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Volatility smiles and the information content of news

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The paper investigates whether the impact of selected news – scheduled and unscheduled – affects only the current conditional variance of financial prices or, by bringing new information to the market, induces also a revision of the implied variance, i.e. the variance expected to prevail over the life to maturity of an option. The latter phenomenon would signal that news is able to change permanently the consensus on the future economic environment. In addition to recent similar analyses which employ the *at-the-money* implied volatility to this aim, tests are also performed on the implied *out-of-money* and *in-the-money* volatilities. These are in fact extremely sensitive to lack of information about the future evolution of the price of the underlying asset: hence, their prices – as well as their implied volatilities – must change significantly after the occurrence of important events.

I. INTRODUCTION

Among the phenomena belonging to the stylized facts of financial data, the existence of a *volatility smile* in option prices has been recently receiving special attention. The smile is the picture obtained by plotting the implied volatility of options with different strike prices – observed at the same time, with similar maturity and written on the same asset – against the strike prices themselves. It overly contradicts the traditional option pricing model of Black and Scholes (1973; BS), according to which the variance of the logarithmic rates of change of the price of the underlying asset is fixed, hence obviously independent of the strike price of the option: as a consequence of this assumption, in the traditional setup the volatility smile is a phenomenon that one should not observe.

Although from a theoretical viewpoint the volatility smile should not exist, the overwhelming empirical evidence in its favour has originated two different lines of interpretation: the former recognizes that the volatility smile is a phenomenon induced by ignorance about the true dynamics of the (stochastic) volatility, an assumption which clearly clashes with the BS world; in this environment, generally working under the no-arbitrage assumption, the search for the true generating process of the conditional variance becomes the main goal of the researcher. The second line of interpretation consists instead of a more straightforward – yet less theoretical – approach to the smile, i.e. that of finding – albeit with highly sophisticated techniques – a curve with the best fit for the observed options prices.

The first approach, which we regard as the *theoretical* one, is intrinsically linked to considerations originally put forward by Knight (1921) and Keynes (1936) regarding the distinction between risk and uncertainty. In the definition of these authors, risk denotes a situation in which economic agents are able to evaluate the probabilities of elementary and complex events, however small such probabilities can be; uncertainty is instead a condition where probabilities are useless as a guide for actions, since there are not appropriate conditions to evaluate them. From a practical viewpoint this distinction means that, in a situation in which the market is dominated by uncertainty, a dealer asked to price a deep *in-* or *out-of-the-money* option will not be able to evaluate the main ingredient of the pricing formula, i.e. the average volatility

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expected to prevail over the option's maturity; in this condition, the most obvious thing he can do – independently of being risk lover, neutral or adverse – is to raise the price of the option above its (perceived) fair level since the variance, being unknown, can take on any value in the $[0, \infty)$ range. Such a situation should not be regarded as unlikely; observing the traded volumes of interest rate options traded at LIFFE and classified according to their moneyness, one notes that active trading takes indeed place only *near-the-money*, while the in- and out-of-the-money options are virtually untraded at all times, which could be taken as an indication that their prices depart from equilibrium (if this exists). This approach – whose aim can be summarized as *the attempt of identifying the true dynamics of the stochastic volatility and use it to correctly price options* – can be found, explicitly or implicitly, in a large number of papers, among which Hull and White (1987), Day and Lewis (1992), Engle and Mustafa (1992), Heynen *et al.* (1993), Lamoureux and Lastrapes (1993), Ball and Roma (1994) and Fornari and Mele (1997a,b).

The more practical approach, which employs a sort of 'reverse engineering' technique, employing the observed options prices to find the best fit for the volatility smile, can instead be found in Heynen (1994), in Xu and Taylor (1994) as well as in a number of papers which make use of nonparametric and parametric approaches (Bossaert and Hillion, 1997).

This study starts from the observation that out- and in-the-money options display higher than expected prices[1] – and volatilities (hence yielding the empirical phenomenon of the volatility smile) – and tests whether such higher values are indeed related to the existence of uncertainty about the future evolution of the variance of the logarithmic rates of change of the price of the underlying asset; thus, the underlying assumption of the first approach outlined above is pursued. To do this there is an examination of whether the impact of selected scheduled and unscheduled news, which are expected to create or resolve uncertainty, is able to affect market's perception of uncertainty hence the implied volatilities extracted from the prices of traded (or quoted) options and they are moved in the direction indicated in a set of hypotheses put forward in the paper.

