001) GLS versions of the modified Peter C. B. Phillips and Perron (1988) unit root tests. Furthermore, the KPSS stationarity test (Denis Kwiatkowski et al. 1992) is employed to ensure robustness. Preliminary statistics as well as unit root and cointegration test results are not reported to save space. However, they will be available upon request.

$$x_t = \alpha_{x,0} + \alpha_1 \cdot x_{t-1} + \alpha_2 \cdot x_{t-2} + \varepsilon_{x,t} \qquad (1)$$

$$\sigma_{x,t}^2 = \exp\{a_{x,0} + b_x \log(\sigma_{x,t-1}^2) + \delta_x[(|z_{x,t-1}| - E|z_{x,t-1}|) + \vartheta_x z_{x,t-1}]\} \qquad (2)$$

where $x = r, y$.

Equation (1) is the conditional mean equation and Equation (2) stands for the conditional variance equation. The order of the autoregressive GARCH term (p) and that of the moving average ARCH term (q), as well as the order of the autoregressive process, have been determined using the Likelihood Ratio test.[4]

Table 1 presents the results from the univariate AR(2)-EGARCH (1,1) models. Starting from the conditional mean equations, most of the estimated parameters are found to be statistically significant. Moving on to the conditional variance equations, the coefficient δ, which measures the ARCH effect, is found to be statistically significant in all series at 1% significance level. In each model, the degree of volatility persistence (b) is less than one. Moreover, by employing two test statistics (i.e. the t-statistic and the F-statistic), we managed to reject the hypothesis that b is equal to one. This implies that all conditional variances are stationary. The asymmetric effect parameter (ϑ) is found to be statistically significant at 1% significance level for the US real stock returns and the US IP growth rate. Similarly, UK real stock return series is statistically significant at the 10% level of significance.

Table 1 Univariate EGARCH (p, q) Models

Parameters	UK		US	
	Stock Returns p=1, q=1	**Real IP Growth** p=1, q=1	**Stock Returns** p=1, q=1	**Real IP Growth** p=1, q=1
α_0	0.002	-0.003*	0.005*	0.0005
	(1.22)	(-5.89)	(2.23)	(1.51)
α_1	0.17*	-0.11**	-0.10*	0.14*
	(2.33)	(-1.95)	(-2.54)	(2.62)
α_2	-0.14***	-0.15*	-0.03	0.12***
	(-1.87)	(-2.65)	(-0.76)	(1.82)
a_0	-0.96*	-4.11*	-2.54*	-0.94*
	(-2.87)	(-5.71)	(-3.76)	(-3.73)
B	0.88*	0.60*	0.61*	0.92*
	(18)	(7.13)	(5.58)	(34.45)
H_0: b=1	t=-3^z, F=5.76^z	t=-5^z, F=22.2^z	t=-3.5^z, F=11.7^z	t=-4^z, F=8.25^z
δ	0.35*	0.87*	0.24*	0.25*
	(2.56)	(4.86)	(2.23)	(2.01)
ϑ	-0.09***	-0.17	-0.25*	-0.17*
	(-1.86)	(-1.60)	(-3.67)	(-3.59)
$L(\Theta)$	598.24	1132.45	652.97	1325.66
LB (12)	14.29	1.88	17.56	0.09
LB^2(12)	8.48	0.78	14.17	0.94
Skewness	-0.56	-0.73	-0.37	-0.26
Kurtosis	4.12	5.61	4.31	4.15
JB	41.87^n	147.51^n	37.69^n	26.41^n

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[4] These test statistics are not reported to save space. They will be available on request.

However, the UK real IP growth rate is not statistically different from zero. For the stock returns, the asymmetric effect corresponds to the leverage effect in stock markets, which states that stock returns tend to be more volatile when stock prices are falling (Black 1976). On the other hand, the evidence of asymmetry in US real IP growth rate implies that IP growth is more volatile during economic recession. This is in line with William G. Schwert (1989), who states that production growth rates are more volatile during economic recessions.

Descriptive statistics, shown in Table 1, examine the statistical adequacy of the selected AR(2)-EGARCH(1,1) models. The Ljung-Box test statistics imply that the null hypothesis of no autocorrelation is accepted for all the standardized and the squared standardized residuals. This finding reveals that the selected EGARCH models have successfully captured all linear and nonlinear dependencies in the series. In addition, the rejection of the normality hypothesis in all series supports the use of robust to non-normality standard errors (Tim Bollerslev and Jeffrey Wooldridge 1992).

