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Evaluating the Widening of Price Limits: Evidence from Tunisian Stock Exchange

Halim DABBOU, Higher Institute of Management Sciences, Sousse

Abstract
This article treats the price limits, a form of circuit breaker used by the stock exchange authorities to calm and stabilize the markets. We will evaluate the decision of widening of the price limits taken by the Tunisian authorities from 03-12-2007. Initially, we will study the change of the characteristics of securities returns after the widening of price limits. In the second time, we will have resort to approach ARIMA of Theobald and Yallup (2004) to measure the speed of adjustment of the prices before and after the date of the widening of price limits. In the third time, we will compare the price formation process before and after the 03-02-2007 by using the methodology of Kim and Rhee (1997).

Key words: price limits, the widening of price limits, excessive fluctuations, ARIMA approach.

1. Introduction

After the stock exchange crisis of October 1987 and Brady s' report (1988), several researchers suggested the introduction of a system of circuit breaker in order to protect the markets from the excessive fluctuations, by operating interruptions of quotation which can take several forms:

- price limits : they are limits of prices forced by the stock exchange authorities to reduce the variations day of the prices ; thus, the transactions can be carried out only if the price belongs to the pre-established interval. In the contrary case (the price is lower than the limit lower or higher than the higher limit), the stock is blocked for a certain period or until the end of the day and the transaction is blocked.
- the suspension of quotation of a particular stock: these suspensions are required by the authorities of market. The timing and the duration of the suspension are with the discretion of the authorities.
- the cut circuit of the whole of the market: it is a blocking system of all the transactions on the market for one period pre-specified if a given index of the market reaches a pre-established level.

Kim and Yang (2004) present a synthesis of the studies treating the various shapes of circuit breakers. They conclude that "we do not know" if the circuit breakers are useful for the markets. In spite of this conclusion, the majority of the markets is equipped with one or more forms of interruption of quotation. In particular, the narrow markets, which are generally order-driven call market, adopt the price limits system.

The main aim of the implementation of price limits is the reduction of the asymmetry information that is responsible for excessive volatility (Spiegle and Subrahmanyam (2000)), for the unwarranted trading uncertainty (Greenwald and Stein (1991)) and of the implementation risk (Kodres and O' Brien (1994)). The trading halts provide the investors more time to evaluate new information and the intermediaries time to consult their customers during strong turbulences periods. This system is judicious to induce more rational decisions and a reduction of over-reaction. It also limits the great price changes due to the speculation and panic in bearish period price.

The authorities hope thus that the prices become more informative, the uncertainty decreases and the non-informed investors will be protected from the excessive movements of price.

However, as point out it by Wong, Liu and Zeng (2009), several theoretical and empirical studies reveal negative effects:

- Delayed prices discovery highlighted by Fama (1989), Lehmann (1989) and Lee, Ready and Seguin (1994): since the trading halts prevent the prices from reaching new equilibrium, the revelation of information and the discovery of the prices are delayed.
- The volatility spillover highlighted by Kuhn, Kurserk and Locke (1991), Kim and Rhee (1997) and Kim (2001): the price limits increase the volatility in the days following the trading halts, since they prevent the immediate corrections and large price changes.
- The trading interference highlighted by Tesler (1989), Fama (1989) and Kim and Rhee (1997): the price limits can interfere with trading implying illiquidity and an intensification of trading the days following that the hitting limits.
- The magnet effect highlighted by Subrahmanyam (1994), Cho, Russel, Tiao and Tsay (2003): the price limits play a role of magnet by attracting the prices, as they get closer to the limits involving an intensification of trading and an increasing of volatility before hitting the limits.
- The price manipulation highlighted by Chen (1993), McDonald and Michayluk (2003): on the markets, the "large hands" can use the price limits to manipulate the not-informed investors. While pushing the prices to hit their limits for some days, several not-informed investors will be attracted by the halt trading and will think that an opportunity arises. These noisy traders tend to overreact and make volatility higher.

Following the majority of the narrow markets, Tunis Stock Exchange adopted price limits which were very tight during its emergence phase before widening them gradually.

In this paper, we will be interested to evaluate the decision of widening price limits carried out the 03-12-2007 on Tunis Stock Exchange. First, we analyze the impact of such decision on the characteristics of stock returns. Second, we will make resort with the speed of adjustment coefficients developed by Theobald and Yallup (2004) to study the impact of this change on the speed of adjustment of the prices.

Lastly, we will use the methodology of Kim and Rhee (1997) to study the impact of the price limits on the price discovery and trading activity before and after the change.

2. Study of the characteristics of return around the date of changement

After a presentation of the descriptive statistics concerning the price limits during the years 2005-2008, we present our database before finishing by a study of the evolution of the *skewness*, *kurtosis* and standard deviation of the stock returns before and after the widening of the thresholds.

Table 1: Statistics of the price limits during the period going 2005 to 2008 on the Tunis Exchange.

Group	Downward price movements	Upward price movements	Downward price movements	Upward price movements	Downward price movements	Upward price movements	Downward price movements	Upward price movements
11 (continuous)	11	40	2	7	2	15	78	133
12 (fixing)	110	86	34	39	10	36	85	130
13	49	30	15	10	10	10	30	24
Total	170	156	51	56	22	61	193	287

Table (1) as well recapitulates the number of price-limit-hit occurrences recorded for downward and upward price movements for the three groups (11, 12 and 13) during the years 2005, 2006, 2007 and 2008.

Beside the change of price limits at the 03-12-2007 and according to which the "maximum" limits passed from -4,5% to -5,91% for the fall and from 4,5% to 6,09% for the rise, the closing price for the securities quoted on group 11 is determined by a fixing as from August 2008.

The relatively high number of trading halts carried out during the year 2005 (compared with the years 2007 and 2008) is explained by speculative movements concerning some stocks which were in distress during the year 2005. Alone, the AMS knew 20 occurrences where lower daily price limits are reached and 20 occurrences where upper daily price limits are reached and the stock Tunisia Lait was halt during 47 days including 27 with the drop.

It is clear that illiquide stocks are more exposed to trading halt as shown by the difference between the number of trading halts on the continuous (groupe11) and those on fixing (groups 12 and 13). This difference can be

as explained by the mechanism of quotation as we only account the halts in end-of-day and that for fixing, the trading is made only two or three times per day.

The significant growth of the hitting lower price limits during the year 2008 (which knew a widening of the thresholds by the authorities) can be explained by the world-wide crisis which has affected Tunis Stock Exchange as from October 2008 and in particular during the day of 06-10-2008.

Moreover, the trading halts noted between 2005 and 2007 touched some stocks several times, whereas in 2008, the majority of the stocks reached their limits at least once. On the other hand, the increase of hitting upper price limits on all the compartments in 2008 remains difficult to explain unless the widening of price limits changed the behavior of the investors and attracted a type of intraday speculators.

2.1 Data

We retained only the stocks having quotations the two years period centered on the date of widening of price limits. We eliminated the stocks which are not frequently traded (less than 50% of the transaction days) in order to avoid possible bias caused by zero return. Our final sample is thus composed of 39 securities quoted on the principal market, mainly on the continuous one. The daily outputs were calculated on the basis of closing price adjusted.

2.2. Results and interpretations

For each treated variable we calculated the median before and after the 03-12-2007 then we had resort to the test of unilateral paired Student and to the Z-test applied to the difference between the series before and after the change, in order to validate or invalidate the assumption of equality of the average. After having treated the sample in its entirety, we divided it into two subsamples according to mode of quotation.

Table 2: Evolution of the characteristics of the stock returns classified by group of quotation one year before and a year after 03-12-2007. The probability reported in the table corresponds to the test of unilateral paired Student.