II. DATA AND ECONOMETRIC STRATEGY

Data consists in the closing prices of all options on futures written on the Btp (Italian 10-year bond) with the shortest available maturity, traded at London's LIFFE; the contracts are observed between 28 March 1994 and 21 March 1997. For each working day in the sample a synthetic description of the volatility smile is employed. In practice, the impact of news on all the available points of the volatility smile is not measured: rather, its terminal points are concentrated on, selected from a huge amount of prices as those corresponding to the deepest in- and out-of-the-money options; the implied volatility of the nearest-the-money[2] option is also collected, which is then used to derive a measure of asymmetry of the volatility smile. News belongs to two categories:

(1) scheduled news, i.e. the release of economic and financial data; belong to this category the release of the Consumer Price Index, the preliminary release of the Consumer Price Index obtained from a sample of major towns, the Producer Price Index as well as the at-issue yield of the T-bills and the rate at which the Bank of Italy clears the temporary financing (repo) operations. In all cases the difference between the actual value and the average of the two preceding values is considered, which is taken to approximate the market forecast of the current innovation of the price indices or the interest rates;
(2) unscheduled news, i.e. news taken from the headlines of the Italian leading financial newspaper, *Il Sole 24 Ore*; two dicotomic dummies are employed, originally developed to record the impact of good and bad news on the volatility of the lira/Deutschemark exchange rate: the former is unity when one observes a negative shock (a shock expected to weaken the lira exchange rate) and is nil in days without news; the latter is unity when one observes a positive shock and is nil elsewhere.[3]

The methodology follows the original scheme developed by Ederington and Lee (1996; EL), who test a number of hypotheses about the impact of information releases on implied volatilities, employing, as in the present study, the implied standard deviation of options written on futures contracts with the shortest available maturity. All

[1] The term 'higher' means higher than implied by the Black and Scholes (1973) model; such prices, however, remain so even when theoretical prices are evaluated according to the model of Hull and White (1987).
[2] The implied volatility of the *closest-to-money* option is not taken, but an average of the implied volatilities of the three closest to maturity options, weighted with their traded values.
[3] The authors are indebted to Massimo Tivegna for providing such information. These two pieces of news were originally classified in more than ten items, i.e. *consumer price rumours*, *fiscal policy measures*, *political instability*; they have been collected into two categories only by first selecting those which were significant when introduced, exogenously, into a GARCH(1,1) model for the current variance of the logarithmic rates of change of the lira/Deutschemark rate. The significant variables have then been merged according to their coefficient (if significant at the 5% level) in each individual equation.

options in their paper were at-the-money since, for such a class of instruments, stochastic volatility induces the minimum bias on the inversion of the analytic expression of the BS formula, a procedure which is necessary to recover the implied volatility originally used by economic agents.

The main hypotheses of EL are that:

H_1: implied volatility (σ_t) tends to fall on days with scheduled announcements;

H_2: implied volatility tends to rise on days with no scheduled announcements;

H_3: implied volatility tends to rise following important unscheduled announcements that cause volatility at time (t) to be higher than anticipated.

The first hypothesis, H_1, follows from the consideration that economic agents have perfect knowledge that at time (t) a piece of information will be released: hence, before that instant of time, volatility will increase, reflecting their uncertainty about the forthcoming outcome; once news appears, uncertainty is resolved, hence volatility reduces. By an analogous reasoning one obtains H_2. In the last assumption, H_3, one recognizes that an unscheduled piece of news plays a relevant effect on the implied volatility only if it manages to increase current volatility beyond its forecast based on the information set available at $(t-1)$.

EL test the relevance of their hypotheses H_1–H_3 on a series made up as $z_t = \ln(\sigma_t/\sigma_{t-1})$. More precisely, taking for example H_1, they check whether the mean of z_t, in days with scheduled announcements, exceeds the corresponding mean of the same series evaluated in days with no scheduled announcements. The same procedure is followed to test the remaining hypotheses, which they find to hold true at the 1% level of confidence.