We now proceed to the second stage of the process. The Cross Correlation Function (CCF) testing procedure is based on the calculation of the sample cross correlation coefficients, $r_{\varepsilon\zeta}(k)$ and $r_{UV}(k)$. The null hypothesis of no causality in mean against the alternative hypothesis of causality at lag k is tested by the following test statistic

$$CCF_m - statistic = \sqrt{T} * r_{\varepsilon\zeta}(k) \qquad (3)$$

Accordingly, to test the null hypothesis of no causality in variance against the alternative hypothesis of causality at lag k, we compute the following test statistic:

$$CCF_v - statistic = \sqrt{T} * r_{UV}(k) \qquad (4)$$

The above CCF statistics have an asymptotic standard normal distribution (Cheung and Ng 1996). Furthermore, Cheung and Ng (1996) have shown that the CCF statistic is robust to non-symmetric and leptokurtic errors and asymptotically robust to distributional assumptions. Thus, if the above test statistic is larger than the critical value of the standard normal distribution, the null hypothesis is rejected.

At this stage we compute the CCF_m and CCF_v test statistics for up to two lags and leads to test for causality in mean and in variance between the series, respectively. The CCF test statistics are shown in Table 2. Lags (-1, -2) refer to causality

tests from stock returns to real IP growth, whereas leads (+1, +2) refer to causality tests from real IP growth to stock returns. First, we present the results for causality in mean between the real economic sector and the stock market. For the case of the UK, the CCF_m test statistic is significant only at the second lead. This implies that changes in stock returns cannot lead changes in IP growth rate. In contrast, the above finding implies that changes in IP growth rate can cause movements in stock returns two months ahead. Despite the evidence of instantaneous causality (feedback in mean) in the US model, both lags are not statistically different from zero. However, there is evidence of causality in the opposite direction. Like the UK case, US real IP growth rate changes can lead movements in US stock returns two months ahead.

Table 2 Cross-Correlation Function (CCF) - test Statistics

Lag/Lead	UK		US	
	Causality in Mean	Causality in Variance	Causality in Mean	Causality in Variance
-2	0.503	3.379*	0.545	-1.213
-1	-0.218	0.005	1.267	0.099
0	1.13	0.266	2.01**	3.528*
+1	1.528	-0.111	1.387	-0.241
+2	1.695***	1.617	1.958***	-0.274

Notes: *, ** and *** denote statistical significance at the 1%, 5% and 10% level, respectively.

Source: Authors' calculations.

Turning to the variance causality test, the results show that UK real stock returns volatility cannot be influenced by the UK IP growth rate variance. On the contrary, the causality in variance from UK real stock return to UK IP growth rate is statistically significant with a lag of two months. This means that there is evidence of volatility spillover from the stock market to the real sector. Moreover, there is evidence of instantaneous causality (feedback in variance) between US stock returns and US IP growth rate. However, there is lack of explicit causality in variance in both directions because neither lag nor lead is statistically significant.

Summing up, the CCF testing procedure has shown that causality in mean is statistically significant with two lags from real IP growth rate to real stock returns for both UK and US models. This evidence is consistent with the view that changes in the expected future economic activity cause changes in current stock prices. For example, an expected future slowdown of the economy increases uncertainty and investment risk, thereby creating disincentives to investing in stock markets. Such a development reduces current stock prices.[5] When it comes to causality in variance tests, there is explicit evidence of causality in variance from UK real stock returns to UK IP growth rate with two months' lag. The mechanism of variance causality from the stock market to real economic activity may work through two possible channels: (a) the consumption channel and (b) the balance sheet channel. The first channel shows that changes in asset prices may affect consumption spending by affecting households' wealth. However, this channel does not seem to be illustrative as much

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[5] This finding is not unexpected and does not contradict previous arguments in the literature. For example, Robinson (1952) argues that financial institutions (including stock markets) follow developments in real economic sector.

of the households' investment in stocks is held in pension accounts (Bernanke and Gertler 2000). Indeed, the empirical evidence in literature (see, for example, Jonathan A. Parker 1999, and Sydney Ludvigson and Charles Steindel 1999) presents no strong connection between stock market movements and consumption. Instead, the second channel is the most significant one. Bernanke and Gertler (1995) show that asset price fluctuations affect real economy through their effects on the balance sheets of households, firms, and financial intermediaries. For example, a decrease in asset prices reduces the available collateral (households and firms use their assets as collateral when they are borrowing) and shrinks the borrower's ability to have access to credit capital. This can have negative short-run effects on aggregate demand and long-run effects on aggregate supply.

