Applied Financial Economics, 2000, **10**, 323–341

Effects of index option introduction on stock index volatility: a procedure for empirical testing based on SSC-GARCH models

LEONARDO BECCHETTI* and ANDREA CAGGESE‡

Università 'Tor Vergata', 00133 Roma - Via di Tor Vergata, Italy and ‡*Linacre College, Oxford University, Oxford UK*

Informed migration, uninformed migration and improved information are the three main potential effects of derivative introduction that, alone or combined, may generate significant changes on volumes, bid–ask and volatility on the underlying asset. Some combinations of these three effects are highly likely to generate observational equivalence making it quite difficult to identify their relative impact in the empirical evidence. This paper aims to provide a marginal contribution to the identification of the prevalent effect by devising an implemented (SSC-GARCH) measure of volatility which evaluates changes in excess reaction to shocks before and after index option introduction in six different countries. The paper finds that the introduction of stock index options: (i) significantly reduces the impact of negative (and, to a lesser extent, positive) shocks on conditional volatility in five out of six countries, (ii) has no significant impact on relative unconditional volatility of stocks belonging to the optioned index in four out of six countries. These results seem compatible with a joint realization of the uninformed migration and the improved information effects.

I. INTRODUCTION

Financial records in recent years witnessed sudden upsurges in market instability on the occasion of critical phases (the stock market crash in October 1987 the global financial crisis in 1998) and a general increase in market volatility in the most important industrialized countries. The contemporary occurrence of these events, with the introduction of derivative products in several markets, led regulatory authorities to suspect that the introduction of derivatives might have increased underlying asset market volatility. This suspicion was reflected, for example, in SEC concerns (Skinner, 1989) and led to the decision of the Japanese regulatory authorities to reduce trading hours, increase margin and commission charges and reduce daily price limits (Robinson, 1993) on derivative markets. Some confusion seems though to exist in the popular press between the direct impact on underlying asset volatility of derivative introduction and its impact on systemic risk which depends mainly on prudential regulation of financial intermediaries trading derivatives. This paper focuses on the first aspect and tests the impact of derivatives introduction on underlying asset in the light of the different hypotheses put forth by the theoretical literature. These hypotheses mainly identify changes in market microstructure and incremental information as the two main determinants of changes in volumes, bid–ask and volatility of underlying asset after derivative introduction.

A relevant weight is given to the first determinant as, for a large part of the literature, changes in financial volatility are induced by changes in the composition between rational and noise (uninformed) (near rational) traders

* Author to whom correspondence should be addressed.

Applied Financial Economics ISSN 0960–3107 print/ISSN 1466–4305 online
http://www.tandf.co.uk/journals/tf/09603107.html

on financial markets (Grossman, 1976; Grossman and Stiglitz, 1980; Hellwig, 1980; Stein, 1980; De Long *et al.,* 1990; Black and Tonks, 1992; Wang, 1993).

The assumption of the existence of heterogeneous traders on financial markets has led to the formulation of two well established hypotheses. According to the first, the introduction of derivatives (and in particular of index derivatives) generates a migration of noise (uninformed) traders from the underlying asset market to the derivative market (Gammill and Perold, 1989; Gorton and Pennacchi, 1993; Choi and Subrahmanyam, 1994 and Kumar *et al.*, 1995) because firm-specific informational asymmetries are less severe on the latter. This migration should reduce volatility on the underlying asset market by reducing the phenomenon of excess reaction to shocks which amplifies fluctuations and is typical of noise (positive feedback) traders (De Long *et al.*, 1990) or of near rational adaptive traders (Wang, 1993). It should also determine a reduction in volumes and an increase in bid–ask spreads.[1]

This hypothesis (which we term as 'uninformed migration hypothesis') is usually tested against the alternative ('informed migration hypothesis') which assumes that derivatives introduction may shift informed traders from the underlying to the derivative market given that options are considered as superior investment vehicles (in terms of leverage and lower transaction costs) (Kumar *et al.*, 1995). With informed migration competitive market-makers face a higher share of less informed players and may find it optimal to reduce their margins. Under this assumption underlying asset volumes are expected to decline, volatility and excess reaction to shocks not to decrease, bid–ask spread to decline in presence of market makers and asymmetric information and to increase without market makers.

Prediction becomes more complex and observational equivalence may arise when we combine these two hypotheses with the arrival of new information on the underlying asset market generated by derivative trading (the simplest example is information on future volatility extracted from option pricing formulas). If we assume that no migration occurs and new information arrives on the underlying asset market we could assist to a reduction of the bid–ask spread and to a reduction of excess reaction to shocks (but not necessarily of volatility *tout court*). A combination of these three hypotheses may give less clear cut predictions and may result in being even more difficult to be tested.

In the light of the above described predictions from financial theory this paper aims to provide a marginal contribution to the interpretation of the 'derivative introduction effect' puzzle by devising a SSC-GARCH model that allows the measurement of excess reaction to shocks and to compare it with traditional measures of unconditional volatility and bid–ask spread.

Most of the currently adopted volatility measures do not provide sufficient information for understanding how much informed migration, uninformed migration and arrival of new information matters when derivatives are introduced. In fact, several authors test the effects of the introduction of derivatives on a sample of individual firm stocks using mean group unconditional standard deviation, corrected for market standard deviation before and after the introduction of derivative trading (Trennepohl and Duke, 1979; Klemkosky and Maness, 1980; Whiteside *et al.*, 1983; French and Roll, 1986; Stoll and Whaley, 1987; Edwards, 1988; Conrad, 1989; Skinner, 1989; DeTemple and Orion, 1990; Damodaran and Lim, 1991; Kumar *et al.*, 1995). This first group of contributions neglects the fact that unconditional measures of price volatility may be adopted only when the distribution of returns is stationary normal variate, while it is well known that the distribution of stock returns is typically nonstationary (Baldauf and Santoni, 1991) and exhibits both skewness and excess kurtosis (Bollerslev *et al.*, 1992). In addition, given that the 'uninformed migration and arrival of new information' joint hypothesis predicts the reduction in the share of uninformed traders on the underlying stock market, the reduction of volatility should occur through reduction in excess sensitivity to shocks and should be more appropriately tested with conditional volatility measures.

A second group of works is based on the estimation of models taking into account the phenomenon of volatility persistence (Baldauf and Santoni, 1991; Antoniou and Holmes, 1992; Lee and Ohk, 1992; Robinson, 1993; Becchetti, 1996; Shastri *et al.*, 1996).

This second group of contributions correctly addresses the conditional volatility issue but does not take into account recent results in the literature of volatility persistence models (Nelson, 1989; Engle, 1990; Engle and Ng, 1993). These results provide techniques for estimating the shape of a 'news' impact curve' (the curve that relates volatility response to sign and magnitude of past shocks) and allow for asymmetries in the conditional second moment reaction to negative and positive shocks.[2]

[1] With market makers and asymmetric information this occurs because competitive market makers face a higher share of well informed players and must increase their margin. Without market makers the same effect on bid–ask spreads should directly follow from the reduction in volumes.

[2] This innovation in methodology is particularly important because an analysis of structural breaks in conditional volatility which is limited to the observation of intercept shifts is clearly not satisfactory. Intercept coefficients are, in fact, likely to absorb spurious effects and are strongly influenced by model misspecification or omission of other relevant variables.

This paper's marginal contribution is in testing the theoretical hypothesis of the effects of derivatives' introduction on the underlying asset market volatility using the 'news impact curve' approach. We think that this approach is a more straightforward test of the hypothesis of volatility reduction induced by reduction in the share of uninformed traders. In fact, if the 'volatility reduction' effect is based on the migration of noise traders from the underlying stock market to the derivative market after its introduction, and if noise traders amplify shocks generating excess volatility, a reduction of stock reaction to news may more directly test the link between changes in volatility and reduction in the share of uninformed traders.

The paper is divided into seven sections. The following section presents a brief survey on methodology and results of previous empirical papers. The third section describes the specifications adopted for the returns equations on the six different markets. In the fourth section the original methodology (the sign and size conditional GARCH) adopted by the paper is introduced in order to discriminate between the different impact of positive and negative shocks on the conditional volatility before and after the introduction of stock index options. The estimating performance of the SSC-GARCH model is compared with eight alternative models of conditional volatility (ARCH, GARCH, Sign switching GARCH, Sign and Volatility Switching GARCH, GJR, VGARCH, AGARCH and NAGARCH). The fifth section presents results of the SSC-GARCH estimates. It shows that, for five out of six countries, index option introduction significantly affects the 'news impact curve' by reducing the impact of negative and (or) positive shocks on conditional volatility. These changes almost eliminate the 'leverage effect' (higher reaction to negative than positive shocks) where it existed *ex ante*. The sixth section shows that the impact of derivative introduction on traditional indicators such as unconditional volatility and bid–ask spreads is not so clear cut. Overall paper results seem then to exclude an informed migration explanation and appear more consistent with the joint hypothesis of uninformed migration and incremental information.

II. THE LITERATURE ON THE EFFECTS OF DERIVATIVES' INTRODUCTION ON UNDERLYING ASSET VOLATILITY: METHODOLOGY AND EMPIRICAL RESULTS

From a methodological point of view, empirical analyses on the effects of derivatives' introduction on underlying asset volatility may be divided into two groups.

The first group uses filtered or unfiltered unconditional volatility measures (CBOE, 1975; Trennepohl and Duke, 1979; Klemkosky and Maness, 1980; Whiteside *et al.*, 1983; French and Roll, 1986; Stoll and Whaley, 1987; Edwards, 1988; Conrad, 1989; Skinner, 1989; DeTemple and Orion, 1990; Damodaran and Lim, 1991; Kumar *et al.*, 1995). The second group takes into account the seminal paper of Engle (1982) and tries to model explicitly the phenomenon of volatility clustering with time-varying second-order moments (Baldauf and Santoni, 1991; Antoniou and Holmes, 1992; Lee and Ohk, 1992; Robinson, 1993; Shastri *et al.*, 1996).

Among the first group, the initial study on the relationship between option pricing an underlying stock price volatility was performed by the CBOE (1975) itself. The analysis of the CBOE underlying stocks during the first four months of 1975 showed a decrease in volatility after option introduction, not supported though by significance tests. Other early studies with inconclusive results were conducted by Trennepohl and Dukes (1979) (analysis of systematic risk shifts on 32 stocks with option introduced in 1973), Klemkosky and Maness (1980) (analysis of systematic risk and volatility on approximately 100 stocks with option quoted on AMEX and CBOE in 1973–75), Whiteside *et al.* (1983) (similar analysis on 71 stocks with quoted options).

More recently, Conrad (1989), Skinner (1989), DeTemple and Orion (1990), and Damodaran and Lim (1990), obtained more conclusive results analysing a greater number of stocks with option quoted on AMEX and CBOE, across a longer time period (1973–1986 for Skinner and DeTemple and Orion). All these studies find a reduction in unconditional volatility after option introduction, while average systematic risk is roughly unaffected.

Two recent works are more closely related to our research: Kumar *et al.* (1995) examine the impact of the listing of options on the Nikkei Stock Average (NSA) on the 225 stocks in the index. They distinguish between nontrading time (close to open price variations) and trading time volatility (open to close price variations), finding that, while the latter decreases only for the stocks in the index, after option introduction, the first decreases for nonindex stocks too. This result is consistent with the hypothesis that option introduction causes a migration of noise trading from the underlying stock to the options market.

Shastri *et al.* (1996), among the second group of studies, examine the impact of the listing of foreign currency options and options on foreign currency futures on the underlying securities. They find, with both unconditional and conditional (bivariate GARCH error correction model) measures, a decline in the volatility of the exchange rates after spot option listing, although they check only for intercept shifts and not for changes in the behaviour of price reactions to shocks.

From a methodological perspective, the conditional volatility approach should be preferred. In fact simple standard deviation measures of changes in volatility through a fixed or a moving window before and after the introduction of derivatives are not appropriate as stock returns usually exhibit nonnormal unconditional sampling distributions especially under the form of excess kurtosis (Bollerslev *et al.*, 1992). In addition, if the theoretical rationale of changes in volatility is based on changes in the composition of heterogeneous quality traders, it should be tested with methodologies modelling volatility persistence which the existence of uninformed (noise) traders typically predicts.

To this purpose, the most recent contribution of Engle and Ng (1993) provides a fundamental, unified approach based on the analysis of the 'news impact curve'. This curve illustrates the crucial relationship between past return shocks and conditional variance for all different specifications adopted in modelling variance clustering. The 'news impact curve' provides an immediate graphical evaluation of the hypothesis on the conditional variance behaviour implied by the model, while the evaluation of the different models is achieved by Engle and Ng through a series of tests.[3]

We think that a proper test of the hypothesis of volatility reduction on underlying stock induced by migration of uninformed traders should be performed using a similar approach for at least two reasons. First, it properly models conditional volatility interpreting effects of the existence of noise (uninformed) traders in the market. Second, it allows us to detect the 'dampening effect' in the reaction to shocks which should be the direct consequence of incremental information and uninformed migration from the underlying asset market.