		Sample		**Groupe11 (continuous)**		**Groupe12 (fixing)**	
Variable	Period	Median	Test	Median	Test	Median	Test
	Total	0,199		0,224		0,007	
Skewness	Before	0,302	0,16	0,306	0,24	0,150	0,22
	After	0,130		0,150		-0,076	
	Total	2,188		2,120		2,224	
Kurtosis	Before	1,288	0,11	1,123	0,47	3,063	0,05
	After	1,859		1,750		2,551	
	Total	0,015		0,015		0,014	
Standard deviation	Before	0,013	0,00	0,013	0,00	0,012	0,01
	After	0,017		0,017		0,016	

Like table (2) shows it, the coefficient of asymmetry of the return dropped after the widening of price limits but the equality of the skewness coefficient before and after the 03-12-2007 was not rejected either by the paired test of Student or by the Z-test. The reduction in of information asymmetry was recorded independently of the quotation mode whereas the skewness became negative for fixing and approached zero for the continuous meaning evolution towards symmetrical distribution.

The increase of the kurtosis, recorded for the median and the average of our sample, is completely awaited since the widening of the price limits allows the prices stocks to reach extreme limits which were not reachable before and increases the probability that the prices move away from their expected values. But by analyzing the evolution of *kurtosis* for the two groups of quotation separately, we find that for fixing, the kurtosis rather decreased (the equality of the kurtosis before and after the change is rejected at the risk of 10% (5%) by the test of paired Student (the Z-test)) whereas for the continuous one it increased. The fall of the kurtosis for group 12 can be explained by the increase in the number of fixings per day which passed from two to three in 2008, the third fixing possibly facilitate obtaining a consensus on the market.

The widening of the price limits of reservation recorded a spectacular increase in the standard deviation of practically all stocks returns (approximately 30%), whatever their mode of quotation. Moreover the two tests used confirm the inequality of the standard deviation before and after the widening of the price limits.

3. Evolution the speed of adjustment of the prices after the widening of the price limits:

The speed of adjustment of the prices is a dimension of the market efficiency which was not very discussed in the literature contrary to two other dimensions: the amplitude and the direction (the sign). We will be interested in this dimension in the Tunisian context while trying to see whether the widening of the thresholds influenced it.

Amihud and Mendelson (1987) derive a direct measurement the speed of adjustment of information by breaking up the variance observed of the return into an intrinsic component and a component noise. They express the return as follows:

$$R_t = P_t - P_{t-1} = g\,(V_t - P_{t-1}) + u_t \qquad (1)$$

Pt is the observable price on the market at the moment t, expressed in logarithm.
Vt is the non observable intrinsic value at the moment t, expressed in logarithm.
$P_t - P_{t-1}$ represents the observable return during period t-1 and t.
g is the coefficient of adjustment of the price; it lies between 0 and 2. If the market does not react to information g will be null; on the other hand a value g ranging between 0 and 1 reflects a partial adjustment of information corresponding to under reaction. Inversely, a value g higher than 1 represents an over-reaction to information. Lastly, when g is equal to 1, we have a perfect adjustment to information.
u_t is a term of error determined by factors connected as well to the noisy trading (Black (1986)) such as the transitory needs for liquidity and a bad interpretation of information that to the market microstructure such as the fluctuations of the bid-ask spread and the discontinuity of the prices.

Whereas Amihud and Mendelson (1987) did not seek to estimate g, Damodaran (1993) drift an approach which can measure the speed of adjustment of information and which he applied to the stocks listed in the NYSE/AMEX and in also NASDAQ to be able to make comparison. Although they detected an error in the formulation of Damodaran (1993), Brisley and Theobald (1996) confirm that g can be used for measuring the speed of adjustment and thus testing the market efficiency.

Theobald and Yallup (2004) develop two estimators of the speed of adjustment derived from the autocorrelation functions which do not suffer, according to them, of 4 types of disadvantages developed in the literature: certain studies were limited to estimate the systematic component of the speed of adjustment instead of estimating it in integrality. Others did not derive a priori the sample distribution enabling them to carry out tests of significativity. The third type of problem ignored by certain studies is relative to non synchronization of transactions. Lastly, certain models require that the prices be completely adjusted with a well specified time interval, refuting the possible over or under reactions on longer intervals.

Under the assumptions of stationnarity of the processes of the return changes and of the noise and nullity of the crossed covariance between them, Theobald and Yallup (2004) find that:

$$1-g = \frac{\mathrm{cov}(R_t, R_{t-2})}{\mathrm{cov}(R_t, R_{t-1})} \qquad (2)$$

On the other hand, in the case of non synchronization of the transactions, due to the thin trading, a reformulation of the model is necessary:

$$1-g = \frac{\mathrm{cov}(R(m,t), R(m,t-2-q))}{\mathrm{cov}(R(m,t), R(m,t-1-q))} \qquad (3)$$

R (m, t) is the return observed exposed for an effect of non synchronization of the transactions and q is the longest delay which influences R (m, t)

Moreover Theobald and Yallup (2004) rearrange the model of adjustment of Amihud and Mendelson (1987) to find that the return can be expressed in the form of an ARMA (1,1) process with the coefficient AR (1) equal to (1-g). Thus as the coefficient AR (1) decreases (g converges towards one), the adjustment is faster and the market, more efficient. For example, in the event of integral adjustment (g=1), the return follows a MA (1) process. In fact, the term of the moving average MA (1) reflects either the effect of the bid-ask spread or the effect of the thin trading.

The authors check that by imposing the condition of stationnarity of the ARMA (1,1) model ($|1-g| \prec 1$), they find the conditions pre-established by Amihud and Mendelson (1987).

On the other hand in the case of non-synchronization of the transactions, the suitable model is of type ARMA (1, 1+q). Consequently, for the stocks which suffer from non-synchronization transactions because of the existence of thin trading the autocorrelation of the noises is more persistent.

In the bases of the conclusion of Theobald and Yallup (2004) which affirm that in general the ARMA method is more powerful than the method of ratio of car-covariance, we choose to use the first method.

3.1. Data

We retained only the stocks which have quotations during the period of two years centered on the date of widening of price limits.

After having eliminated the stocks which were not frequently exchanged (less than 50% of the days of transaction), we keep 39 securities quoted as well on fixing as on the continuous.

The daily returns were calculated on the basis of adjusted prices.

3.2. Methodology

- In order to estimate the speed of adjustment, we make resort to the equation used by Theobald and Yallup (2004) relative to a process ARMA (1,1).

$$R_{i,t} = c_i + \varphi_i R_{i,t-1} + \varepsilon_{i,t} + \theta_i \varepsilon_{i,t-1} \qquad (4)$$

Where $R_{i,t}$ is the return of stock i at the moment t.

φ_i is the autoregressive coefficient of order 1 which makes possible to the calculation of g of stock i (g=1- φ_i).

θ_i, is the coefficient of the moving average of order 1 which absorbs the effect of the bid-ask spread and non synchronization of the transactions.

We calculate then, the average of g on the whole sample, for the securities quoted on the continuous and the securities quoted on fixing as well before than after the date of the widening of the thresholds. A test of Student will enable us to validate or reject the assumption of total adjustment (g=1).

More ever, a unilateral paired test of Student will be used to test the equality of the coefficients before and after the date of widening of the price limits.

- In order to estimate the duration of complete adjustment of the prices, we re-estimate the initial model but with different time intervals (from 2 to 5 days).

The corresponding equation arises as follows:

$$R_{i,t} = c_i + \varphi_i R_{i,t-y} + \varepsilon_{i,t} + \theta_i \varepsilon_{i,t-1} \qquad (5)$$

Where y is there the interval of differentiation which will take values 2, 3, 4 and 5.