However, EL test their hypotheses on the implied volatility of at-the-money options, where the contributions of news to the creation or the resolution of uncertainty may not be fully detectable. It is argued that if information is indeed valuable, in the sense that economic agents can effectively employ it to diminish their uncertainty about the future evolution of the variance of the underlying asset price, so that probabilities can be evaluated, then this must reflect above all on the prices of deep in- and out-of-the-money options, the most affected by lack of information about the future evolution of the price of the underlying asset. The prices of the latter should then change significantly on days when information is created or resolved, i.e. days with scheduled or unscheduled announcements. Following the same reasoning as in Ederington and Lee (1996) one is led to hypothesize that:

H_4: the out-of-the-money implied variance, i.e. the maximum height of the left-hand side (in other words the implied variance of the option with the lowest observed moneyness) of the volatility smile, will tend to decrease on days with scheduled announcements;

H_5: the out-of-the-money implied variance, i.e. the maximum height of the left-hand side of the volatility smile, will tend to increase on days with no scheduled announcements;

H_6: the out-of-the-money implied variance, i.e. the maximum height of the left-hand side of the volatility smile, will tend to increase on days with important unscheduled announcements that cause volatility at time t to be higher than anticipated.

In a similar manner we can define hypotheses H_7–H_9 by replacing out-of-the-money options with in-the-money options (i.e. employing the implied variance of options with the highest moneyness). After denoting the implied volatility of an out-of-the-money option with (σ^{o}) and that of an in-the-money option by (σ^{i}), we initially perform the above tests of hypothesis in a similar way as in EL (1996). However, we subsequently employ a different procedure which does not rely on the difference between the means of $\{\ln(\sigma_t/\sigma_{t-1})\}$ evaluated in days characterized or not by the occurrence of news. As we will show, in fact, though such means are not significantly different from nil, since their standard errors can become extremely wide in large samples, yet news are able to play a significant effect on the implied – i.e. future – variance and on the current variance of the underlying asset. This is evidenced through a set of regressions which also address another argument faced in the paper, providing information about which part of the volatility is actually influenced by the occurrence of news. To make the latter point clearer, denoted by σ_t^2 the implied variance of an at-the-money option, i.e. the expected volatility over the option's life to maturity, which in discrete time can be written as:

$$\sigma_t^2 = (1/T_t) \sum_{u=t+1,\tau\mathrm{e}} \sigma_u^2 \tag{1}$$

where T_t is the remaining life of the option and τe the expiration date. By noting that $T_t = T_{t-1} + 1$, EL cast the revision of the implied voatility between days $(t-1)$ and (t) as:

$$(\sigma_t^2 - \sigma_{t-1}^2) = (1/T_t)\left[(\sigma_{t-1}^2 - \sigma_{1|t-1}^2) + \sum_{u=t+1,\tau\mathrm{e}} (\sigma_{u|t}^2 - \sigma_{u|t-1}^2)\right] \tag{2}$$

where the term on the left-hand side is the change of the expected volatility over the option's life occurred between $(t-1)$ and (t); the first term in square brackets on the right-hand side is the contribution of the variance expected to prevail at time (t) – evaluated as of $(t-1)$ – to the expected variance over the option's maturity; the second term on the right-hand side is the revision of the u-step-ahead implied volatility between couples of consecutive – future – days, up to the expiration of the option. Dividing Equation 2 by σ^2_{t-1}, the left-hand side then provides the same variable employed in the EL's paper; however, as already mentioned, this indicator may not be able to indicate whether the revision observed for the implied variance is only due to a – temporary – increase (or decrease) of the current volatility or is indeed genuine, i.e. coming from a revision of all future volatilities up to the maturity of the option. To shed light on this we regress both the overall revision, the left-hand side of Equation 2, and the part due to a modification of the current volatility, the first term on the right-hand side, on the dummies which record the occurrence of the unscheduled and the scheduled news, i.e.:

$$[\sigma^{\mathrm{o}}_t - \sigma^{\mathrm{o}}_{t-1}] = \mu^{\mathrm{o}} + \alpha^{\mathrm{o}}_p U_{p,t} + \beta^{\mathrm{o}}_q S_{q,t} + \varepsilon^{\mathrm{o}}_t \quad \text{(\textit{out-of-the-money}; overall revision)} \tag{3}$$

$$[\sigma_t - \sigma_{t-1}] = \mu + \alpha_p U_{p,t} + \beta_q S_{q,t} + \varepsilon_t \quad \text{(\textit{at-the-money}; overall revision)} \tag{4}$$

