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More on the impact of US macroeconomic announcements: Evidence from French and German stock markets' volatility

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Abstract

This paper investigates the impact of US scheduled macroeconomic announcements on the domestic, the French and the German market, respectively using an augmented version of the multivariate DCC-GARCH model. Our setting allows to separate the direct effect (common response), from the indirect effect (volatility transmission) of the US macroeconomic announcements on the two European markets. Empirical results show evidence of a direct reaction of French and German investors to some common as well as specific US macroeconomic news. More interestingly, a significant bidirectional volatility spillover after the release of some macroeconomic news is found to be apparent, either between the US and German markets or between the US and French markets, although the French market shows a more sensitivity to US macroeconomic surprises than the German market. These findings suggest a stronger integration of the US stock market with the French market rather than with the German market.

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1. Introduction

Scheduled macroeconomic announcements are still receiving a considerable amount of interest in both the financial press and the academic literature. Most of studies are attempting to test if such news have an impact on financial markets and what are the indicators mostly considered by investors, especially when valuing stock prices. Understanding the effect of scheduled macroeconomic announcements on equity markets is of great interest for testing the market efficiency hypothesis and anticipating the reaction of domestic as well as foreign investors and policymakers to news arrival.

Previous studies on stock markets have focused on investigating the impact of macroeconomic announcements on stock prices (e.g. Mcqueen and Roley, 1993; Rigobon and sack, 2006; Dubreuille and Mai, 2009, Dimpfel, 2011) rather than on stock volatility, insofar as fewer papers have addressed the latter issue (e.g. Flannery and Protopapadakis, 2002; Jones et al., 2005; Harju and Hussain, 2011). Moreover, some papers have tested the relationship between US macroeconomic announcements and some foreign stock markets. This is motivated by the central role of the U.S in determining the development of the world economy. Thus, major U.S. economic indicators are not only important for the valuation of firms in the U.S.A, but also in other countries (Nikkinen and Sahlstrom, 2004). Dubreuille and Mai (2009) argues that the volatility in the European stock market doubles five minutes following US macroeconomic announcements. Engle and Rangel (2008) find evidence of a significant relationship between the market volatility and macroeconomic variables such as inflation, growth and macroeconomic volatility.

This paper is an empirical analysis of the relationship between US scheduled macroeconomic announcements and French and German stock market's volatility. Using daily data over the period from February 3rd, 2000 to Mai 31st, 2011 for the US, French and German stock markets, we find evidence of common responses of French and German markets to some US macroeconomic announcements. This first result is in line with the literature and confirms that US macroeconomic news are regarded by foreign investors as an important source of information when valuing stock prices.

A second question is also of concern when studying the impact of US macroeconomic announcements on volatility of foreign stock markets: what explains the latter's reaction to such announcements? In a standard fashion, and according to the efficiency market hypothesis, an unanticipated U.S. macroeconomic announcement, as any other public information, must be directly incorporated in stock prices. (Jones et al., 2005; Dubreuille and Mai, 2009 ; Flannery and Protopapadakis, 2002 ; Harju and Hussain, 2011). Another theoretical explanation is that this reaction is indirect and due to cross market hedging (Fleming et al., 1998). Explicitly, macroeconomic announcements, like any other information may affect the volatility of the U.S. stock market. By observing the movement occurring in the US financial market volatility, investors in the local market may react and follow this movement, which therefore causes a transmission effect from the U.S. to the foreign market.

Several studies have focused on this channel of volatility transmission between financial markets, as commonly called the volatility spillovers effect. The issue of news transmission has been widely investigated in the recent literature on volatility spillover in the context of stock markets (Hsin, 2004 ; Harju and Hussain, 2008), exchange markets (Kanas, 2000; Chen and Gau, 2010 ; Ben Omrane and Heinen, 2011), CDS markets (Galil and Soffer, 2011) options markets (Diavatopoulos et al, 2012) interest rate markets (Monticini et al., 2011), metal futures markets (Elder et al., 2012) and commodity markets (Roache and Rossi, 2010). These studies generally find evidence of return and volatility transmission across major market returns and volatilities and argue that good (bad) news in one market can stabilize (destabilize) other markets. But, this distinction between good and bad news is in some cases criticized. This is because, in some circumstances, the same information may be considered as good or bad news, depending on investors perception of it, making unclear the distinction between the two categories of news. McQueen and Roley (1993) have shown that some macroeconomic announcements may be good news during periods of expansion and bad news during periods of recession. A second example would be the corporate layoff announcements. While some authors (Chatrath et al. 1995; Collet, 2002) show that those announcements lead to an increase in the stock returns, other studies (Aggarwal and Kolev, 2012) argue the opposite effect. Thus, in light of these works, it becomes unclear whether such announcements are considered as good or bad news for stock markets. It is so necessary to broach the subject of volatility transmission by considering the nature and the type of the announcement, rather than its sign.

