NARROW PRICE LIMIT AND STOCK PRICE VOLATILITY IN EMERGING MARKETS: EMPIRICAL EVIDENCE FROM AMMAN STOCK EXCHANGE

Ritab S. Al-Khouri, Yarmouk University, Jordan
Moh'd M. Ajlouni, Yarmouk University, Jordan

ABSTRACT

This paper empirically investigates the behaviour of daily stock return volatility around price limit hits for a sample of 159 (189) securities listed in Amman Stock Exchange (ASE), over the years 2003(2004). More specifically, we investigate whether daily return volatility for stocks that hit a price limit is lower (higher) in the post limit hit period than in the pre limit hit period. Such a finding would be consistent with the overreaction hypothesis, also referred to as the volatility spill over hypothesis. Our results indicate that stocks-hit experience their highest level of volatility on the day when stocks-hit reach their upper daily price limits of 5% (day 0), and decreases significantly one day after the hit. Similar results are found when stock hits reach their lower daily price limits of -5%, however with less magnitude. Results on the different sectors reveal that the banking sector experiences the highest volatility. However, when the stocks-hit reach its lower limit, the service sector shows the highest volatility as compared to the other sectors in the industry. Therefore, our results are more consistent with the overreaction hypothesis and that the price-limit technique is effective in reducing the volatility by providing a time-out to cool-off.

INTRODUCTION

Learning from the experience of stock market crashes, especially the Kuwaiti stock market (Al-Manakh) crash in 1982, and the black Monday stock crisis in October 1987 in the USA, the Amman Stock Exchange (ASE), like many other exchanges established a narrow limit on daily price movement to control volatility.

This paper empirically investigates the behaviour of daily stock return volatility around price limit hits for a sample of 159 (189) securities listed in ASE for the years 2004 (2005). Price limits set by the market establish literal boundaries where security prices are allowed to move within a trading day, thereby, provide a *cooling off* period. However, since price limits prevent one-day large price changes from occurring, they may cause price adjustments to spread out over a longer period of time. The absence of high liquidity in ASE may worsen information uncertainty and cause an increase in return volatility after the limit hit period when trading starts the next day. Therefore, daily return volatility for stocks that hit a price limit is expected to be lower (higher) in the post limit hit period than in the pre limit hit period according to the overreaction hypothesis (*volatility spill over hypothesis*).

This paper provides insight into stock market dynamics and systematic weaknesses, which will subsequently help us suggest certain reforms. It contends that price limits might not have the same effect across exchanges due to the marked differences in both market architecture and institutional characteristics. Markets can be organized as periodic call auctions, continuous auctions, or as continuous dealer markets. Most of the literature focuses on markets where trading takes place continuously or the market clears frequently during operating hours. This study, however, investigates the issue in a market characterized by thin trading, low liquidity, and the non-existence of different trading instruments and mechanisms.

The main restrictions of the daily price limit and short-selling limits, used to dampen volatility that affect small investors, might have major implications on stock prices. Such implications include, producing high correlation between stock prices, making future prices predictable, reducing the efficiency of the market and hindering the formation of efficient portfolios. Since price limits directly interfere with asset price resolution, their impact on volatility and consequently on returns have recently attracted special interest from policy makers, investors, practitioners and academic researchers in the emerging market of Jordan. In order to protect the stock exchanges, authorities must make informed decisions. These decisions cannot be worthwhile unless they are based on serious studies. Therefore, the issue of price limit is very important and worth studying.

The ASE has many features that make the study of price limit important. First, trading in ASE does not rely on dealers or market makers. Therefore, market liquidity is limited by the amount of securities supplied and demanded by traders who submit their market or limit orders. The second feature of ASE, as is the case in many emerging exchanges, is the implementation of a price limit. Contrary to other exchanges, since 1992 ASE has been regulated by narrow daily price change limits of +/-5% on individual securities as. The regulatory purpose of setting up this price limit was to dampen speculative overreactions of stock prices hoping to protect small investors. The third feature of ASE is the lack of trading instruments such as short-selling and the non existence of derivative securities as well as the restrictions of some trading mechanisms, such as trading on margin, which is limited to some stocks and restricted to some brokers and customers.

Although few research papers in the literature investigate the issue of price limits and circuit breakers, no unanimity is being reached as to the usefulness of price limits in reducing the volatility of stock markets. Proponents of price limit rules believe in its importance in managing settlement risk since it helps avoid defaults by brokers and their clients by limiting the size of intra-day losses and margin calls. Moreover, price limits are related to the objective of providing and facilitating the restoration of orderly trading (*cooling off effect*) and allows traders in the market some time to evaluate information and think rationally with less emotion during times of panic trading (*time-out period*). It helps dampen the overreaction in the stock markets and decreases the risk that investors bear during turbulent trading days. Therefore, price limit mechanisms are supposed to ensure smooth prices. Finally, limits help retain confidence of small investors who may stay away from the market due to large swings in stock prices, and it makes the job for manipulators and insider traders more difficult to take advantage of other investors.