$$[\sigma^{\mathrm{i}}_t - \sigma^{\mathrm{i}}_{t-1}] = \mu^{\mathrm{i}} + \alpha^{\mathrm{i}}_p U_{p,t} + \beta^{\mathrm{i}}_q S_{q,t} + \varepsilon^{\mathrm{i}}_t \quad \text{(\textit{in-the-money}; overall revision)} \tag{5}$$

$$[\sigma^{\mathrm{oc}}_t - h_{t|t-1}] = \mu^{\mathrm{oc}} + \alpha^{\mathrm{otc}}_p U_{p,t} + \beta^{\mathrm{oc}}_q S_{q,t} + \varepsilon^{\mathrm{oc}}_t \quad \text{(\textit{out-of-the-money}; effect on current variance)} \tag{6}$$

$$[\sigma_t - h_{t|t-1} = \mu_{\mathrm{c}} + \alpha^{\mathrm{c}}_p U_{p,t} + \beta^{\mathrm{c}}_p S_{p,t} + \varepsilon^{\mathrm{c}}_t \quad \text{(\textit{at-the-money}; effect on current variance)} \tag{7}$$

$$[\sigma^{\mathrm{ic}}_t - h_{t|t-1}] = \mu^{\mathrm{ic}} + \alpha^{\mathrm{ic}}_p U_{p,t} + \beta^{\mathrm{ic}}_p S_{p,t} + \varepsilon^{\mathrm{ic}}_t \quad \text{(\textit{in-the-money}; effect on current variance)} \tag{8}$$

where μ, μ^{c}, μ^{o}, μ^{oc}, μ^{i}, μ^{ic} are real parameters, α_p, α^{c}_p, α^{o}_p, α^{oc}_p, α^{i}_p, $\alpha^{\mathrm{ic}}_p(p \cdot 1)$ vectors of parameters β_q, β^{c}_p, β^{o}_q, β^{oc}_q, β^{i}_q, $\beta^{\mathrm{ic}}_q(q \cdot 1)$ vectors of parameters, ε_t, $\varepsilon^{\mathrm{c}}_t$, $\varepsilon^{\mathrm{o}}_t$, $\varepsilon^{\mathrm{oc}}_t$, $\varepsilon^{\mathrm{i}}_t$, $\varepsilon^{\mathrm{ic}}_t$ error terms with zero mean and homoscedastic variance; $h_{t|t-1}$, the conditional standard deviation of the underlying price changes at time (t) based on the information available up to $(t-1)$, comes from the estimation of a GARCH(1,1) model[4] (Bollerslev, 1986); $U_{p,t}$ and $S_{q,t}$ are respectively sets of p and q unscheduled and scheduled news.

The implied volatilities taken from the dataset of options are based on the method of Black (1976), which is suited for options on futures. Obviously, such a measure of expected average standard deviation over the life to maturity of the options will be seriously biased for extremely in- and out-of-the-money options, just the ones which are focused upon; however, such a bias will not be disruptive for the results under the hypothesis that its influence, for a given moneyness, is fixed over time; in this situation the bias vanishes when one works with the logarithmic rates of change of the implied standard deviations of options of a given – fixed – moneyness.

The above hypotheses, labelled H_4–H_9, can also be expressed in a different, more stringent, way. To illustrate the point, one could replace H_4 with

H_{10}: the slope and the skewness of the volatility smile will tend to decrease on days with scheduled announcements

where by slope (SL_t) of the volatility smile we refer to the change of in- and out-of-the-money volatility relative to the change occurred for at-the-money volatility, i.e.

$$SL^{\mathrm{o}}_t = (\sigma^{\mathrm{o}}_t - \sigma^{\mathrm{o}}_{t-1}) - (\sigma_t - \sigma_{t-1}) \tag{9}$$

$$SL^{\mathrm{i}}_t = (\sigma^{\mathrm{i}}_t - \sigma^{\mathrm{i}}_{t-1}) - (\sigma_t - \sigma_{t-1}) \tag{10}$$

with the superscript i denoting the slope of the in-the-money branch of the volatility smile and o the slope of the out-of-the-money branch. The quantities in Equations 9 and 10 represent the change of the volatility smile's height – i.e. the difference between the implied volatility of the highest or lowest moneyness option and the implied volatility of the at-the-money option – between days $(t-1)$ and (t). Skewness (SK_t) means instead the change of the out-of-the-money implied volatility relative to the change occurred for the in-the-money implied volatility:

$$SK_t = (\sigma^{\mathrm{o}}_t - \sigma^{\mathrm{o}}_{t-1}) - (\sigma^{\mathrm{i}}_t - \sigma^{\mathrm{i}}_{t-1}) \tag{11}$$