A test of Student will be used for the three sets of stocks in order to validate or not the assumption of complete adjustment.

To study the impact of the absence of transactions on the estimate the speed of adjustment, we compare the quality of adjustment of the data by the ARMA (1,1) process with that of the ARMA (1,2) process by using two criteria SC and AIC. If the ARMA (1,2) model dominates the ARMA (1,1) model, we confirm the impact of the absence of transactions on the estimate. In the opposite case, the results will mean that the absence of transactions does not have a notable influence on the estimate of the speed of prices adjustment of the information.

3.3. Results and interpretations

The results of the ARMA(1,1) model show that over all the period, 30% of the stocks have a negative AR (1) (thus a coefficient of adjustment higher than one) representing an over-reaction to information. On the other

hand, the average of the coefficients is lower than 1, as well for the whole of the period as over the two under-periods.

Whereas during the year which precedes the widening of price limits, on average only 81% of information are integrated in the prices the day of its arrival, the year which follows, the rate of information incorporation reaches the 89%.

The test of Student, applied to the whole of the stocks, shows that before the widening of the thresholds, the under-reaction is significant ($g \neq 1$). On the other hand, we cannot reject the assumption $g=1$ for the year which follows the widening of the price limits. Thus, the widening of the price limits improved the speed of adjustment of information and allowed a complete adjustment of the prices.

Sights the characteristics of the quotation system, we considered to be useful to distinguish between the securities quoted on fixing and those on the continuous.

Our results show that for the securities quoted on continuous, the widening of price limits was beneficial from the point of view of market efficiency since the speed of information incorporation has been accelerated (the rate of incorporation passed from 77% to 92%) and that the under-reaction disappeared (we cannot reject the assumption $g=1$ during the year which follows the widening of price limits).

For the securities quoted on fixing, the widening of the thresholds generated an under-reaction which did not exist a year before. In fact, before the widening of the thresholds, there was a total adjustment the day of arrival of the information which fell to 75% after.

According to Student test, we cannot accept the assumption ($g=1$); on the other hand, the unilateral paired Student test does not confirm the difference between the coefficients before and after widening of price limits.

By analyzing the results of estimate of ARMA (1,1) model for various intervals with differentiation for the stocks quoted on continuous and over the period which precedes widening price limits, we note that even after two days, the incorporation of information is still not total (it is on average equal to 96% but, statistically the coefficient is significantly different from one) and that it was needed 3 days for a complete integration of information. We also note, an over-reaction the 4th day, but which does not persist, since it disappears the next day.

For the period which follows the widening of price limits we note that during the five analyzed days, we cannot reject the assumption of total incorporation of information for the average of the stocks quoted on the continuous; on the other hand, we note that after two days, all the stocks recorded an incorporation of the information ranging between 82% and 113%, whereas the first day the rate of incorporation lay between 13% and 193%.

With regard to the stocks quoted on fixing, we note that after the widening of price limits, the speed of information adjustment is two days since we cannot reject the assumption $g=1$ for the second day; this average amounts to 95% compared with 75% at the second day. In the same way, we observe an over-reaction the fifth day after the information arrival. For the period which precedes widening of price limits, we record a correct average reaction during the analyzed period.

By using two criteria SC and AIC, we conclude the superiority of the ARMA (1,1) model compared to the ARMA (1,2) model. In addition, by carrying out individual comparisons, we note divergences between the two criteria in 28% of the cases. Whereas SC criterion shows the superiority of the ARMA (1,1) model for 75% of stocks, AIC criterion admits this result only for 50% of the stocks.

By analyzing the results for each category of stocks according to the mode of quotation, we note that the superiority of the ARMA (1,1) model is clearer for the stocks quoted on the continuous (which suffer less from the problem of thin trading). Moreover, for stocks quoted on fixing, the superiority of the ARMA (1,1) model is not obvious since it is not confirmed by AIC criterion.

Broadly however, the problem of non synchronization caused by the frequent absence of non transaction has only a limited influence on the estimate the speed of information adjustment.

4. Evaluation of the widening of price limits on the trading activity: nonparametric approach

The aim of this paragraph is to test the first three assumptions concerning the undesirable effects of price limits, before and after the widening of the thresholds, by using the nonparametric methodology of Kim and Rhee (1997).

4.1. Data

The study period is spread out between the 06-01-2005 and 31-12-2008. We chose a day frequency for the various tests. The database is published by the stock exchange of Tunis, that we adjusted (capital growths, splits and distributions of dividends). We retained only stocks quoted on continuous because those quoted on fixing suffer of illiquidity and are exposed to too frequent halts trading. Lastly, we also eliminated the stocks that are new listed.

We eliminated all the successive halts trading happened during a period inferior to 20 days, in order to avoid the problem of overlapping and interference between the hats trading, thus keeping, only the halt trading isolated. On the whole, the sample comprises 21 stocks.

4.2. Nonparametric methodology of Kim and Rhee (1997)

That is to say Pi,t adjusted closing price of stock i at the moment t. The return Ri,t can be defined as the logarithm of the difference between the closing prices two successive trading days:

Rit = Ln Pi,t - Ln Pi,t-1

To identify the moment of the hitting limits, we used Official Bulletins of Tunis Stock Exchange where the upper and down price-limit-hit are announced respectively by the letters H and B. Normally, the higher limit is reached when the closing price matches the closing price of the day before, plus the maximum allowable upward:

$$Pi,t = Sup(i,t) \geq Pi,t-1 *(1+Sup) \quad (6)$$

With Sup is maximum variation expressed as a percentage. Since December 3rd, 2007, it cannot be identified a priori in the Tunisian context anymore, because the thresholds became dynamic. We can however know his maximum value which is of 6,09%.

In a similar way, the lower limit is reached when the closing price matches the previous day's closing price minus the maximum allowable downward price movement:

$$Pi,t = Sdow(i,t) \leq Pi,t-1 *(1- Sdow) \quad (7)$$

With Sdow, the maximum allowable downward price movement, expressed as a percentage, is equal to 5,91%.

For reasons of comparison, the stocks which did not reach the thresholds are classified in two groups. The first group (while following the notations of Kim and Rhee (1997)) is composed of the stocks which reached at least 90% of Sup or 90% of Sdow; it is noted Stocks0,90. The second group, noted Stocks0,80, is composed of the stocks which reached at least 80% of the authorized maximum variation but without exceeding the 90%. The use of the Stocks0,80 group show that the difference between the group of stocks that reach their daily price limits and groups of Stocks0,90 is not due to the difference between the price changes on day zero, if no difference is observed between the two groups, Stocks0,90 and Stocks0,80.

a- Test of the volatility spillover hypotheses

We choose a 21 day event window centered on hitting limit day and going of t = -10 to t = + 10. The same step was adopted for the stocks which reach the limits of 90% and of 80% of the authorized maximum variation.

Two measurements of the variance are used:

- The most used measurement is the square of the return:

$$Vol_{i,t} = (R_{i,t})^2 \quad (8)$$

Where $R_{i,t}$ represents close to close return.

- Another measurement, Voli,t, using the highest and lowest prices of the day, is defined as follows:

$$Vol_{i,t} = \left[\frac{HIGH_{i,t} - LOW_{i,t}}{0,5(HIGH_{i,t} + LOW_{i,t})} \right] \quad (9)$$

Where $HIGH_{i,t}$ is the highest price of stock i at day t and $LOW_{i,t}$ the lowest price.

In the case of upper price-limit-price, we regarded the limit reached as being the highest price; in the same way, in the lower case we estimated the lowest price by the lower limit hit. On the other hand, if the stock is blocked throughout the day, we assume that volatility is equal to zero, which lead to downward bias in the estimated volatility the hitting day.

