Evolution of Market Uncertainty Around Earnings Announcements

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Résumé
Cet article propose une analyse, théorique et empirique, de l'évolution de la volatilité implicite autour des dates d'annonce de bénéfices. La volatilité implicite (ISD) peut être interprétée comme l'anticipation du marché du niveau moyen de volatilité instantanée d'une action jusqu'à l'expiration de l'option. Dans ce cadre d'analyse, cet article propose un modèle d'évolution de l'ISD tenant compte de deux caractéristiques de la volatilité instantanée: la persistance de la volatilité et l'effet de levier. Ce modèle indique que l'ISD doit diminuer après une annonce de bénéfice excepté lors de la divulgation d'une mauvaise nouvelle. Dans ce cas, l'ISD devrait rester stable, voire même augmenter à la date d'annonce. Une analyse empirique est ensuite menée sur le marché helvétique sur la période 1989-1998. Dans l'ensemble, les résultats confirment les implications du modèle théorique.

Abstract
This paper investigates, theoretically and empirically, the dynamic of the implied volatility (ISD) around earnings announcements dates. The volatility implied in option prices can be interpreted as the market's expected level of volatility over the remaining life of the option. In this framework the paper proposes a theoretical model of the evolution of the ISD that takes into account two well-known features of the instantaneous volatility: volatility clustering and the leverage effect. The model indicates that the ISD should decrease after an earnings announcement except after a bad news where it should be stable or even increase. An empirical investigation is conducted on the Swiss market over the period 1989-1998. The results confirm the main implications of the theoretical model.

Evolution of Market Uncertainty around Earnings Announcements

1. Introduction

The impact of information disclosures on asset returns is the focus of many studies in financial economics. Since the seminal work of Ball and Brown (1968) most of the attention has been concentrated on the effect of information releases on stock returns. This literature generally finds that stock prices adjust relatively quickly to the information contained in earnings announcements which confirms the efficient market hypothesis. An issue which has received far less attention in previous research is the impact of firm specific news on the uncertainty regarding the evolution of future stock prices. Different methods are available to estimate the volatility of stock prices but most of them reflect the past as they are based on historical data. The only forward-looking measure of market uncertainty can be obtained from derivative markets by computing the implied standard deviation from option prices. Our paper focuses on the behaviour of the implied volatility around earnings announcements and provides new results about how the market participants perceive changes of future volatility around this event.

Patell and Wolfson (1979) are the first to investigate this issue both theoretically and empirically on the US market. Their theoretical model of the evolution of uncertainty is built on the work of Merton (1973) who states that the implied volatility represents the average instantaneous volatility until the expiration of the option if the instantaneous volatility is a deterministic function of time. This property is particularly interesting as it means that the behaviour of the implied volatility around earnings announcement dates depends on the expectations of market participants on the evolution of the instantaneous volatility until the expiration of the option. Patell and Wolfson (1979) assume that the instantaneous volatility is constant except on the disclosure date where it rises because of the uncertainty linked to the content of the announcement. If this is true, the pattern that should be observed in terms of implied volatilities is a rise before the announcement date, a peak on the day before the announcement and a fall to its long-term level on the disclosure date. They investigate empirically the evolution of the implied standard deviation (ISD) around annual earnings announcement dates on a sample of 83 events (28 firms quoted on the Chicago Board Options Exchange over the period 1974-1978). The ISD are computed from call options prices by inverting the Black-Scholes formula. The results display a pattern which is relatively similar to what they assumed, except that it takes several days for the ISD to decrease to its long-term level. Patell and Wolfson (1981) repeat the empirical investigation on a similar period but on a larger sample which also includes interim earnings announcements. Consistent with their assumptions they report a significant increase of the ISD on the 20 days before the announcement date and a significant drop two days after. Donders and Vorst (1996) investigate the same issue on the Dutch market. Their sample consists of 96 interim and annual earnings announcements of 23 firms over the period 1991-1992. Their results are more pronounced than those obtained for the US market in the sense that the implied volatility increases significantly during the pre-event period and reaches a maximum on the day preceding the announcement date. On the event date, they report a sharp decrease in the implied volatility and a strong increase of the instantaneous volatility which is consistent with Patell and Wolfson's assumptions on the evolution of ISD. Their results are qualitatively similar when adjusted for the market implied volatility. Finally, the authors simulate a trading rule based on the observed features of the ISD. Despite the large variations in the implied volatilities they report in their analysis, the investment strategies based on predictable changes in the ISD are not economically significant once transaction costs are taken into account. Donders, Kouwenberg and Vorst (1999) extend the previous study by considering more events on the Dutch market (190 earnings announcements over the period 1991-1993), computing the ISD from call and put options and analyzing microstructure features of the option market, as volume, open interest and spread. The conclusions are similar to those obtained in Donders and Vorst (1996) except that it takes two days for the ISD to decrease to normal levels.

Levy and Yoder (1993) and Ederington and Lee (1996) analyze the impact of another type of information on the ISD: unscheduled news. Earnings announcements are typically scheduled news as the date of disclosure is known in advance by market participants. However, many unscheduled news marginally or strongly affect stock prices: the announcement of merger with another company or the discovery of a new product are news which occurence cannot be anticipated by the market. In that case, the evolution of the ISD is different. In most cases, a rise in the instantaneous volatility is to be expected as the new (unexpected) piece of information induces uncertainty about the future prospects of a firm. This means that the ISD should increase on the announcement date and should not drop as for scheduled announcements. This is exactly what is found for options of target firms on the announcement of a merger and acquisition in the US by Levy and Yoder (1993) and for the ISD of options on futures on interest rates and exchange rates by Ederington and Lee (1996). The latter authors also confirm that the ISD decreases on days with scheduled news. They investigate this issue in a different framework as they study the impact of the US Government macroeconomic announcements on the ISD of options on interest rate and exchange rate futures.

Our paper extends the literature on the evolution of ISD around earnings announcements dates. It provides an alternative framework for analyzing the behaviour of ISD which is related to well-known empirical facts about instantaneous volatility i.e. volatility clustering and the leverage effect. Volatility clustering can be defined as the presence of autocorrelation in volatility. In other words, it means that a day with high (low) volatility is very likely to be followed by a day with high (low) volatility. The leverage effect has been first explicited by Black (1976) and is related to the way the instantaneous volatility reacts to past news. More precisely, the volatility has been shown to increase more after a negative (bad) news than a positive (good) news. This type of distinction on the informational content of the disclosure is common in the classical literature on the reaction of stock return to earnings announcements but has never been explored in studies on the evolution of the ISD.[1] This paper provides a theoretical analysis of these questions. It also documents them empirically over the period January 1989-May 1998, using daily data from markets where these issues have not been investigated so far: the Swiss stock and option markets.

The rest of the paper is organized as follows. Section 2 presents our propositions about the evolution of the ISD around earnings announcements and the testable implications of the model. Section 3 presents the data, the methodology for computing the ISD and the criteria used to discriminate between good and bad news. Section 4 provides the results of the empirical analysis performed on the Swiss market. Section 5 summarizes the paper and offers some concluding remarks.