III. AN EMPIRICAL PROCEDURE FOR THE ANALYSIS OF THE IMPACT OF DERIVATIVES ON MARKET VOLATILITY: THE ESTIMATE OF THE 'BEST BASE EQUATION'

On the basis of recent achievements in the literature of time varying volatility the present analysis examines the effects of the introduction of equity index options on six European markets (The UK, The Netherlands, Switzerland, Austria, Germany, France).

In order to evaluate the necessity of using SSC-GARCH models we start by testing the following general model of stock return behaviour for the six markets:

$$R_t = \alpha_0 + \sum_j \beta_j DW_j + \sum_i \gamma_i R_{t-i} + \sum_i \delta_i RUS_{t-1} \qquad (1)$$

where R_t is the one-day difference between logs of stock prices for the relative market, RUS_t is the same difference for the US stock market, DW_j are five dummies for 'day of the week' effects.

The base equations (Table 1) have some common elements. The hypothesis of random walk for these small and medium stock exchange markets is rejected, consistently with several previous results in literature (Taylor, 1986). Lagged daily log returns of the own market, days of the week, and lagged and contemporary log returns in the US 'dominant' market have small but significant effects on the dependent variable. The effect of the US market is quite strong in all equations, while the Austrian market seems to have the higher degree of inefficiency with a quite strong effect of one lag returns. The negative Monday effect is the most relevant day of the week effect consistently with several previous results in literature (Taylor, 1986).[4]

Kurtosis and skewness tests, performed on the residuals obtained from best estimation of the base equations, show that the distribution is stationary but not normal variate. The existence of excess kurtosis confirms the 'stylized fact' of thick tails for financial time series, which was firstly observed by Mandelbrot (1963a, b) and suggests the adoption of an ARCH-type specification for our estimates.

To discriminate among different ARCH-type models we use a test proposed by Engle and Ng (1993) with the following specification for the error term of the base equation:

$$\varepsilon_t = a_0 + \sum_i a_i \varepsilon_{t-i} + e_t \qquad (2)$$

On the basis of this equation sign bias, negative size bias and positive size bias tests are carried out. The regressions for these three tests are respectively the following:

$$h_t = a + bD^+_{t-1} + e_t \qquad (3)$$

$$h_t = a + bD^-_{t-1}\varepsilon_{t-1} + e_t \qquad (4)$$

$$h_t = a + bD^+_{t-1}\varepsilon_{t-1} + e_t \qquad (5)$$

[3] The most important tests are: (i) the sign bias test; (ii) the negative size bias test; (iii) the positive size bias test; (iv) the excess kurtosis test and (v) the Pagan–Sabau (PS) test.

[4] Several attempts of including yield curve variables have been made in each market given that partial and total cross-correlation functions show the existence of a weak correlation between leads in the yield curve and the dependent variable. The inclusion of such variables is not significant. Even though it is difficult to deny the importance of the effects of interest rates on stock index performance, according to the common experience of stock exchange behaviour, it is clear that any measure of the yield curve is only a proxy for market expectations on interest rates which is the relevant variable to be taken into account. This could explain the observed results of weak cross correlation between yield curve leads and the dependent variable and the absence of correlation between yield curve lags and the same variable.

Table 1. *Base equations for the six countries*

Austria							
$R_t = 0.1\text{E}-03$	$+0.299R_{t-1}$	$-0.048R_{t-3}$	$+0.034R_{t-5}$	$+0.056R_{tr-9}$	$+0.292Rus_{t-1}$	$+0.038Rus_{t-5}$	$-0.7\text{E}-03Wed$
(1.18)[a]	(14.57)	(−2.38)	(1.67)	(2.75)	(11.09)	(1.45)	(−2.52)
France							
$R_t = 0.3\text{E}-03$	$+0.094R_{t-1}$	$+0.029R_{t-7}$	$+0.067R_{t-9}$	$+0.034R_{t-10}$	$+0.269Rus_{t-1}$	$+0.047Rus_{t-5}$	
	(5.81)	(1.83)	(4.28)	(2.19)	(14.93)	(2.74)	
	$+0.104Rus_{t-7}$	$-0.9\text{E}-03Mon$	$-0.4\text{E}-03Thu$				
	(5.87)	(−5.04)	(−2.16)				
Germany							
$R_t = 0.2\text{E}-03$	$-0.035R_{t-1}$	$+0.352Rus_{t-1}$	$-0.107Rus_{t-2}$	$+0.079Rus_{t-8}$	$-0.7\text{E}-03Mon$	$+0.4\text{E}-03Fri$	
(1.49)	(−1.74)	(14.41)	(−4.40)	(3.37)	(−2.90)	(1.69)	
Switzerland							
$R_t = 0.2\text{E}-03$	$+0.057R_{t-5}$	$+0.041R_{t-8}$	$-0.037R_{t-9}$	$-0.025Rus_{t-2}$	$+0.027Rus_{t-3}$	$+0.074Rus_{t-5}$	$+0.045Rus_{t-7}$
(3.51)	(3.34)	(2.38)	(2.21)	(−1.84)	(1.99)	(5.21)	(3.32)
	$-0.032Rus_{t-9}$	$-0.6\text{E}-03Mon$					
	(−2.09)	(−4.44)					
The Netherlands							
$R_t = 0.3\text{E}-03$	$-0.050R_{t-1}$	$+0.506Rus_{t-1}$	$-0.101Rus_{t-2}$	$+0.067Rust-3$	$-0.038Rus_{t-5}$		
	(−2.26)	(25.2)	(−4.47)	(3.34)	(−1.93)		
	$+0.044Rus_{t-6}$	$+0.22Rus_{t-10}$	$-0.7\text{E}-03Mon$				
	(2.25)	(1.14)	(−3.74)				
United Kingdom							
$R_t = 0.1\text{E}-03$	$+0.073R_{t-1}$	$+0.035R_{t-4}$	$+0.037R_{t-9}$	$+0.029R_{t-10}$	$+0.274Rus_{t-1}$	$-0.118Rus_{t-2}$	
(1.36)	(3.64)	(1.95)	(2.06)	(1.63)	(15.97)	(−6.77)	
	$+0.048Rus_{t-3}$	$-0.5\text{E}-03Mon$	$+0.2\text{E}-03Thu$	$+0.4\text{E}-03Fri$			
	(2.85)	(−2.62)	(1.38)	(2.26)			

R_t = log returns of market index.
Rus = log returns of Dow Jones Composite 65 index.
Mon, Tue, Wed, Thu, Fri = day-of-the-week dummies.
[a] The values in parentheses are the t-statistics of the coefficients.

where D^-_{t-1} is a dummy which takes value of 1 when the residual of the stock return equation in the previous period is negative and value of 0 when it is positive. D^+_{t-1} is just equal to $1 - D^-_{t-1}$. When the t-ratio on the coefficient b is significant in one of the three equations, this indicates a misspecification in the 'news' impact curve'.

An alternative way of testing the three biases is the following: filtered unpredictable stock returns are calculated according to the following formula $\nu_t = u_t/\sqrt{h_t}$ and then ν_t^2 is regressed on D^-_{t-1}, $D^-_{t-1}u_t$, and $D^+_{t-1}u_t$ to test for the presence of the three biases. An additional test that may be carried out together with size and bias ones is the Pagan and Sabau (1988) (PS) test. In this case what has to be done is a regression of the log of stock price rate of change squared on an intercept and on the conditional variance estimated in the GARCH model:

$$R_t = a + bh_t + \varepsilon_t \tag{6}$$

Under the null hypothesis of GARCH capturing most data nonlinearity the intercept must be equal to zero and the slope is expected to be equal to one.

The presence of these biases indicates the need for a specification which can consider a different impact of past shocks on conditional variance according to the size and bias of the past shock such as the SSC-GARCH model.

IV. THE EMPIRICAL PROCEDURE FOR THE ANALYSIS OF THE IMPACT OF DERIVATIVES ON MARKET VOLATILITY: THE SSC-GARCH MODEL COMPARED WITH NINE MODELS OF CONDITIONAL VOLATILITY

The model adopted for testing the impact of index option introduction on stock market volatility is a sign and size conditional ARCH model (SSC-GARCH) where the second equation is given by:

$$h_t = b_0 + b_1\varepsilon^2_{t-1} + b_2h_{t-1} + b_3S^-_{t-1} + b_4S^+_{t-1}\varepsilon^2_{t-1} + b_5S^-_{t-1}\varepsilon^2_{t-1} + b_6D_{\text{IO}}S^-_{t-1} + b_7D_{\text{IO}}S^+_{t-1}\varepsilon^2_{t-1} + b_8D_{\text{IO}}S^-_{t-1}\varepsilon^2_{t-1} \tag{7}$$

Table 2. *Base equations – residual statistics*

	Austria	France	Germany	Switzerland	The Netherlands	United Kingdom
Log likelihood	7553	14 596	9787	15 451	8859	11 073
Kurtosis	5.5	8.24	11.9	30.3	1.22	5.78
Skewness	0.032	−0.01	−0.93	−2.12	0.14	−0.29
Positive sign bias test[a]	−0.73	2.29	−10.27	−11.02	−5.37	−10.92
Positive size bias test[b]	10.32	−19.03	7.23	8.3	1.73	9.82
Negative size bias test[c]	−9.07	10.6	−0.32	−1.72	2.37	−0.43

Notes:
[a] Values of the t statistic of the b coefficient in Equation 5.
[b] Values of t statistic of the b coefficient in Equation 7.
[c] Values of the t statistic of the b coefficient in Equation 6.

Table 3. *Austria – 1986 observations – sample period: 08/01/86 – 30/12/93 – option introduction date: 7/8/92*

ARCH (5)							
$h_t = 0.4\text{E}-05$	$+0.2\text{E}-05D_{\text{IO}}$	$+0.476\varepsilon_{t-1}^2$	$+0.115\varepsilon_{t-2}^2$	$+0.135\varepsilon_{t-3}^2$	$+0.025\varepsilon_{t-4}^2$	$+0.229\varepsilon_{t-5}^2$	$+0.1\text{E}-08\,Trnd$
(10.54)	(1.79)	(13.75)	(4.97)	(6.67)	(1.81)	(8.77)	(3.45)
GARCH(1,1)							
$h_t = 0.2\text{E}-06$	$-0.2\text{E}-06D_{\text{IO}}$	$+0.695h_{t-1}$	$+0.291\varepsilon_{t-1}^2$	$+0.4\text{E}-09\,Trnd$	$+0.8\text{E}-06\,Pr$	$-0.2\text{E}-05D_{\text{IO}}Pr$	
(1.56)	(−0.929)	(49.13)	(13.43)	(3.01)	(7.65)	(−1.92)	
Sign switching GARCH(1,1)							
$h_t = 0.1\text{E}-06$	$+0.3\text{E}-07D_{\text{IO}}$	$+0.696h_{t-1}$	$+0.301\varepsilon_{t-1}^2$	$+0.6\text{E}-090\,Trnd$	$+0.7\text{E}-06\,Pr$		
(0.70)	(3.24)	(52.43)	(14.42)	(4.33)	(5.89)		
$-0.3\text{E}-05D_{\text{IO}}Pr$	$+0.1\text{E}-05\,Ssw$						
(−2.44)	(6.06)						
Sign and volatility switching GARCH(1,1)							
$h_t = 0.2\text{E}-05$	$+0.53h_{t-1}$	$+0.416\varepsilon_{t-1}^2$	$-0.177D_{\text{IO}}\varepsilon_{t-1}^2$	$+0.057\,Svsw$	$-0.057D_{\text{IO}}Svsw$	$+0.1\text{E}-08\,Trnd$	
(7.34)	(13.06)	(13.55)	(−2.68)	(2.58)	(−1.59)	(2.92)	
SSC-GARCH(1,1)							
$h_t = 0.2\text{E}-05$	$+0.567h_{t-1}$	$+0.499S_{t-1}^{+}\varepsilon_{t-1}^2$	$+0.419S_{t-1}^{-}\varepsilon_{t-1}^2$	$-0.1\text{E}-05S_{t-1}^{-}$	$+0.6\text{E}-9\,Trnd$		
(6.37)	(15.02)	(11.57)	(8.65)	(−2.74)	(1.44)		
	$+0.7\text{E}-05D_{\text{IO}}S_{t-1}^{-}$	$-0.327D_{\text{IO}}S_{t-1}^{+}\varepsilon_{t-1}^2$	$-0.252D_{\text{IO}}S_{t-1}^{-}\varepsilon_{t-1}^2$				
	(4.6)	(−4.03)	(−2.11)				
GJR							
$h_t = 2\text{E}-05$	$+0.554h_{t-1}$	$+0.471\varepsilon_{t-1}^2$	$-0.104D_{\text{IO}}\varepsilon_{t-1}^2$	$-0.288S_{t-1}^{-}\varepsilon_{t-1}^2$	$+0.233D_{\text{IO}}S_{t-1}^{-}\varepsilon_{t-1}^2$	$+0.1\text{E}-08\,Trnd$	
(6.44)	(14.16)	(11.30)	(−1.73)	(−3.59)	(1.68)	(2.71)	
VGARCH(1,1)							
$h_t = 0.2\text{E}-05$	$+0.739h_{t-1}$	$+0.1\text{E}-04\varepsilon_{t-1}/h_{t-1}$	$-0.9\text{E}-05\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$-0.7\text{E}-05D_{\text{IO}}\varepsilon_{t-1}/h_{t-1}$	$+0.7\text{E}-05D_{\text{IO}}\varepsilon_{t-1}/\sqrt{h_{t-1}}$		
(3.58)	(21.06)	(8.65)	(−4.39)	(−2.31)	(1.75)		
NAGARCH(1,1)							
$h_t = 0.1\text{E}-05$	$+0.619h_{t-1}$	$+0.528\varepsilon_{t-1}^2$	$-27\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$-52D_{\text{IO}}\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+0.9\text{E}-09\,Trnd$		
(4.69)	(15.97)	(6.97)	(−1.89)	(−0.94)	(1.9)		
AGARCH							
$h_t = 0.2\text{E}-05$	$+0.558h_{t-1}$	$+0.432\varepsilon_{t-1}^2$	$-0.278D_{\text{IO}}\varepsilon_{t-1}^2$	$-0.4\text{E}-04\varepsilon_{t-1}$	$+0.7\text{E}-03D_{\text{IO}}\varepsilon_{t-1}$	$+0.1\text{E}-08\,Trnd$	
(4.93)	(15.14)	(5.85)	(−1.86)	(−0.11)	(0.86)	(2.11)	