Volatilities are calculated for the group of stocks that reach their daily price limits ($Stocks_{hit}$) and the two groups Stocks0,80 and Stocks0,90 during the 21 day event window and are then compared by using the Wilcoxon signed-rank test for the two samples. The assumption of spillover is validated if stocks that reach their daily price limits have higher volatility than the others stocks normally during post limit hitting days.

b- Test of trading interference hypothesis

The same window and Wilcoxon test are used here, but applied to a proxy trading activity instead to volatility.

We preferred to adopt a methodology different from that of Kim and Rhee (1997) who used the day-to-day change of turnover ratio. Let us announce, that the existence of a high number of not-trading days for several stocks, obliged us to eliminate them from our sample, and that is likely to cause a bias in our results. Thus we took a turnover measures the ratio of the number of trading volume of each stock on a day given on the total number of his share outstanding. When we met trading volume excessively high, we replaced it by an arbitrary value of 100000 dinars, which corresponds to the floor of a transaction of block. A trading volume is considered to be extreme if it exceeds the average plus the standard deviation calculated over all the period.

The assumption of interference is validated when the trading activity of the stocks group that reach their daily price limits is higher than that of the two other groups, before and after, date zero.

c- Test of delayed price discovery hypotheses

In order to test the assumption of delay, we examine the dynamics of the prices around the opening and the closing of the market. If we note:

Oi,t, opening price of stock i the day t

and Pi,t,closing price of stock i the day t

Then, open-to-close return of stock i, the day t, can be written as follows:

$Rdi,t = Ln(Pi,t /Oi,t)$ (10)

and the close-to-open return is equal to:

$Rni,t+1= Ln(Oi,t+1 /Pi,t)$ (11)

Consequently, the open-to-open return is:

$Roi,t,t+1= Rdi,t + Rni,t+1$ (12)

Empirical analysis of the combinations [Rdi, T, Rni, t+1] during price-limit-hits on day 0 enables us to conclude to a delay in the price discovery.

On the basis of the fact that the return can be either positive (+), or negative (-), or no one (0), Kim and Rhee (1997) enumerated nine cases possible of combinations [Rdi, T, Rni, t+1] to know {[+, +], [+, -], [+, 0], [0, +], [0, -], [0,0], [-, +], [-, -], [-, 0]}.

For upper limi hits, the two configurations {[+, +], [0, +]} reflects a reinforcement of the tendency that il means price continuation, the configurations {[+, -], [0, -], [-, +], [-, -], [-, 0]} reflect an inversion of the prices whereas {[+, 0], [0,0]} corresponds to a stagnation of the prices (not of change).

For the lower limit hits, the cases {[-, -], [0, -]} is regarded as a continuation of the prices, the cases {[+, -], [0, +], [-, +], [+, +], [+, 0]} like a reversal of trend and finally the cases {[-, 0], [0, 0]} like a situation without change.

Since we use closing price and not the higher aund the lower price on the day {[-, +], [-, 0], [-, -]} are not possible configurations when the higher limit is reached. In the same way the return sequences {[+, -], [+, 0], [+, +]} are non-existent cases for the lower limit hits.

The calculation of the frequencies of the various remaining configurations for the three groups of stocks will permit to operate comparisons. The delayed price discovery hypotheses will be validated if we find more continuations of tendency for the Stockshit group than for the two other groups. This would imply that the price limits prevent the prices from reaching their equilibrium prices during the hitting day. A nonparametric standard binomial test is used to test the significativity of the difference between the two groups $Stocks_{hit}$ and Stocks0,90.

4.3. Results and interpretations

a- The spillover hypotheses

The study of the evolution of the volatility measured by the squared return, over all the study period confirms the spillover assumption for upper and lower limits. Like table *(1)* of the appendix shows, the day after trading halts, the volatility of the $stocks_{hit}$ is significantly higher than that of the stocks belonging to the two other groups.

For the three groups, we find that volatility reached its maximum on day zero, which is evident since the return achieved its maximum this day. Moreover, the group made up of the stocks which reach their price limits presents the highest maximum. We notice finally that the spillover of volatility, which is spread out over one day after the hitting day, is more marked for the lower limits.

Our results corroborate partially those of Kim and Rhee (1997), Tooma (2004) and Nath (2005) respectively on the Japanese markets, Egyptian and Indian.

The use of the second measurement of volatility provides us different results. For the upper limits, we detect a volatility of $stocks_{hit}$ lower than those of both others on day zero according to Wilcoxon test (table (3) of the

appendix). This result is explained by a bias caused by the trading halts concerning all the day and which underestimates real volatility. In addition we find averages of volatility, around the hitting day, very important compared with those of the two other goups but the difference is not statistically significant; on the contrary, the test used does not reject the assumption of inferiority of the volatility for the forth day at the risk of 5%. The non significativity of the difference is explained by a divergence of the results between the stocks.

For lower limits, with the risk of 5%, no significant difference was detected except for the day zero where the volatility of $Stocks_{hit}$ is largely higher than that of the two other groups.

Before:

For the two types of limits, we confirm the spillover hypotheses by estimating volatility by the first measurement, and we find that volatility is stabilized two days after the hitting day.

The use of the second measurement appears inappropriate to us in the Tunisian context because of the stocks illiquidity which generates an undervaluation of volatility. For the upper limits, we note that the average of volatility is much higher during the period which surrounds the hitting day but that the difference is not significant because of the stocks disparities; we can thus suspect a heterogeneity in nature of the trading halts. For the loxer limits, as table (2) of the appendix shows, the results appear aberrant since we find a volatility of the Stockshit group largely lower than those of the two other groups, during all the period surrounding the hitting day, whereas on the contrary, it is on average twenty times equal to the average volatility of the Stocks0,90 group. By inspecting the data, we found that for the majority of the titles, volatility is null around the hitting day.

In the case of arrival of bad information on the market, the opening price will condition the evolution of the day and there will not be a great intra day fluctuations, as if the consensus were reached for the remainder of the day. In fact, throughout the day, the investors will refuse to trade at a price different from the opening by fear to cause a trading halts with lower limits which will destroy their portfolios.

Afterwards:

We note that the widening of the price limits influenced the dynamics of volatility around the hitting day following a change in the investors behavior.

For the lower limits, we can affirm the presence of the volatility persistence after the trading halts: it was necessary four (five) days so that the volatility estimated by the first (second) measurement returns on its normal level. This result, completely unexpected, can be explained by the increase in the activity of speculation around the trading halts.

With regard to the lower limits, the first measurement of volatility shows us a persistence of volatility over a long duration which can be explained by the effect of the crisis of 2008 which at least indirectly has affected Tunis Stock Exchange. In fact, the reluctance to investe, the ambiguity and the stress which reigned at this period can explain this dynamics of volatility.

To finish, we can suspect the existence of a magnet effect on the Stock Exchange of Tunis since during certain days surrounding date zero, the volatility of the Stocks0,90 group was lower than that of the Stocks0,80 group. This result reflects a highher degree of information accuracy in case of great fall price. However, the hitting of the thresholds is accompanied by an increase in volatility.

The use of the relative difference between the highest and the lowest prices of the day (the second measurement), produces different results since no significant growth compared to the groups Stocks0,90 and Stocks0,80 was recorded at the same time (table (4) of the appendix).