The opponents of price limit, however, argue that limits usually are associated with certain costs to traders. Price limit interferes with liquidity and price discovery and accelerates movements toward the limits (*i.e. magnet effect hypothesis*). Critics also claim that price limit causes higher volatility levels on subsequent days (*i.e. spill over hypothesis*), and interferes with trading due to limitations imposed by these limits (i.e. *trading interference hypothesis*). It is particularly harmful to trading in relatively illiquid stocks, however, these carry no significant outstanding positions that could cause settlement risk, and hinders the introduction of new derivative products.

INSTITUTIONAL BACKGROUND OF ASE

A daily price change limit of 10% was first introduced in ASE during the 1980s, but it was reduced to 2% during the Gulf War in 1991. However, since 1992, the price limit is set at 5%, similar to that of the Austria and Turkey stock exchanges.

The trading system in ASE is similar to limit order market systems used in other exchanges. Specifically, it implements the French program (GL) of trading screens. This system is used by both brokers and

trading monitors each according to his/her purposes. Trading in ASE takes place from Sunday to Thursday and closes on Fridays, Saturdays and on public holidays. Each trading day orders are entered 30 minutes prior to the market open at 9:30 am local time, which is followed by a continuous trading cession after the opening auction from 10 to 12 pm. There is one trading session (10 am to 12 pm). During the pre-opening phase the brokers enter the market and limit orders. At the opening phase, the entered orders are executed if the orders are within the permitted limits of the price change (± 5%) from the last closing price.

In this market, trading is permitted only at prices within limits determined by the reference price of the previous day. If the security price moves outside the equilibrium price, trading in the market ceases until either the price moves back to equilibrium or until the next day when the new limit is set based on the reference price of the current day. The reference price is usually equivalent to the closing price of the previous day. When the security is not traded, for a few days, however, an upper limit of 5% daily is added to the last closing price which forms the reference price. Therefore, a large move in the underlying equilibrium price may cause the price to move the limit on several successive days with no trading taking place.

The source of liquidity in ASE is the limit orders in the order book, provided by both investors and brokers, since there are no floor traders, market makers or specialists with special quoting obligations or trading privileges. Investors place orders in the order book through brokers who are connected directly to the electronic trading system. The brokers can trade on their own accounts, as well as, on behalf of outside investors. This choice of trading might be determined by the profitability of supplying liquidity in different market conditions or in different stocks.

LITERATURE REVIEW

The literature on the effect of price limits indicate that price limits are mainly implemented by smaller, emerging and less developed exchanges. The smaller and less developed the exchange is, the narrower the price limits used, mainly because of the lack of suitable risk management system and the lack of liquidity. The more developed the exchange is, however, the wider the price limit implemented, and is used sometimes in addition to circuit breakers, or sometimes, according to their needs, as the only circuit breakers.

The effect of price limits on stock exchanges is inconclusive, while many studies show a positive effect of price limits (see Kodres and O'Brien (1994), Hopewell and Schwartz (1978), Ma et. al (1989), Ma *et al.* (1990), and Huang *et al.* (2001), other studies (Lee, Ready, and Seguin (1994),Gay *et al.* (1994), Kim and Rhee (1997), Chen (1998), Cho *et al.* (2003), and Chan *et al.* (2005)) have challenged the expected advantage of price limits.

Kodres and O'Brien (1994), for example, examine the effect of price limits, and find that price limits may promote better risk sharing than unconstrained trading when price fluctuations are driven by news about fundamentals. In their seminal work, Hopewell and Schwartz (1978) notice large abnormal price adjustments over the suspension period, and an anticipatory behavior of stock returns prior to the suspension. According to the authors, this behaviour is consistent with a quick adjustment to new equilibrium. Ma, Rao and Sears (1989) find that after a price limit hit, prices tend to stabilize or reverse. They also find a decline in return volatility and more stability in volume traded. Lee and Kim (1995) investigate the data of the Korea Stock Exchange and find that price limits reduce stock price volatility.

Other research studies challenge the usefulness of price limits. The literature documents three main

issues related to the problems associated with price limits, volatility spillover, the delay in price discovery and the trading interference hypotheses (see for example, Lee, Ready, and Seguin (1994) Kim and Rhee 1997, and Bidlik and Gulay 2003 among others).

Lee, Ready, and Seguin (1994) find that trading halts at the NYSE do not reduce either volume nor price volatility, but merely interfere with the normal trading activity and making delay in price discovery. They show a higher level of both volume and volatility on the period followed immediately the trading halt. Therefore, price limits prevent the stock from reaching to its equilibrium price at a single trading day and have to wait until the next trading day to continue toward the new true (i. e. equilibrium) price. This is consistent with the delay in price discovery. Kim and Rhee (1997), conclude that price limits used on the Tokyo Stock Exchange might be ineffective.