2. Evolution of the ISD around earnings announcements

2.1. The theoretical framework

In order to predict the evolution of the ISD around earnings announcement it is necessary to give an economic interpretation of the implied volatility. Technically, the ISD is the volatility parameter which makes the option price obtained from a theoretical option pricing model equal to the option price observed on the market. More specifically, Merton (1973) states that an instantaneous volatility that varies deterministically through time is consistent with the classical Black and Scholes (1973) option pricing formula which assumes constant volatility. He asserts that in this case today's implied volatility, ISD_0, represents the average instantaneous volatility, $s^2(t)$, until t, the maturity of the option.[2]

$$ISD_0 = \frac{1}{t}\int_0^t s^2(t)dt \tag{1}$$

Heynen, Kemna and Vorst (1994) show that a similar interpretation holds, under simplifying assumptions, when the instantaneous volatility moves stochastically through time as in the model of Hull and White (1987) and also when the instantaneous volatility follows a GARCH process as in the model of Duan (1995). The implied volatility is therefore a forward-looking measure of uncertainty. It provides the market's assessment of the average volatility that will affect stock prices until the expiration of the option.

[1] If the realized earnings are above (below) market expectations, this is considered as good (bad) news and the stock price rises (drops) after such an event. For an illustration of this type of analysis, see Campbell, Lo and MacKinlay (1997, chap. 4).

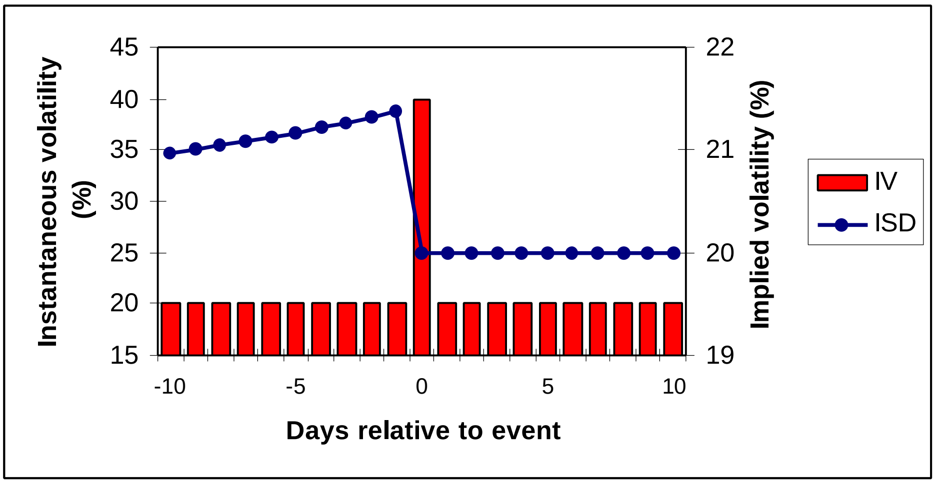
[2] Several papers test this relation empirically, more precisely they investigate whether the implied volatility is a good predictor of future realized volatility or not. See for instance Christensen and Prabhala (1998), Adjaoute, Bruand and Gibson-Asner (1998) and the references therein.

First we will review the standard model of evolution of the ISD that has been proposed in the literature.[3] In the case of a scheduled information investors know that some information will be released on a precise date, prior to the maturity of the option, and expect a higher instantaneous volatility on that day as there is uncertainty with the informational content of the announcement. Assuming that no other event occurs during this period, one would expect the implied volatility to significantly decrease after disclosure of some scheduled information. This should be accompanied by a higher instantaneous volatility (positive or negative price change) on the event date. This idea can be rewritten in a more formal way by defining s^2_{normal} as the level of volatility on a day without news announcement and s^2_{high} as the level of volatility on a day with scheduled information. The implied standard deviation ($ISD_{0,\tau}$) on day 0 is the average volatility until the maturity of the option τ:

$$ISD_{0,t} = \sqrt{\frac{t-1}{t} s^2_{normal} + \frac{1}{t} s^2_{high}} \tag{2}$$

where t is the number of days until the expiration of the option. Figure 1 depicts the evolution of uncertainty according to this set of assumptions. The bars represent the instantaneous volatility (IV) which is constant except on the announcement date and the line depicts the evolution of implied volatility (ISD). According to this model, the ISD should increase progressively and reach a peak on the day before the announcement as investors expect the instantaneous volatility to be higher on the earnings disclosure date. It should then drop to its long-term level on the announcement date as the uncertainty linked to the content of the announcement is resolved, assuming there are no further shocks on instantaneous volatility to be expected before the maturity of the option.

Figure 1: Standard model of evolution of ISD and IV around earnings announcements

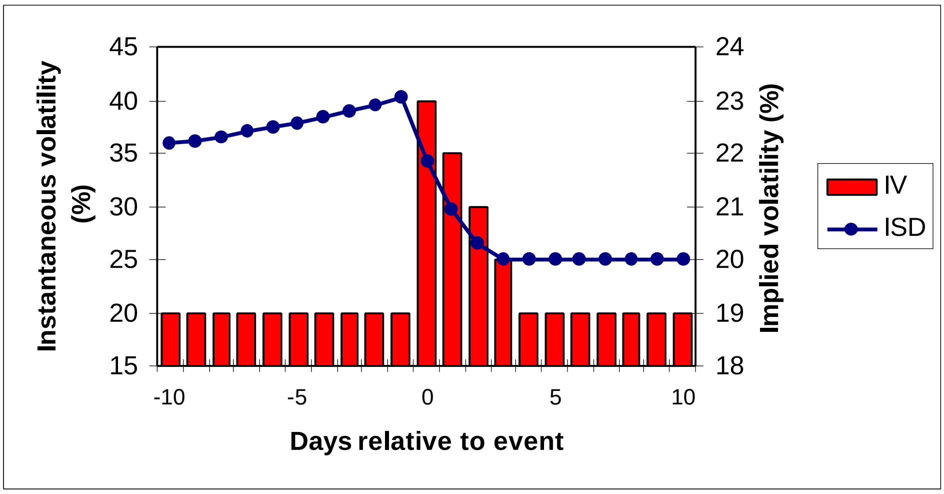


Note: IV is the instantaneous volatility and ISD represents the implied standard deviation. This figure is obtained assuming the following values of the parameters: the maturity of the option is 20 days after the event date, IV=20% except on the announcement date where it is equal to 40%. The ISD is obtained with the model described in equation (2).

[3] This is the model used in Patell and Wolfson (1979, 1981), Donders and Vorst (1996) and Donders, Kouwenberg and Vorst (1999).

For nearly two decades the empirical literature on the dynamic behaviour of volatility has recognized a certain number of stylized facts. One of these recurrent observations is that there is a certain persistence in shocks to volatility. This means that if volatility rises abruptly it takes some time before it returns to normal level.[4] In our context, it seems reasonnable to assume that higher volatility persists after a disclosure of information as it may take some time before the market participants interpret the content of the earnings announcement and reach a consensus about the future prospects of the firm on the basis of this new piece of information. This means that the instantaneous volatility may remain at slightly higher levels than the normal for some days. If investors expect this phenomenon to happen after an earnings announcement it will be reflected in the evolution of the ISD. Using the same type of graph as in figure 1 and according to the dynamics described by equation (1), we show in figure 2 how should the ISD be affected by this feature of the IV.