In conclusion, we can affirm that the widening of price limits did not permit to achieve the goals generally discounted by the authorities, at least for the upper limits, since the spillover of volatility was accentuated to be spread out over a longer duration. Whereas for the lower price limits, we suspect the existence of a magnet effect.

b- The trading interference hypotheses

Once certain stocks are not trated daily, we preferred to analyze the turnover ratio rather than the day-to-day change of turnover ratio. Not only, the elimination of no-trading days of not-transaction can skew the results, but also we think that the use of growth rate is prone to criticism: it can bring us to erroneous conclusions since it is normal that following a big raise of trading volume on day t, a brutal fall will be enregistred at the following day t+1.

The results represented in the table (5) show that the market reaction in terms of volume varies according to the kind of limits. For the upper limits, we can validate the assumption of interference since the trading activity weakened the hitting day and two days front, in comparison with that of the Stocks0,90 group (comparable on the other hand with that of the Stocks0,80 group). Whereas the reduction of trading the hitting day can be explained partially by the freezing of the stocks during a certain time, preventing the investors to trade during all that day. The reduction which preceded is it accidental!

With regard to the lower limits no difference was recorded between the two groups $Stock_{hit}$ and Stock0,90 excepect for day zero where the test of Wilcoxon does not reject the inferiority of trading of stocks which reach their price limits compared to stocks belonging to the group Stock 0,90, at the risk of 5%. On the other hand, we find that during several days surrounding date zero, the trading activity is less important for the Stock0,90 group than for the Stock0,80 group what calls into question any linear relation between volume and return. In fact, for the extreme negative variations of the prices, the investors will hesitate to trade by hoping that the tendency will change and that their losses will not be final. Several behavioral theories (over-confidence, for example) confirm such behavior.

The difference noted between the upper and lower limits can be also explained by the prohibition of the short sale on the Tunisian market and thus the limitation of the speculation in the case of prices fall.

Before:

Contrary to the stocks of the groups Stock0,90 and Stock0,80, the stocks that reach the upper limits knew an abnormal trading activity around date zero and in particular the hitting day and a day afterwards. In fact, their trading volume is considered to be lower than that of the group Stock0,90, on day zero but higher the following day (table (6) *of the appendix*).

For the stocks that reach the lower limits, no difference between the two groups $Stock_{hit}$ and Stock0,90 were noted. We conclude that the trading interference hypotheses cannot be accepted for the lower price limits, contrary to the case of upper limits.

Afterwards:

For the upper limits, the widening of the thresholds reduced the differences between the two groups Stockhit and Stock0,90 with regard to the trading activityon day zero; the trading interference is thus limited, at the period of pre-trading halts. In fact, with this increase in the thresholds, the investors are less constrained and they can trade with an almost normal frequency (table (6) of the appendix).

For the lower limits, the rejection of the assumption of trading interference is confirmed and the dynamics of the trading volume of the Stock0,90 are more approached to the Stock0,80 group, while exhibant a lower volume for days -2, +3 and +9.

We conclude, that the widening of the thresholds reduced in a marginal way the trading interference which relates to only the upper limits.

c- The delayed price discovery hypotheses

Before breaking up the sample into two sub periods separated by the date of regulation change, we carried out calculations on the total period. The table (7) of the *appendix* presents the frequency of continuation, inversion and stagnation of the closing prices for the three groups of stocks.

For the upper limits, the probability of trend continuation is almost the same for the three groups of stocks, contrary to that of trend reversal which is significantly higher for the stocks that reach the limits making thus weaker, the probability of stagnation. Since the tendency did not continue abnormally beyond the thresholds, the assumption of delayed price discovery can only be rejected. On the other hand, the excessive reversal caused by the thresholds can be explained either by the magnet effect or by price handling.

For the whole of the stocks that reach the lower limits, the continuation frequency is about 30%, whereas that of reversal is of 68%. For the stocks belonging to the group Stocks0,90 (stocks0,80), the continuation frequency exceeds the 54% (52%), thus rejecting the assumption of delayed of price discovery. The nonparametric binomial test used rejects the assumption of equality of the continuation frequency, reversal and stagnation for the stockshit group, compared with both others.

Since the trend reversal is the configuration most frequently observed for the stocks that reach the limits, we can affirm that the thresholds limited overreaction of the investors. On the other hand, this overreaction of investors is difficulty explained by handling in the case of the price falls, sight prohibition of the short sales on Tunis Stock Exchange.

Before:

Tables (8) and (9) of the appendix synthesize the results found concerning the assumption of delayed price dicovery for the three samples before the date of change of the limits values.

The frequency of continuation is almost equal for the Stocks0,90 and (57% against 63%) $stocks_{hit}$ (59% against 58%) whereas it is weaker for stocks0,80 (47%) but the difference is not statistically significant. The stocks hitting the upper limits are likely more to reverse their tendency, compared with the stocks belonging to the two other groups, which have a higher frequency of stagnation.

These results coincide with those obtained for the all analysis period. Seen the tight limits (which did not exceed 4,5% for the securities marketable quoted on the continuous one) and the importance of the costs of transaction (between 0,4% and 0,8% of the amount of the transaction in brokerage fees, plus a stock exchange commission of 0,2% and the VAT), we draw aside the idea of an intensive intra-day intervention of the speculators; on the other hand it is extremely probable that certain investors used the thresholds to draw the attention of the other investors while making the stock more visible.

For lower limits the frequency of continuation is largely weaker than that found for the total period (14% against 29%) whereas the frequency of reversal is much higher. Therefore, once the limit is hit, the tendency is reversed. Apart from the magnet effect which can explain such result we can think of an intervention of certain investors to maintain the prices.

At this level, we can affirm that there is not a delay of price adjustment caused by the price limits but quite to the contrary a trend of prices towards higher levels. It is clear that methodology used does not enable us to affirm if the new prices are equilibrium prices or transitorily (the shortly after the reservation), the market increased, to fall the following days.

Afterwards:

The frequencies of continuation, reversal and stability of the three groups of stocks during the period which follows the date of the 03-12-2007 as well as the associated statistical tests are presented in the tables (8) and (9) *of the appendix*. Although the study period was characterized by the world-wide crisis of 2008 which generated as well an escape of the Tunis Stock Exchange foreign investors as well as a fall of Tunindex as from October, the number of upper limit hitting knew an important jump compared with the other years. It is probable thus, that the activities of speculation and handling were accentuated during this period especially that the widening of the thresholds increased volatility and made it possible certain investors to practice a intra-day portofolio management.

The found results reject the assumption of delayed price adjustment and than they are not different from those found for the total period. Thus, the widening of the thresholds does not have affected the process of price adjustement of favorable information. For the lower limitsl, the widening of the thresholds made increase the frequency of continuation for the stocks hitting the limits (from 14% to 44%) until reaching the level of the two other groups. On the other hand, the difference between the $stocks_{hit}$ group and the two others reside at the level of the frequencies of reversal and stagnation. The prices of the stocks that reach the lower limits tend to increase rather than to remain stable compared with the stocks belonging to the other groups.

It seems that lower price-limit-hit during this period were caused by a revision of anticipations of the majority of the investors concerning the future prospects for the firms. Whereas the found results reject the assumption of delayed price discovery, the quasi majority of stocks listed on Tunis Stock Exchange did not cease falling during two months just after lower price-limit-hit.

5. Conclusion

By studying the evolution of the characteristics of stocks returns after the widening of the thresholds, we found that contrary to the *skewness* and the *kurtosis* which were not touched, the volatility of the stocks, measured by the return standard deviation, increased.

In addition, by using "approach ARIMA" of Theobald and Yallup (2004) allowing to measure the speed of price adjustment, we found that the widening of the thresholds improved the speed of price adjustment. This improvement related only to the securities listed on the continuous. On the contrary, the process of information integration was destabilized for the stocks quoted on fixing.