The other effect of price limits found in the literature is the "*magnet effect*". Arak and Cook (1997); Cho *et al.* (2003), among others, discuss this magnet effect of price limits. In this effect security prices tend to accelerate toward the bounds. This effect could be due to a fear of market illiquidity (Subrahmanyam (1994), and the behaviour of market participants (Arak and Cook (1997)). In a recent study on Taiwan Stock Exchange Cho *et al.* (2003), find a clear effect in the movement of securities toward the upper limit, while weak evidence if found of acceleration toward the lower limit as prices reach the bound. Chan *et al.* (2005) using data from Kuala Lumpur stock Exchange find that price limit could cause order imbalances prior to the limit hit.

This paper extends the literature by giving an evidence of the effect of narrow price limit on stock market volatility, a market which is characterized by thin trading, lack of liquidity and the lack of different trading instruments.

DATA DESCRIPTION

For the purpose of testing the research hypotheses, we use daily prices for 159 companies in 2003 and 189 companies in 2004 listed in ASE in both the first and second markets between January 1, 2003 and December 31, 2004. These companies represent all the four sectors classified according to ASE. These sectors are banks, insurance, services and manufacturing. Table (1) shows summary statistics for our data. The table shows 466 trading days during the period 1/1/2003-12/31/2004, with an average daily return for all sectors/markets of 0.18%. The banking sector experience the highest return, and the insurance and industry sectors have the lowest returns 0.12%. There are 242 (224) trading days in 2003 (2004), with an average daily return of 0.20% (0.20%), and the banking sector experiences the best return during both sub periods, while the insurance (industry) sector experiences the lowest return in 2003 (2004).

METHODOLOGY

This paper follows a similar methodology adopted by Kim and Rhee (1997). First, we identify the days where the high (low) price matches its previous day's closing price plus (minus) the price limit. Then we measure the price volatility around the days, when the price hits the limit.

In order to identify those days when prices hit the limit, we assume that the upper price limits are reached for a specific stock when $Ht \geq Pt\text{-}1 + LIMITt$. Where Ht represents the high price on day t, Pt-1 represents the previous day's closing price and LIMITt is the 5% maximum allowable upward price movement for each day t. Likewise, we assume that the lower price limits are reached for a specific stock when $Lt \leq Pt\text{-}1 - LIMITt$. Where Lt represents the low price on day t, Pt-1 represents the previous day's closing price and LIMITt is the 5% maximum downward price movement for each day t. For this purpose, we compute the

close-to-close changes using day t-1 closing price and day t closing price for stock j using the following equation:

$$R_{jt} = \frac{P_{jt} - P_{jt-1}}{P_{jt-1}} \quad (1)$$

R_{jt} is daily movement of the stock j on day t.
P_{jt} is the closing price of stock j on day t.
P_{jt-1} is the closing price of stock j on day t.

In addition, on days when price limits are reached, we classify stocks that did not reach the price-limit into six subgroups. Stocks that having price movements, up or down, in the ranges of 4.90% - 4.99%, 4.80% - 4.89%, 4.70% - 4.79%, 4.60% - 4.69% and 4.50% - 4.59%. That is within at least 90% of reaching the daily limit, and those stocks whose price movements are less than 90% of reaching the daily limit. These Stocks are referred to as Stock4.90%, Stock4.80%, Stock4.70%, Stock4.60% and Stock4.50%, respectively. The subscripts denote the magnitude of a stock's price change on Day 0, the limit-hit-day. Stock hit refer to those stocks which hit their daily price limit.

Table (1) reports the number of price-limit-hit occurrences, as well as the number of occurrences for each of the other five categories, outlined above, for both upper and lower price movements for each sector in each market, as well as the aggregate results, during the period 1/1/2003 - 31/12/2004.

It can be seen from panel C in table 1 that there are 1033 price-limit hits, of which 603 occur when upper daily price-limits are hit and 430 occurrences when lower price-limits are hit, i.e. Stock hit. These numbers indicate that ASE price-limits prevents more stock price increases than decreases. This preliminary conclusion is, in fact, consistent with that of Tokyo Stock Exchange (TSE) (Kim and Rhee, 1997, p. 890) and Istanbul Stock Exchange (ISE) (Bildik and Gulay, 2003, p. 9). In addition, the table shows that such conclusion is valid for each sector in each market. Also, the same has been found in a year-by-year analysis. The results, as reported in panel A and panel B, reveal that in 2003 (2004) there were 392 (211) occurrences of upper daily price-limit hits and 290 (140) occurrences of lower daily price-limit hits.

Similarly, there are 2258 (782) occurrences when daily price movements approached but did not reach the upper (lower) price-limit, i.e. Stock4.90%, Stock4.80%, Stock4.70%, Stock4.60% and Stock4.50% , during the period 1/1/2003-31/12/2004. There are 1095 (376) occurrences when the price approached but did not reach the upper (lower) price-limit in 2003 and 1163 (406) in 2004 respectively.