2.2 Results from the Bivariate EGARCH (*p,q*) Model

We estimate bivariate EGARCH (*p,q*) models in order to examine the relation between stock returns and industrial production growth, within a country, in a multivariate context. Testing among alternative specifications of the EGARCH model, the Likelihood Ratio test statistic has implied the estimation of the bivariate EGARCH (1,1) model for the case of the UK and the bivariate EGARCH (2,1) model for the case of the US.[6] Focusing on the estimated parameters of the conditional variance equations, Table 3 shows that all spillover coefficients ($\delta_{rr,1}$; $\delta_{yy,1}$; $\delta_{ry,1}$; $\delta_{yr,1}$) are statistically different from zero. This implies that short-term volatility dynamics between the stock market and the real economy, within a country are characterized by conditional heteroskedasticity. Moreover, b_r and b_y coefficients in both countries are less than one but close to unity, implying that volatility is very persistent in the stock market and real economic sectors.[7]

Next, we focus on volatility spillover effects. For the case of the UK, we have found positive and significant reciprocal spillover effects between the stock market and real activity. Spillover effects from the stock market to real economic activity ($\delta_{yr,1}$=0.55) are slightly higher than those from the opposite direction ($\delta_{ry,1}$=0.52). Both are significantly high, which implies that an increase in stock return volatility entails an increase in IP growth volatility, and vice-versa.

As in the causality in variance case, the volatility transmission mechanism from the stock market to real economic activity can be explained by the balance sheet channel. As stock prices change, the cost of borrowing for the firms changes as well. In case of stock prices decline, firm's available collateral is reduced and the limited borrowers' access to credit capital causes a fall in investment and in future output.

Similarly, volatility can be transmitted from the real economic sector to the stock market. This is because changes in the current and future IP growth rate cause reallocations of portfolio assets. However, this is possible to activate a cyclical volatility transmission mechanism, which may be influenced by the balance sheet channel as well. Specifically, Carlstrom et al. (2002) argue that the economic slowdown re-

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[6] These test statistics, which have not been reported in order to save space, are available upon request.

[7] Volatility persistence coefficients (b_r and b_y) are given by $b_r = \sum_{i=1}^{p} b_{r,i}$ and $b_y = \sum_{j=1}^{p} b_{y,j}$. The unconditional variance is finite if $b_r<1$ and $b_y<1$.

duces stock prices, hence, the value of the firms' assets. Then, as the amount of collateral decreases and the cost of borrowing becomes higher, real economic activity exhibits an unstable downward behavior.

A question arises is whether volatility transmission is symmetric or asymmetric. Both spillover effects are asymmetric since $\theta_{ry,1}$ and $\theta_{yr,1}$ are statistically significant and negative. This means that a negative shock (bad news) in the stock market increases volatility in real economy more than a positive shock (good news). In other words, a fall in stock return causes higher volatility in IP growth rate than an increase in stock return. This asymmetric effect is similar to the leverage effect, which states that stock returns tend to be more volatile when stock prices are falling. As a result, negative shocks increase stock market volatility which, through the balance sheet channel, is exported to the real economy. In other words, the leverage effect works in the direction of exporting more volatility to the real sector when stock returns fall (bad news).

Table 3 Bivariate EGARCH (p, q) Models

Parameters	UK p=1, q=1	US p=2, q=1
b_r	0.96*	0.95*
	(685)	(170)
b_y	0.97*	0.93*
	(194)	(116)
$\delta_{rr,1}$	0.47**	-0.06*
	(2.04)	(-3.17)
$\delta_{yy,1}$	0.47**	0.15*
	(1.96)	(4.67)
$\delta_{ry,1}$	0.52*	0.18*
	(11.45)	(6.84)
$\delta_{yr,1}$	0.55*	0.14*
	(2.89)	(4.32)
$\vartheta_{ry,1}$	-0.07*	-0.013***
	(-5.46)	(-1.91)
$\vartheta_{yr,1}$	-0.05*	-0.014
	(-3.28)	(-0.88)
ρ_{ry}	0.16	0.06
	(1.79)***	(1.64)
Log Likelihood	1656.72	1880.98