The literature on volatility spillover and the event studies on reactions to macroeconomic announcements have evolved independently. However, much is to be gained through an integration of these themes. This allows one to give some more explanations to the issue of the impact of US macroeconomic announcements on foreign markets and particularly answer the following question: do the movements observed in foreign stock markets after the release of U.S. economic news represent common responses to such information (direct responses) or a transmission effect from one market to another (indirect response)? This study is the first attempt to answer the latter question since, to the best of our knowledge, there is no previous works investigating this matter.

The remaining of the paper is organized as follows. In section 2 we introduce our econometric setting. Section 3 presents the data and preliminary results. Section 4 discusses the main findings of the paper. Section 5 concludes.

2. **The model**

In this section we present our empirical methodology used to further investigate whether the movements observed in the French and German stock markets, after the release of macroeconomic announcements represent either common responses (i.e direct responses) to such information or a transmission effect from the US market (i.e indirect effect) or even both. Since there is neither consensus nor a definite answer to the previous issue, our study is an attempt to contribute to the related literature, by introducing a new empirical model with a large set of US macroeconomic announcements.

2.1 The basic model

The methodologies used in the literature to highlight the volatility transmission between international markets can be classified into two categories: stochastic volatility models and multivariate GARCH models. The former have been used only in few studies on the subject (Andersen and Bollerslev, 1998; Wongswan, 2003), while an abundant literature has been dedicated to the latter. Early related studies (e.g. Lin *et al.* 1994; Hsin, 2004) use univariate GARCH models and carry out a two-stage estimation to account for spillover effects. The disadvantage of using univariate setting is to not take into account the causalities that could exist between the considered stock markets. Recently, the literature on volatility transmission has known the emergence of a new wave of papers using the multivariate GARCH models which allow for the joint modeling of variances and covariances between international stock markets.

As far as volatility of international stock markets is of concern, GARCH-type models have shown a particular interest in the literature on volatility transmission. Among the different specifications of the multivariate GARCH models, (i.e CCC, DCC, VECH and BEKK[1]), we

[1] CCC: Constant Conditional Correlation of Bollerslev, *1990*; DCC: Dynamic Conditional Correlation of Engle, 2002; VECH: Multivariate GARCH with time varying covariances of *Bollerslev,* Engle and Wooldridge, 1988; BEKK: Multivariate GARCH of Baba, Engle, Kraft and Kroner, 1991;

choose the DCC-GARCH of Engle (2002). This choice is motivated by the following three reasons. First, the superiority of the DCC-GARCH model over the other multivariate GARCH specifications when studying financial markets dynamics is largely documented in the literature, as it accommodates for dynamic correlation between financial and economic data. This characteristic represents one of the most important stylized facts of financial and economic data. Second, Longin and Solnik (1995) argue that the conditional correlation between equity markets is not constant. Finally, compared to the other multivariate GARCH specifications, the DCC-GARCH presents the advantage of having less parameters to be estimated, which allow us to augment the model by introducing our sample of macroeconomic variables and testing for the direct/indirect effects of US macroeconomic news without burdening the estimation procedure.
Specifically, we adopt the bivariate form of the DCC-GARCH (Engle, 2002) model to investigate the interdependence of stock markets. The conditional mean is given by:

$$\begin{cases} Y_t = \mu + \Phi Y_{t-1} + \varepsilon_t \\ \varepsilon_t = H_t^{1/2} \epsilon_t \end{cases} \tag{1}$$

where

- $Y_t = \left(r_t^i, r_t^{US}\right)'$ with r_t^i and r_t^{US} being the returns on market *i* and the US market at time *t*, respectively[2];
- Φ is a (2x2) matrix of coefficients of the form: $\Phi = \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix}$;
- $\varepsilon_t = \left(\varepsilon_t^i, \varepsilon_t^{US}\right)'$ with ε_t^i and ε_t^{US} being error terms from the mean equations of market *i* and the US market respectively;
- ϵ_t is a 2x1 random vector with $E(\epsilon_t) = 0_{2x1}$ and $Var(\epsilon_t) = I_2$;
- $H_t \equiv D_t C_t D_t$ with $D_t = diag\left(\sqrt{h_t^i}, \sqrt{h_t^{US}}\right)$; $h_t^i$and h_t^{US} being the conditional variances of r_t^i and r_t^{US}respectively.
- $C_t = \{\rho_{ij,t}\}$ represents the conditional correlation matrix between market *i* and US market.