To test the volatility spill over hypothesis, we measure daily price volatility by the following equation:

$$V_{jt} = (R_{jt})^2 \quad (2)$$

Where:
V_{jt} is the daily price volatility for stock j on day t.
R_{jt} is the daily return on stock j on day t.

We apply a 21-day event window. That is from Day -10 to Day +10, where Day 0 represents the event-day, that is the limit-hit-day, Day -1 represents one day before the event day and Day +1 represents one

day after the event day, and so forth. Also, the same event window is applied to a control group of stocks that experienced a maximum (minimum) of +4% (-4%) daily price movements, but did not reach the upper (lower) price limit hit +5% (-5%). This control group is used as a benchmark for the volatility of price limit hits during post-limit days. The second successive same price limit hits are excluded in order to eliminate the high price limit-day volatility bias that occurs when these consecutive hits are considered independent events. Hence, the sample size for upper price limit hit events (+5%) for all sectors are reduced from 603 to 556, whereas the sample size for the control sample (+4%) is 1729. Additionally, the lower price limit hit events (-5%) for all sectors is reduced from 430 to 368, whereas the sample size for the control sample (-4%) is 689.

Table 1: Summary Statistics

Panel A: presents the sample size of each of these six categories during the study period 1/1/2003 to 31/12/2003 for both upward and downward price movements.

Stock Category	**Bank Sector**			**Insurance Sector**			**Service Sector**			**Industry Sector**			**Total Sectors**		
	M1	M2	M1+M2	M1	M2	M1+M2	M1	M2	M1+M2	M1	M2	M1+M2	M1	M2	M1+M2
Downdward Price Movements															
-5.0%	120	1	121	8	6	14	18	24	42	12	101	113	158	132	290
-4.9%	2	0	2	6	4	10	24	7	31	20	10	30	52	21	73
-4.8%	12	0	12	10	2	12	10	18	28	21	10	31	53	30	83
-4.7%	8	1	9	5	8	13	18	13	31	21	22	43	52	44	96
-4.6%	4	0	4	3	4	7	7	15	22	11	14	25	25	33	58
-4.5%	9	1	10	2	8	10	6	10	16	19	11	30	36	30	66
SubTotal	***155***	***3***	***158***	***34***	***32***	***66***	***83***	***87***	***170***	***104***	***168***	***272***	***376***	***290***	***666***
Upward Price Movements															
4.5%	10	2	12	7	15	22	21	35	56	40	57	97	78	109	187
4.6%	18	2	20	11	16	27	31	34	65	51	35	86	111	87	198
4.7%	43	4	47	18	15	33	40	36	76	59	46	105	160	101	261
4.8%	30	1	31	15	10	25	35	36	71	59	35	94	139	82	221
4.9%	33	3	36	7	10	17	48	28	76	66	33	99	154	74	228
5.0%	128	3	131	14	9	23	32	49	81	34	123	157	208	184	392
SubTotal	262	15	277	72	75	147	207	218	425	309	329	638	850	637	1487
Downdward and Upward Price Movements															
Grand Total	**417**	**18**	**435**	**106**	**107**	**213**	**290**	**305**	**595**	**413**	**497**	**910**	**1226**	**927**	**2153**
No. of Co's	**15**	**1**	**16**	**11**	**14**	**25**	**19**	**27**	**46**	**34**	**38**	**72**	**79**	**80**	**159**
Average Daily Returns (242 days)			0.30%			0.13%			0.20%			0.18%			0.20%

Panel B: presents the sample size of each of the six categories during the study period 1/1/2004 to 31/12/2004 for both upward and downward price movements.

Stock Category	**Bank Sector**			**Insurance Sector**			**Service Sector**			**Industry Sector**			**Total Sectors**		
	M1	M2	**M1+M2**	M1	M2	**M1+M2**	M1	M2	**M1+M2**	M1	M2	**M1+M2**	M1	M2	**M1+M2**
Downdward Price Movements															
-5.0%	12	7	19	6	13	19	27	18	45	27	30	57	72	68	**140**
-4.9%	6	0	6	4	6	10	22	12	34	12	8	20	44	26	70
-4.8%	4	2	6	4	6	10	18	15	33	17	20	37	43	43	86
-4.7%	8	1	9	6	4	10	23	11	34	13	23	36	50	39	89
-4.6%	4	1	5	7	9	16	15	21	36	16	14	30	42	45	87
-4.50%	2	1	3	5	5	10	8	14	22	16	23	39	31	43	74
SubTotal	***36***	***12***	***48***	***32***	***43***	***75***	***113***	***91***	***204***	***101***	***118***	***219***	***282***	***264***	***546***
Upward Price Movements															
4.5%	9	8	17	5	20	25	33	28	61	25	28	53	72	84	156
4.6%	17	4	21	14	19	33	49	42	91	44	39	83	124	104	228
4.7%	14	8	22	19	21	40	54	36	90	49	44	93	136	109	245
4.8%	36	5	41	14	14	28	65	22	87	92	37	129	207	78	285
4.9%	54	3	57	7	17	24	56	24	80	67	21	88	184	65	249
5.0%	15	8	23	11	21	32	36	54	90	30	36	66	92	119	**211**
SubTotal	***145***	***36***	***181***	***70***	***112***	***182***	***293***	***206***	***499***	***307***	***205***	***512***	***815***	***559***	***1374***
Downdward and Upward Price Movements															
Grand Total	**181**	**48**	**229**	**102**	**155**	**257**	**406**	**297**	**703**	**408**	**323**	**731**	**1097**	**823**	**1920**
No. of Co's	**13**	**3**	**16**	**10**	**16**	**26**	**26**	**35**	**61**	**35**	**51**	**86**	**84**	**105**	**189**
Average Daily Returns (224 days)			0.30%			0.11%			0.13%			0.08%			0.20%