Lastly, while resorting to the methodology of Kim and Rhee (1997), we compared the price formation before and after the widening of the price limits. Our results show that for the upper price limits, the spillover of volatility was accentuated after the widening of the limits following a change in the behavior of certain investors and that the trading interference was reduced. We finally concluded, that the assumption of delayed price discovery is rejected for the two types of price limits before and after the widening of limits and that the magnet effect noted for the lower price limits disappeared after widening from the limits.

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Appendix
Table n°1: The volatility spillover (total period)

$$Vol_{i,t} = (R_{i,t})^2$$

This table provides average volatilities for each day for the 21- day period surrounding the event day 0 for the three stock groups.

>>>, >> and > indicates that the number on the left is higher than that on the right on a level of significance of 1%, 5% and 10% respectively.

	Upper limit reaches						Lower limit reaches				
	hit		90		80		hit		90		80
-10	0,695		1,319		0,585	-10	0,684		0,641		0,975
-9	0,574		0,614		0,645	-9	0,701		0,512		0,560
-8	0,983	>>	0,365	<<	1,100	-8	1,220	<	0,877		0,765
-7	0,658		0,480		0,850	-7	0,676		0,734	<	0,968
-6	0,710		0,517		0,871	-6	0,967		0,723		0,734
-5	0,699		0,482	<	0,774	-5	1,164		0,744	<	1,158
-4	0,690		0,783		0,700	-4	0,720		0,769		1,014
-3	0,661		0,594		0,829	-3	1,129		1,261		1,280
-2	0,683		0,773		0,695	-2	0,923		1,055		1,722
-1	1,197		1,446		1,678	-1	1,254		1,012		1,449
0	4,407	>>>	4,195	>>>	3,107	0	5,077	>>>	2,630	<<	3,847
1	2,454	>>	1,174		0,734	1	3,181	>>>	0,745		1,361
2	0,858		0,634	<	0,706	2	1,109		0,762		0,933
3	0,753		0,599		0,856	3	0,560		0,556		0,648
4	0,665		0,492		0,692	4	1,046		0,853		0,826
5	0,863		0,516		0,952	5	1,079		0,827		0,857
6	0,614		0,467	<	0,792	6	1,002		0,763		1,885
7	0,650		0,504		1,188	7	1,195		0,693		0,674
8	0,669		0,560		0,535	8	0,945		0,624		0,565
9	0,567		0,472		0,786	9	0,926		1,528		0,486
10	0,529		0,534		0,444	10	0,896		0,593		0,627

Table n° 2: Volatility spillover (before and after 03-12-2007)

$$Vol_{i,t} = (R_{i,t})^2$$

This table provides average volatilities for each day for the 21- day period surrounding the event day 0 for the three stock groups.

>>>, >> and > indicates that the number on the left is higher than that on the right on a level of significance of 1%, 5% and 10% respectively.

Before	Upper limit reaches						Lower limit reaches				
	hit		90		80		hit		90		80
-10	0,532		1,560		0,693	-10	0,683		0,457		0,543
-9	0,543		0,743		0,451	-9	0,725		0,480		0,448
-8	0,889		0,482		1,002	-8	2,145	<	1,133		0,504
-7	0,713		0,462		0,956	-7	0,611		1,212		0,657
-6	0,735		0,459		0,637	-6	0,918		0,995		0,774
-5	0,525		0,371	<<	0,848	-5	1,431		0,928		1,069
-4	0,570		0,555		0,553	-4	0,876		0,914		1,090
-3	0,585		0,664		0,723	-3	1,263		1,925		0,884
-2	0,676		0,731		0,800	-2	0,633		0,665		0,393
-1	1,018	<<	1,562		1,770	-1	1,060		1,565		0,281
0	3,802	>>>	3,461	>>>	2,867	0	4,431	>>>	3,777	>>>	2,880
1	2,834	>>>	0,861		1,023	1	3,474	>>>	0,792		0,891
2	0,605		0,629		0,706	2	0,824		0,974		0,615
3	0,590		0,705	<	0,962	3	0,494		0,478		0,569
4	0,766		0,732		0,666	4	0,871		1,040		0,562
5	0,852		0,594		0,792	5	0,764		1,389		0,682
6	0,741	<	0,566	<	1,069	6	0,917	<	1,086		1,195
7	0,657		0,477	<	1,773	7	1,674		1,094		0,492
8	0,750		0,450		0,781	8	0,897		0,777		0,451
9	0,542		0,453		0,823	9	1,382		2,558		0,478
10	0,545		0,399		0,738	10	1,160		0,411		0,300
Afterwards	Upper limit reaches						Lower limit reaches				
	hit		90		80		hit		90		80
-10	1,002		0,201		0,483	-10	0,685		0,7698		1,474
-9	0,633		0,422		0,831	-9	0,677		0,5347		0,69
-8	1,161		0,523		1,194	-8	0,295		0,6985		1,066
-7	0,554		0,545		0,749	-7	0,742		0,3992	<<	1,325
-6	0,661		1,231		1,095	-6	1,015		0,5324		0,688
-5	1,028		1,070		0,704	-5	0,897		0,6162		1,261
-4	0,917		0,957		0,840	-4	0,564		0,6671		0,927
-3	0,804		1,061		0,930	-3	0,995		0,7962		1,737
-2	0,698		1,040		0,595	-2	1,213		1,3279		3,256
-1	1,535		1,045		1,590	-1	1,447	>>	0,625	<<<	2,797
0	5,549	>>>	3,916	>>	3,336	0	5,722	>>>	1,8265	<<<	4,963
1	1,737		1,019		0,458	1	2,887	>>>	0,7122	<	1,903
2	1,336	>>	0,413	<<	0,706	2	1,394	>	0,6139	<<	1,301
3	1,061	>>	0,249		0,756	3	0,626		0,6107		0,738
4	0,475		0,558	<<	0,717	4	1,219	>>>	0,7226	<	1,131
5	0,882		0,352		1,105	5	1,393	>>	0,4332		1,059
6	0,374		0,721		0,529	6	1,086		0,5365		2,681
7	0,636		0,926		0,628	7	0,714		0,4123		0,885
8	0,515		0,713		0,301	8	0,994	>>	0,5164		0,696
9	0,614		0,793		0,751	9	0,470		0,8068		0,496
10	0,499		0,651	>>	0,163	10	0,631		0,7202		1,005

Table n°3: Volatility spillover (total period)

$$Vol_{i,t} = \left[\frac{HIGH_{i,t} - LOW_{i,t}}{0{,}5(HIGH_{i,t} + LOW_{i,t})} \right]$$

This table provides average volatilities for each day for the 21- day period surrounding the event day 0 for the three stock groups.
>>>, >> and > indicates that the number on the left is higher than that on the right on a level of significance of 1%, 5% and 10% respectively.

total	Upper limit reaches						Lower limit reaches				
	hit		90		80		hit		90		80
-10	12,448		14,579		20,046	-10	14,696		13,508		14,297
-9	44,054		12,380		19,248	-9	10,913		10,614	<	16,620
-8	17,844		15,267		16,902	-8	12,450		12,478		13,352
-7	17,573		13,939		16,489	-7	13,014		11,671		15,783
-6	16,848		16,938		20,620	-6	16,458	>	8,593	<<<	16,966
-5	35,759		16,290		19,514	-5	15,241		12,014	<<	18,374
-4	15,622		17,619		19,615	-4	15,146		10,883		14,006
-3	16,147		14,828		17,119	-3	14,186		15,520		15,770
-2	17,079		15,641		19,423	-2	10,738		14,488		21,228
-1	41,977		18,699		24,183	-1	15,684		17,473	<	27,642
0	22,693	<<	28,521	<<	50,084	0	266,535	>>>	19,598		26,911
1	23,793		20,313		24,468	1	26,217		19,925		22,459
2	19,958		21,040		24,156	2	18,223		13,985		17,683
3	38,250		16,719		24,247	3	13,723		14,850		20,217
4	34,506	<<	17,877		21,263	4	15,383		17,738		17,810
5	39,700	>	14,800		16,585	5	14,557		11,005	<	16,924
6	15,885		16,914		15,045	6	16,514		13,869	<<	23,357
7	35,628		15,615		18,422	7	12,041		13,739		14,981
8	56,627		16,645		21,314	8	12,995		14,154		16,666
9	35,107		16,206		18,389	9	14,058		14,416		11,671
10	13,560		14,774		14,289	10	14,849		16,662		17,812

Table n°4: Overflow of volatility (Before and after 03-12-2007)

$$Vol_{i,t} = \left[\frac{HIGH_{i,t} - LOW_{i,t}}{0{,}5(HIGH_{i,t} + LOW_{i,t})} \right]$$

This table provides average volatilities for each day for the 21- day period surrounding the event day 0 for the three stock groups.