The dynamic conditional correlation (DCC) process of orders M and N has the following representation:

$$C_t = (Q_t^*)^{-1} Q_t (Q_t^*)^{-1} \tag{2}$$

with $Q_t = \left(1 - \sum_{m=1}^{M} a_m - \sum_{n=1}^{N} b_n\right)\bar{Q} + \sum_{m=1}^{M} a_m (\xi_{t-m}\xi'_{t-m}) + \sum_{n=1}^{N} b_n Q_{t-n}$ (3)

and $\xi_t = \left\{ \varepsilon_{it} / \sqrt{h_{it}} \right\}$ is the vector of the standardized residuals extracted from the estimation of the univariate GARCH, $Q_t = \{q_{iUS,t}\}$, is the variance-covariance matrix of these conditional standardized residuals, $\bar{Q} = E(\xi_t \xi_t)$ represents the unconditional variance-covariance matrix, and finally $Q_t^* = \begin{bmatrix} \sqrt{q_{11}} & 0 \\ 0 & \sqrt{q_{22}} \end{bmatrix}$ is the diagonal matrix containing the square root of the diagonal elements of Q_t. DCC model's parameters are estimated using quasi maximum likelihood method.

[2] In this paper the subscript *i* refers to the French and German markets

2.2 The augmented model

We introduce a new model that allows one to detect not only the direct reaction of the French and German stock markets to the release of US macroeconomic announcements, as it is commonly documented in the literature, but also the transmission (indirect) effect from US stock market to the foreign stock markets. We also investigate the possibility of the existence of the joint effect. To do so, we consider two augmented DCC-GARCH models. The first one is modified by adding the variance of the US market in the variance equation of the French or German market and vice versa. Doing this allows us to test for the evidence of volatility transmission across all pairs of the considered financial markets. Formally, the regression format is as follows:

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} + \theta_i h_{US,t-1} \tag{4}$$
$$h_{US,t} = \omega_{US} + \alpha_{US} \varepsilon_{US,t-1}^2 + \beta_{US} h_{US,t-1} + \theta_{US} h_{i,t-1} \tag{5}$$

Afterwards, we augment the basic model by jointly adding the variance of the US market in the variance equation of the French or German market and vice versa as well as the US macroeconomic shocks simultaneously in the two volatility equations. The model has the following specification:

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} + \sum_{k=1}^{11} \delta_{i,k} S_{k,t} + \sum_{k=1}^{11} \theta_{i,k} D_k h_{US,t-1} \tag{6}$$
$$h_{US,t} = \omega_{US} + \alpha_{US} \varepsilon_{US,t-1}^2 + \beta_{US} h_{US,t-1} + \sum_{k=1}^{11} \delta_{US,k} S_{k,t} + \sum_{k=1}^{11} \theta_{US,k} D_k h_{i,t-1} \tag{7}$$

S_t is the standardized surprise[3] of the k^{th} US macroeconomic announcement, D_k is a dummy variable taking the value 1 on the days of k^{th} news announcements, and 0 otherwise. The term $\sum_{k=1}^{11} \theta_{ik} D_k h_{US,t-1}$ in eq. (4) allows detecting the volatility spillover from US market to market *i* (i.e. French or German market) after the release of US macroeconomic indicators, while the term $\sum_{k=1}^{11} \emptyset_{ik} S_{k,t}$ captures the direct effect of the US announcements on the volatility of market *i*.

3. Data

Prices of the three international stock market indices i.e SP500, CAC40 and DAX are collected from Datastream over the period from February 3rd, 2000 to Mai 31st, 2011. Unlike previous studies which use low frequency data (i.e. month to month) that produce autocorrelation in returns series and thus introduce bias in the dependence relation between markets (Lin et al., 1994; Soriano and Climent, 2005), we use daily data in order to adequately capture the rapidity and intensity of the dynamic interaction between the two markets. However, when using daily data, one should handle out the problem of nonsynchronous trading, which arises due to the difference between trading hours across countries.