Figure 2: Evolution of ISD and IV assuming persistence in volatility



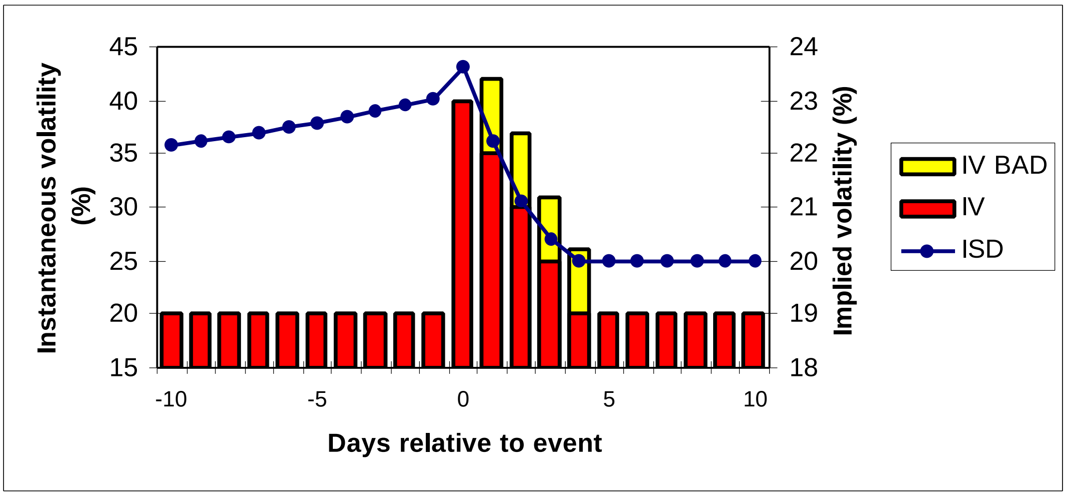
Note: IV is the instantaneous volatility and ISD represents the implied standard deviation. This figure is obtained assuming the following values of the parameters: the maturity of the option is 20 days after the event date, IV=20% except IV_0=40%, IV_1=35%, IV_2=30% IV_3=25%. The ISD is obtained with a discrete version of the model described in equation (1).

The first difference with the classical case is that the ISD is higher before the announcement date as investors expect that there is an increased instantaneous volatility some days after the event. The second difference is that the ISD decreases progressively to its long-term level. The number of days it takes to reach its long-term level depends on the degree of persistence of a shock to volatility. In figure 2, we assume that it takes 3 days. This volatility clustering phenomenon may explain why previous literature finds that in several cases the ISD decreases to its long-term level progressively and not on the announcement date only as assumed in the classical framework.

[4] See for instance the literature on GARCH models which is surveyed in Bollerslev, Chou and Kroner (1992)

A second well-known feature of the empirical literature on the dynamic of volatility is the so-called leverage effect already identified by Black (1976). This effect implies that a negative shock (a bad news) has a larger impact on volatility than a positive shock (a good news) of the same magnitude. In our specific case, this means that if there is a bad news (typically that the earnings of the company have been disappointing with respect to the expectations of the market) the instantaneous volatility may even rise after the announcement date. This will also change the behaviour of the ISD around the announcement date but in a different fashion than that proposed in figure 2. As the bad news is unexpected it cannot be accounted for before the disclosure date. It will increase the instantaneous volatility on the event date and the following days, but this will only be integrated in the ISD after the earnings have been disclosed. Figure 3 shows the behaviour of the ISD around a bad news.

Figure 3: Evolution of ISD and IV around a bad news earnings announcements



Note: IV is the instantaneous volatility, IV BAD is the instantaneous volatility induced by the revelation of a bad news on the announcement date and ISD represents the implied standard deviation This figure is obtained assuming the following values of the parameters: the maturity of the option is 20 days after the event date, IV=20% except IV_0=40%, IV_1=35%, IV_2=30% IV_3=25%. The ISD is obtained with a discrete version of the model described in equation (1).

IV represents the evolution of the instantaneous volatility assuming persistence (it is the same as in figure 2). IV BAD is the additional instantaneous volatility induced by the revelation of the unexpected bad news on day 0. As before, we assume that the additional volatility does not disappear immediately but is present for some time. This seems reasonnable as the market has to adjust to this unexpected information and has to analyze the new prospects of the firm. The effect on the ISD is unchanged up to the day before the announcement when the market is not expecting this bad news. On day 0, the market discovers the informational content of the announcement and expects a higher instantaneous volatility due to the bad news on the few days following the event. This is why the ISD rises on day 0 and decreases only on date 1. After this event it comes back progressively to its long-term level.

2.2. Testable implications of the model

The theoretical framework proposed above provides several testable implications. A common feature to all models of ISD behaviour around earnings announcement dates is that the ISD should rise until the eve of the earnings announcement. This is due to the fact that the market anticipates a shock to volatility on the event date whatever the informational content of the earnings announcement is. This defines the first testable implication of the model:

I1: *The ISD increases before earnings announcement date for all types of events.*

A second implication general to all the models is that the ISD returns to its long-term level after the information disclosure. In the case of a bad news this may not be true in the very short-term but after a few days it should also return to its long-term level once the market has adjusted to the new information. This defines the second testable implication:

I2: *The ISD decreases after the earnings announcement date for all types of events.*

The third implication is related to the difference between good and bad news. In the case of good news the model assumes that the ISD should fall on the announcement date as a large part of the uncertainty linked to the announcement is resolved. This defines I3.

I3: *For good news the ISD falls on the earnings announcement date.*

A way to discriminate between the classical model of evolution of ISD around earnings announcement and our model assuming volatility clustering is to observe the behaviour of ISD over a few days after the announcement date. If it drops on the event date and remains stable after that, this will favour the Patell and Wolfson assumption. On the other hand, if it continues to decline on the few days after the announcement date, this will support the model assuming persistence in shocks to volatility described (as in figure 2). The fourth testable implication is linked to information disclosures containing bad news. According to our model and depending on the behaviour of the instantaneous volatility after such events, we assume at least that the ISD should not decline on the event date. We therefore have the following implication:

I4: *For bad news the ISD does not decrease on the earnings announcement date.*

Whether these implications are verified in the markets is an empirical question. Volatility clustering seems to be present according to some previous results in the literature but the differential effect between good and bad news on ISD has never been considered before. The rest of the paper is devoted to the empirical investigation of these issues on the Swiss market, which is an independent sample of those considered in the previous literature.

3. The data

3.1. Stock prices and earnings announcement dates

The evolution of ISD around Swiss firms' earnings announcements is investigated using daily data over the period January 1989-May 1998. Our sample can be considered as representative of the Swiss market as it contains data on all the companies that have quoted options on the Swiss Options and Financial Futures Exchange (SOFFEX) and covers the market almost since its inception in 1988. Analyzing earnings announcements over a longer period than previous studies offers an important advantage as it covers various economic conditions which increases the probability of having all types of business conditions and therefore having earnings announcements with positive and negative content. We have data on 17 firms in the sample which are: ABB-BBC, Alusuisse, Ciba-Geigy, Ciba SC, Clariant, Crédit Suisse, Holderbank, Nestlé, Novartis, Roche, Sandoz, Swiss Ré, SBS, SMH, UBS, Winterthur and Zurich. Daily closing prices for stocks and the date and amount of dividends are retrieved from *Datastream International*. This is also the origin of the interest rate for the 1-month Euroswiss Franc contracts which is used to represent the riskfree rate.

Contrary to practice in the United States and similarly to most European countries, there is no publication or service in Switzerland which systematically collects the earnings announcement dates and their content. We obtained these dates by direct correspondence with the companies and we systematically checked them using the Swiss financial newspaper *Neue Zürcher Zeitung* and to some extent the *Reuters Business Briefing* database. Our final sample contains 178 events. During the period under analysis, the studied companies have announced earnings once or twice per year. As Swiss firms disclose earnings very regularly it is reasonable to assume that these events are fully anticipated by market participants. This is corroborated by the fact that different financial newspapers announce the date of the earnings announcements and that some investment services predict their content.