Notes: R_t = log returns off Austrian traded Index (ATX); R_{us} = log returns of Dow Jones Composite 65 Index; Wed = Wednesday dummy; D_{IO} = option contract introduction dummy (ATX option); $Trnd$ = linear trend; Pr = sign persistence dummy; Ssw = sign switching dummy (D^+); $Svsw$ = sign and volatility switching series (D^+ Vt).

where two other dummies are introduced to keep into account the size effect of positive sign shocks (S_{t-1}^{+}, which takes value of 1 if the $t-1$ shock is positive and zero otherwise) and the size effect of negative sign shocks (S_{t-1}^{-}, which takes value of 1 if the $t-1$ shock is negative and zero otherwise). The advantage of this model is that it allows us to estimate the different impact of positive and negative shocks on H_t and gives a clear interpretation of structural changes in the 'news impact curve' after the introduction of index options.

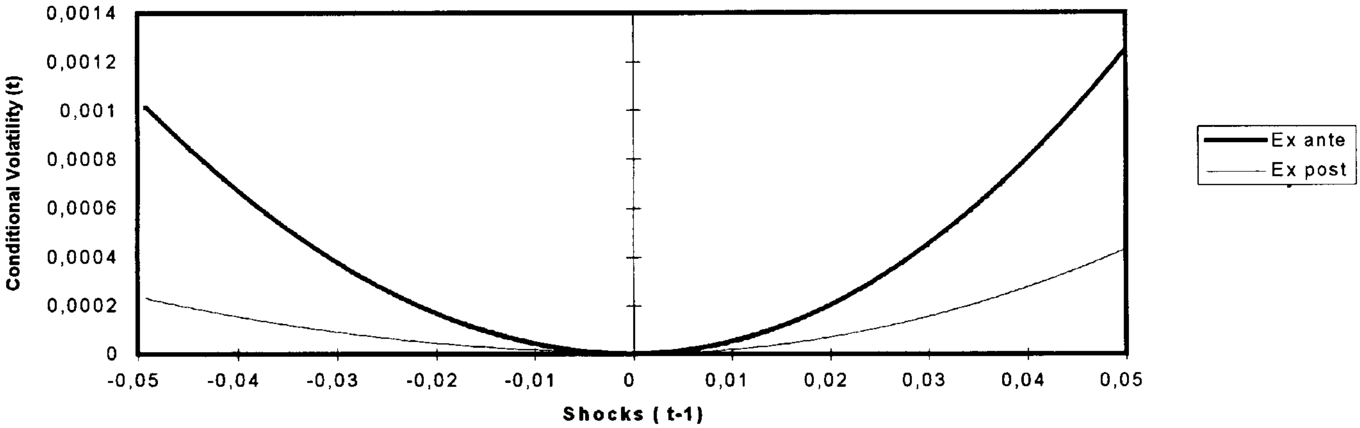

Fig. 1. *News impact curve – SSCGarch: Austria*

Table 4. *Austria – residual statistics*

	Arch(5)	Garch(1,1)	SSwGarch	S-vSwG	SSC-Garch	GJR	VGarch	NaGarch	AGarch
Log likelihood	7875	7886	7894	7885	7872	7858	7842	7863	7862
Kurtosis	5.82	5.90	5.95	5.83	5.88	5.85	5.80	5.91	5.84
Skewness	0.015	0.023	0.021	0.05	0.057	0.056	0.060	0.06	0.056
Kurtosis (st. residuals)	6.19	7.46	7.10	7.48	6.92	7.42	6.34	7.03	7.61
Skewness (st. residuals)	−0.69	−0.82	−0.81	−0.62	−0.72	−0.675	−0.57	−0.6	−0.65
Positive sign bias test	1.23	1.20	0.37	0.243	−0.302	−0.176	−0.1	−0.02	−0.14
Negative size bias test	0.45	0.420	−0.33	−0.53	−0.542	−0.455	0.384	0.12	−0.37
Positive size bias test	−1.15	−0.29	0.008	0.314	0.726	0.527	−0.171	0.25	0.705
Pagan–Sabau intercept	0.1E − 04	0.1E − 04	0.1E − 04	0.1E − 04	0.1E − 04	0.6E − 05	0.1E − 04	0.7E − 05	0.1E − 04
(std. error)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.3E − 05)	(0.2E − 05)	(0.2E − 05)
Pagan–Sabau coefficient	0.59	0.67	0.65	0.64	0.56	0.78	0.52	0.91	0.61
(std. error)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.03)	(0.03)	(0.06)	(0.04)

The relative performance of this model and its capacity of modelling conditional volatility is compared with that of the other eight traditional ARCH-type models (ARCH, GARCH, sign switching GARCH, sign and volatility switching GARCH, GJR, VGARCH, AGARCH and NAGARCH). A detailed description of the features of these models is provided in the Appendix.

V. EMPIRICAL RESULTS IN THE FIVE EUROPEAN MARKETS

The Austrian market exhibits a high degree of weak inefficiency as its index stock returns are strongly autocorrelated with a long run elasticity to lagged own returns close to 0.3. The impact of one lag Austrian returns (R_{t-1}) on the dependent variable is quite strong and the overall explanatory power of the returns equation in terms of R^2 is superior to that of all other countries. The effect of past returns of the dominant market (the US market) is strongly significant with a long run elasticity (close to 0.3). Autocorrelation, dependence from the US market and a small Wednesday effect, explain almost 20% of index returns (Tables 1 and 2).

Looking at the log-likelihood, the hierarchy among the eight estimated models of conditional volatility gives expected results. The least squares model is outperformed by all conditional volatility models. Asymmetrically centred models (VGARCH, AGARCH and NAGARCH) clearly underperform with respect to symmetrically centred ones (GARCH, SSC-GARCH and sign switching GARCH) (Tables 3 and 4). The sign switching GARCH has the best likelihood but the NAGARCH outperforms it in terms of PS coefficient. Quite surprisingly and differently from what happens in all other countries' estimates, conditional volatility models do not reduce kurtosis in the Austrian case (Table 4).

The analysis of changes after the introduction of index options shows that the hypothesis of intercept shifts cannot be significantly supported on the base of both ARCH(5) and GARCH(1,1) results. The introduction of index options, though, seems to have determined two more relevant effects: (i) a reduction in the sign persistence effect (confirmed both in GARCH(1,1) and sign switching

Table 5. *France – 3653 observations – sample period: 01/01/80 – 31/12/93 – option introduction date: 9/11/88*

ARCH (5)							
$h_t = 0.5\mathrm{E}-05$	$-0.6\mathrm{E}-02Ds$	$-0.2\mathrm{E}-05D_{\mathrm{IO}}$	$+0.195\varepsilon_{t-1}^2$	$+0.98\varepsilon_{t-2}^2$	$+0.120\varepsilon_{t-3}^2$	$+0.085\varepsilon_{t-4}^2$	
(10.77)	(−3.12)	(−2.42)	(10.01)	(6.19)	(7.53)	(5.63)	
$+0.098\varepsilon_{t-5}^2$	$+0.4\mathrm{E}-09Trnd$						
(8.62)	(3.35)						
GARCH(1,1)							
$h_t = 0.6\mathrm{E}-06$	$-Ds0.6\mathrm{E}-02$	$-0.2\mathrm{E}-06D_{\mathrm{IO}}$	$+0.784h_{t-1}$	$+0.141\varepsilon_{t-1}^2$	$+0.2\mathrm{E}-09Trnd$	$+0.2\mathrm{E}-06Pr$	$+D_{\mathrm{IO}}Pr$
(4.01)	(−3.82)	(−0.929)	(51.68)	(12.68)	(3.16)	(2.53)	(−0.30)
Sign switching GARCH(1,1)							
$h_t = -0.6\mathrm{E}-06$	$-Ds0.6\mathrm{E}-02$	$-0.2\mathrm{E}-06D_{\mathrm{IO}}$	$+0.787h_{t-1}$	$+0.139\varepsilon_{t-1}^2$	$+0.2\mathrm{E}-09Trnd$	$+0.2\mathrm{E}-06Pr$	
(3.84)	(−3.84)	(−0.896)	(53.01)	(12.65)	(3.31)	(2.53)	
	$+D_{\mathrm{IO}}Pr$	$-0.4\mathrm{E}-06Ssw$					
	(−0.30)	(−3.19)					
Sign and volatility switching GARCH(1,1)							
$h_t = 0.1\mathrm{E}-05$	$+0.68h_{t-1}$	$+0.224\varepsilon_{t-1}^2$	$-0.098D_{\mathrm{IO}}\varepsilon_{t-1}^2$	$-0.07Svsw$	$+0.09D_{\mathrm{IO}}Svsw$	$+0.2\mathrm{E}-09Trnd$	
(2.74)	(16.4)	(8.33)	(−2.50)	(−3.13)	(2.82)	(3.31)	
SSC-GARCH(1,1)							
$h_t = 0.2\mathrm{E}-05$	$-0.011Ds$	$+0.673h_{t-1}$	$+0.211S_{t-1}^{+}\varepsilon_{t-1}^2$	$+0.273S_{t-1}^{-}\varepsilon_{t-1}^2$	$-0.4\mathrm{E}-06S_{t-1}^{-}$	$+0.6\mathrm{E}-10Trnd$	
(2.80)	(−3.71)	(17.62)	(5.36)	(6.58)	(−0.88)	(0.24)	
	$+0.2\mathrm{E}-05D_{\mathrm{IO}}S_{t-1}^{-}$		$-0.119D_{\mathrm{IO}}S_{t-1}^{+}\varepsilon_{t-1}^2$	$-0.156D_{\mathrm{IO}}S_{t-1}^{-}\varepsilon_{t-1}^2$			
	(3.76)		(−2.23)	(−2.75)			
GJR							
$h_t = 0.1\mathrm{E}-05$	$+0.704h_{t-1}$	$+0.196\varepsilon_{t-1}^2$	$-0.114D_{\mathrm{IO}}\varepsilon_{t-1}^2$	$+0.042S_{t-1}^{-}\varepsilon_{t-1}^2$	$+0.014D_{\mathrm{IO}}S_{t-1}^{-}\varepsilon_{t-1}^2$	$+0.4\mathrm{E}-09Trnd$	
(2.26)	(18.36)	(5.38)	(−2.40)	(0.831)	(0.192)	(3.10)	
VGARCH(1,1)							
$h_t = 0.1\mathrm{E}-05$	$+0.78h_{t-1}$	$+0.7\mathrm{E}-05\varepsilon_{t-1}/h_{t-1}$	$-0.6\mathrm{E}-05\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$-0.3\mathrm{E}-05D_{\mathrm{IO}}\varepsilon_{t-1}/h_{t-1}$			
(1.68)	(23.24)	(7.11)	(−3.95)	(−2.15)			
	$+0.5\mathrm{E}-06D_{\mathrm{IO}}\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+0.8\mathrm{E}-09Trnd$					
	(−0.259)	(3.37)					
NAGARCH(1,1)							
$h_t = 0.2\mathrm{E}-05$	$+0.645h_{t-1}$	$+0.174\varepsilon_{t-1}^2$	$+11.80\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+33.36D_{\mathrm{IO}}\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+0.5\mathrm{E}-09Trnd$		
(3.19)	(16.21)	(2.75)	(0.972)	(0.756)	(3.18)		
AGARCH							
$h_t = 0.2\mathrm{E}-05$	$+0.655h_{t-1}$	$+0.342\varepsilon_{t-1}^2$	$+0.8\mathrm{E}-02D_{\mathrm{IO}}\varepsilon_{t-1}^2$	$-0.1\mathrm{E}-02\varepsilon_{t-1}$	$-0.9\mathrm{E}-03D_{\mathrm{IO}}\varepsilon_{t-1}$	$+0.8\mathrm{E}-09Trnd$	
(3.57)	(16.40)	(5.76)	(0.082)	(−2.81)	(−1.69)	(3.67)	

Notes: R_t = log returns of datastream total market index for France; *Mon* = Monday dummy; *Rus* = log returns of Dow Jones Composite 65 index; *Thu* = Thursday dummy; D_{IO} = option contract introduction dummy (CAC index option), *Trnd* = linear trend; *Pr* = sign persistence dummy; *Ssw* = sign switching dummy; *Svsw* = sign and volatility switching series; *Ds* = stock market crash of October 1987 dummy.