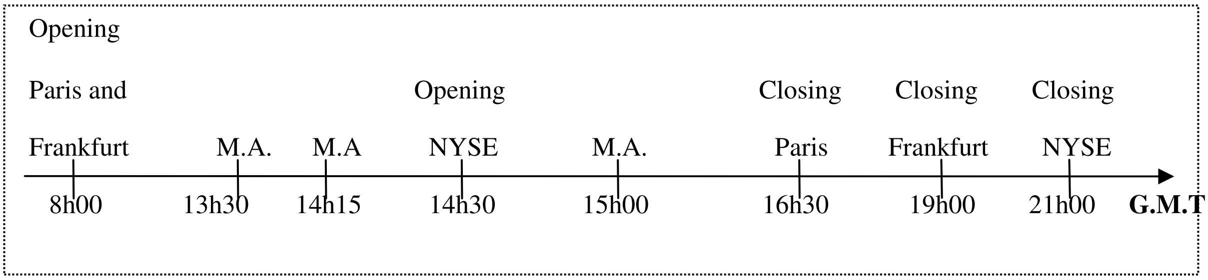
In general, three different cases may occur when daily data are used: the total overlapping, which means that there is no difference in trading calendar between markets, the partial overlapping and finally, the non overlapping markets. The first is the easiest to handle by simply using close to close or open to open data (Karolyi, 1995). In the last case, some authors (e.g. Bae and Karolyi, 1994; Koutmos and Booth, 1995) suggest to use the close to open returns in order to avoid the bias produced by the overlap period. The second case is the

[3] A surprise is the unexpected component of the macroeconomic announcement and calculated as the difference between the real change and the market expected change. This issue will be explained with more details in section 3.

most complicate to treat. An increase in volatility can be observed in the first market to open when the second one starts trading, reflecting information contained in the opening prices. This effect can produce false spillovers, both in mean and volatility (Martens and Poon, 2001; Soriano and Climent, 2005). Correcting for the partial overlap is therefore crucial when using daily data.

Figure (1) duplicates the opening and closing hours of the three markets considered in this paper as well as the release time of major US macroeconomic announcements. This figure clearly shows that we are facing the problem of partial overlap.

Figure 1: Opening and closing time differences across markets and macroeconomic announcements



Note: This figure represents the opening and closing hours of French, German and U.S. stock markets (G.M.T). It also duplicates the release time of US macroeconomic announcements (M.A). Most of them are released at 1:30 PM. Few other announcements are published at 2:15 PM (Industrial Production) or 3:00 PM (Consumer Confidence, Advanced Indicators)

While some authors ignore the partial overlap problem (Hsin, 2004; Susmel and Engle, 1994), others give more attention to that situation and suggest some solutions to generate synchronized data and avoid the bias that it entails. For instance, Forbes and Rigobon (2002) calculate two-day returns to control for the fact that markets are not open during the same time period. Hamao et *al.* (1990) suggest splitting the trading day into overlapping and non overlapping times and considering only the former when studying the transmission effect. Nevertheless, this method generates discontinuities in the data and thus is not suitable for time series data. Burns et al. (1998) generate data-based artificially synchronized correlations.

In this paper, we follow Martens and Poon (2001) and use “synchronous data”. Indeed, the method consists in collecting data from the two markets – in the bivariate case – at the same time each day. Employing this methodology in the context of the present paper amounts to computing the CAC40, DAX and SP500 returns respectively as price index log-difference as collected at 4:00 P.M every day. The latter time point is selected to ensure that all US macroeconomic indicators have been published.

Regarding macroeconomic announcements, the data sample consists of the following U.S. news which have been shown to significantly affect equity prices in recent papers[4]:

- Consumer and producer price indices (monthly) as indicators of inflation;
- Unemployment rate (monthly) considered as one of the most timely indicators of the economic state;

[4]See e.g. Jones et al. (2005), Rigobon and sack (2006) and Dubreuille (2007). The data is also chosen according to its availability in Money Market Services Database.

- Industrial production (monthly), the gross domestic production (quarterly), the leading indicator, the ISM index and the trade balance to proxy the state of the economic activity
- Consumer confidence index (monthly) and household consumption (monthly)
- Housing starts (monthly) as a real estate indicator

In this paper, American economic announcements are used to investigate their effect on the French and German stock markets respectively. Announcement days of macroeconomic indicators are collected from both BLS (Bureau of Labor Statistics) web site and checked afterwards through *Bloomberg*. We also carry out a separation of expected and unexpected components of news. To do this, we follow the previous related literature and compute the surprise as the difference between the real changes of the indicator value and the median market consensus forecast. We then standardize the obtained surprises for the sake of comparability (Fleming and Remolona, 1997; Balduzzi *et al*., 2001). *Bloomberg* and MMS[5] forecasts are used to measure the market median consensus forecasts of macroeconomic news.