Such measures induce more restrictive conditions than H_5–H_9 in that they require the change of out- or in-the-money volatilities to be larger than that occurred for at-the-money volatilities; thus, they require not only that news influence implied variance, but also that its effect be stronger for values of the moneyness different from unity. More explicitly, under Equations 9–11 volatility, at any moneyness, will significantly change as a result of the information brought about by the arrival of a specific piece of news. In addition to this, the change in the slope or in the skewness of the volatility smile implies that the arrival of news has also changed the higher moments of the probability distribution of the underlying asset price changes, not just its expectation, both by decreasing the variance (thus flattering the smile) or favouring the occurrence of movements in one specific direction (skewness effect).

[4] The series $h_{t|t-1}$ is estimated according to the following model, called GARCH(1,1): $r_t = \log(P_t) - \log(P_{t-1}) = k + \phi r_{t-1} + \varepsilon_t$; $\varepsilon_t | I_{t-1} \sim \mathrm{N}(0, h^2_{t|t-1})$; $h^2_t = \omega + \alpha\varepsilon^2_{t-1} + \beta h^2_{t-1}$, where k, ϕ are real parameters, $\omega > 0$, $\alpha, \beta \geqslant 0$, P_t is the price of the underlying asset. This specification for the conditional variance is adopted given the ability of the model at over-performing a number of alternative specifications (Bollerslev *et al.*, 1992). Further, the GARCH(1,1) has been shown (Nelson, 1990; Fornari and Mele, 1997a) to represent the discrete-time counterpart of the continuous time option pricing scheme of Hull and White (1987), hence being an appropriate candidate in the actual implied volatility context.

Table 1. *Level of the implied volatility in days with and without the occurrence of news*

	Days with unscheduled news	Days with scheduled news	Days with no news
Out-of-the-money	10.56 (2.15)	10.09 (2.27)	14.47 (4.10)
At-the-money	9.47 (2.05)	9.47 (2.05)	11.03 (2.80)
In-the-money	14.51 (3.57)	14.71 (3.98)	9.98 (2.74)

Note: Standard errors in parentheses; values in per cent per year.

Table 2. *Change of the implied volatility in days with and without the occurrence of news*

	Days with unschedule news	Days with scheduled news	Days with no news
Out-of-the-money	0.183 (6.16)	−0.355 (5.72)	0.109 (5.46)
At-the-money	−0.589 (12.20)	−0.737 (11.57)	−0.523 (12.74)
In-the-money	−0.215 (13.88)	0.054 (12.07)	0.456 (8.50)

Note: Standard errors in parentheses.

III. RESULTS

Tables 1 and 2 report the average level and the average rates of change, with the corresponding standard errors, of the out-of-the-money, the at-the-money and the in-the-money implied volatility derived from options on Btp futures. According to the hypotheses put forward in the previous section, if news has a permanent impact on expected volatility, the average level or the average rate of change of the implied volatility on days characterized or not by the occurrence of news would be significantly different.

However, this does not seem to be the case. In fact, though the means of the levels and the rates of change of the implied volatilities are different among the various categories of options, they are not significantly so: the standard errors are in fact so large that individual means cannot be regarded as significantly different from nil. Thus, there is no evidence of a different pattern – across moneynesses – in the reaction of implied volatilities changes to the occurrence of news.

The evidence drawn from Figs 1 and 2 is at odds with the numbers reported in Tables 1 and 2. The former figure shows the differences between implied and actual volatility (i.e. EL's first component), while in the latter figure the revision of implied volatility occurred between days $(t-1)$ and (t), evaluated for out-of-the-money, at-the-money and in-the-money options. What one deduces is that, especially for the series in Fig. 2, there is a strong heteroscedasticity in the revision of the implied volatility, a phenomenon which may be in a tight relation with the arrival of new information, i.e. with the occurrence of news.