Panel C: presents the sample size of each of the six categories during the study period 1/1/2003 to 31/12/2004 for both upward and downward price movements.

Stock Category	**Bank Sector**			**Insurance Sector**			**Service Sector**			**Industry Sector**			**Total Sectors**		
	M1	M2	**M1+M2**	M1	M2	**M1+M2**	M1	M2	**M1+M2**	M1	M2	**M1+M2**	M1	M2	**M1+M2**
Downdward Price Movements															
-5.0%	132	8	140	14	19	33	45	42	87	39	131	170	230	200	430
-4.9%	8	0	8	10	10	20	46	19	65	32	18	50	96	47	143
-4.8%	16	2	18	14	8	22	28	33	61	38	30	68	96	73	169
-4.7%	16	2	18	11	12	23	41	24	65	34	45	79	102	83	185
-4.6%	8	1	9	10	13	23	22	36	58	27	28	55	67	78	145
-4.5%	11	2	13	7	13	20	14	24	38	35	34	69	67	73	140
SubTotal	*191*	*15*	*206*	*66*	*75*	*141*	*196*	*178*	*374*	*205*	*286*	*491*	*658*	*554*	*1212*
Upward Price Movements															
4.5%	19	10	29	12	35	47	54	63	117	65	85	150	150	193	343
4.6%	35	6	41	25	35	60	80	76	156	95	74	169	235	191	426
4.7%	57	12	69	37	36	73	94	72	166	108	90	198	296	210	506
4.8%	66	6	72	29	24	53	100	58	158	151	72	223	346	160	506
4.9%	87	6	93	14	27	41	104	52	156	133	54	187	338	139	477
5.0%	143	11	154	25	30	55	68	103	171	64	159	223	300	303	603
SubTotal	***407***	***51***	***458***	***142***	***187***	***329***	***500***	***424***	***924***	***616***	***534***	***1150***	***1665***	***1196***	***2861***
Downdward and Upward Price Movements															
Grand Total	**598**	**66**	**664**	**208**	**262**	**470**	**696**	**602**	**1298**	**821**	**820**	**1641**	**2323**	**1750**	**4073**
No. of Co's	**28**	**4**	**32**	**21**	**30**	**51**	**45**	**62**	**107**	**69**	**89**	**158**	**163**	**185**	**348**
Average Daily Returns (466 days)			0.34%			0.12%			0.14%			0.12%			0.18%

Panel 3, Note 1: M1 refers to the First Market and M2 refers to the Second Market.

Note 2: Stocks are categorized into six groups based on the level of their price movements on Day 0 (the event day). Stocks 5% denote stocks that reach their daily price limit up (+) or down (-). Where limit refers to the maximum allowable daily price movement on Day t. Stocks 4.9% denote stocks that experience a price change of 4.9% from

the previous day's close, but do not reach a price limit. Stocks 4.8% denote stocks that experience a price change of 4.8% from the previous day's close, but do not reach a price limit. And so forth up to a price change of 4.5% from the previous day's close. Each number in the table represents the number of hits for each of these six levels of price changes for each sector in each market.

The volatility measure is computed for each stock. We compute averages for each day within the event window. A finding that price-limit-hit stocks experience greater volatility during post limit days than those that experience no hits supports the volatility spill over hypothesis. In addition, we computed the t-statistics of the Wilcoxon signed-rank test for volatility differences between the price-limit-hit group and that of the control group. Here we assume that the sample distribution of the differences in matched pairs is symmetric and we test the null hypothesis that the distribution is centred on zero difference. Discarding pairs for which the difference is zero, we rank the remaining absolute differences in ascending order. The sums of the ranks are calculated and the smaller of these sums is the Wilcoxon test statistic. The null hypothesis is rejected if the t-statistic is less than or equal to the value of the cumulative distribution function of the standard normal distribution (Newbold (1991), p. 421). The t-statistic is calculated as the difference between the control sample and the price-limit-hit sample, divided by the standard error, as follows (Hair *et al.* (1998), p. 360):

$$t-statistic = \frac{Mean_{\text{Control Sample}} - Mean_{\text{Price-Limit-Hit Sample}}}{\sqrt{\frac{VAR_{\text{Control Sample}}}{SampleSize_{\text{Control Sample}}} + \frac{VAR_{\text{Price-Limit-Hit Sample}}}{SampleSize_{\text{Price-Limit-Hit Sample}}}}} \quad (3)$$

The model above is calculated for the upper and the lower price-limit-hits.