3.2. Option prices and computation of the ISD

The first attempt to evaluate the stock's future volatility with the ISD was made by Latané and Rendleman (1976). They match the observed option prices with those computed with the Black and Scholes (1973) formula to obtain the ISD. In our case, this formula appears inappropriate for the following reasons: the model assumes that the options are of European-type and that they do not pay dividends. The options on individual stocks of the Swiss market are American-type options on dividends paying stocks and could therefore be exercised prematurely. In order to take into account the early exercise premium of American options, the Roll-Geske-Whaley formula is the most appropriate.[5] This formula gives the value of an American call option on a stock paying a single dividend until the expiration of the option. Moreover, when there is no dividend during the remaining life of the option, this formula is equivalent to the Black and Scholes formula. Using the current call option price, underlying

[5] See Hull (1993, pp.244-246).

stock price, riskless interest rate, exercise price and time to maturity of the option, the ISD is computed using a Newton-Raphson iterative search procedure. To overcome the problems related to the non-uniqueness of input data (various times-to-maturity and various exercise prices) of the stock ISD, most of the authors in this literature justify their choices with empirical evidence and seldom with theoretical arguments. In the empirical part of this paper, we compute the ISD from at-the-money call options close to maturity but with at least 20 days to maturity. The choice of using at-the-money options is mainly motivated by the fact that they are the most liquid and therefore avoid problems linked to liquidity and the non-synchronicity of stock and option prices.[6] The choice of a minimal maturity of 20 days is motivated by the fact that the ISD computed with options very close to maturity presents some unusal behaviour.[7]

3.3. Determination of good and bad news

In order to analyze the effect on the ISD of earnings disclosures with different informational contents, the total sample is partitioned in two sub-samples, the good news and the bad news, according to two partition criteria. The first is the difference between actual earnings per share (EPS) and the consensus (median EPS) forecasted by financial analysts surveyed by the Institutional Brokers Estimate System (I/B/E/S). The financial analysts' forecast error is obtained as follows: $\varepsilon = (EPS_t - FY_t)/ EPS_t$, where EPS_t represents the observed earnings per share on date t and FY_t the median forecasted earnings per share with a one-year horizon. This criterion is a classic unexpected earnings measure which seems to be a powerful indicator to identify the informational content of an earnings announcement, at least for the US market.[8] For other markets it may not be as accurate as shown by Benos and Rockinger (1998) for the French market. These authors have shown that another measure, the return on the announcement date which has first been proposed by Foster, Ohlson and Shefrin (1984) is more powerful to discriminate between the informational content of good and bad news. The idea is that the nature of news has many dimensions, the difference between expected and realized earnings is just one of them. The return on the other hand, captures the way the market has interpreted the announcement ex post. It will be our second measure to discriminate the informational content of the announcement. In our case, a drawback of using analysts' forecast errors is that it does not cover the totality of our sample. The I/B/E/S database provides informations on slightly less than 58% of our events (103 announcements) which reduces considerably our information set. Another problem is that I/B/E/S data are monthly data and therefore assume that analysts revise their estimates once a month. It may well be that before an announcement, analysts revise more frequently their estimates and that the difference computed with I/B/E/S data may not be the real surprise which happened on the event day. Other partition criteria have been used in the accounting and corporate finance literature. These are: the sign of the announced EPS, the sign of the difference between EPS_t

[6] Stucki (1992) reports that at-the-money options are the most actively traded options contracts on the Swiss exchange.
[7] See for example Patell and Wolfson (1981).
[8] For an illustration of this type of study see Campbell, Lo and MacKinlay (1997, chapter 4)

and EPS_{t-1}, the difference between EPS_t and ($\alpha + \beta \cdot EPS_{mt}$), (where EPS_{mt} represents the earnings of the whole market at time t, α and β are firm specific parameters estimated on a previous period). As these measures are only based on realizations of EPS and do not consider the market's expectations about earnings we do not use them to identify the informational content of earnings announcements.

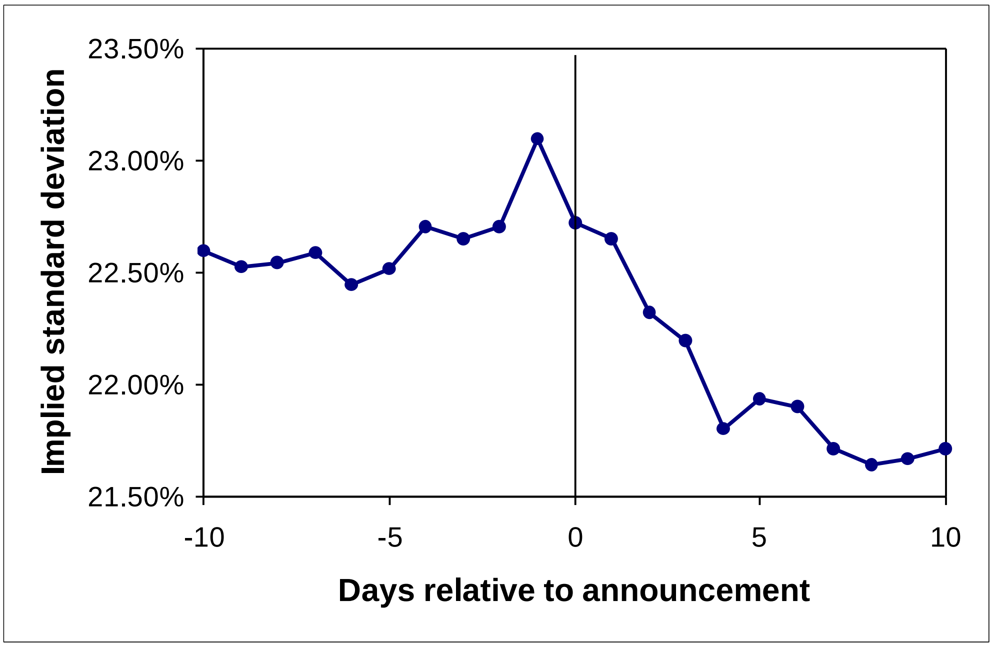
For both measures we use a breakpoint of -1% return or forecast error to separate bad news from good news. This choice is mainly motivated by the fact that the leverage effect has been documented for large negative shocks and should therefore not be present for small negative differences in returns or forecast errors. Moreover it is well established that the forecasts produced by analysts are most of the time too optimistic and that the forecast errors are on average negative.

4. Empirical results

4.1. Impact of earnings announcements on ISD

In a first step we analyze the evolution of the average ISD around earnings announcements on the whole sample of 178 announcements. More precisely, we compute the average ISD for an event windows of 10 days before and after the information disclosure. Figure 4 shows the evolution of the average ISD around the event date.[9]

Figure 4: Evolution of ISD around earnings announcements for Swiss firms



Note: The ISD is computed by applying the Roll-Geske-Whaley formula to at-the-money options with at least 20 days to maturity. Each point represents the average ISD over the 178 events on a particular day. Day 0 is the earnings announcement date.

[9] Our results are presented in terms of raw ISD. We also investigated the behaviour of market-adjusted ISD as proposed by Donders and Vorst (1996). All the results we obtain are qualitatively very similar to those obtained for raw ISD.

The results display a similar pattern to the one presented in figure 2. The average ISD slightly increases before the information disclosure indicating that the market expects some uncertainty on the event day. On the announcement date, the average ISD decreases for the next 4 days indicating some level of persistence in the instantaneous volatility and also the presence of events containing bad news. This is in contrast with the results obtained by Donders and Vorst (1996) who find that the ISD sharply decreases on the announcement day and those of Donders, Kouwenberg and Vorst (1999) which report a 2-day decrease. This could be explained by the fact that their sample is concentrated in 2 years and that the firms they consider mostly announced good news as there were in good economic conditions. As our sample is longer (9 years) it covers all types of economic conditions and it has more chances to contain firms which announced bad news.