Notes: p is the order of the autoregressive GARCH terms. q is the order of the moving average ARCH terms. b_r and b_y measure volatility persistence of stock returns and real IP growth, respectively. $\delta_{rr,1}$ and $\delta_{yy,1}$ are the measures of the ARCH effect in stock returns and real IP growth, respectively. $\delta_{ry,1}$ is the volatility spillover from real IP growth to stock returns. $\delta_{yr,1}$ is the volatility spillover from stock returns to real IP growth. $\vartheta_{ry,1}$ and $\vartheta_{yr,1}$ are asymmetric spillover effects. ρ_{ry} is the correlation coefficient of the standardized residuals between stock returns and real IP growth. *, ** and *** denote statistical significance at the 1%, 5% and 10% level, respectively. Robust t-statistics in parentheses.

Source: Authors' calculations.

Moreover, the negative and statistically significant coefficient of $\theta_{ry,1}$ (-0.07) implies that negative disturbances in the real economic sector cause higher volatility to the stock market than positive developments. This is consistent with the evidence

that asset returns are more volatile during economic slowdown, as originally observed by Robert R. Officer (1973), Black (1976), and Schwert (1989). These authors have argued that during economic recessions, assets' value decrease and the proportion of the levered value increases. Hence, stock returns are more volatile during recessions because highly levered assets are riskier (i.e. exhibit higher volatility).

When it comes to the US model, significant spillover coefficients imply that volatility can be imported from one sector to the other. Specifically, both coefficients ($\delta_{ry} = 0.18$ & $\delta_{yr} = 0.14$) are statistically significant and positive, implying a bidirectional spillover effect. The spillover effect from the stock market to real activity is slightly lower than that of the opposite direction. Furthermore, the spillover effect from the stock market to the real economic sector is found to be symmetric because the asymmetry coefficient $\theta_{yr,1}$ is not statistically different from zero. This finding implies that a decrease in stock returns has the same effect on IP growth volatility as an increase in stock returns. In contrast, the coefficient of asymmetry $\theta_{ry,1}$ is statistically significant at a 10% significance level. This implies that the US stock market is expected to be more volatile when US output growth falls.

In line with the evidence from the UK model, the volatility transmission mechanism from the stock market to real economic sector runs through the balance sheet channel. Similarly, volatility from the real output growth to the stock market is transmitted via the changes in the expectations for the domestic economy and the economic condition of the firms which both alter stock prices. Furthermore, the stock market tends to be more volatile when IP growth rate falls because of the higher volatility of the highly levered assets. However, the symmetric nature of the volatility spillover effect from the stock market to the real economic sector needs to be investigated. The lack of asymmetry does not mean that the leverage effect is inactive in the US stock market. Indeed, the results from the univariate EGARCH analysis, as shown in Table 3, imply the validity of the leverage effect in the US stock market.

One possible explanation is that the leverage effect does hold, but the applied US monetary policy may have weakened the linkage between the stock market and the real activity sector, such that the leverage effect cannot export "extra" volatility to the real sector. This policy is the inflation targeting regime applied by the FED during the 1990s. The key fact of this regime is that monetary authorities adjust interest rates in front of stock market instability in order to isolate the real economy from financial instability. Specifically, they apply the "leaning against the wind" policy, increasing interest rates when stock prices rise and reducing them when stock prices are falling. By lowering interest rates (i.e. expansionary monetary policy) in front of stock prices decline, the balance sheet channel has a neutral effect on the transmission mechanism, reducing the vulnerability of the real economy. Namely, monetary policy easing makes access to credit less complex even if balance sheets become worse as a result of stock market losses. A complementary explanation is given by Bernanke and Gertler (2000), who show that an asset price decline may not affect the real economy only if balance sheets are initially strong. They argue that this was actually the case for the US economy during the 1990s (i.e. US balance sheets were in excellent condition).