Table 1: Descriptive statistics

Panel A: Indices descriptive statistics

	CAC 40	DAX	S&P 500
Mean	-0.0001	1.42E-05	-3.88E-05
Std Error	0.0148	0.015493	0.012696
Skewness	0,0077	-0.125177	0.030282
Kurtosis	7,631	7.348376	12.70839
ARCH(10)	574.824***	656.038***	709.007***
p-value	[0.000]	[0.000]	[0.000]
ARCH(20)	641.607***	709.149***	828.292***
p-value	[0.000]	[0.000]	[0.000]
Q(10)	1617***	1714,9***	2159,9***
p-value	[0.000]	[0.000]	[0.000]
Q(20)	2686.4***	1870***	3244.4***
p-value	[0.000]	[0.000]	[0.000]

Panel B: Descriptive statistics of (non standardized) macroeconomic surprises

	CPI	PPI	HCONN	UNEMM	GDP	IP	CONF	HS	LI	ISM	TB
Observationsnss	136 (M)	136 (M)	136 (M)	136 (M)	47 (Q)	136 (M)	136 (M)	136 (M)	136 (M)	136 (M)	136 (M)
Mean	-0.005	0.035	-0.006	-0.012	-0.16	-0.084	-0.03	8.992	-0.004	0.089	0.016
Std Error	0.18	0.523	0.201	0.158	0.874	0.467	5.26	89.477	0.224	2.111	3.231
Maximum	0,4	1.6	0.6	0.5	0.8	1.5	12.8	275	0.6	7.4	11.1
Minimum	-0,6	-1.3	-0.8	-0.5	-5.6	-3.3	-13	-253	-0.5	-6.1	-9.1

(M): Monthly, **(Q):** Quarterly
CPI: Consumer price index**, PPI:** Producer price index**, HCON:** Household consumption**, UNEM:** Unemployment rate**, GDP:** Gross domestic production, **IP:** Industrial production**, CONF:** Consumer confidence, **HS:** Housing starts, **LI:** Leading indicators, **ISM:** ISM manufacturing, **TB:** Trade Balance

[5] MMS : Money Market Services Database

Panel C: Unconditional Correlations across stock markets

	CAC40	DAX	SP500
CAC40	1	0.915	0.813
DAX		1	0.781
SP500			1

Note: This table shows the descriptive statistics of SP500, DAX, CAC40 (Panel A), US macroeconomic announcements (Panel B) and unconditional correlations of stock markets (Panel). *** indicates significance at the 1% level.

The stochastic properties of all considered data series are summarized in table 1. We report, in Panel A, basic statistics of stock markets returns series. The average daily returns are low and negative for the French and US markets under the effect of the global financial crisis and positive and close to zero for the German market. Skewness is negative for Germany and positive for France and U.S.A indicating that extreme negative and positive returns are likely to be present in stock markets' returns. Kurtosis values are high meaning that outliers may occur with a higher probability than that of a normal distribution. We also carried out the LM ARCH test of Engle (1982) and the Ljung-Box test of serial dependence. Results show that the null hypotheses (i.e no ARCH effect for the first test and serial independence for the second) are rejected at the 1% significance level for the three returns series. This confirms that a GARCH modeling is adequate to capture the heteroskedasticity and persistence in the volatilities series.

Panel B shows the main properties of the US macroeconomic news. Results reveal that most of the news are also characterized by negative daily average returns due to the global financial crisis.

Panel C reveals high positive unconditional correlations across the three considered financial markets suggesting that these markets move together. The lowest correlation is recorded between the German and US stock markets and amounts to 78%. This means that these markets are highly dependent on each others.

According to the previous results, the VAR-GARCH framework seems to be adequate to account for the clearly revealed characteristics of our data sample namely the high correlation between the stock market indices, the heteroskedasticity and the persistence in variance.

4. Results and discussion

4.1 Volatility transmission across markets

Estimation results of the first augmented model c.f Eqs (4) et (5) are reported in tables 2 and 3 for the pairs CAC40-SP500, DAX-SP500 respectively. Regarding the dynamic conditional correlation, results show evidence of time varying conditional correlation between the pairs considered above, insofar as the two coefficients a_1 and b_1 are highly significant. Thus, the DCC specification is more adequate to fit the joint dynamic of the considered stock market returns pairs than the CCC one and so allows accounting for more of the largely documented stylized facts in these markets.