In order to investigate more formally the results displayed in figure 1, we compare the level of ISD before and after the event in table 1. This table shows the average change in ISD on a given date before and after the event. For instance, in the mean column we observe that on average, the ISD is 3.85% lower 10 days after the event than 10 days before. Formal tests of these changes are provided by standard t-test on the mean and also by non-parametric tests on the median change. We also provide the percentage of cases (events) where there is a reduction of ISD after the event.

Table 1: Comparison of pre- and post-event ISD

Days $t_1 : t_2$	Mean (μ) of $\ln(\sigma_{t1}/\sigma_{t2})$	standard-deviation of $\ln(\sigma_{t1}/\sigma_{t2})$	t-stat (H_0: μ=0)	Median (M) change	Wilcoxon (H_0: M=0)	% of events where $\ln(\sigma_{t1}/\sigma_{t2})<0$
-1 : 0	-0.0179	0.0976	-2.44*	-0.0205	2.64**	56.18%
-10 : +10	-0.0385	0.1623	-3.16**	-0.0366	2.92**	57.87%
-9 : +9	-0.0379	0.1524	-3.32**	-0.0242	2.71**	55.06%
-8 : +8	-0.0423	0.1623	-3.47**	-0.0257	2.92**	60.11%
-7 : +7	-0.0422	0.1520	-3.70**	-0.0302	3.43**	61.24%
-6 : +6	-0.0210	0.1582	-1.77*	-0.0174	2.06*	57.87%
-5 : +5	-0.0223	0.1673	-1.78*	-0.0126	1.50	55.62%
-4 : +4	-0.0387	0.1525	-3.38**	-0.0145	2.71**	57.87%
-3 : +3	-0.0187	0.1531	-1.63	-0.0186	2.11*	56.74%
-2 : +2	-0.0155	0.1217	-1.70*	-0.0174	1.88*	58.43%
-1 : +1	-0.0194	0.0990	-2.61**	-0.0094	2.71**	54.49%

Note: This table compares the change in ISD between date t_1 and t_2. The first column gives the average change in ISD, the second column its standard deviation and the third a t-test that the average change is equal to zero. The next column gives the median change and a non-parametric test that the median is equal to zero is in the fifth column. The last column gives the percentage of events with negative changes. ** indicates that a result is significant at the 1% confidence level and * indicates at the 10% confidence level.

The results indirectly confirm implications I1 and I2, in the sense that we observe that the post-event ISD is on average significantly inferior to the pre-event ISD. More precisely, the ISD is significantly inferior at the 1% (10%) level in 6 (9) out of 10 cases with parametric tests and also in 6 (9) cases with non-parametric tests. Moreove,r the proportion of cases with inferior ISD is always larger than 50%. This table confirms the results of figure 4 for the average change in ISD on the earnings announcement date. We observe that on average the ISD decreases by 1.79% and is significant according parametric and non-parametric tests. In order to document more precisely the evolution of ISD through time, we run different regressions using dummy variables. We regress the daily variation in ISD on a constant, a dummy variable for the event date and a dummy variable covering a post-event period or more formally:

$$\Delta ISD_{it} = a + bD_{event} + cD_{post,n} + e_{it} \qquad \textit{for i=1,...,178 and t=-9,...,+10} \qquad (3)$$

where $DISD_{it} = \ln(ISD_{it}/ISD_{it-1})$ is the daily variation in ISD for event *i* at time *t*. It contains the change in ISD for all the dates in our sample (we have 3560 observations in our total sample). D_{event} is a dummy which equals 1 on the event date and zero for all other dates. This coefficient measures the average variation on the event date. $D_{post,n}$ is a dummy which equals 1 for a *n*-day period after the event date and zero otherwise. It measures the average variation in ISD *n* days after the event. The results of these regressions are provided in table 2.

Table 2: Regression analysis of daily changes in ISD around earnings announcements

n	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
a	-.0011 (-0.60)	-.0003 (-0.14)	.0000 (0.04)	.0013 (0.69)	.0011 (0.54)	.0012 (0.58)	.0021 (1.02)	.0029 (1.32)	.0026 (1.15)	.0029 (1.21)
b	-.0168* (-2.24)	-.0176* (-2.34)	-.0180* (-2.39)	-.0192* (-2.55)	-.0190* (-2.51)	-.0191* (-2.52)	-.0200** (-2.64)	-.0208** (2.73)	-.0205** (-2.68)	-.0208** (-2.71)
c	-.0004 (-0.06)	-.0078 (-1.45)	-.0074* (-1.64)	-.0115** (-2.74)	-.0082* (-2.09)	-.0072* (-1.91)	-.0088* (-2.43)	-.0095** (-2.71)	-.0078* (-2.28)	-.0075* (-2.20)

Note: Every column gives the estimates of equation (3) for different lengths of the post-event period covered by the post-event dummy variable. Figures in parentheses are t-statistics. ** indicates that a result is significant at the 1% confidence level and * indicates at the 10% confidence level.

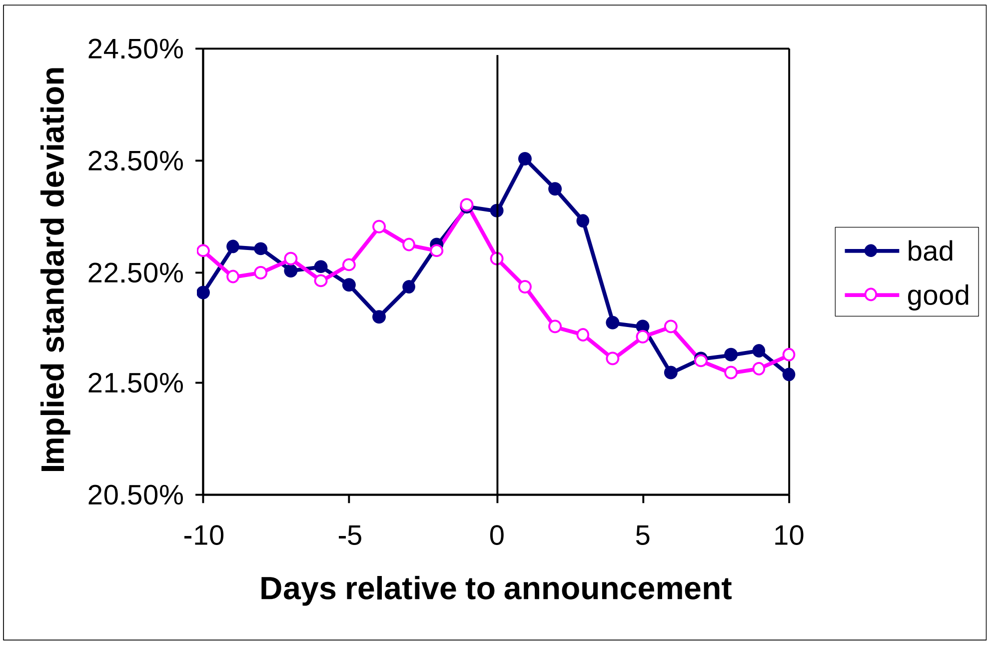
The constant *a* in equation (3) represents the average variation of days not covered by the variable D_{event} and $D_{post,n}$. For instance the first column provides the average variation of the ISD during two periods: the 10 days preceding the earnings announcement and the period running from day 2 to day 10 after the event date. The results for *a* in the last column are a direct test of I1, i.e. does the ISD increase before the event date? The results of the estimation indicate that the ISD increases on average at a rate of 0.3% per day but this figure is not significant. Looking closer at figure 4, we see that from days -10 until day -6 the ISD is flat and increases only from day -5 to day 1. This means that I1 is only weakly confirmed. The results in the second row give the value of coefficient *b* in equation (3) which is the average variation in ISD on the event date. They confirm the results in table 1 that there is a significant drop in ISD on the earnings announcement date. Analyzing the results for the coefficent *c* in equation (3) of the dummy $D_{post,n}$ we observe that it is negative for all days and that it is most of the time significant, which confirms implication I2 that the ISD decreases after the event when all types of announcements are considered. Moreover, as the decrease in ISD lasts several days, it confirms the presence of some persistence in shocks to instantaneous volatility after the event dates.