GARCH(1,1)) and (ii) a reduction in the impact of positive and negative shocks on conditional volatility supported by SSC-GARCH and by AGARCH and GJR (Fig. 1). The SSC-GARCH has the advantage of insulating the significant reduction of the impact of positive shocks on conditional volatility. This result is consistent with the hypothesis of migration of uninformed traders from the underlying stock market after index option introduction.

French stock returns exhibit lower autocorrelation than Austrian returns. The long run elasticity to lagged own returns is around 0.2 (0.1 lower than in Austria) but the long run elasticity to US returns is 0.4 (0.1 higher than in Austria) (Table 1).

Conditional volatility models almost completely explain in this case deviations from normality in the data as, in all the specifications examined, excess kurtosis drops from 7 to zero when residuals are normalized. As for all other countries, symmetrically centred models perform better than asymmetrically centred ones according to the presented diagnostics (Tables 5 and 6).

Among symmetrically centred models, the SSC-GARCH is more successful in modelling excess kurtosis of the data, while it gives less satisfying results in terms of the PS test. With regard to regression coefficients, the negative intercept effect of derivative introduction is significant only in the simple ARCH(5) model while it is completely absorbed

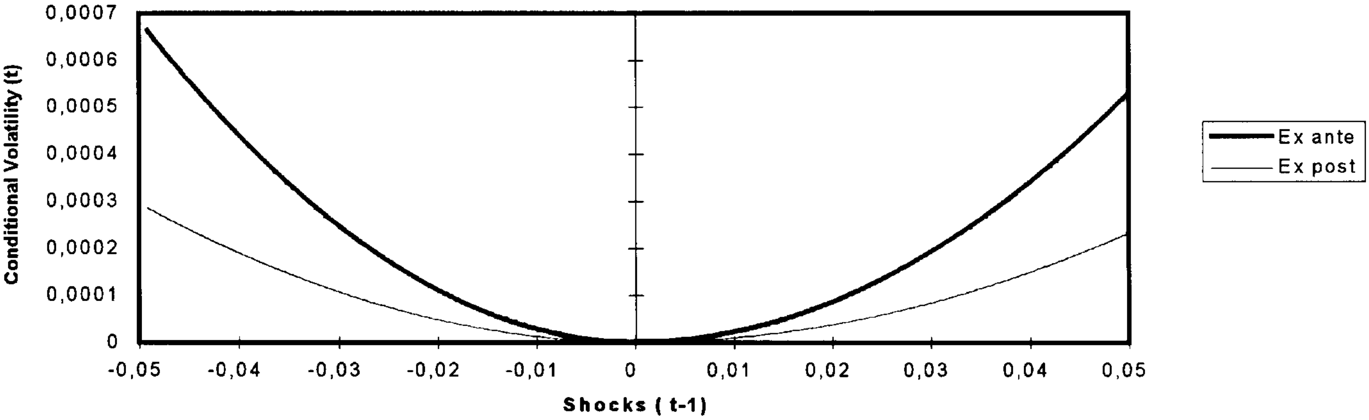

Fig. 2. *News impact curve – SSCGarch: France*

Table 6. *France – residual statistics*

	Arch(5)	Garch(1,1)	SSwGarch	S-vSwG	SSC-Garch	GJR	VGarch	NaGarch	Agarch
Log likelihood	15 081	15 115	15 118	15 105	15 111	15 116	15 060	15 107	15 114
Kurtosis	11.05	10.92	10.92	12.65	12.51	12.33	10.92	12.71	12.52
Skewness	−0.13	−0.13	−0.14	0.14	0.12	0.10	−0.03	0.13	0.12
Kurtosis (st. residuals)	3.42	4.08	4.02	3.38	3.05	3.63	2.71	3.43	2.6
Skewness (st. residuals)	−0.02	−0.03	−0.02	−0.20	−0.16	−0.21	−0.15	−0.23	−0.15
Positive sign bias test	0.53	0.36	1.02	−0.48	0.91	0.63	0.04	0.41	0.3
Negative size bias test	0.036	0.42	0.36	−0.04	−0.61	−0.49	1.56	−0.96	−0.76
Positive size bias test	−1.17	−1.57	−1.68	−0.34	−0.49	−0.36	−2.94	−0.57	−0.6
Pagan–Sabau intercept	0.6E−05	0.3E−05	0.3E−05	0.6E−05	0.7E−05	0.6E−05	0.5E−05	0.1E−04	0.1E−04
(std. error)	(0.1E−05)	(1E−05)	(0.1E−05)	(0.1E−05)	(0.1E−05)	(0.1E−05)	(0.1E−05)	(0.1E−05)	(0.1E−05)
Pagan–Sabau coefficient	0.81	0.96	0.97	0.81	0.75	0.78	1.5	0.41	0.58
(std. error)	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.07)	(0.02)	(0.9)

by volatility persistence in all other models. The introduction of index options significantly reduces conditional volatility responses to positive and negative shocks (SSC-GARCH). As a result of these changes, the preexisting slight ‘leverage effect’ (higher impact of negative shocks) is cancelled in the second subsample (Table 6 and Fig. 2). This result is confirmed also in the GJR model by the coefficients indicating responses to shocks of both signs and degree of asymmetry.

The sign persistence effect seems particularly significant in the French stock market and is not dumped by derivatives’ introduction. This means that a sequence of shocks of the same sign generates additional volatility and that the market is exposed to ‘excess panic’ or ‘excess euphoria’.

The results obtained show quite clearly that in this case a slightly increasing volatility trend throughout the whole sample period and the reduction of the impact of shocks on volatility after derivatives’ introduction are two consistent phenomena. Their joint occurrence may have induced regulatory authorities to think that derivatives are responsible for higher market instability.

The German base equation shows the existence of a small but significant negative Monday effect, which is common to all countries with the exception of Austria (Table 1).

For Germany as well the volatility trend is significantly positive in all the considered specifications. With regard to changes in the ‘news’ impact curve’ induced by the introduction of index options, the intercept effects remain negative for all specifications. The SSC-GARCH reveals strong *ex ante* leverage effect which is consistently reduced after the change in regime. GJR coefficients on $D_{\mathrm{IO}}S^{-}_{t-1}\varepsilon^{2}_{t-1}$ and $S^{-}_{t-1}\varepsilon^{2}_{t-1}$ confirm this interpretation (Table 7 and Fig. 3).

Diagnostics shows that the GARCH and sign switching GARCH models seem to perform better than others in terms of PS tests, while the SSC-GARCH confirm better results in terms of elimination of excess kurtosis and sign and size biases (Table 8).

The Swiss market presents a high degree of efficiency with an elasticity to lagged own returns close to 0.13 and an insignificant return autocorrelation. The correlation with US index returns is also quite low, compared with that of the other countries considered (Table 1). Excess kurtosis of the base equation residual is exceptionally high meaning that market shocks are generally of small amount and clustered around the zero average.

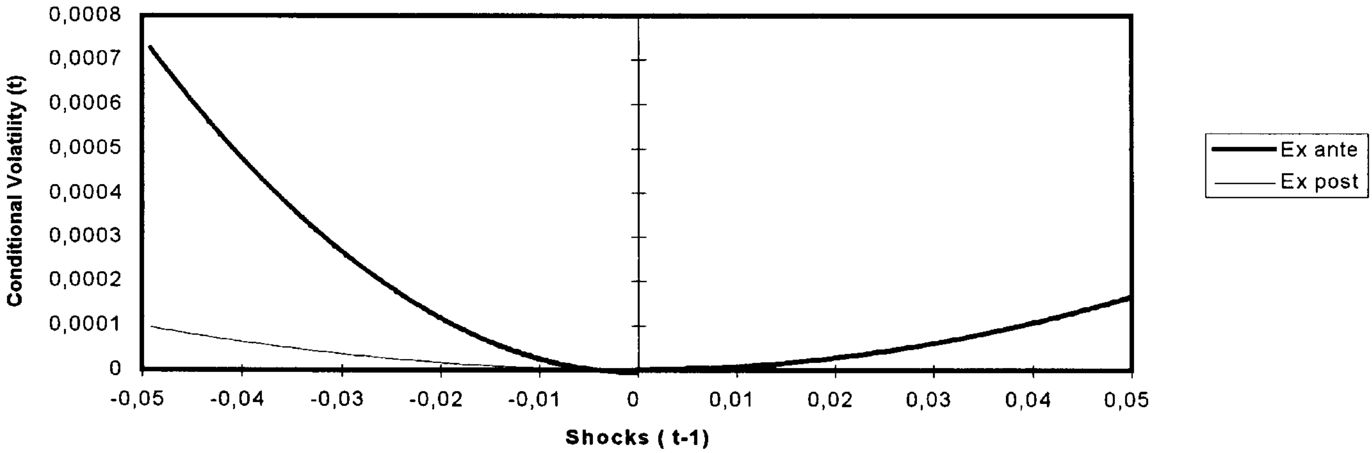

Fig. 3. *News impact curve – SSCGarch: Germany*

Table 7. *Germany – 2551 observations – sample period: 03/01/84 – 30/12/93 – option introduction*

ARCH(5)							
$h_t = 0.5E-05$	$-0.4E-05D_{IO}$	$+0.138\varepsilon^2_{t-1}$	$+0.085\varepsilon^2_{t-2}$	$+0.189\varepsilon^2_{t-3}$	$+0.216\varepsilon^2_{t-4}$	$+0.084\varepsilon^2_{t-5}$	$+0.4E-08Trnd$
(6.87)	(−3.21)	(6.02)	(4.28)	(8.69)	(8.12)	(6.24)	(4.58)
GARCH(1,1)							
$h_t = 0.3E-06$	$-0.2E-05D_{IO}$	$+0.828h_{t-1}$	$+0.109\varepsilon^2_{t-1}$	$+0.1E-08Trnd$	$+0.1E-06Pr$	$-0.4E-06D_{IO}Pr$	
(2.00)	(−5.59)	(60.9)	(13.3)	(8.84)	(1.17)	(−2.04)	
Sign switching GARCH(1,1)							
$h_t = 0.4E-06$	$-0.3E-05D_{IO}$	$+0.829h_{t-1}$	$+0.11\varepsilon^2_{t-1}$	$+0.1E-08Trnd$	$-0.9E-07Ssw$		
(3.54)	(−8.72)	(64.12)	(14.55)	(8.96)	(−0.49)		
Sign and volatility switching GARCH(1,1)							
$h_t = 0.8E-06$	$-0.3E-05D_{IO}$	$+0.825h_{t-1}$	$+0.122\varepsilon^2_{t-1}$	$+0.04D_{IO}\varepsilon^2_{t-1}$	$+0.4E-09Trnd$	$-0.1Svsm$	$+0.23D_{IO}Svsw$
(0.92)	(−4.58)	(16.72)	(5.59)	(0.99)	(0.88)	(−4.16)	(5)
SSC-GARCH(1,1)							
$h_t = 0.2E-05$	$+0.713h_{t-1}$	$+0.065S^+_{t-1}\varepsilon^2_{t-1}$	$+0.302S^-_{t-1}\varepsilon^2_{t-1}$	$+0.1E-06S^-_{t-1}$	$+0.1E-9Trnd$		
(2.15)	(15.53)	(1.79)	(9.51)	(0.175)	(0.22)		
	$+0.7E-05D_{IO}S^-_{t-1}$	$-0.067D_{IO}S^+_{t-1}\varepsilon^2_{t-1}$	$-0.263D_{IO}S^-_{t-1}\varepsilon^2_{t-1}$				
	(5.91)	(−1.50)	(−4/27)				
GJR							
$h_t = -0.6E-06$	$+0.819h_{t-1}$	$+0.022\varepsilon^2_{t-1}$	$-0.023D_{IO}\varepsilon^2_{t-1}$	$+0.219S^-_{t-1}\varepsilon^2_{t-1}$	$-0.138D_{IO}S^-_{t-1}\varepsilon^2_{t-1}$	$+0.8E-09Trnd$	
(0.87)	(17.22)	(0.796)	(−0.596)	(6.03)	(−1.77)	(2.34)	
VGARCH(1,1)							
$h_t = 0.1E-09$	$+0.987h_{t-1}$	$+0.4E-05\varepsilon_{t-1}/h_{t-1}$	$-0.5E-05\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$-0.3E-05D_{IO}\varepsilon_{t-1}/h_{t-1}$			
(0.001)	(22.84)	(3.77)	(−2.64)	(−1.89)			
	$+0.1E-05D_{IO}\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+0.9E-09Trnd$					
	(0.558)	(1.29)					
NAGARCH(1,1)							
$h_t = 0.3E-06$	$+0.843h_{t-1}$	$+0.141\varepsilon^2_{t-1}$	$-1.03\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$-20.39D_{IO}\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+0.5E-09Trnd$		
(3.19)	(17.22)	(1.69)	(−0.06)	(−0.22)	(1.8)		
AGARCH(1,1)							
$h_t = 0.7E-06$	$+0.847h_{t-1}$	$+0.168\varepsilon^2_{t-1}$	$-0.105D_{IO}\varepsilon^2_{t-1}$	$-0.3E-03\varepsilon_{t-1}$	$+0.8E-04D_{IO}\varepsilon_{t-1}$	$+0.6E-09Trnd$	
(0.80)	(16.18)	(3.23)	(−1.20)	(−0.78)	(0.10)	(1)	

Notes: *Rt* = log returns of Deutsche Aktien index (DAX); *Rus* = log returns of Dow Jones Composite 65 index; *Mon* = Monday dummy; *Fri* = Friday dummy; *Trnd* = linear trend; D_{IO} = option contract introduction dummy (DAX index option); *Pr* = sign persistence dummy; *Ssw* = sign switching dummy; *Svsm* = sign and volatility switching series.