Comparing the results from the UK model with those from the US model, we observe that, in each economy, both sectors are characterized by a dynamic short-run relationship, implying a bi-directional volatility spillover effect. The size of the spillover effects in the UK is much higher than the corresponding spillovers in the US. Specifically, the estimated coefficient of volatility spillover from the UK real IP growth to the UK stock market is 0.52, which is considerably higher than the corresponding estimated coefficient (0.18) for the case of the US. Likewise, the estimated coefficient measuring the transmission of stock market volatility to the real sector is, by far, higher in the UK (0.55) than in the US (0.14). This means that there is stronger interdependence between the stock market and real activity in the UK than in the US. This may also be explained by the applied "leaning against the wind" policy in the US, as outlined above. However, the UK monetary policy, in the form of an explicit inflation targeting regime, is not considerably different from the US monetary policy. Thus, the query is what is different in the case of the US. A careful look at historical data of stock indices and interest rates provides us with the view that US monetary authorities have applied the "leaning against the wind" policy in a more systematic way than UK monetary authorities have done.[8] Historical facts confirm that US monetary authorities have reacted in that way. For example, FED decreased interest rates in periods of high financial instability, such as the stock market crises in 1987 and in 2001. Along the lines of the inflation targeting regime, monetary authorities should ignore stock prices movements that are not expected to create inflationary pressures (Bernanke and Gertler 2000). Hence, the low level of the UK inflation rate may explain why UK monetary authorities decided not to adjust the interest rate all the time.

Examining the symmetric nature of the volatility transmission mechanism from the stock market to real activity sector, there is evidence of symmetric spillover effects only in the case of the US. In contrast, bad news in UK stock market increases volatility in UK real activity more than good news. A fall in stock returns causes excess stock market volatility in the UK because of the leverage effect. Thus, the increased stock market volatility is exported, via the balance sheet channel, to the real sector. On the other hand, although the US stock market does not escape from the leverage effect, the applied US monetary policy in the form of an implicit inflation targeting regime works as a shield, insulating the real economy from the stock market in periods of high financial instability. Similarly, the more systematic application of the "leaning against the wind" policy in the US than in the UK may explain the presence of asymmetry in the volatility transmission mechanism only in the UK. In contrast, volatility from the real activity sector to the stock market is asymmetrically transmitted in both countries.

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[8] This statement is derived based on the examination of the monthly basis movements in US and UK stock markets in comparison with changes in FED's and Bank of England's interest rates. Since 1990, we have found more violations of the "leaning against the wind" rule in the UK rather than in the US.

Table 4 EGARCH (p,q): Diagnostics

	UK	US
Residuals – Stock Returns		
LB (4)	5.93	0.60
LB^2(4)	2.29	1.57
Residuals – Real IP Growth		
LB (4)	9.27	19.26*
LB^2(4)	21.68*	0.16
LB^2(16)	28.36	-------
Cross Product		
LB (4)	1.71	0.96
LB^2 (4)	0.75	0.19

Notes: * denotes statistically different from zero at 1% significance level. LB stands for Ljung-Box statistics.

Source: Authors' calculations.

Finally, we apply diagnostic tests, as shown in Table 4, on the standardized residuals and cross-standardized residuals to confirm robustness of our estimation. The Ljung-Box statistics, applied on the standardized and squared standardized stock market residuals, imply that in both models the residuals are serially uncorrelated. On the other hand, the same test applied on the standardized real activity residuals implies evidence of autocorrelation in the residuals for the case of the US. However, there is no evidence of autocorrelation in the squared standardized residuals.

Although UK standardized real activity residuals are not autocorrelated, there is some evidence of serial correlation in the squared standardized residuals, which can be eliminated by including a higher order of lags (i.e. 16 lags). The Ljung-Box test statistic, applied on the cross product of the standardized residuals for the two variables, implies that the assumption of constant conditional correlation (Tim Bollerslev 1990) can be accepted for both EGARCH models. Therefore, the validity of the above assumption and the robustness of our estimation are confirmed.

3. Conclusion

The main research objective of this study was to identify the short-run dynamic relationships between stock market and real economy for the cases of the UK and the US. Due to the evidence of linear and nonlinear dependencies between the series, which imply volatility clustering between the series, we estimated univariate as well as bivariate EGARCH (*p,q*) models. The univariate EGARCH (*p,q*) model is the benchmark model for the utilization of the two-stage Cross Correlation Function (CCF) testing procedure developed by Cheung and Ng (1996). The results show that causality in mean is statistically significant with two lags from the real IP growth rate to the real stock returns for both UK and US models. On the other hand, there is evidence of causality in variance from the UK real stock returns to UK IP growth rate with two months' lag.