As for the volatility transmission, our results show a strong evidence of volatility transmission from the US market to the French and German markets, with a stronger transmission from the US market to the French market than from the US market to the German one. Furthermore, the coefficients measuring the volatility spillover from the US market to the French and German markets are positive. Indeed, a positive (negative) shock causes an increase (decrease) of volatility in the US market which, in turn, leads to a rise of volatility of the CAC40 and DAX stock markets. Similarly, a positive (negative) shock in the French market leads to an increase of the CAC40's volatility. However, there is no evidence of volatility transmission from the French or the German market to the US market. Our results are in line with the conclusions of Becker et al. (1995); Hsin (2004) and Beine et al. (2009) who argue for the existence of a volatility spillover from the US market to some international stock markets. Fratzscher (2002) finds evidence of the reverse effect i.e volatility transmission from the European market to the US market and shows that this effect is increasing over time.

Table 2: Estimation of the augmented model in Eqs (5) and (6) for the pair CAC40-SP500

	CAC40		**SP500**	
	Coefficient	t-value	Coefficient	t-value
Mean Equation				
Constant	**5.222E-4**	2.717	**5.371E-4**	3.587
CAC(1)	**-0.066**	-3.895	**0.064**	4.991
SP (1)	**0.071**	3.659	**-0.105**	-6.077
Variance Equation				
Constant	**2.644E-6**	4.700	**7.781E-7**	3.113
ε_{t-1}^{cac}	**0.088**	12.022	----	----
ε_{t-1}^{sp}	----	----	**0.087**	11.840
h_{t-1}^{sp}	**0.069**	4.274	**0.896**	90.617
h_{t-1}^{cac}	**0.855**	67.443	0.937 E-3	1.625
DCC Equation				
a_1	**0.039 (7.597)**			
b_1	**0.957 (160.245)**			
Log-Likelihood	19434.077			
AIC	-13.398			
SIC	-13.369			
Q(12)	59.406 [0.125]			

Note: This table shows the estimation results of equations (4) and (5) for the pair (CAC40, SP500). Bold entries indicate significant coefficients.

Table 3: Estimation of the augmented model in Eqs (5) and (6) for the pair DAX-SP500

	DAX		SP500	
	Coefficient	*t*-value	Coefficient	*t*-value
Mean Equation				
Constant	**7.902E-4**	4.008	**5.291E-4**	3.590
SP(1)	0.030	0.833	**-0.110**	-3.849
DAX (1)	-0.032	-1.101	**0.052**	2.432
Variance Equation				
Constant	**2.057E-6**	4.694	**9.949E-7**	4.161
ε_{t-1}^{SP}	----	----	**0.091**	13.713
ε_{t-1}^{DAX}	**0.081**	10.429	----	----
h_{t-1}^{SP}	**0.026**	3.009	**0.899**	128.925
h_{t-1}^{DAX}	**0.895**	89.497	2.397E-3	0.879
DCC Equation				
a_1	**0.027 (5.630)**			
b_1	**0.971 (177.661)**			
Log-Likelihood	19242.111			
AIC	-13.272			
SIC	-13.243			
Q(12)	52.147 [0.136]			

Note: This table shows the estimation results of equations (4) and (5) for the pair (DAX, SP500). Bold entries indicate significant coefficients.

4.2 Direct and indirect effects of US macroeconomic announcements

In this sub-section we attempt to investigate whether the movements observed in the French and German markets after the release of the US macroeconomic surprises represent common responses to such news, or depict a transmission effect from the US market, or even a simultaneous effect i.e common responses and spillover effect. To do so, we estimate the augmented DCC-GARCH model as described by Eqs. (6) and (7). Estimation results are reported in tables 4 and 5 for the CAC40-SP500, DAX-SP500 pairs respectively.

Regarding the direct effect of US macroeconomic surprises on the French stock market results in tables 4 show that the volatility of the CAC40 stock index increases significantly following a surprise increase in the US unemployment rate, the US GDP and the US ISM index, with the second having the biggest size effect. Additionally, the French market volatility decreases after a surprise increase of industrial production and housing starts, with a more sensitivity to the former type of news. The previous results confirm the hypothesis that French investors react to US macroeconomic news by adjusting their trading positions and adapting their portfolios with the arrival of US surprises. Table 4 also reports a volatility transmission from the US market to the French market after a surprise in the US industrial production, the ISM index and the leading indicators. Indeed, an increase in the previous three indicators leads to