4.2. Dissociating between good and bad news using stock returns

We now investigate whether the ISD behaves differently according to the content of announcement as hypothesized in section 2. We first dissociate the events containing good news from those with bad news with the return observed on stocks on the announcement date. According to the return criterion, 45 events can be considered as having conveyed bad news and 133 can be been interpreted as unexpectedly good or at least with results which confirm the expectations of market participants. These events are considered as good news. As before, we compute the average ISD for both groups for 20 days around the earnings announcement date. The results are presented in figure 5.

We observe a behaviour of ISD which is generally in accordance with the implications of the model in section 2. In the case of good news, the ISD decreases slowly to its long-term level in 4 days after day -1.

Figure 5: Evolution of ISD for good and bad news according to stock returns



Note: The ISD is computed by applying the Roll-Geske-Whaley formula to at-the-money options with at least 20 days to maturity. Each point represents the average ISD over the 178 events on a particular day. Day 0 is the earnings announcement date. The bad news sample contains events having experienced less than –1% return on the event date.

On the other hand, after a bad news we observe that the ISD remains stable on day 0 and even increases in day 1. The decrease to its long-term level takes 2 days after the event. The results do not exactly match the prediction of section 2 but are relatively similar. As in table 1, the average level of ISD before and after the news is compared in table 3 for good news.

Table 3: Comparison of pre- and post-event ISD for good news

Days $t_1 : t_2$	Mean (μ) of $\ln(\sigma_{t1}/\sigma_{t2})$	standard-deviation of $\ln(\sigma_{t1}/\sigma_{t2})$	t-stat (H_0: μ=0)	Median (M) change	Wilcoxon (H_0: M=0)	% of events where $\ln(\sigma_{t1}/\sigma_{t2})<0$
-1 : 0	-0.0240	0.0982	-2.82**	-0.0291	3.17**	60.90%
-10 : +10	-0.0403	0.1621	-2.86**	-0.0357	2.41*	57.14%
-9 : +9	-0.0391	0.1517	-2.96**	-0.0306	2.40*	57.14%
-8 : +8	-0.0439	0.1672	-3.02**	-0.0269	2.52*	60.15%
-7 : +7	-0.0470	0.1569	-3.45**	-0.0395	3.25**	63.91%
-6 : +6	-0.0162	0.1609	-1.15	-0.0159	1.52	56.39%
-5 : +5	-0.0296	0.1613	-2.11*	-0.0149	1.59	56.39%
-4 : +4	-0.0531	0.1549	-3.95**	-0.0223	3.29**	62.41%
-3 : +3	-0.0357	0.1386	-2.97**	-0.0325	2.83**	60.15%
-2 : +2	-0.0280	0.1234	-2.62**	-0.0296	2.81**	63.91%
-1 : +1	-0.0338	0.0903	-4.32**	-0.0256	3.81**	58.65%

Note: This table compares the change in ISD between date t_1 and t_2 for events with a return on the event day larger than –1%. The first column gives the average change in ISD, the second column its standard deviation and the third a t-test that the average change is equal to zero. The next column gives the median change and a non-parametric test that the median is equal to zero is in the fifth column. The last column gives the percentage of events with negative changes. ** indicates that a result is significant at the 1% confidence level and * indicates at the 10% confidence level.

The results in table 3 show that the average and median level of ISD is systematically lower after the event than before which again indirectly confirm implications I1 and I2. Moreover, we observe that the magnitude of reduction in ISD is larger after the event for good news than for the whole sample. The decrease of ISD on the event date is also significant and larger for the good news than for the whole sample (2.40% vs. 1.79%) indicating that more uncertainty is resolved after a good news. This confirms implication I3. The same analysis is provided for events with bad news.

Table 4: Comparison of pre- and post-event ISD for bad news

Days $t_1 : t_2$	Mean (μ) of $\ln(\sigma_{t1}/\sigma_{t2})$	standard-deviation of $\ln(\sigma_{t1}/\sigma_{t2})$	t-stat (H_0: μ=0)	Median (M) change	Wilcoxon (H_0: M=0)	% of events where $\ln(\sigma_{t1}/\sigma_{t2})<0$
-1 : 0	0.0002	0.0945	0.01	0.0180	0.16	44.19%
-10 : +10	-0.0395	0.1647	-1.60	-0.0457	1.65*	62.79%
-9 : +9	-0.0417	0.1562	-1.79*	0.0084	1.15	51.16%
-8 : +8	-0.0427	0.1484	-1.92*	-0.0091	1.40	62.79%
-7 : +7	-0.0356	0.1379	-1.73*	-0.0135	1.14	55.81%
-6 : +6	-0.0409	0.1500	-1.82*	-0.0199	1.49	65.12%
-5 : +5	-0.0077	0.1848	-0.28	-0.0046	0.26	55.81%
-4 : +4	-0.0050	0.1416	-0.23	0.0072	0.50	46.51%
-3 : +3	0.0232	0.1853	0.84	0.0176	0.61	48.84%
-2 : +2	0.0188	0.1108	1.13	0.0265	1.20	44.19%
-1 : +1	0.0230	0.1117	1.38	0.0200	1.10	44.19%

Note: This table compares the change in ISD between date t_1 and t_2 for events with a return on the event day smaller than –1%. The first column gives the average change in ISD, the second column its standard deviation and the third a t-test that the average change is equal to zero. The next column gives the median change and a non-parametric test that the median is equal to zero is in the fifth column. The last column gives the percentage of events with negative changes. ** indicates that a result is significant at the 1% confidence level and * indicates at the 10% confidence level.

The picture is radically different around bad news announcements. The first column shows that the post-event ISD is on average lower than in the pre-event period for days 4 to 10. Moreover, these averages are only marginally significant in 4 out of 7 cases. For days 3 to 1 the ISD is even higher after the announcement date than before although these averages are not statistically significant. On the event date, the ISD remains stable which means that, according to equation (1), some unexpected uncertainty has been introduced after the event, which would confirm our leverage effect explanation and implication I4. The results of the regression analysis are given in table 5.