Next, by estimating bivariate EGARCH (*p,q*) models, we found that volatility in both sectors is very persistent. Moreover, we found evidence that volatility from one sector can be transmitted to the other, implying significant interdependencies between the stock market and real activity, within an economy. The volatility trans-

mission mechanism from the stock market to the real sector runs through the balance sheet channel. Stock price fluctuations affect real economy through their effects on the balance sheets of households and firms. For example, a decrease in stock prices reduces the available collateral and shrinks the borrower's ability to have access to credit capital. Similarly, volatility can be transmitted from the real economic sector to the stock market. This is because changes in the current and future IP growth rate cause reallocations of portfolio assets.

Besides the evidence of stronger interdependence in the UK rather than in the US, volatility spillovers from the stock market to the real sector are found to be symmetric only in the case of the US. The symmetric nature of the spillover effects means that negative shocks (bad news) and positive shocks (good news) in the stock market affect real activity's volatility in the same way. However, this does not happen in the case of the UK. In line with the leverage effect, a decrease in UK stock returns has a greater effect on the volatility of the UK real activity than an increase in returns. Conversely, a decline in US stock returns equally affects US real sector's volatility as an increase in stock returns. This finding does not seem strange if we examine the objectives of the monetary policy framework applied by the FED. Although the US stock market does not escape from the leverage effect, the FED's policy to insulate the real economy from stock market instability explains the lack of asymmetry in the volatility transmission mechanism for the case of the US. Specifically, they apply the "leaning against the wind" policy, increasing interest rates when stock prices rise and reducing them when stock prices are falling. Monetary policy easing makes access to credit less complex even if balance sheets become worse as a result of stock market losses. Then, the balance sheet channel has a neutral effect on the transmission mechanism, reducing the vulnerability of the real economic sector.

Given that UK monetary policy is not substantially different from the US monetary policy, what could explain the lack of variance causality, the lower estimated spillover coefficients, and the symmetric nature of the transmission mechanism in the case of the US? One possible explanation is that the "leaning against the wind" policy has been applied more systematically in the US rather than in the UK. An alternative explanation is given by Bernanke and Gertler (2000). They argue that the excellent condition of the US balance sheets during the 1990s has protected the US economy from negative disturbances. Finally, volatility from the real activity sector to the stock market is asymmetrically transmitted in both countries. During economic recessions, stock prices decrease and the proportion of the levered value increases. Hence, stock returns are more volatile during recessions because highly levered assets exhibit higher volatility.

Beyond the above explanation, this study provides lessons for policy makers, especially in developing countries with unstable financial markets. Thus, the lesson states that policy makers should be concerned about financial instability and must take steps in order to protect real activity from unexpected instability shocks. An appropriate monetary policy framework is of the form of flexible inflation targeting, adjusting interest rates in a stabilizing way in case of stock market instability. Specifically, they have to apply the "leaning against the wind" policy, increasing interest rates when stock prices rise and reducing them when stock prices are falling. The

necessity of policy steps is even stronger when stock returns are falling because the leverage effect produces more stock market volatility. Thus, in periods of high financial instability, monetary authorities should adjust interest rates in a systematic way until the economy and the financial system are stabilized. In front of a decrease in stock prices, the loosening of the monetary policy (i.e. lower interest rates) inactivates, in some degree, the balance sheet channel, making real economic activity less vulnerable to financial distress. In addition, the inflation targeting regime can also stabilize the stock market because the low inflation rate provides the investors confidence and stabilizes the financial markets.

Finally, in relation with the recent global financial crisis, we can state that the source of this crisis (i.e. "nonfundamental" factors, such as the poor regulatory practice and the irrational investing behavior) may explain its impact on the global economy. However, an interesting fact is that the applied monetary policy, in the form of an inflation targeting regime, in the US, in the UK, and in other major economies, could not protect the global economy from financial instability. This finding may imply that the monetary policy cannot always insulate the real economic sector from negative shocks, especially in periods of extreme uncertainty, panic, and general pessimism. Another feature of the latest financial crisis, which has not been adopted in our analysis, is that it had an international impact on financial markets, causing knock-on effects on domestic financial sectors, and thus, on national economies.[9] Although the relevance of this study with the recent global financial crisis does exist, the conclusions of this study do not completely fit to the case of the recent crisis. To provide an explanation for this result, the special characteristics of the recent crisis should be thoroughly investigated. This is left for a future study.

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[9] In this study, we have examined the relationship between the financial sector and the real economic sector, within a country, for the UK and the US. We have not taken into account any spillover effects between the two sectors across countries.

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