Table 4: Estimation of the augmented model Eqs (7) and (8) / CAC40 - SP500

Variables	**CAC40**	***t*-value**	**SP500**	***t*-value**
Mean Equation				
Constant (10^3)	**0.565**	2.897	**0.546**	3.600
CAC(1)	**-0.072**	-3.372	**0.062**	3.459
SP(1)	**0.080**	3.516	**-0.101**	-4.985
Variance Equation				
Constant (10^5)	**0.306**	6.100	**0.077**	2.795
ε_{t-1}^2	**0.082**	9.226	**0.082**	10.470
h_{t-1}	**0.874**	70.044	**0.887**	68.347
Direct Effects				
Unemployment	**0.232 E-4**	4.276	**0.935 E-5**	3.233
CPI	-0.729 E-5	-1.375	0.465 E-5	1.492
Household Cons	-0.175 E-5	-0.320	-0.216 E-5	-0.726
Industrial Prod	**-0.234 E-4**	-3.914	**-0.106 E-4**	-2.621
Housing Starts	**-0.136 E-4**	-4.450	0.141 E-5	0.552
GDP	**0.377 E-4**	1.933	0.166 E-4	1.447
Consumer Confidence	-0.276 E-5	-0.504	0.479 E-5	1.388
ISM Index	**0.187 E-4**	4.193	-0.403 E-6	-0.151
PPI	-0.436 E-5	-0.914	-0.422 E-5	-1.544
Leading Indicators	0.194 E-6	0.049	-0.848 E-7	-0.037
Trade Balance	-0.893 E-6	-0.220	0.706 E-6	0.329
Indirect Effects				
Unemployment	0.102	1.029	0.018	0.437
CPI	-0.187	-1.562	-0.009	-0.255
Household Cons	-0.060	-0.702	-0.018	-0.747
Industrial Prod	**0.209**	2.191	-0.005	-0.198
Housing Starts	0.050	0.343	**0.128**	2.370
GDP	0.100	0.776	0.051	0.958
Consumer Confidence	0.111	1.617	0.014	0.381
ISM Index	**0.333**	3.717	**0.158**	3.591
PPI	0.124	1.626	0.062	1.588
Leading Indicators	**0.301**	4.415	**0.067**	2.105
Trade Balance	0.066	0.963	0.020	0.629
DCC Equation				
a_1	**0.038 (8.049)**			
b_1	**0.958 (178.470)**			
Log-Likelihood	19481.200			
AIC	-13.408			
SIC	-13.289			
Q(12)	60.293 [0.109]			

Note: This table shows the estimation results of equations (6) and (7) for the pair (CAC40, SP500). Bold entries indicate significant coefficients an increase in the volatility of the US market, which in turn impacts positively the volatility of the French market. More interestingly, the opposite direction is marked by a significant spillover effect from the French market to the US market after the release of US housing starts, US ISM index and US leader indicators. An increase in the CAC's volatility leads to an increase in the SP500's volatility with the higher effect for the ISM index and the lower effect for leading indicators. These results confirm the hypothesis that some of the US macroeconomic announcements are able to generate volatility transmission from the US market to the French market and vice versa.

Similarly, US macroeconomic surprises directly affect the volatility of the German market. Results in table 5 show that the volatility of the German market increases significantly shortly after an increase of US unemployment rate and ISM index and a decrease of housing starts. It should be noted that these same surprises affect directly the French markets in the same direction with a greater impact of the ISM index. Moving to the indirect effects of US macroeconomic surprises on the German market, table 5 shows evidence of volatility transmission from the US market to the German market after the release of the US industrial production and the leading indicators. Indeed, an increase in the SP500 volatility leads to an increase in the DAX's volatility after the release of the two previous indicators. At the same time, an apparent spillover effect is recorded from the German market to the US market following the release of US news on GDP, ISM index and household consumption. The former factor impacts negatively the US market while the last two factors affect positively the volatility of SP500.

All in all, our results show evidence of a significant impact of the US macroeconomic surprises on French and German stock markets. This impact is split into two types namely the direct effect (common response) and indirect effect (volatility transmission). Additionally, the French investors are more sensitive to US macroeconomic announcements than the Germans. In fact, they react directly to five out of eleven news and indirectly to three out of eleven news while the Germans react directly to only three out of eleven US news and indirectly to two out of eleven US news. Moreover, taken together, our results show that the volatility transmission is bidirectional since a significant volatility transmission from the French and German markets to the US market is revealed. Indeed, following the release of US ISM index release, a positive increase in the French and the German market volatilities leads to an increase in the US market volatility but with larger effect of the French market on the US one. Furthermore, a more volatility transmission is recorded from the French market to the US market after the release of US industrial production and US leading indicators respectively. As for the additional volatility spillover from the German market to the US market, it is detected following the release of US household consumption and US GDP. Our results are in line with the findings of Dimpfel (2011) who shows evidence of German market reaction to US news announcements.