Table 5: Regression analysis of daily changes in ISD around earnings announcements

n	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Results for good news (133 announcements)										
a	-.0002 (-0.12)	.0006 (0.27)	.0009 (0.41)	.0017 (0.78)	.0013 (0.56)	.0010 (0.43)	.0024 (0.99)	.0035 (1.37)	.0031 (1.18)	.0030 (1.11)
b	-.0238** (-2.72)	-.0246** (-2.81)	-.0249** (-2.84)	-.0258** (-2.93)	-.0253** (-2.88)	-.0250** (-2.84)	-.0264** (-2.99)	-.0275** (-3.10)	-.0271** (-3.05)	-.0270** (-3.03)
c	-.0094 (-1.24)	-.0126 (-0.01)	-.0105* (-1.96)	-.0118* (-2.37)	-.0078* (-1.66)	-.0056 (-1.25)	-.0086* (-2.02)	-.0100* (-2.42)	-.0081* (-2.00)	-.0072* (-1.79)
Results for bad news (45 announcements)										
a	-.0035 (-1.04)	-.0028 (-0.81)	-.0024 (-0.66)	.0001 (0.03)	.0004 (0.11)	.0017 (0.42)	.0014 (0.33)	.0013 (0.29)	.0013 (0.27)	.0024 (0.50)
b	.0037 (0.26)	.0030 (0.21)	.0026 (0.18)	.0000 (0.01)	-.0002 (-0.01)	-.0015 (-0.10)	-.0011 (-0.08)	-.0011 (-0.07)	-.0011 (-0.07)	-.0022 (-0.15)
c	.0263* (1.67)	.0065 (0.60)	.0018 (0.22)	-.0105 (-1.38)	-.0095 (-1.34)	-.0119* (-1.71)	-.0093 (-1.39)	-.0080 (-1.22)	-.0071 (-1.09)	-.0085 (-1.30)

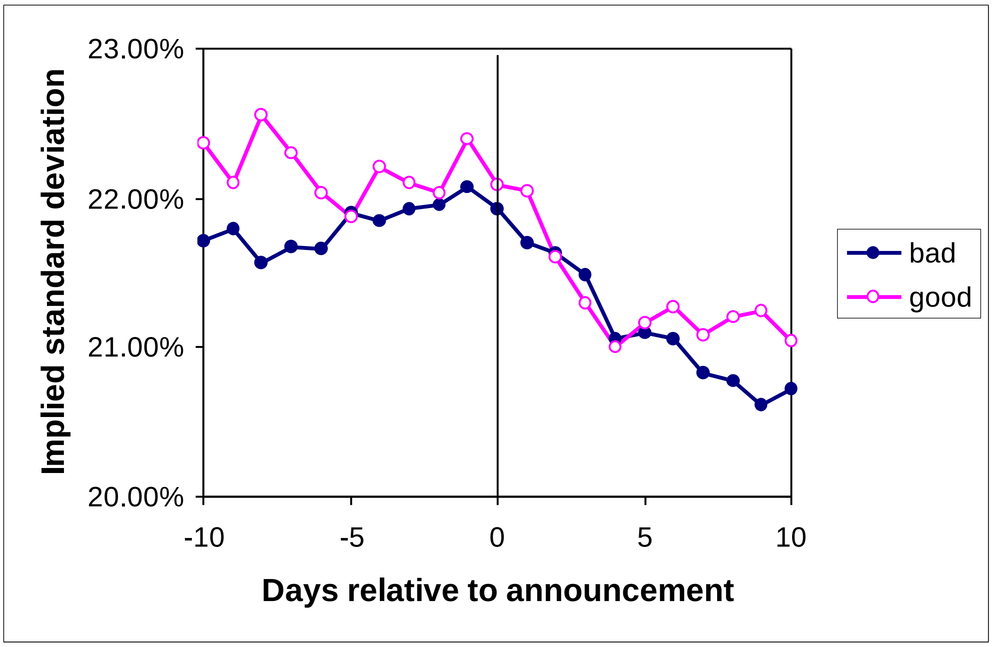
Note: Every column gives the estimates of equation (3) for different lengths of the post-event period covered by the post-event dummy variable. Figures in parentheses are t-statistics. ** indicates that a result is significant at the 1% confidence level and * indicates at the 10% confidence level.

The results in table 5 confirm those obtained in tables 3 and 4. We first observe that for good and bad news the pre-event period is characterized by a very modest positive average (the coefficient of *a* for *n*=10) but it is not significant. As for the whole sample this only weakly confirms I1. The table also reports a difference for the event date and post-event period. For good news, the decrease on the event date is significant and larger than for the whole sample which confirms I3. For bad news this coefficient is not different from zero which confirms I4. The post-event period also presents some differences. For the good news it is relatively similar to the whole sample as it is mostly negative and significant. For the bad news subsample we observe a rise on the first days after the event and then a decline but which is never significant after the earnings announcement. This is compatible with our leverage effect assumption.

4.3. Dissociating between good and bad news using analysts' forecast errors

A similar type of analysis is performed with events discriminated according to the analysts' forecast errors. The results, unfortunately cannot be compared with those of the previous subsection as the sample is smaller and data is available from the I/B/E/S database for 103 earnings announcement of our sample. Events conveying good and bad news are determined on the basis of analysts' forecast error. With this criterion 57 events can be considered as good news and 46 events are considered as bad news. The evolution of the average ISD is computed for both subsamples and the results are presented in figure 6.

Figure 6: Evolution of ISD for good and bad news according to analysts' forecast errors



Note: The ISD is computed by applying the Roll-Geske-Whaley formula to at-the-money options with at least 20 days to maturity. Each point represents the average ISD over the 178 events on a particular day. Day 0 is the earnings announcement date. The bad news sample contains events having forecast error inferior to -1% .

The graph in figure 6 is quite different from that obtained in figure 5. Both average ISD behave fairly similarly as they decrease on the announcement date and on the few next days. This seems to confirm the doubts previously expressed about the use of earnings surprise to discriminate between good and bad news. In order to ascertain this, more formal tests are provided for both subsamples. Tables 6 and 7 compare the behaviour of the ISD before and after the earnings announcements.

There is no significant difference between the results shown in tables 6 and 7. They look very much like those of the whole sample or of good news according to stock returns. The ISD appears to be lower after the event than before but this is less signficant than for the whole sample. It is however interesting to note that the decrease in ISD is not significant on the announcement date which could be due to the presence of events with non-negative change in ISD on the event date in both subsamples.

Table 6: Comparison of pre- and post-event ISD for good news

Days $t_1 : t_2$	Mean (μ) of $\ln(\sigma_{t1}/\sigma_{t2})$	Standard-deviation of $\ln(\sigma_{t1}/\sigma_{t2})$	t-stat (H_0: μ=0)	Median (M) change	Wilcoxon (H_0: M=0)	% of events where $\ln(\sigma_{t1}/\sigma_{t2})<0$
-1 : 0	-0.0133	0.0938	-1.07	-0.0063	0.82	50.88%
-10 : +10	-0.0540	0.1618	-2.51*	-0.0095	1.95*	52.63%
-9 : +9	-0.0378	0.1505	-1.89*	-0.0329	1.62	54.39%
-8 : +8	-0.0580	0.1775	-2.46*	-0.0356	2.12*	63.16%
-7 : +7	-0.0629	0.1444	-3.28**	-0.0440	2.70**	66.67%
-6 : +6	-0.0330	0.1395	-1.78*	-0.0243	1.93*	68.42%
-5 : +5	-0.0258	0.1768	-1.10	-0.0116	1.06	52.63%
-4 : +4	-0.0522	0.1470	-2.68**	-0.0268	2.35*	59.65%
-3 : +3	-0.0433	0.1560	-2.09*	-0.0500	1.98*	61.40%
-2 : +2	-0.0200	0.1034	-1.46	-0.0131	1.24	57.89%
-1 : +1	-0.0189	0.1152	-1.24	-0.0006	1.07	50.88%

Note: This table compares the change in ISD between date t_1 and t_2 for events with analysts' forecast error superior to -1%. The first column gives the average change in ISD, the second column its standard deviation and the third a t-test that the average change is equal to zero. The next column gives the median change and a non-parametric test that the median is equal to zero is in the fifth column. The last column gives the percentage of events with negative changes. ** indicates that a result is significant at the 1% confidence level and * indicates at the 10% confidence level.