Table 8. *Germany – residual statistics*

	Arch(5)	Garch(1,1)	SSwGarch	S-vSwG	SSC-Garch	GJR	VGarch	NaGarch	AGarch
Log likelihood	10 117	10 160	10 159	10 156	10 173	10 169	10 147	10 162	10 158
Kurtosis	12.04	12.42	12.41	12.61	12.76	12.66	12.45	12.62	12.67
Skewness	−0.70	−0.74	−0.74	−0.73	−0.73	−0.73	−0.73	−0.73	−0.72
Kurtosis (st. residuals)	9.61	8.15	8.20	9.06	6.96	9.12	9.39	9.97	9.98
Skewness (st. residuals)	0.90	−0.77	−0.76	−0.82	−0.61	−0.75	−0.83	−0.88	−0.89
Positive sign bias test	−0.11	−0.33	−0.24	−0.75	0.06	−0.25	−0.64	−0.60	−0.22
Negative size bias test	−0.58	−0.27	−0.31	0.03	0.13	0.09	0.82	−0.41	−0.67
Positive size bias test	−1.03	−1.25	−1.26	−0.23	−0.05	0.21	−1.9	−0.7	−0.62
Pagan–Sabau intercept	0.1E − 04	0.4E − 05	0.4E − 05	0.1E − 04	0.1E − 04	0.1E − 04	0.3E − 05	0.7E − 05	0.5E − 05
(std. error)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.3E − 05)	(0.2E − 05)	(0.2E − 05)
Pagan–Sabau coefficient	0.60	0.94	0.94	0.67	0.68	0.67	0.96	0.77	0.66
(std. error)	(0.04)	(0.06)	(0.05)	(0.04)	(0.04)	(0.04)	(0.07)	(0.04)	(0.04)

Table 9. *Switzerland – 3653 observations – sample period: 01/01/80–30/12/93 – option introduction date: 7/12/88*

ARCH(5)							
$h_t = 0.1\text{E}-05$	$+0.1\text{E}-5D_{\text{IO}}$	$+0.272\varepsilon_{t-1}^2$	$+0.089\varepsilon_{t-2}^2$	$+0.180\varepsilon_{t-3}^2$	$+0.103\varepsilon_{t-4}^2$	$+0.087\varepsilon_{t-5}^2$	$+0.1\text{E}-08Trnd$
(7.69)	(2.72)	(13.57)	(5.58)	(13.22)	(7.92)	(5.32)	(2.72)
GARCH (1,1)							
$h_t = 2\text{E}-06$	$+\ 0.4\text{E}{-}06D_{\text{IO}}$	$+0.763h_{t-1}$	$+0.181\varepsilon_{t-1}^2$	$+0.2\text{E}-09Trnd$			
(5.65)	(5.40)	(84.24)	(23.04)	(7.75)			
Sign switching GARCH(1,1)							
$h_t = 0.2\text{E}-06$	$+0.4\text{E}-06D_{\text{IO}}$	$+0.777h_{t-1}$	$+0.154\varepsilon_{t-1}^2$	$+0.2\text{E}-09Trnd$	$-0.3\text{E}-07Pr$		
(4.07)	(4.63)	(61.15)	(20.63)	(6.54)	(1.24)		
	$-0.1\text{E}-06D_{\text{IO}}Pr$	$-0.2\text{E}-06Ssw$					
	(−1.90)	(−4.21)					
Sign and volatility switching GARCH(1,1)							
$h_t = 0.6\text{E}-06$	$+0.497h_{t-1}$	$+0.318\varepsilon_{t-1}^2$	$+0.077D_{\text{IO}}\varepsilon_{t-1}^2$	$+0.1\text{E}-08Trnd$	$-0.05Svsw$	$+0.349D_{\text{IO}}+\ Svsw$	
(4.32)	(20.48)	(16.42)	(2.61)	(11.78)	(−2.96)	(13.67)	
SSC-GARCH(1,1)							
$h_t = 0.4\text{E}-06$	$-0.011Ds$	$+0.605h_{t-1}$	$+0.195S_{t-1}^{+}\varepsilon_{t-1}^2$	$+0.403S_{t-1}^{-}\varepsilon_{t-1}^2$	$+0.3\text{E}-06S_{t-1}^{-}$		
(1.85)	(−3.71)	(21.34)	(5.90)	(15.14)	(2.08)		
	$-0.189D_{\text{IO}}S_{t-1}^{+}\varepsilon_{t-1}^2$	$-0.258D_{\text{IO}}S_{t-1}^{-}\varepsilon_{t-1}^2$	$+0.4\text{E}-05D_{\text{IO}}S_{t-1}^{-}$	$+0.3\text{E}-9Trnd$			
	(−5.04)	(−5.55)	(11.76)	(2.66)			
GJR							
$h_t = 0.3\text{E}-06$	$+0.653h_{t-1}$	$+0.139\varepsilon_{t-1}^2$	$-0.151D_{\text{IO}}\varepsilon_{t-1}$	$+0.219S_{t-1}^{-}\varepsilon_{t-1}^2$	$+0.216D_{\text{IO}}S_{t-1}^{-}\varepsilon_{t-1}^2$	$+0.6\text{E}-09Trnd$	
(2.62)	(20.93)	(4.93)	(−4.60)	(6.07)	(3.59)	(4.73)	
VGARCH(1,1)							
$h_t = -0.3\text{E}-06$	$+0.803h_{t-1}$	$+0.3\text{E}-05\varepsilon_{t-1}/h_{t-1}$	$-0.2\text{E}-05\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+0.2\text{E}-05D_{\text{IO}}\varepsilon_{t-1}/\sqrt{h_{i-1}}$			
(1.75)	(23.91)	(7.75)	(−5.03)	(2.69)			
	$-0.2\text{E}-05D_{\text{IO}}\varepsilon_{t-1}/h_{t-1}$						
	(−2.77)						
NGARCH(1,1)							
$h_t = 0.3\text{E}-06$	$+0.675h_{t-1}$	$+0.160\varepsilon_{t-1}^2$	$+23.90\varepsilon_{t-1}/h_{t-1}$	$-16.43D_{\text{IO}}\varepsilon_{t-1}/h_{t-1}$	$+0.6\text{E}-09Trnd$		
(1.71)	(13.74)	(2.67)	(1.52)	(−0.45)	(4.80)		
AGARCH							
$h_t = 0.8\text{E}-06$	$+0.656h_{t-1}$	$+0.456\varepsilon_{t-1}^2$	$-0.382D_{\text{IO}}\varepsilon_{t-1}^2$	$-0.8\text{E}-03\varepsilon_{t-1}$	$+0.1\text{E}-02D_{\text{IO}}\varepsilon_{t-1}$	$+0.5\text{E}-09Trnd$	
(4.71)	(17.59)	(9.60)	(−6.56)	(−4.70)	(4.64)	(2.77)	

Note: R_t = log returns of datastream total market index for Switzerland; *Mon* = Monday dummy; *Rus* = log returns for Dow Jones Composite 65 index; *Trnd* = linear trend; D_{IO} = option contract introduction dummy (SMI index option); *Pr* = sign persistence dummy; *Ssw* = sign switching dummy; *Svsw* = sign and volatility switching series.

Table 10. *Switzerland – residual statistics*

	Arch(5)	Garch(1,1)	SSwGarch	S-vSwG	SSC-Garch	GJR	VGarch	NaGarch	AGarch
Log likelihood	16 159	16 187	16 181	16 141	16 243	16 226	16 107	16 162	16 169
Kurtosis	34.40	34.83	34.51	32.86	33.11	33.07	33.18	33.03	32.94
Skewness	−2.43	−2.45	−2.42	−2.23	−2.27	−2.26	−2.25	−2.23	−2.23
Kurtosis (st. residuals)	17.09	18.89	18.85	14.10	9.78	15.92	21.19	20.84	17.94
Skewness (st. residuals)	−1.39	−1.49	−1.45	−1.14	−0.64	−1.10	−1.65	−1.60	−1.44
Positive sign bias test	−1.88	−1.91	−1.58	−1.02	0.31	−1.72	−1.5	−1.63	−1.55
Negative size bias test	−0.56	−0.25	−0.08	−1.15	−0.06	0.25	0.35	−0.66	−0.76
Positive size bias test	−0.16	−0.49	−0.77	−0.45	−0.03	0.71	−1.6	0.11	−0.22
Pagan–Sabau intercept	0.3E − 05	0.2E − 05	0.1E − 05	0.4E − 05	0.4E − 05	0.4E − 05	0.4E − 05	0.8E − 05	0.5E − 05
(std. error)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)
Pagan–Sabau coefficient	0.71	0.79	0.90	0.64	0.61	0.56	1.56	0.26	0.50
(std. error)	(0.035)	(0.038)	(0.40)	(0.03)	(0.03)	(0.03)	(0.07)	(0.01)	(0.02)

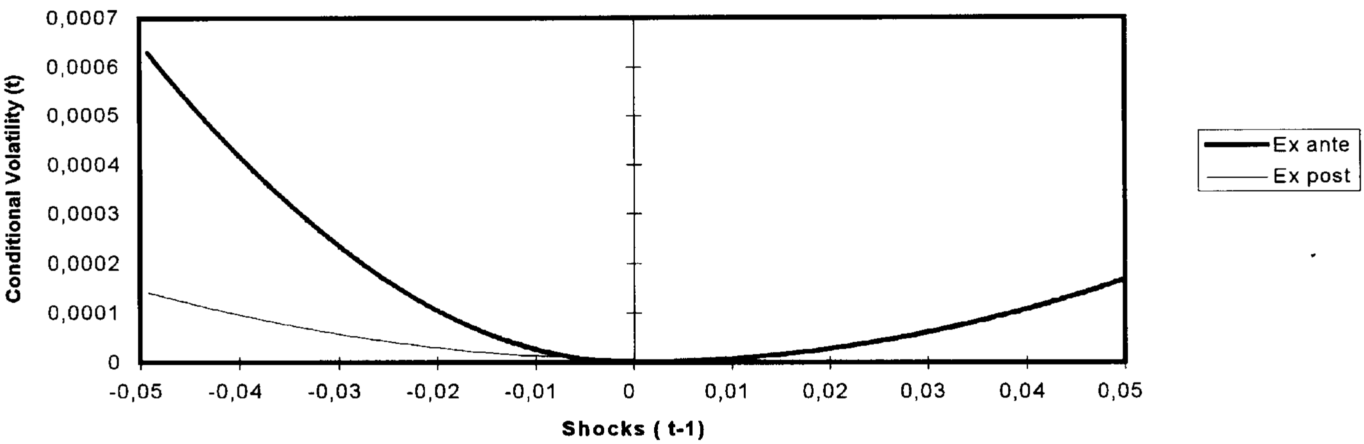

Fig. 4. *News impact curve – SSCGarch: The Netherlands*

Conditional volatility models in this case reduce only part of the excess volatility (Tables 9 and 10).

The results obtained from the nine models show the presence of an increasing volatility trend through all the sample period with insignificant sign persistence. About the effects of the introduction of derivatives, the significant small increase in the intercept after the introduction (ARCH and GARCH and sign switching GARCH) is more than offset by the reduction of positive and negative shocks. The asymmetry in the reaction of conditional volatility to positive and negative shocks is quite strong and it is almost eliminated by the change in regime after derivatives' introduction (Fig. 4). This can be deduced not only by the SSC-GARCH coefficients, but also by the positive and significant sign of $D_{IO}S^{-}_{t-1}\varepsilon^{2}_{t-1}$ in the GJR.

Test results confirm previous considerations on the hierarchy of the tested models: (i) symmetrically centred models perform better than asymmetrically centred models both in the log-likelihood and in the PS test; (ii) among symmetrically centred models, SSC-GARCH has better diagnostics (Engle-Ng test, log-likelihood and reduction of excess kurtosis). The positive sign bias existing in GARCH, sign switching GARCH and GJR is in fact eliminated and the difference in excess kurtosis among SSC-GARCH and other symmetrically centred models is relevant.

The Dutch stock market exhibits the higher relative degree of dependence from the US market with a long term elasticity to US stock index returns of around 0.48. Conversely, return autocorrelation is negative and almost insignificant. The stock market reveals itself to be efficient in a weak sense but also strongly dependent on the US market (Table 1).