The findings reported in Tables 1 and 2 change significantly when one regresses the daily rates of change of implied volatilities (with a specific regression run for a specific moneyness) on the dummies which record the occurrence of scheduled and unscheduled news. The six regressions (Equations 3–8) are run with ordinary least squares. The first three of them (labelled *overall revision*)

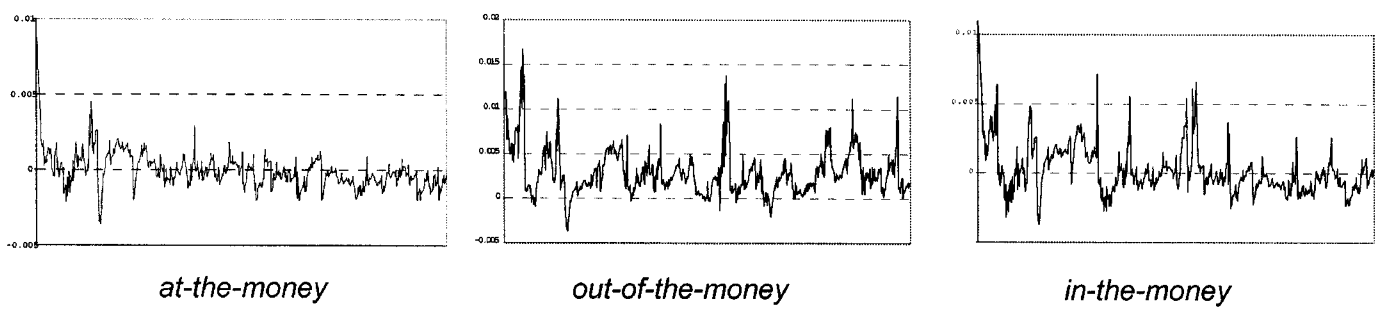

Fig. 1. *Difference between implied volatility and current volatility for out-of-the-money, at-the-money and in-the-money options on long term interest rates*

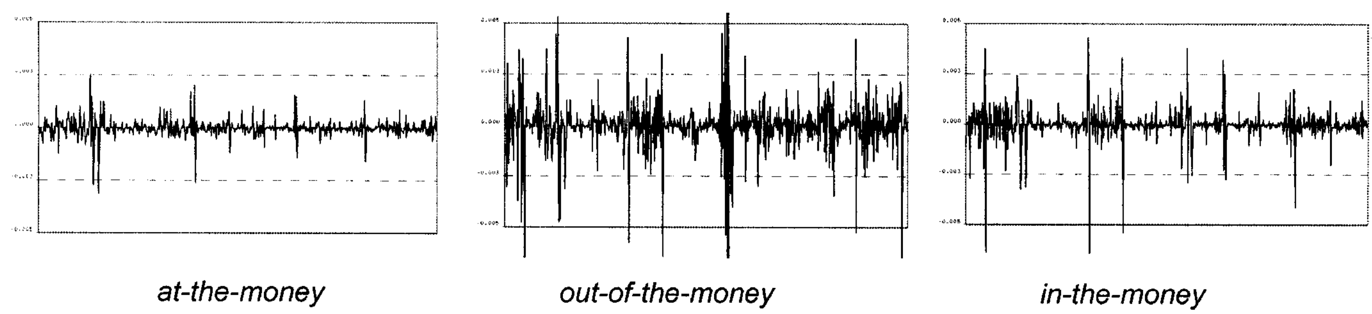

Fig. 2. *Revision of implied volatility between day* (t – 1) *and* (t) *for out-of-the-money, at-the-money and in-the-money options on long term interest rates*