>>>, >> and > indicates that the number on the left is higher than that on the right on a level of significance of 1%, 5% and 10% respectively.

Front	Upper limit reaches						Lower limit reaches				
	hit		90		80		hit		90		80
-10	10,519		24,873		13,829	-10	8,576	<<<	15,293		9,893
-9	55,724		14,620		15,887	-9	4,393	<<<	12,808		12,845
-8	15,824		15,613		13,967	-8	6,736	<<<	15,735		12,507
-7	13,945		13,493		12,582	-7	5,765	<<<	13,991		15,221
-6	15,528		14,214		13,818	-6	10,061	<<<	15,162		12,641
-5	43,236		12,527		15,759	-5	6,450		13,110		16,418
-4	13,083		18,091		17,963	-4	9,497	<<<	14,950		12,725
-3	13,710		12,416		16,391	-3	5,271	<<<	12,866		12,667
-2	13,595		13,696		15,431	-2	5,015	<<<	13,943		13,385
-1	47,595		43,633		19,625	-1	9,815	<<<	16,332		14,469
0	12,597	<<<	20,806		23,589	0	464,813	>>>	21,975		14,311
1	17,753		17,693		20,123	1	5,297	<<<	17,134		15,050
2	15,122	<<	23,057		20,083	2	5,548	<<<	19,446	>>	11,153
3	45,620		16,506		19,049	3	3,712	<<<	17,338		12,431
4	42,277	<<<	17,759		16,127	4	8,297	<<<	17,078	>	9,517
5	49,051		14,691		14,590	5	4,709	<<<	15,576		12,973
6	12,696	<	16,806		14,365	6	5,963	<<<	17,253		20,355
7	43,923		15,138		14,531	7	4,944	<<<	14,136		9,061
8	76,413		14,741		13,439	8	3,518	<<<	14,251	>	11,548
9	44,456		15,206	<	19,413	9	6,350	<<<	14,684	>>>	8,223
10	12,542		13,222		15,135	10	10,508		12,637		13,068
Afterwards	Upper limit reaches						Lower limit reaches				
	hit		90		80		hit		90		80
-10	22,920		14,087		20,046	-10	20,815		22,035		19,378
-9	24,923	>>	13,243		19,248	-9	17,433		17,782		20,975
-8	22,410		14,375		16,902	-8	18,165		17,379		14,327
-7	17,205		15,088		16,489	-7	20,263		16,838		16,432
-6	25,470		23,957		20,620	-6	22,855	>>>	9,184	<<	21,957
-5	18,143		25,987		19,514	-5	24,033		21,805		20,631
-4	19,880		24,078		19,615	-4	20,795	>>	8,703		15,485
-3	26,119		21,041		17,119	-3	23,100		14,380		19,351
-2	32,238	>>	21,209		19,423	-2	16,462		19,426		30,278
-1	49,843		26,288		24,183	-1	21,552		40,145		42,842
0	59,289		48,401		50,084	0	68,258		48,711		41,450
1	44,863	>>	27,649		24,468	1	47,137		25,904		31,008
2	36,297		23,519		24,156	2	30,899		31,233		25,218
3	31,697	>>>	17,268	<	24,247	3	23,733	<	32,695		29,200
4	28,163	>>	18,182		21,263	4	22,469		32,186		27,378
5	30,385	>>	16,541		16,585	5	24,404	>	16,295		21,483
6	28,074		17,191		15,045	6	27,066		21,857		26,820
7	21,285		18,322		18,422	7	19,139		21,299		21,811
8	21,184		22,145		21,314	8	22,472		14,843		22,572
9	18,250		18,784		18,389	9	21,767	<	34,753	>>	15,648
10	19,539		18,772		14,289	10	19,191		32,801		23,286

Table n°5: The trading interference (total period)

This table provides average trading volume for each day for the 21- day period surrounding the event day 0 for the three stock groups.

>>>, >> and > indicates that the number on the left is higher than that on the right on a level of significance of 1%, 5% and 10% respectively.

volume	Upper limit reaches						Lower limit reaches				
total	hit		up90		up80	total	hit		dow90		dow80
-10	1,206		1,182		1,475	-10	1,151		1,128		1,459
-9	0,976		1,015		1,389	-9	0,853		0,886		1,388
-8	1,543		1,070		1,180	-8	1,098		0,974		1,218
-7	1,328	>	1,040		1,463	-7	1,341		0,898	<	1,490
-6	1,172		1,161		1,405	-6	1,554		1,210	<<	1,744
-5	1,225		1,039		1,274	-5	1,376		1,267		1,279
-4	1,594		1,279		1,574	-4	1,394		1,207	<<	1,413
-3	1,682	>>	1,157		1,577	-3	1,272		1,380	<<	1,637
-2	1,393		1,552		1,947	-2	1,372		1,300	<<<	1,768
-1	1,761		1,705		1,929	-1	1,016		1,499	<<	1,791
0	1,785	<<<	2,603		3,660	0	1,068	<<	1,580		1,701
1	2,824	>>>	1,599		2,483	1	1,879		1,248	<	1,511
2	1,677		1,498		2,022	2	1,353		0,909	<<<	1,519
3	1,423		1,385		2,296	3	1,710		1,071	<<<	1,570
4	1,529		1,480		1,584	4	1,140		0,903		1,175
5	1,332		1,246		1,824	5	1,186		1,200	<<<	1,856
6	1,226		1,233		1,639	6	1,294		1,087	<<	1,788
7	1,060		1,087		1,302	7	1,017		1,304		1,668
8	1,227		1,268		1,414	8	1,073		1,238		1,429
9	1,296		1,314		1,914	9	1,098		1,155	<<	1,382
10	1,155		1,049		2,096	10	0,994		1,348		1,583

Table n°6: The trading interference (Before and after 03-12-2007)

This table provides average trading volume for each day for the 21- day period surrounding the event day 0 for the three stock groups.

>>>, >> and > indicates that the number on the left is higher than that on the right on a level of significance of 1%, 5% and 10% respectively.