The previous results - mainly those concerning the bidirectional volatility spillover between the French market and the US market on one side, and between the German market and the US market on the other - show that the interactions between the two pairs of markets are in both directions and therefore highlight an important integration between them i.e between US-French markets and between US-German markets. These findings are in line with those of De Sentis and Gerard (1997), although these transmissions are more pronounced from the US market to the European markets rather than from the European markets to the US market.

Table 5: Estimation of the augmented model DAX – SP500

Variables	**DAX**	***t*-value**	**SP500**	***t*-value**
Mean Equation				
Constant (10^3)	**0.733**	4.371	**0.483**	3.844
DAX(1)	-0.037	-1.591	**0.050**	2.826
SP(1)	0.035	1.191	**-0.108**	-4.670
Variance Equation				
Constant	**0.255 E-5**	4.562	**0.100 E-5**	3.412
ε_{t-1}^2	**0.075**	9.055	**0.088**	7.450
h_{t-1}	**0.904**	79.069	**0.895**	56.916
Direct Effects				
Unemployment	**0.146 E-4**	3.209	**0.816 E-5**	3.186
CPI	-0.204 E-5	-0.317	0.256 E-5	0.641
Household Cons	-0.932 E-5	-1.528	-0.428 E-5	-1.415
Industrial Prod	-0.712 E-5	-1.172	**-0.654 E-5**	-1.777
Housing Starts	**-0.107 E-4**	-3.224	-0.107 E-5	-0.371
GDP	0.220 E-5	0.091	0.123 E-5	1.032
Consumer Confidence	0.890 E-6	0.161	0.368 E-5	1.146
ISM Index	**0.991 E-5**	2.154	-0.568 E-5	-0.233
PPI	-0.232 E-5	-0.377	-0.682 E-5	-0.217
Leading Indicators	0.123 E-5	0.280	0.102 E-5	0.509
Trade Balance	-0.657 E-5	-1.602	0.138 E-5	0.606
Indirect Effects				
Unemployment	0.028	0.362	-0.014	-0.400
CPI	-0.126	-1.607	-0.009	-0.279
Household Cons	-0.034	-0.482	**-0.053**	-1.818
Industrial Prod	**0.166**	1.821	0.018	0.589
Housing Starts	-0.035	-0.268	0.050	1.298
GDP	0.038	0.368	**0.079**	2.186
Consumer Confidence	-0.006	-0.056	-0.002	-0.072
ISM Index	0.044	0.595	**0.094**	2.995
PPI	-0.044	-0.607	0.016	0.572
Leading Indicators	**0.337**	2.620	0.039	1.255
Trade Balance	0.065	0.955	-0.014	-0.556
DCC Equation				
a_1	**0.027 (4.280)**			
b_1	**0.971 (138.450)**			
Log-Likelihood	19274.863			
AIC	-13.267			
SIC	-13.148			
Q(12)	50.461 [0.376]			

Note: This table shows the estimation results of equations (6) and (7) for the pair (DAX, SP500). Bold entries indicate significant coefficients.

5. Conclusion

This paper investigates the effects of US macroeconomic surprises on European and US stock market index volatilities using an augmented multivariate GARCH framework. We introduce a multivariate GARCH model that accounts for the cross effects of volatilities which allows measuring the volatility transmission across the European and US markets. Afterwards, we augment the GARCH model by jointly adding the markets' cross volatilities and the impact of US macroeconomic surprises.

Our setting provides interesting insights into the dynamics of international equity markets. This paper mainly contributes to the existing literature by separating the direct effect from indirect effect of US macroeconomic surprises on the two European markets. Thus, this paper presents evidence of common reactions of European investors to US macroeconomic announcements. The latter reactions represent the direct effects of US macroeconomic surprises on the European markets. The paper allows also explaining the causes of volatility transmission between the European markets and the US market by selecting the most significant surprises that drive this volatility spillover as well as the direction of the transmission. The volatility transmission is considered as the indirect effect of US macroeconomic news on European markets in our setting.

The results indicate significant common responses of European investors to US macroeconomic indicators with an emphasis toward a greater sensitivity of French investors. A bidirectional volatility spillover across the international stock markets is recorded after the release of some US macroeconomic surprises again with a stronger interdependence between the US and French markets compared to that between the US and German markets.

These results have important implications for market participants and portfolio managers as US macroeconomic announcements have direct and indirect impacts on asset prices. Thus, accurate assessment of responsiveness of asset prices to US macroeconomic news can be of help to European as well as American investors in making correct trading decisions and formulating appropriate risk management strategies.

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