Table 3. *The effects of news on implied volatility of long term rates*

	Volatility revision out-of-the-money (o)	Volatility revision at-the-money	Volatility revision in-the-money (i)	Implied volatility minus current volatility (o)	Implied volatility minus current volatility	Implied volatility minus current volatility (i)
μ	$1.78 \cdot 10^{-5}$	$-1.53 \cdot 10^{-5}$	$1.15 \cdot 10^{-5}$	**$2.90 \cdot 10^{-3}$**	**$-1.67 \cdot 10^{-4}$**	$7.66 \cdot 10^{-5}$
	(0.30)	(−0.91)	(0.35)	**(26.07)**	**(−3.35)**	(0.99)
α_1	28.35	**36.26**	8.56	3.06	**149.05**	**200.81**
	(0.72)	**(3.21)**	(0.39)	(0.04)	**(4.30)**	**(3.88)**
α_2	−0.66	−9.55	−12.13	**86.77**	**106.54**	**143.31**
	(0.02)	(−1.16)	(−0.76)	**(1.62)**	**(4.30)**	**(3.87)**
β_1	**$-9.78 \cdot 10^{-4}$**	$-2.29 \cdot 10^{-4}$	$1.11 \cdot 10^{-4}$	$-1.93 \cdot 10^{-4}$	$6.90 \cdot 10^{-4}$	$7.41 \cdot 10^{-4}$
	(−1.62)	(−1.28)	(0.33)	(−0.17)	(1.30)	(0.93)
β_2	**$-2.09 \cdot 10^{-3}$**	**$-3.77 \cdot 10^{-4}$**	**$-1.66 \cdot 10^{-3}$**	$-1.58 \cdot 10^{-3}$	$2.03 \cdot 10^{-4}$	$-4.59 \cdot 10^{-4}$
	(−3.09)	**(−1.94)**	**(−4.35)**	(−1.27)	(0.33)	(−0.52)
β_3	$3.11 \cdot 10^{-4}$	$1.89 \cdot 10^{-4}$	$2.42 \cdot 10^{-4}$	$-7.54 \cdot 10^{-5}$	$3.83 \cdot 10^{-4}$	$2.45 \cdot 10^{-4}$
	(0.70)	(1.48)	(0.95)	(−0.09)	(0.97)	(0.42)
β_4	$-5.94 \cdot 10^{-5}$	$-1.11 \cdot 10^{-4}$	$-2.44 \cdot 10^{-4}$	**$-2.24 \cdot 10^{-3}$**	$-4.50 \cdot 10^{-4}$	**$-9.83 \cdot 10^{-4}$**
	(−0.13)	(−0.83)	−(0.93)	**(−2.52)**	(−1.09)	**(−1.60)**
β_5	$2.76 \cdot 10^{-5}$	$1.75 \cdot 10^{-6}$	$-3.80 \cdot 10^{-6}$	$5.89 \cdot 10^{-5}$	$1.96 \cdot 10^{-5}$	$-3.55 \cdot 10^{-5}$
	(0.38)	(0.08)	(−0.09)	(0.89)	(0.30)	(−0.37)

Note: *t*-ratios in parentheses; the coefficients reported in bold are significant.

have as a dependent variable the out-of-the-money, the at-the-money and the in-the-money revision of the implied volatility between $(t-1)$ and (t), respectively. The last three (*effect of the current variance*) have instead as a regressand the difference between the out-of-the-money, the at-the-money and the in-the-money implied volatility and the conditional variance as of time (t); the latter comes from a GARCH(1,1) model applied to the residual of a regression of the logarithmic rates of change of the Btp price on a constant and a one-period lag of the same series. Table 3 shows the results.

In all of the 11 cases in which the coefficients are significant, the sign is always as expected, with unscheduled news taking up a positive value and scheduled news influencing negatively the expected variance. The effect of unscheduled news, as measured by α_1 and α_2, turns out to influence the absolute change of the implied volatility (i.e. the revision of volatility) only for at-the-money options, in the case of bad news; owing to this, the implied volatility over the life of the option tends to rise in reaction to bad news, but it is not influenced by good news. Among the scheduled news, the difference between the current consumer prices observed in a sample of towns and an average of the past two realizations of such index leads to significant revision of the average expected variance, for the in- and out-of-the-money options; the associated coefficient is negative, which supports the idea that volatility tends to fall on days with scheduled announcements; there is also a marginal significance of news regarding the overall consumer price index on the revision of the out-of-the-money volatility. Among the remaining scheduled news, the effects of the T-bill auctions and the repo rates are not significant.

The occurrence of unscheduled news influences much more significantly the first EL's component, i.e. the difference between the implied volatility and the conditional volatility as of time (t) (the latter being estimated from a GARCH(1,1) scheme) than the revision of the implied variance. This is true especially for the at-the-money and the in-the-money options, where bad news increases volatility more than good news, hence revealing the presence of the leverage effect originally noted by Black (Nelson, 1991). For out-of-the-money options there is only a marginal effect of good news on the revision of the expected variance. Among the scheduled news the innovation related to the repo rates is the only variable which turns out to be significant, above all for the out-of-the-money options and, more marginally, for the in-the-money ones.

To summarize, the results confirm the findings of EL for at-the-money options, namely that expected volatility increases in days with unscheduled news. Among the scheduled news, only consumer prices tend to reduce the average expected variance. Both types of news (scheduled and unscheduled) are instead more significant in explaining the difference between the average expected variance over the option's life and the conditional variance as of time (t). This latter result indicates that news contributes to explain above all the amount of volatility observed at time (t) and instead has much less influence on the average expected variance; only for at-the-money options this influence becomes relevant. Since the out-of-the-money and the in-the-money implied volatilities are affected only marginally by scheduled or unscheduled news we can conclude that the latter do not affect the distribution of the implied volatility (as synthesized by the fourth moment of the Btp price changes, i.e. by the variance of the variance), but only its expected value.