Front	Upper limit reaches						Lower limit reaches				
	hit		up90		up80		hit		dow90		dow80
-10	1,114	<	1,300		1,403	-10	0,845		1,169		1,097
-9	0,921		1,131		1,372	-9	0,549		0,744	<<	1,581
-8	1,520		1,195		1,437	-8	1,086		0,924		1,256
-7	1,141		1,041		1,166	-7	1,493		0,687		1,696
-6	1,043		1,013		1,484	-6	1,420		1,381		1,423
-5	1,225		0,897		1,444	-5	1,067		1,239		1,191
-4	1,585		1,362		1,668	-4	1,107		1,282	<	1,300
-3	1,713		1,198		1,227	-3	1,433		2,176		1,801
-2	1,216		1,680		1,840	-2	1,608		1,482		1,107
-1	1,430		1,839	<	2,535	-1	0,879		1,285	<<	1,568
0	1,059	<<<	2,757		4,065	0	0,916		1,581		2,233
1	2,568	>>	1,646		2,814	1	1,260		1,207	<<	1,696
2	1,788		1,559		2,148	2	0,853		0,534	<<<	1,410
3	1,526		1,349	<	2,223	3	1,455		1,001	<<	1,345
4	1,579		1,412	<	1,765	4	0,868		0,957		1,313
5	1,241		1,251		1,598	5	1,011		1,053	<<	2,175
6	1,197		1,399		1,428	6	0,731		1,300	<	1,743
7	1,056		1,090		1,336	7	1,241		1,824		1,546
8	1,089		1,217	<<	1,476	8	0,739		1,334		1,787
9	1,333		1,332		1,307	9	0,643		1,433		1,196
10	1,032		1,239		1,483	10	1,019		1,611		1,759
Afterwards	Raise						Drop				
	hit		up90		up80		hit		dow90		dow80
-10	1,379		0,879	<<	1,547	-10	1,458		1,099		1,604
-9	1,080		0,716	<	1,405	-9	1,156		0,985		1,311
-8	1,587		0,748		0,924	-8	1,110		1,008		1,202
-7	1,681	>	1,039	<<	1,760	-7	1,189		1,046		1,408
-6	1,417		1,543		1,326	-6	1,689		1,090	<	1,872
-5	1,224		1,403		1,105	-5	1,684		1,286		1,313
-4	1,611		1,065		1,480	-4	1,681		1,154		1,459
-3	1,624		1,053		1,928	-3	1,111		0,822	<	1,571
-2	1,727		1,219		2,054	-2	1,136		1,173	<<<	2,032
-1	2,386		1,361		1,323	-1	1,153		1,650		1,881
0	3,158		2,206	<	3,256	0	1,219		1,580		1,488
1	3,308	>>>	1,479		2,152	1	2,498		1,276		1,438
2	1,467		1,343		1,896	2	1,853		1,171		1,562
3	1,229		1,475	<<	2,368	3	1,965		1,120	<<	1,660
4	1,433		1,655		1,403	4	1,412		0,865		1,119
5	1,505		1,233		2,051	5	1,361		1,302		1,728
6	1,282		0,804	<	1,849	6	1,857		0,938		1,806
7	1,069		1,079		1,267	7	0,794		0,940		1,717
8	1,487		1,398		1,351	8	1,407		1,172		1,285
9	1,227		1,268	<<	2,520	9	1,553	>	0,960	<<	1,456
10	1,387	>	0,559	<<	2,709	10	0,970		1,164		1,513

Table n°7: Delayed price discovery for all the period

Panel has	The frequency of the price changes around the reservations for the three groups					
	Upward price movements			Downward price movements		
	Hit	Stock0.90	Stock0.80	Hit	Stock0.90	Stock0.80
Plus-plus	0,5556	0,4937	0,4419	0,2963	0,3810	0,4348
Plus-moins	0,4074	0,2405	0,1860	0,6852	0,2381	0,1304
Plus-zero	0,0123	0,0886	0,2093	0,0185	0,0238	0,2609
zero-plus	0,0247	0,1013	0,0465	0,0000	0,0952	0,0000
zero-moins	0,0000	0,0000	0,0233	0,0000	0,1667	0,0870
zero-zero	0,0000	0,0506	0,0000	0,0000	0,0952	0,0870
continuation	0,5802	0,5949	0,4884	0,2963	0,5476	0,5217
reversal	0,4074	0,2405	0,2093	0,6852	0,3333	0,1304
stagnation	0,0123	0,1392	0,2093	0,0185	0,1190	0,3478

Panel b: results of the				
	Upward		Downward	
situation	hit-0,9	hit-0,8	hit-0,9	hit-0,8
continuation	-0,015	0,092	-0,2513	-0,2254
	(- 0,269)	(1,654)	(- 3,7105)	(- 3,3165)
reversal	0,167	0,198	0,3519	0,5548
	(3,515)	(4,383)	(5,4848)	(12,1045)
stagnation	-0,127	-0,197	-0,1005	-0,3293
	(- 3,299)	(- 4,357)	(- 2,2811)	(- 5,0808)
Statistics Z are between the brackets				

Table n°8: Delayed price discovery for upper limits before and after the date of 03-12-2007

Panel A						
	Before 03-12-2007			After 03-12-2007		
	Hit	Stock0.90	Stock0.80	Hit	Stock0.90	Stock0.80
Plus-plus	0,5385	0,5000	0,3684	0,5862	0,4762	0,6000
Plus-moins	0,4231	0,2069	0,2632	0,3793	0,3333	0,1500
Plus-zero	0,0000	0,0517	0,2105	0,0345	0,1905	0,2500
zero-plus	0,0385	0,1379	0,1053	0,0000	0,0000	0,0000
zero-moins	0,0000	0,0000	0,0526	0,0000	0,0000	0,0000
zero-zero	0,0000	0,0690	0,0000	0,0000	0,0000	0,0000
continuation	0,5769	0,6379	0,4737	0,5862	0,4762	0,6000
reversal	0,4231	0,2069	0,3158	0,3793	0,3333	0,1500
stagnation	0,0000	0,1207	0,2105	0,0345	0,1905	0,2500

Panel B: results of the nonparametric binomial test					
	Before			Afterwards	
situation	hit-0,9	hit-0,8		hit-0,9	hit-0,8
continuation	**-0,0610**	0,1032		0,1100	-0,0138
	-0,9154	1,4910		1,1863	-0,1516
reversal	**0,2162**	0,1073		0,0460	0,2293
	3,8484	1,6644		0,5252	3,4583
stagnation	**-0,1207**	-0,2105		-0,1560	-0,2155
	-2,6716	-3,7238		-2,1393	-2,6803
Statistics Z are between the brackets					

Table n°9: Delayed price discovery for lower limits before and after the date of 03-12-2007

Panel has	before 03-12-2007			after 03-12-2007		
	Hit	Stock0.90	Stock0.80	Hit	Stock0.90	Stock0.80
Moins-moins	0,1481	0,3548	0,2727	0,4444	0,4545	0,5833
Moins-plus	0,8148	0,1935	0,0909	0,5556	0,3636	0,1667
Moins-zéro	0,0370	0,0000	0,2727	0,0000	0,0909	0,2500
zéro-plus	0,0000	0,1290	0,0000	0,0000	0,0000	0,0000
zéro-moins	0,0000	0,1935	0,1818	0,0000	0,0909	0,0000
zéro-zéro	0,0000	0,1290	0,1818	0,0000	0,0000	0,0000
continuation	0,1481	0,5484	0,4545	0,4444	0,5455	0,5833
reversal	0,8148	0,3226	0,0909	0,5556	0,3636	0,1667
stagnation	0,0370	0,1290	0,4545	0,0000	0,0909	0,2500

Panel b: results of the nonparametric binomial test					
	Front			afterwards	
situation	hit-0,9	hit-0,8		hit-0,9	hit-0,8
continuation	-0,40	-0,30		-0,10	-0,13
	-4,17	-3,19		-1,05	-1,46
reversal	0,49	0,72		0,19	0,38
	5,47	13,08		2,07	5,42
stagnation	-0,09	-0,41		-0,09	-0,25
	-1,42	-4,35		-1,64	-3,00
Statistics Z are between the brackets					
table: delay of adjustment of the prices					