Table 7: Comparison of pre- and post-event ISD for bad news

Days $t_1 : t_2$	Mean (μ) of $\ln(\sigma_{t1}/\sigma_{t2})$	Standard-deviation of $\ln(\sigma_{t1}/\sigma_{t2})$	t-stat (H_0: μ=0)	Median (M) change	Wilcoxon (H_0: M=0)	% of events where $\ln(\sigma_{t1}/\sigma_{t2})<0$
-1 : 0	-0.0134	0.1208	-0.75	-0.0257	1.47	56.52%
-10 : +10	-0.0656	0.1730	-2.57*	-0.0750	2.51*	63.04%
-9 : +9	-0.0841	0.1656	-3.44**	-0.0738	2.99**	63.04%
-8 : +8	-0.0748	0.1944	-2.61*	-0.0636	2.42*	60.87%
-7 : +7	-0.0519	0.1772	-1.98*	-0.0397	1.86*	63.04%
-6 : +6	-0.0338	0.1817	-1.26	-0.0269	1.15	56.52%
-5 : +5	-0.0472	0.1755	-1.82*	-0.0120	1.16	58.70%
-4 : +4	-0.0497	0.1660	-2.03*	-0.0210	1.59	60.87%
-3 : +3	-0.0170	0.1463	-0.78	-0.0055	0.78	52.17%
-2 : +2	-0.0146	0.1239	-0.79	-0.0181	1.08	58.70%
-1 : +1	-0.0213	0.1153	-1.25	-0.0210	1.36	52.17%

Note: This table compares the change in ISD between date t_1 and t_2 for events with analysts' forecast error inferior to -1%. The first column gives the average change in ISD, the second column its standard deviation and the third a t-test that the average change is equal to zero. The next column gives the median change and a non-parametric test that it is equal to zero is in the fifth column. The last column gives the percentage of events with negative changes. ** indicates that a result is significant at the 1% confidence level and * indicates at the 10% confidence level.

For the sake of completeness, we also provide the results of the regresssion analysis for both subsamples. They confirm the evidence found in tables 6 and 7. They show that the average drop in the ISD on the event date (*b* coefficients) are not significant. They also indicate that the average change in the ISD in the post-event period (*c* coefficients), although negative as postulated by the model, are not significant. The lack of statistical significance for these results can be attributed to the fact that both subsamples are relatively small and that more noise is present in the estimates in the sense that the individual ISD evolutions are more dispersed around the mean.

Table 8: Regression analysis of daily changes in ISD around earnings announcements

n	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Results for good news (57 announcements)										
a	-.0020 (-0.60)	-.0010 (-0.31)	.0001 (0.02)	.0007 (0.20)	.0005 (0.14)	-.0001 (-.02)	0.0012 (0.32)	.0006 (0.16)	-.0001 (-.03)	.0003 (0.06)
b	-.0114 (-0.89)	-.0123 (-0.96)	-.0134 (-1.05)	-.0141 (-1.10)	-.0139 (-1.08)	-.0133 (-1.03)	-.0145 (-1.13)	-.0139 (-1.08)	-.0132 (-1.02)	-.0136 (-1.05)
c	-.0036 (-0.27)	-.0104 (-1.03)	-.0139* (-1.69)	-.0135* (-1.75)	-.0101 (-1.39)	-.0066 (-0.93)	-.0090 (-1.34)	-.0065 (-1.00)	-.0043 (-0.68)	-.0045 (-0.73)
Results for bad news (46 announcements)										
a	-.0025 (-0.68)	-.0024 (-0.65)	-.0023 (-0.60)	-.0005 (-0.12)	-.0006 (-0.15)	-.0008 (-0.20)	.0003 (0.07)	.0027 (0.62)	.0028 (0.66)	.0016 (0.37)
b	-.0180 (-0.61)	-.0110 (-0.61)	-.0111 (-0.62)	-.0130 (-0.72)	-.0128 (-0.71)	-.0126 (-0.70)	-.0137 (-0.76)	-.0161 (-0.89)	-.0163 (-0.89)	-.0150 (-0.83)
c	-.0055 (-0.33)	-.0028 (-0.24)	-.0029 (-0.29)	-.0109 (-1.18)	-.0081 (-0.97)	-.0061 (-0.76)	-.0083 (-1.09)	-.0130* (-1.77)	-.0118* (-1.64)	-.0083 (-1.18)

Note: Every column gives the estimates of equation (3) for different lengths of the post-event period covered by the post-event dummy variable. Figures in parentheses are t-statistics. ** indicates that a result is significant at the 1% confidence level and * indicates at the 10% confidence level.

The fact that both subsamples present a similar behaviour when the nature of news is determined by the analysts' forecast errors indicates that the ISD does not react the same way to bad surprises in earnings as it does to negative return on the event dates. This is probably due to the fact that earnings surprises are just one dimension of the informational content of an earnings announcement. It may well be that a bad surprise is accompanied by an encouraging news for the prospect of the company which could compensate the bad news generated by results below those that were expected by the analysts. On the other hand, the return captures the way the market has reacted to the earnings announcement in all its dimensions. It could very well be that a negative return is associated to a positive earnings surprise. This is confirmed by a further analysis of both criteria as 73% of the bad news according to earnings surprise are considered as good news according to the return criterion and 57% of the good news according to the earnings surprise are considered as bad news according to the returns on the event date. These differences could also be due to the fact the earnings forecasts we use are revised every month and that the analysts may revise more frequently their forecasts before an earnings announcement. These more frequent revisions before an announcement date are therefore not reflected in our data and could be responsible for the lack of correspondence between both measures and the difference in results for the evolution of ISD.

5. Conclusions

This paper investigates the evolution of market uncertainty around earnings announcement dates, more specifically the behaviour of the volatility implied in option prices around these events. This volatility is widely regarded as the option market's forecast of future volatility over the remaining life of the option. Based on this definition previous literature has proposed a model of evolution of the ISD assuming that the instantaneous volatility increases on the day of the information disclosure and remains at a constant level for the other days. This paper proposes an alternative theoretical model based on empirical observations on the dynamics of the instantaneous volatility. The first is that there is some persistence in volatility, an increase in volatility on a day induces above average volatility on the few next days. The second is the so-called leverage effect which indicates that volatility rises after an unexpected bad news. The implication of the model are that it takes several days until the ISD returns to its long-term level and that after an earnings announcement with an unexpectedly deceiving content or interpeted as such by the stock market, the ISD does not decrease on the event day and remains relatively high before going back to its long-term level. These propositions are then empirically investigated on a comprehensive sample of firms having quoted options on the Swiss market over the period 1989-1998. The results indicate that the prediction of our model are verified in that it takes several days until the ISD returns to its long-term level after an earnings announcement confirming the presence of persistence in shocks to volatility. The leverage effect is investigated by partitioning our sample in two groups: the announcements with bad news and those disclosing good news. Two different criteria have been used to partition the sample: the return on the event date and the analysts' forecast errors computed with the I/B/E/S database. The results show that the ISD behaves differently and does not decrease on the event day with the partition based on the returns. When bad news are determined with the earnings surprise there is no difference in behaviour of the ISD. This may be due to the fact that the earnings surprise is not the sole determinant of the informational content of the earnings announcement and to the fact that analysts revise more frequently their forecasts before a company discloses its results. The conclusion of these investigations is that the behaviour of ISD reflects the presence of the leverage effect when bad news are defined as information causing large drops in stock prices on the earnings announcement date. One of the contributions of the paper is to show that the leverage effect which is usually documented for stock returns is also present in the volatilities obtained from option markets.

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