The ARCH(5) coefficients are relatively lower in magnitude compared with those of other countries, while the degree of conditional volatility persistence in the GARCH is very high. The trend is positive and significant in all model specifications (with the exception of the sign and volatility switching GARCH), while the SSC-GARCH results show a significant reduction in the impact both of negative shocks on conditional volatility after the introduction of derivatives. This result confirms that the introduction of equity index options has the effect of eliminating the 'leverage effect' (intended as the asymmetry in the volatility reaction to negative and positive shocks) (Table 11 and Fig. 5). A peculiarity of Dutch data is that in this case

Table 11. *The Netherlands – 2055 observations – sample period: 02/01/78–15/11/85 – option introduction*

ARCH(5)						
$h_t = 0.2\text{E}-05$	$+0.2\text{E}-05D_{\text{IO}}$	$+0.09\varepsilon^2_{t-1}$	$+0.138\varepsilon^2_{t-2}$	$+0.05\varepsilon^2_{t-3}$	$+0.001\varepsilon^2_{t-4}$	$+0.119\varepsilon^2_{t-5}$
(5.99)	(−2.67)	(3.22)	(4.78)	(2.16)	(0.89)	(4.75)
	$+0.4\text{E}-08Trnd$					
	(6.86)					
GARCH (1,1)						
$h_t = 0.1\text{E}-06$	$-Ds0.6\text{E}-02$	$+0.2\text{E}-06D_{\text{IO}}$	$+0.877h_{t-1}$	$+0.069\varepsilon^2_{t-1}$	$+0.4\text{E}-09Trnd$	$+0.8\text{E}-07Pr$
(1.73)	(−3.82)	(0.88)	(40.23)	(5.76)	(2.96)	(1.20)
	$-0.4\text{E}-6D_{\text{IO}}Pr$					
	(−2.50)					
Sign switching GARCH(1,1)						
$h_t = -0.2\text{E}-06$	$+0.2\text{E}-06D_{\text{IO}}$	$+0.875h_{t-1}$	$+0.071\varepsilon^2_{t-1}$	$+0.4\text{E}-09Trnd$	$+0.6\text{E}-07Pr$	$-0.3\text{E}-06D_{\text{IO}}Pr$
(1.85)	(0.78)	(40.05)	(5.81)	(2.98)	(0.99)	(−2.32)
	$-0.9\text{E}-07Ssw$					
	(−0.84)					
Sign and volatility switching GARCH(1,1)						
$h_t = 0.5\text{E}-06$	$+0.739h_{t-1}$	$+0.137\varepsilon^2_{t-1}$	$-0.086D_{\text{IO}}\varepsilon^2_{t-1}$	$+0.1\text{E}-08Trnd$	$-0.02Svsw$	$+0.4\text{E}-02D_{\text{IO}}+Svsw$
(0.903)	(6.36)	(3.72)	(−1.64)	(1.65)	(−0.51)	(−0.08)
SSC-GARCH(1,1)						
$h_t = 0.18\text{E}-05$	$+0.562h_{t-1}$	$+0.066S^+_{t-1}\varepsilon^2_{t-1}$	$+0.260S^-_{t-1}\varepsilon^2_{t-1}$	$-0.1\text{E}-05S^-_{t-1}$	$+0.2\text{E}-8Trnd$	
(2.56)	(4.68)	(1.57)	(3.98)	(−2.28)	(2.73)	
	$-0.051D_{\text{IO}}S^+_{t-1}\varepsilon^2_{t-1}$	$-0.205D_{\text{IO}}S^-_{t-1}\varepsilon^2_{t-1}$				
	(−0.836)	(−2.37)				
GJR						
$h_t = 0.5\text{E}-06$	$+0.746h_{t-1}$	$+0.085\varepsilon^2_{t-1}$	$-0.048D_{\text{IO}}\varepsilon^2_{t-1}$	$+0.086S^-_{t-1}\varepsilon^2_{t-1}$	$-0.093D_{\text{IO}}S^-_{t-1}\varepsilon^2_{t-1}$	$+0.1\text{E}-08Trnd$
(0.78)	(5.76)	(2.10)	(−0.77)	(1.38)	(−1.03)	(1.55)
NAGARCH(1,1)						
$h_t = 0.2\text{E}-06$	$+0.813h_{t-1}$	$+0.208\varepsilon^2_{t-1}$	$-29.64\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+67.64D_{\text{IO}}\varepsilon_{t-1}/\sqrt{h_{t-1}}$	$+0.9\text{E}-09Trnd$	
(0.26)	(6.18)	(1.37)	(−0.60)	(0.585)	(1.21)	

Note: R_t = log returns of datastream total market index for The Netherlands; *Mon* = Monday dummy; *Rus* = log returns for Dow Jones Composite 65 index; *Trnd* = linear trend; D_{IO} = option contract introduction dummy (EOE index option); *Pr* = sign persistence dummy; *Svsw* = sign and volatility switching series; *Ssw* = sign switching dummy.
AGARCH and VGARCH results are not significant and are then omitted due to multicollinearity problems.

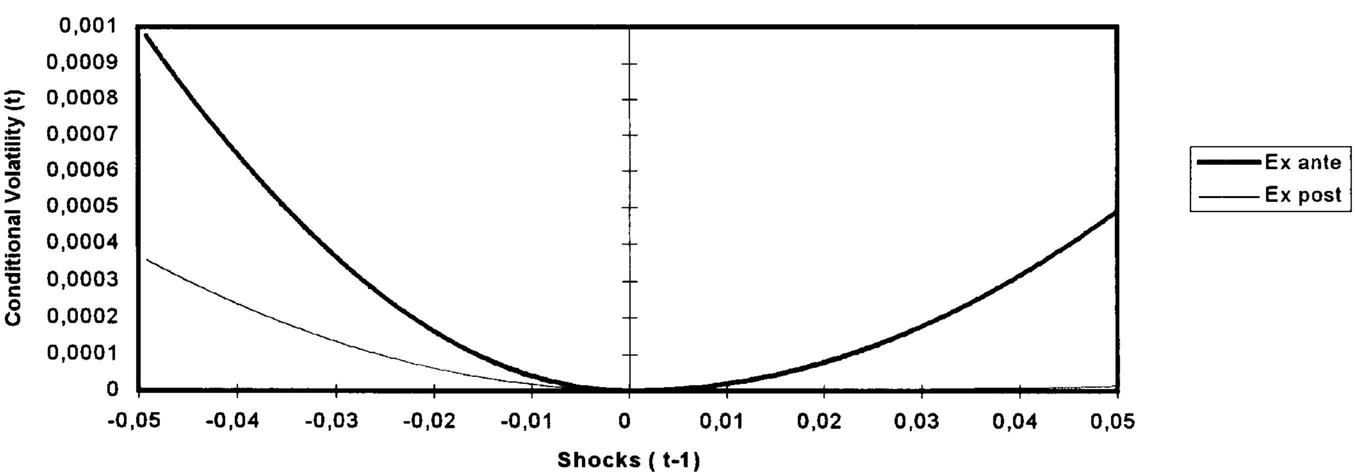

Fig. 5. *News impact curve – SSCGarch: Switzerland*

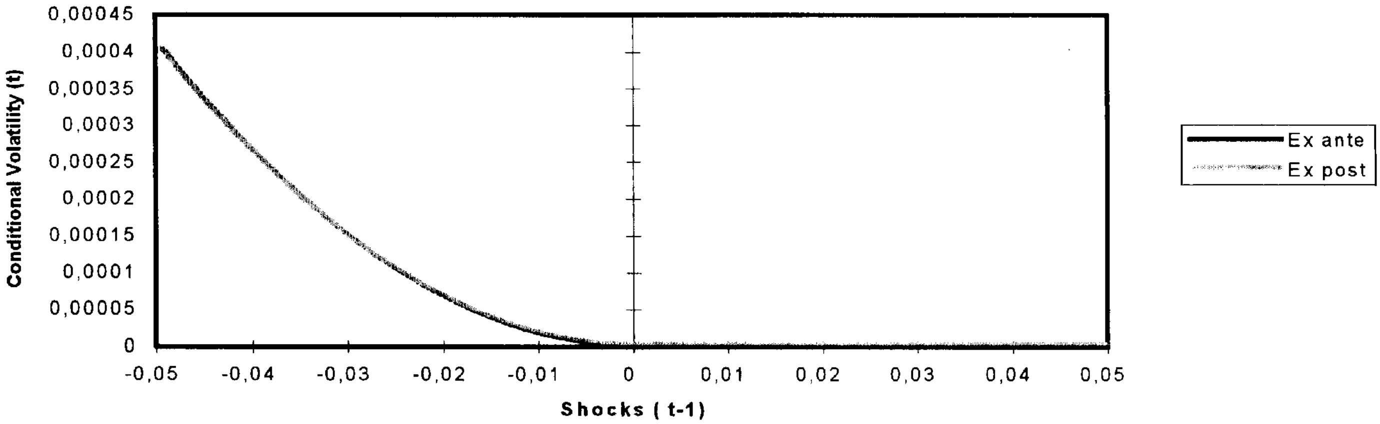

Fig. 6. *News impact curve – SSCGarch: UK*

Table 12. *Netherlands – residual statistics*

	Arch(5)	Garch(1,1)	SSwGarch	S-vSwG	SSC-Garch	GJR	NaGarch
Log likelihood	8919	8930	8930	8920	8919	8923	8927
Kurtosis	1.31	1.32	1.32	1.30	1.29	1.29	1.28
Skewness	0.14	0.14	0.15	0.13	0.14	0.14	0.14
Kurtosis (standardized)	0.87	0.98	0.99	0.96	0.89	0.95	0.91
Skewness (standardized)	0.14	0.14	0.15	0.14	0.13	0.14	0.13
Positive sign bias test	1.7	1.7	1.96	0.15	0.45	1.98	1.77
Negative size bias test	−1.33	−1.20	−1.26	−0.27	−0.34	−0.98	−1.10
Positive size bias test	−1.57	−1.78	−1.77	−0.49	−0.52	−1.26	−1.62
Pagan–Sabau intercept	0.1E − 05	− 0.8E − 07	−0.2E − 07	0.1E − 05	0.1E − 05	0.9E − 06	0.3E − 06
(std. error)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)	(0.1E − 05)
Pagan–Sabau coefficient	1.17	1.33	1.32	1.16	1.18	1.23	1.29
(std. error)	(0.11)	(0.12)	(0.12)	(0.12)	(0.13)	(0.13)	(0.14)

residuals have kurtosis values lower than 3 and conditional volatility models further reduce it. With regard to diagnostics, all estimated models seem to have problems in avoiding sign and size bias effects with the exception of the SSC-GARCH (Table 12). The results of the PS test are extremely good as, for almost all the models, the estimated conditional volatility is not significantly different from the actual variance of the best equation (the PS coefficient is not significantly different from 1).

The UK market is the only exception to the general tendency of a reduction in the impact of negative and positive shocks on conditional volatility after option index introduction. The intercept effect is in fact significant only in the ARCH(5) specification while it is absorbed in all models in which conditional volatility is considered as a regressor. Only negative shocks seem to affect ex ante conditional volatility and nothing changes after the introduction of index options (Tables 13 and 14 and Fig. 6).

VI. THE IMPACT OF INDEX OPTION LISTING ON ADDITIONAL INDICATORS

A significant reduction of excess reaction to shocks after derivative introduction is consistent with different hypotheses on the combination of the three main potential effects described in the introduction (informed migration, uninformed migration and additional information). It may arise simply by improved information, by a combination of improved information and uninformed migration and by a combination of informed migration and improved information in which the latter prevails. We then wonder whether additional investigation on underlying asset unconditional volatility and implicit bid–ask spreads might partially tackle this problem of observational equivalence.