RESULTS ON UPPER LIMIT HITS

Table (2) outlines the volatility in daily returns around upper price limit hits of +5%, as well as around the benchmark of price movement of +4%, for each sector as well as for the overall market. Also, the table reports the t-statistics according to Wilcoxon signed-rank test.

As we expected, stocks-hit experience their highest level of volatility on the day when stock-hits reached their upper daily price limits (day 0). Clearly, it can be seen from the table that the volatility of stocks-hit increased from 0.20% on day -10 to 0.31% on day -5 and jump to 5.03% on day 0, then decreased significantly to 0.18% on Day +1 and fluctuate down-ward significantly up to day +10 when it reached lowest volatility of 0.15%. Panel (A) in figure (1) shows the behavior of this volatility.

Although similar behavior can be seen in each sector, the table reveals that the banking sector has the highest volatility, followed by the manufacturing sector and the service sector, and finally, the insurance sector. Also, the volatility of the banking sector during post-limit hit days are the most significant in comparison to the control group. Similar patterns can be seen in the manufacturing sector. However, none of the post-limit day's volatility in the insurance and the service sectors is significant. Panels (B), (C), (D), and (E) in figure (1) show the behavior of the volatility in the banking, insurance, services and industry sectors, respectively.

Table 2: Volatility in the Daily Returns around Upper Limit Price Hits

	ALL SECTORS			BANKS			INSURANCE		
Days	**PLH +5%**	**+4%**	**T-Value**	**PLH +5%**	**+4%**	**T-Value**	**PLH +5%**	**+4%**	**T-Value**
-10	**0.20%**	0.07%	-0.9578	**0.47%**	0.07%	-1.0764	**0.01%**	0.05%	0.4030
-9	**0.21%**	0.08%	-0.5357	**0.48%**	0.06%	-2.5351**	**0.03%**	0.03%	0.0826
-8	**0.25%**	0.23%	-0.0163	**0.67%**	0.05%	-2.1129**	**0.01%**	0.04%	0.2564
-7	**0.24%**	0.06%	-1.3953	**0.33%**	0.05%	-4.0862**	**0.07%**	0.04%	-0.4988
-6	**0.27%**	0.06%	-1.9517**	**0.80%**	0.04%	-2.4778**	**0.03%**	0.04%	0.1979
-5	**0.31%**	0.10%	-0.6086	**0.91%**	0.05%	-2.3694**	**0.05%**	0.05%	-0.0222
-4	**0.32%**	0.12%	-0.3629	**0.47%**	0.05%	-2.7667**	**0.08%**	0.04%	-0.4933
-3	**0.41%**	0.06%	-1.9871**	**0.51%**	0.05%	-3.3456**	**0.08%**	0.04%	-0.7506
-2	**0.34%**	0.10%	-1.0356	**0.33%**	0.05%	-3.8043**	**0.06%**	0.06%	0.0121
-1	**0.20%**	0.15%	-0.1323	**0.30%**	0.08%	-1.8109**	**0.05%**	0.07%	0.1913
t0	**5.03%**	0.23%	-2.3149**	**10.58%**	0.23%	-1.1346	**3.22%**	0.23%	-1.7661**
+1	**0.18%**	0.13%	-0.1531	**0.32%**	0.09%	-3.097**	**0.10%**	0.08%	-0.3817
+2	**0.16%**	0.12%	-0.1013	**0.25%**	0.09%	-1.3886	**0.07%**	0.08%	0.1159
+3	**0.18%**	0.07%	-2.0972**	**0.31%**	0.10%	-0.7906	**0.07%**	0.06%	-0.2600
+4	**0.22%**	0.06%	-3.0167**	**0.43%**	0.06%	-2.3784**	**0.08%**	0.05%	-0.2715
+5	**0.23%**	0.07%	-1.8741**	**0.44%**	0.08%	-1.3730	**0.05%**	0.05%	0.0298
+6	**0.23%**	0.06%	-1.6883	**0.62%**	0.05%	-1.9921**	**0.06%**	0.04%	-0.2819
+7	**0.19%**	0.05%	-3.3263**	**0.40%**	0.06%	-2.0512**	**0.07%**	0.04%	-0.4378
+8	**0.25%**	0.05%	-2.2158**	**0.38%**	0.05%	-2.7759**	**0.06%**	0.03%	-0.6246
+9	**0.21%**	0.06%	-3.5854**	**0.31%**	0.06%	-2.8170**	**0.04%**	0.05%	0.1082
+10	**0.15%**	0.05%	-1.9534**	**0.39%**	0.05%	-2.2352**	**0.05%**	0.04%	-0.0920