Table 4 shows the results of the ordinary least squares regressions of the two slopes and the skewness of the

Table 4. *The effects of news on the volatility smile of long term rates*

	Slope of the out-of-the-money branch	Slope of the in-the-money branch	Skewness of the volatility smile
μ	$2.68 \cdot 10^{-5}$	$3.32 \cdot 10^{-5}$	$6.34 \cdot 10^{-6}$
	(0.95)	(0.60)	(0.12)
α_1	−27.70	−7.90	19.80
	(−1.45)	(−0.21)	(0.56)
α_2	−2.58	8.89	11.47
	(−0.19)	(0.33)	(0.45)
β_1	$3.34 \cdot 10^{-4}$	$-7.56 \cdot 10^{-4}$	$\mathbf{-1.09 \cdot 10^{-3}}$
	(1.13)	(−1. 32)	**(−2.00)**
β_2	$\mathbf{-1.28 \cdot 10^{-3}}$	$\mathbf{-1.72 \cdot 10^{-3}}$	$-4.36 \cdot 10^{-4}$
	(−3.91)	**(−2.67)**	(−0.72)
β_3	$5.27 \cdot 10^{-5}$	$1.22 \cdot 10^{-4}$	$6.89 \cdot 10^{-4}$
	(0.24)	(0.29)	(0.17)
β_4	$-1.32 \cdot 10^{-4}$	$5.22 \cdot 10^{-5}$	$1.84 \cdot 10^{-4}$
	(−0.58)	(0.12)	(0.44)
β_5	$-5.55 \cdot 10^{-6}$	$2.58 \cdot 10^{-5}$	$3.14 \cdot 10^{-5}$
	(−0.16)	(0.38)	(0.48)

Note: *t*-ratios in parentheses; the coefficients reported in bold are significant.

volatility smile on the dummy variables which record the arrival of scheduled and unscheduled news, reported in Equations 9–11. In these cases unscheduled news have no effect, which implies that economic agents revise their expectations of at-the-money, out-of-the-money and in-the-money implied volatilities by a similar percentage. As far as scheduled news are concerned, again only the information regarding consumer prices is able to change the slope and the skewness of the volatility smile: the overall index affects the skewness while the index recorded in a sample of major towns significantly modifies both the in- and the out-of-the-money slopes. The three coefficients are negative in all cases which indicates that news are indeed able to reduce uncertainty, as evidenced by a reduction of the difference between out- and at-the-money and between in- and at-the-money volatilities.[5]

IV. CONCLUSIONS

The paper has analysed the impact of scheduled and unscheduled news on the implied variance of long term rates, a measure derived from the prices of options written on the Btp futures traded at LIFFE. Under the null hypothesis that news helps create or resolve uncertainty the paper has tested whether the shape of the volatility smile changes significantly in relation to the arrival of such news. The three extreme points of the volatility smile, corresponding to the volatility implied in the deepest in-, the deepest out- and the at-the-money options, are affected by the arrival of news; the same happens for the two slopes of the volatility smile, i.e. the difference between out- and at-the-money volatility and between in- and at-the-money volatility, which are influenced above all by the unscheduled news and by those related to the consumer price index innovations. The skewness is only affected by consumer price index news and does not react to the arrival of unscheduled or other scheduled news. The paper provides evidence in favour of the hypothesis that news may help resolve uncertainty: however, their effect is much more evident on the current conditional variance, whereas it influences only marginally the expected variance over the life to maturity of the option.

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[5] Analogous regressions run for options on the eurolira futures (3-month rates) are much more difficult to interpret according to the hypotheses developed in the paper (data are not discussed concerning the level and the change of the implied volatilities in days characterized or not by the occurrence of news, which did not favour the hypotheses). There is no effect of both scheduled and unscheduled news on the revision of the implied variance, but the same variable marginally affects the current volatility; as concerns the scheduled news, only that regarding the T-bills auction, and much more marginally the consumer price index, influences the revision of the implied variance; however, in all cases, they have the wrong sign, i.e. their coefficients are positive.

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