The implicit bid–ask is calculated using the Roll (1984) formula: $s = 2\sqrt{-\mathrm{cov}\,(r_{t-1}, r_t}$, in which unconditional

Table 13. *United Kingdom – 2655 observations – sample period: 02/01/78 – 04/03/88 – option introduction date: 3/5/84*

ARCH(5)								
$h_t = 0.7\text{E}-05$	$-0.01Ds$	$-0.2\text{E}-05D_{\text{IO}}$	$+0.101\varepsilon_{t-1}^2$	$+0.131\varepsilon_{t-2}^2$	$+0.109\varepsilon_{t-4}^2$	$+0.80\varepsilon_{t-4}^2$	$+0.059\varepsilon_{t-5}^2$	$-0.1\text{E}-09Trnd$
(9.65)	(−21.34)	(−2.42)	(3.98)	(5.78)	(4.94)	(3.46)	(2.63)	(−0.27)
GARCH(1,1)								
$h_t = 0.7\text{E}-06$	$+0.3\text{E}-06D_{\text{IO}}$	$+0.827h_{t-1}$	$+0.106\varepsilon_{t-1}^2$	$-0.4\text{E}-010Trnd$	$+0.12\text{E}-06Pr$	$+D_{\text{IO}}Pr$		
(3.27)	(−0.929)	(43.34)	(8.80)	(−0.42)	(0.92)	(−2.10)		
Sign switching GARCH(1,1)								
$h_t = 0.7\text{E}-06$	$+0.3\text{E}-06D_{\text{IO}}$	$+0.827h_{t-1}$	$+0.106\varepsilon_{t-1}^2$	$+0.4\text{E}-010Trnd$	$+0.1\text{E}-06Pr$			
(3.24)	(1.26)	(42.81)	(8.63)	(−0.36)	(−0.63)			
	$-0.4\text{E}-06D_{\text{IO}}Pr$	$-0.1\text{E}-06Ssw$						
	(−2.11)	(−0.63)						
Sign and volatility switching GARCH(1,1)								
$h_t = 0.1\text{E}-05$	$+0.817h_{t-1}$	$+0.077\varepsilon_{t-1}^2$	$+0.036D_{\text{IO}}\varepsilon_{t-1}^2$	$+0.2\text{E}-09Trnd$	$-0.07Svsw$	$+0.136D_{\text{IO}}Svsw$		
(1.15)	(9.18)	(2.52)	(0.698)	(−0.43)	(−2.42)	(2.63)		
SSC-GARCH(1,1)								
$h_t = 0.2\text{E}-05$	$+0.789h_{t-1}$	$+0.028S_{t-1}^+\varepsilon_{t-1}^2$	$+0.166S_{t-1}^-\varepsilon_{t-1}^2$	$-0.3\text{E}-06S_{t-1}^-$	$-0.6\text{E}-9Trnd$	$+0.1\text{E}-05D_{\text{IO}}S_{t-1}^-$		
(1.76)	(10.98)	(0.786)	(3.01)	(1.30)	(−1.33)	(1.30)		
	$+0.065D_{\text{IO}}S_{t-1}^+\varepsilon_{t-1}^2$	$-0.047D_{\text{IO}}S_{t-1}^-\varepsilon_{t-1}^2$						
	(1.30)	(−0.568)						
GJR								
$h_t = 0.5-\text{E}05$	$+0.888h_{t-1}$	$+0.025\varepsilon_{t-1}^2$	$+0.031D_{\text{IO}}\varepsilon_{t-1}^2$	$+0.031S_{t-1}^-\varepsilon_{t-1}^2$	$-0.049D_{\text{IO}}S_{t-1}^-\varepsilon_{t-1}^2$		$-0.3\text{E}-10Trnd$	
(0.44)	(12.07)	(0.738)	(0.627)	(0.627)	(−0.565)		(−0.08)	
VGARCH(1,1)								
$h_t = 0.2\text{E}-06$	$+0.938h_{t-1}$	$+0.1E-05\varepsilon_{t-1}/h_{t-1}$		$-0.1\text{E}-05\varepsilon_{t-1}/\sqrt{h_{t-1}}$		$-0.3\text{E}-06D_{\text{IO}}\varepsilon_{t-1}/h_{t-1}$		
(0.20)	(15.95)	(1.78)		(−0.81)		(−0.27)		
	$+0.2\text{E}-06D_{\text{IO}}\varepsilon_{t-1}/\sqrt{h_{t-1}}$		$+0.1\text{E}-09Trnd$					
	(0.21)		(3.37)					
NAGARCH(1,1)								
$h_t = 0.4\text{E}-06$	$+0.884h_{t-1}$	$+0.087\varepsilon_{t-1}^2$	$-0.06\varepsilon_{t-1}/\sqrt{h_{t-1}}$		$+9.66D_{\text{IO}}\varepsilon_{t-1}/\sqrt{h_{t-1}}$		$+0.5\text{E}-010Trnd$	
(0.33)	(10.89)	(0.91)	(−0.002)		(0.319)		(0.123)	
AGARCH								
$h_t = 0.1\text{E}-05$	$+0.870h_{t-1}$	$+0.124\varepsilon_{t-1}^2$	$+0.006D_{\text{IO}}\varepsilon_{t-1}^2$	$-0.3\text{E}-03\varepsilon_{t-1}$	$-0.3\text{E}-04D_{+\text{IO}}\varepsilon_{t-1}$		$+0.2\text{E}-10Trnd$	
(0.95)	(11.18)	(1.75)	(0.06)	(−0.81)	(−0.05)		(−0.04)	

R_t = log returns of FTSE all share index; *Rus* = log returns of Dow Jones Composite 65 index; *Mon* = Monday dummy; *Thur* = Thursday dummy; *Fri* = Friday dummy; *Trnd* = linear trend; D_{IO} = option contract introduction dummy (FTSE100 index option); *Pr* = sign persistence dummy; *Ds* = stock market crash of October 1987 dummy; *Ssw* = sign switching dummy; *Svsw* = sign and volatility switching series.

volatility is close to close variance. As sample period we consider 250 days around the event and we eliminate 50 days around the event to avoid contamination with direct effects of the listing itself. Stocks added or deleted from the optioned index during the sample period are ruled out to avoid other contaminating effects.

Table 15 compares *ex ante* and *ex post* mean values of the selected indicators for the restricted sample of stocks belonging to the optioned index and for the control sample of stocks listed in the same market but not included in the index. We use the nonparametric Wilcoxon sign-rank test to measure the significance of unconditional volatility and implicit bid–ask changes between the *ex ante* and the *ex post* estimation period, separately, in the restricted and in the control sample. To test the significance of changes in the restricted sample, net of changes in the control sample, we use the nonparametric Wilcoxon rank-sum test as the two samples include a different number of stocks.

Results on changes in unconditional volatility in Table 15 are similar to those on changes in conditional volatility intercepts of the estimated ARCH-type models and show a significant relative reduction in the case of Germany and a significant relative increase in the case of The Netherlands (Wilcoxon rank-sum test). Results on implicit bid–ask spreads are inconclusive except for the case of Germany where we find a significant relative increase. Overall findings then seem to support the joint hypothesis of uninformed migration and incremental information as the negative impact on excess reaction to shocks typical of

Table 14. *UK – residual statistics*

	Arch(5)	Garch(1,1)	SSwGarch	S-vSwG	SSC-Garch	GJR	NaGarch	NaGarch	AGarch
Log likelihood	11 276	11 300	11 300	11 270	11 281	11 285	11 259	11 106	11 289
Kurtosis	8.95	8.43	8.44	8.908	9.19	9.23	9.34	9.31	9.97
Skewness	−0.1	−0.13	−0.13	−0.09	−0.03	−0.05	0.01	−0.3	0.04
Kurtosis (standardized)	0.72	0.85	0.84	2.10	1.27	1.36	1.44	1.67	1.52
Skewness (standardized)	−0.15	−0.16	−0.16	0.03	−0.04	−0.01	0.02	−0.01	−0.01
Positive sign bias test	0.30	0.46	0.63	−1.40	0.93	−0.1	−0.18	−0.38	1.04
Negative size bias test	−0.90	−1.16	−1.17	−0.06	−0.96	−0.69	0.82	−1.02	−1.57
Positive size bias test	−1.76	−1.70	−1.71	0.176	0.25	0.168	−2.27	−0.45	−1.16
Pagan–Sabau intercept	0.8E − 06	0.9E − 06	0.8 − 06	0.2E − 05	0.8E − 06	0.6E − 05	−0.7E − 05	0.1E − 04	0.8E − 05
(std. error)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.2E − 05)	(0.1E − 05)	(0.1E − 05)
Pagan–Sabau coefficient	1.18	1.16	1.17	1.05	1.18	0.78	1.88	0.39	0.59
(std. error)	(0.09)	(0.89)	(0.09)	(0.08)	(0.10)	(0.03)	(0.15)	(0.04)	(0.056)

Table 15. *The impact of index option listing on unconditional volatility and implicit bid–ask spread of stocks included in the optioned index and in the relative control samples*

	Unconditional volatility					
	Austria	Germany	Switzerland	The Netherlands	United Kingdom	France
Stocks in the optioned index						
Mean volatility before listing	3.47E − 05	3.91E − 05	2.64E − 05	5.91E − 05	4.38E − 05	6.22E − 05
Mean volatility after listing	5.32E − 05	1.97E − 05	2.58E − 05	8.25E − 05	4.21E − 05	4.55E − 05
% of stocks with reduced volatility	20	100	29.4	35.2	53.3	70.9
Wilcoxon signed rank statistics (p-value)	−1.58 (0.11)	4.54 (0.00)	−1.16 (0.24)	−1.77 (0.07)	0.55 (0.58)	3.05 (0.00)
Stocks not in the optioned index						
Mean volatility before listing	3.35E-05	4.55E-05	7.56E-05	0.000209	1.5E-05	0.006743
Mean volatility after listing	4.77E-05	4.95E-05	4.31E-05	0.00012	1.4E-05	0.005784
% of stocks with reduced volatility	32.14	61.6	68.5	46.9	12.79	68.04
Wilcoxon signed rank statistics (p-value)	−2.32 (0.02)	2.60 (0.01)	5.36 (0.00)	−1.59 (0.011)	0.89 (0.37)	2.65 (0.00)
Wilcoxon rank sum test (p-value)	0.56 (0.57)	−4.55 (0.00)	2.65 (0.00)	0.96 (0.33)	−0.11 (0.91)	0.11 (0.90)
	Implicit bid–ask spread					
Stocks in the optioned index						
Wilcoxon signed rank statistics (p-value)	−0.56 (0.57)	−2.59 (0.00)	−1.01 (0.30)	−3.43 (0.00)	1.43 (0.15)	−0.35 (0.72)
Stocks not in the optioned index						
Wilcoxon signed rank statistics (p-value)	−0.36 (0.71)	−3.69 (0.00)	−0.26 (0.78)	−3.91 (0.00)	–	−0.50 (0.71)
Wilcoxon rank sum test (p-value)	0.23 (0.81)	−2.55 (0.01)	1.13 (0.25)	1.13 (0.25)	1.36 (0.17)	−0.50 (0.85)

each of these two effects is accompanied by an effect in different direction on unconditional volatility (increasing by the arrival of new information[5] and decreasing by the uninformed migration and by the improved information) which is consistent with the resulting nonsignificant changes on relative unconditional volatility in our sample. The only exception is Germany where relative uncondi-

[5] If all agents have common priors, rational expectations, the same preferences and endowments and agree on the interpretation of any piece of information no trade should occur after arrival of public and even private information (Admati, 1991). With noise trading, though, additional information is likely to generate more volatility. For recent theoretical and empirical studies on the interaction between information arrival, noise trading and volatility see Dantin and Moresi (1990), Laux and Ng (1993), and Locke and Sayers (1993).

tional volatility is significantly reduced and uninformed migration then seems to prevail.

VII. CONCLUSIONS

Uninformed migration, informed migration and incremental information are three potential effects of derivative introduction on the underlying asset market. Both uninformed migration and incremental information, by reducing the share of noise or less informed traders, are expected to dampen the phenomenon of excess reaction to shocks which is typical of this type of traders.

The paper tries to test directly this hypothesis with a new methodology based on an original model of conditional volatility (SSC-GARCH). The SSC-GARCH may be considered a more direct test of the 'uninformed migration hypothesis' for two main reasons: (i) it models volatility persistence which is the predicted effect of the presence of uninformed traders on the market; (ii) it directly measures the significance of changes in reaction to shocks (and then of changes in volatility persistence) which should be a signal of informed/uninformed migration from the underlying asset market. The analysis focuses on the effects of the introduction of index options on market stability in six European markets (Austria, France, Germany, The UK, The Netherlands, Switzerland).

The estimating performance of the SSC-GARCH is compared with that of nine other conditional volatility models according to four criteria: (i) the magnitude of the log-likelihood; (ii) the capacity of eliminating positive sign, positive size and negative size biases (Engle and Ng tests); (iii) the capacity of the estimated variance of mimicking the actual residual variance (P–S test); (iv) the capacity of the conditional volatility model to eliminate part or all of the excess kurtosis contained in the data. On the basis of these four criteria, models with a symmetrically centred 'news' impact curve' seem to perform better than asymmetrically centred models. In particular, among symmetrically centred models, we present a sign and size conditional GARCH (SSC-GARCH) which singles out effects of positive and negative shocks on conditional volatility; (v) changes in other indicators such as unconditional volatility and implicit bid–ask spreads after option listing seem to support the hypothesis of a joint effect of uninformed migration and incremental information against the alternative of the occurrence of only one of these two effects.

ACKNOWLEDGEMENTS

Paper prepared for the CNR Strategic Project 92.4716 st 74 'Technological change and industrial development. Policies for international technological cooperation'. Working Unit ISPE n.3. The authors thank Philippe Aghion, Michele Bagella, Criana Connal, Fabio Fornari, Luca Lambertini, Massimo Lo Cicero, Luigi Paganetto, and an anonymous referee for helpful comments and suggestions. The usual disclaimer applies.

REFERENCES

Admati, A. R. (1991) The informational role of prices: a review essay, *Journal of Monetary Economics*, **28**, 347–61.

Antoniou, A. and Holmes, P. (1992) The relationship between future trading and spot price volatility: distinguishing between the message and the messenger, *Discussion Paper 82-02*, Brunel University, UK.

Baldauf, D. and Santoni, F. (1991) Stock price volatility: some evidence from an ARCH model, *Journal of Future Markets*, **11**, 191–200.

Becchetti, L. (1996) The effect of bond plus equity warrant issues on stock volatility: an empirical analysis with conditional and unconditional volatility measures. *Applied Financial Economics*, **6**, 327–35.

Bera, M. K. and Higgins, M. L. (1993) ARCH models; properties, estimation and testing, *Journal of Economic Surveys*, **7**, 305–62.