	SERVICES			INDUSTRY		
Days	**PLH +5%**	**+4%**	**T-Value**	**PLH +5%**	**+4%**	**T-Value**
-10	**0.06%**	0.08%	0.0987	**0.21%**	0.07%	-0.5568
-9	**0.13%**	0.15%	0.0347	**0.16%**	0.05%	-2.2278**
-8	**0.13%**	0.48%	0.0835	**0.17%**	0.13%	-0.0457
-7	**0.29%**	0.06%	-1.0154	**0.20%**	0.08%	-0.4538
-6	**0.11%**	0.10%	-0.0471	**0.16%**	0.05%	-1.2032
-5	**0.13%**	0.10%	-0.1601	**0.19%**	0.14%	-0.0572
-4	**0.29%**	0.09%	-0.6448	**0.32%**	0.19%	-0.1004
-3	**0.11%**	0.08%	-0.4997	**0.68%**	0.06%	-1.3702
-2	**0.39%**	0.09%	-1.3536	**0.38%**	0.13%	-0.4508
-1	**0.30%**	0.22%	-0.1209	**0.11%**	0.15%	0.0505
t0	**3.26%**	0.23%	-1.7607**	**3.84%**	0.23%	-2.6959**
+1	**0.12%**	0.10%	-0.3627	**0.18%**	0.18%	-0.0077
+2	**0.11%**	0.09%	-0.3450	**0.16%**	0.16%	0.0003
+3	**0.13%**	0.08%	-0.6266	**0.17%**	0.06%	-2.0120**
+4	**0.16%**	0.07%	-0.9086	**0.18%**	0.06%	-2.0100**
+5	**0.13%**	0.07%	-1.0671	**0.23%**	0.07%	-0.8838
+6	**0.09%**	0.09%	0.0058	**0.15%**	0.05%	-2.1364**
+7	**0.09%**	0.06%	-0.8994	**0.19%**	0.05%	-2.4988**
+8	**0.37%**	0.07%	-1.1437	**0.12%**	0.05%	-1.7501**
+9	**0.12%**	0.06%	-1.2756	**0.27%**	0.05%	-2.2687**
+10	**0.08%**	0.07%	-0.0835	**0.09%**	0.04%	-1.4468

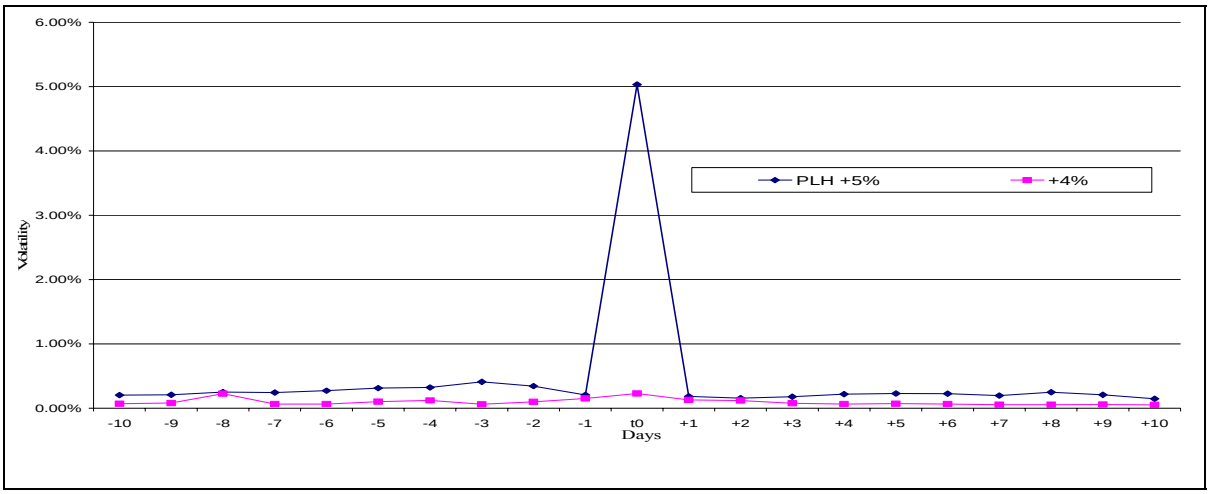
Note: Stocks are categorized into two groups (+5% and +4%) based on the level of their price movements on Day 0. Stocks 5% denote stocks that reach their upper daily price limit (+). Limit refers to the maximum allowable daily price movement on Day t. The main categories are presented for upward price movements. Each number (in %) in the table represents the volatility of daily returns at and around price limit hit for each sector during the period 1/1/2003 to 31/12/2004. T-value is computed according to Wilcoxon signed-rank test.