Black, F. and Scholes, M. (1973) The pricing of options and corporate liabilities, *Journal of Political Economy*, **81**, 637–59.

Black, J. M. and Tonks, I. (1992) Asset price variability in a rational expectation equilibrium, *European Economic Review*, **36**, 1367–77.

Bollerslev, T., Chou, R. Y. and Kroner, K. (1992) ARCH modeling in finance: a review of the theory and empirical evidence, *Journal of Econometrics*, **52**, (1–2), 5–60.

CBOE (1975) Analysis of volume and price patterns in stocks underlying CBOE options from December 30, 1974 to April 30, 1975, *Mimeo*, Chicago University.

Choi, H. and Subrahmanyam, A. (1993) Using intra-day data to test for the effect of index futures on underlying stock markets, *Journal of Futures Markets*, **14**, 293–322.

Conrad, J. (1989) The price effect of option introduction, *Journal of Finance*, **44**, 487–98.

Damodaran, A. and Lim, J. (1991) The effect of option listing on the underlying stocks' return process, *Journal of Banking and Finance*, **15**, 647–64.

Dantine, J. P. and Moresi, S. (1990) Volatility, information and noise trading, *Universitè de Lausanne Cahiers de Reserche Economiques*, 9015.

De Long, J. B., Shleifer, A., Summers, L. and Waldman, R. J. (1990) Noise trader risk in financial markets, *Journal of Political Economy*, **98**, 701–38.

DeTemple, J. and Orion, P. (1990) Option listing and stock return: an empirical analysis, *Journal of Banking and Finance*, **14,** 781–801.

Edwards, F. R. (1988) Does future trading increase stock market volatility? *Financial Analysis Journal*, **44**, 63–9.

Engle, R. F. (1982) Autoregressive conditional heteroskedasticity with estimates of the variance of UK inflation, *Econometrica*, **50**, 987–1008.

Engle, R. F. (1990) Stock volatility and the crash of '87: discussion, *Review of Financial Studies*, **3**(1), 103–6.

Engle, R. F. and Ng, V. (1993) Measuring and testing the impact of news on volatility, *Journal of Finance*, **48**, (5), 1749–78.

Fornari, F. and Mele, A. (1994) A stochastic variance model for absolute returns, *Economic Letters*, **46**(3), 211-14.
French, K. and Roll, R. (1986) Stock return variances: the arrival of information and the reaction of the traders, *Journal of Financial Economics*, 17.
Gammill, J. F. and Perold, A. F. (1989) The changing character of stock market liquidity, *Journal of Portfolio Management*, **15**(3), 13–18.
Gorton, G. B. and Pennacchi, G. G. (1993) Security baskets and index-linked securities, *Journal of Business*, **66**(1), 1–27.
Grossman, S. J. (1976) On the efficiency of competitive stock markets where agents have diverse information, *Journal of Finance*, **31**, 81–101.
Grossman, S. J. and Stiglitz, J. E. (1980) The impossibility of informationally efficient markets, *American Economic Review*, **70**, 393–408.
Harvey, A. C. (1993) Long memory in stochastic volatility, *mimeo*, London School of Economics.
Hellwig, M. (1980) On the aggregate of information in competitive markets, *Journal of Economic Theory*, **22**, 477–98.
Klemkosky, R. C. and Maness, T. S. (1980) The impact of options on the underlying securities, *Journal of Portfolio Management*, **6**(2), 12–18.
Kumar, R., Sarin, A. and Shastri, K. (1995) The impact of index options on the underlying stock: the evidence from the listing of Nikkei stock average options, *Pacific-Basin Finance Journal*, **3**, 303–17.
Laux, P. A. and Ng, L. K. (1993) The sources of GARCH: empirical evidence from an intraday returns model incorporating systematic and unique risk, *Journal of International Money and Finance*, **12**(5), 543–60.
Lee, S. B. and Ohk, K. Y. (1992) Stock index future listing and structural change in time-varying volatility, *Journal of Future Markets*, **12**(5), 493–509.
Locke, P. R. and Sayers, C. L. (1993) Intra-day futures price volatility: information effects and variance persistence, *Journal of Applied Econometrics*, **8**(1), 15–30.
Mandelbrot, B. (1963a) The variation of certain speculative prices, *Journal of Business*, **36**, 394–419.
Mandelbrot, B. (1963b) New methods in statistical economics, *Journal of Political Economy*, **71**, 421–40.
Nelson, D. B. (1989) Price volatility, international market links, and their implications for regulatory policies: commentary, *Journal of Financial Services Research*, **3**(2–3), 247–54.
Pagan, A. and Sabau, H. (1988) Consistency tests for heteroskedasticity and risk models, *mimeo*, University of Rochester.
Robinson, G. (1993) The effect of future trading on cash market volatility: evidence from London Stock Exchange, *Working Paper*, n.19; Bank of England, UK.
Skinner, D. J. (1989) Option market and stock return volatility, *Journal of Financial Economics*, **23**(1), 61–78.
Stein, J. L. (1980) The dynamics of spot and forward prices in an efficient foreign exchange market with rational expectations, *Amerian Economic Review*, **70**(4), 565–83.
Stoll, H. R. and Whaley, R. E. (1990) The dynamics of stock index and stock index future returns, *Journal of Financial and Quantitative Analysis*, **25**, 441–68.
Taylor, D. (1986) *Modelling Financial Time Series*, Wiley and Sons, London.
Trennepohl, G. L. and Duves, W. P. (1979) CBOE options and stock volatility, *Review of Business and Economic Research*, **14**(3), 49–60.
Wang, Y. (1993) Near-rational behaviour and financial market fluctuations, *The Economic Journal*, **103**, 1462–78.

APPENDIX: THE EIGHT MODELS OF CONDITIONAL VOLATILITY

The first simple model of conditional volatility estimated for the European markets is an ARCH(5) specification. The ARCH includes as additional variables: (i) a dummy testing the existence of structural breaks after the introduction of index options (D_{IO}) which takes value 0 before and value 1 from the day index options started being traded on the relevant national market.

The second model is a GARCH with 'sign persistence'. The advantage over the first model is that it allows us to model the effects of infinite lags in past shocks in a declining way with a parsimonious structure that reduces the number of parameters to estimate. The GARCH (1,1) we propose is the following:

$$R_t = a_0 + \sum_i a_i x_{it} + \varepsilon_t \qquad \varepsilon_t | I_{t-1} \sim N(0, h_t) \tag{A1}$$

$$h_t = b_0 + b_1 \varepsilon_{t-1}^2 + b_2 h_{t-1} + b_3 D_{\mathrm{IO}} + b_4 Pr + b_5 D_{\mathrm{IO}} Pr \tag{A2}$$

where a negative and significant value for b_3 indicates a reduction of market volatility after the introduction of index option.

The variable Pr is a dummy which tests the existence of additional 'sign persistence' effects on conditional volatility. This dummy is such that $Pr_t = 0$ if $\mathrm{sign}[\varepsilon_{t-1}] \neq \mathrm{sign}[\varepsilon_{t-2}]$ and $Pr_t = n$ where n is the number of consecutive past shocks which have the same sign as ε_{t-1}.

The underlying theoretical argument for the introduction of a 'sign persistence' dummy is that 'pyramiding' (market euphoria) and 'depyramiding' (market panic) effects are generated by a sequence of shocks of the same sign so that sign persistence of the shocks generates additional volatility. The relevance of the size and sign bias tests, though, indicates that the best specification for the model must evaluate the different impacts of negative and positive shocks of various size.

The third model proposed is a sign switching GARCH model (SGARCH, Mele-Fornari, 1994). This is the simplest way to keep account of the problem of the asymmetric reaction to shocks of different sign. The conditional variance in the second equation is modelled as:

$$h_t = b_0 + b_1 \varepsilon_{t-1}^2 + b_2 h_{t-1} + b_3 D^+ + b_3 D_{\mathrm{IO}} D^+ \tag{A3}$$

where D^+ is a dummy variable which is equal to 1 when the lagged shock is positive and equal to -1 when the lagged shock is negative.

The main feature of this model is that it implies an 'intercept break' constraint to the 'news impact curve' assuming that:

$$+\lim_{\varepsilon_{t-1}\to 0_t} h_t = \alpha_1 \qquad -\lim_{\varepsilon_{t-1}\to 0_t} h_t = \alpha_2$$

where $\alpha_1 < \alpha_2$.

The fourth model proposed is a two stage nonlinear asymmetric ARCH (NAGARCH). In the traditional NAGARCH model conditional variance is specified as (Engle and Ng, 1993):

$$h_t = b_0 + b_1 h_{t-1}^2 + b_2(\varepsilon_{t-1} + b_3\sqrt{h_{t-1}})^2 \tag{A4}$$

and presents a news impact curve symmetric and centred at $\varepsilon_{t-1} = (-b_3)\sqrt{h_{t-1}}$.

We estimated a NAGARCH model whose second equation is given by:

$$h_t = \omega_0 + \omega_1 h_{t-1}^2 + \omega_2\varepsilon_{t-1}^2 + \omega_3\varepsilon_{t-1}\sqrt{h_{t-1}} + \omega_4 D_{IO}\varepsilon_{t-1}^2 + \omega_5 D_{IO}\varepsilon_{t-1}\sqrt{h_{t-1}} \tag{A5}$$

In absence of significant changes in the equation after the introduction of index options we expect that $\omega_4 = \omega_5 = 0$.

The fifth model proposed is a GJR (Glosten, Jagannathan and Runkle). In the traditional GJR (Glosten *et al.*, 1989) model conditioned variance is given by:

$$h_t = b_0 + b_1 h_{t-1} + b_2\varepsilon_{t-1}^2 + b_3 S_{t-1}^-\varepsilon_{t-1}^2 \tag{A6}$$

where S_{t-1}^- is a dummy that takes value 1 if the $t-1$ shock is negative and zero otherwise. This model captures asymmetry having a steeper slope for negative than for positive ε_{t-1}.

The second model equation of our model is:

$$h_t = b_0 + b_1 h_{t-1} + b_2\varepsilon_{t-1}^2 + b_3 S_{t-1}^-\varepsilon_{t-1}^2 + b_4 D_{IO}\varepsilon_{t-1}^2 + b_5 D_{IO} S_{t-1}^-\varepsilon_{t-1}^2 \tag{A7}$$

where a significant and positive b_3 would indicate the existence of a ‘leverage effect’ with higher impact of negative shocks and a significant and positive b_5 would indicate that changes in the ‘leverage effect’ have occurred after the introduction of index options.

The sixth model proposed is an asymmetric ARCH. In the traditional AGARCH model conditional variance is given by:

$$h_t = b_0 + b_1(\varepsilon_{t-1} + b_2)^2 + b_3 h_{t-1} \tag{A8}$$

The ‘news’ impact curve’ is centred at positive ε_{t-1} and is then capable of capturing the asymmetric reaction to shocks of different sign. We estimate an AGARCH model where the second equation is given by:

$$h_t = \omega_0 + \omega_1\varepsilon_{t-1}^2 + \omega_2 h_{t-1} + \omega_3\varepsilon_{t-1} + \omega_4 D_{IO} h_{t-1} + \omega_5 D_{IO}\varepsilon_{t-1} \tag{A9}$$

If we assume no structural breaks then $\omega_4 = \omega_5 = 0$. The original parameters of the AGARCH are given by the following combination of the reparametrized equations where $b_1 = \omega_1$, $b_3 = \omega_2$ and $b_3 = \omega_3/2\omega_1$ and the intercept is $b_0 = \omega_0 - \omega_1(\omega_2/2\omega_1)^2$.

The seventh model proposed is a VGARCH. In the traditional VGARCH model the conditional variance is modelled as:

$$h_t = b_0 + b_1 h_{t-1} + b_2(\varepsilon_{t-1}/\sqrt{h_{t-1}} + b_3)^2 \tag{A10}$$

We estimate a VGARCH model where the second equation is given by:

$$h_t = \omega_0 + \omega_1 h_{t-1} + \omega_2\varepsilon_{t-1}/h_{t-1} + \omega_3\varepsilon_{t-1}/\sqrt{h_{t-1}} + \omega_4 D_{IO}\varepsilon_{t-1}/h_{t-1} + \omega_5 D_{IO}\varepsilon_{t-1}/\sqrt{h_{t-1}} \tag{A11}$$

where ω_5 tests for changes in the conditional volatility equation after the introduction of index options. The original parameters of the VGARCH are obtained by the following combination of the original parameters where $b_1 = \omega_1$, $b_2\omega_2$, and $b_3 = \omega_3/2\omega_2$ and the intercept is $b_0 = \omega_0 - \omega_1(\omega_3/2\omega_2)^2$.

The eighth model is a sign and volatility switching ARCH model (Engle and Ng, 1993). According to this method the estimated equation is the following:

$$h_t = b_0 + b_1\varepsilon_{t-1}^2 + b_2 h_{t-1} + b_3 D^+ v_t + b_3 D_{IO} D^+ v_t \tag{A12}$$

where h_t is the conditional variance and:

$$v_t = \varepsilon_t - h_t \tag{A13}$$

is the unconditional standard deviation of the dependent variable.

To test if the change of regime modifies the news impact curve we obviously test in this case the significance of the $D_{IO}D^+ v_t$ coefficient.