In fact, movements in the daily returns volatility started on day -6, at which the difference from the control group is significant. But eased afterward until day -3, when it almost doubled, then halted until the price limit hit day. The volatility relaxed significantly during the post-limit hit days. This behavior has led many researchers, such as Ma *et al.* (1989), to conclude that price limit is an effective tool in reducing volatility of the stock exchange.

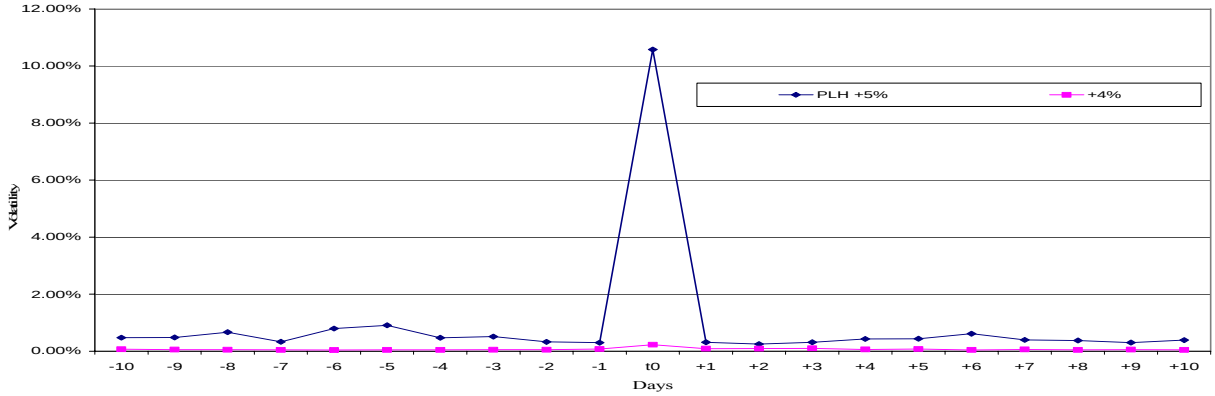
However, there are two arguments, cited in the literature and reported in our results in table (2), against this conclusion: The first argument is based on the Over-reaction hypothesis. Kim and Rhee (1997) argue that it is normal for volatility to drop after extremely large volatility days. Table (2) shows similar results to those of Bildik and Gulay (2003), Kim and Rhee (1997), Lehman (1989) and Miller (1989). That is the volatility of the control group stocks, which did not reach the price-limit, reduced significantly after the event day. This might indicate that regardless of the price-limit regulation, daily returns volatility will decline after it reaches a highest level. This would lead to conclude that the peaked daily returns volatility is due to overreaction by market participants and the decline is due to cooling-off result.

Figure 1: Daily Returns Volatility around Upper Price Limit Hits

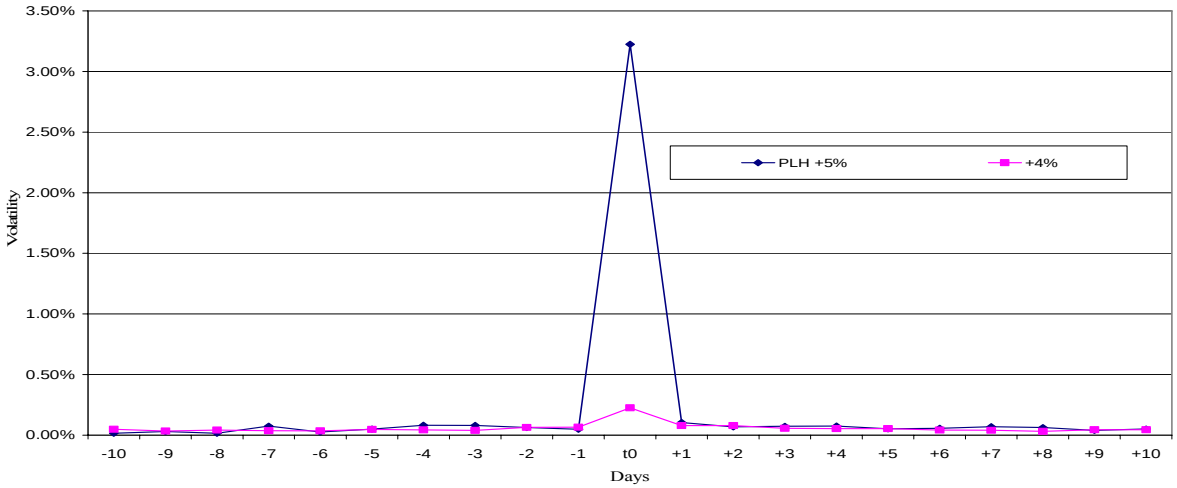
Panel A: for All Sectors



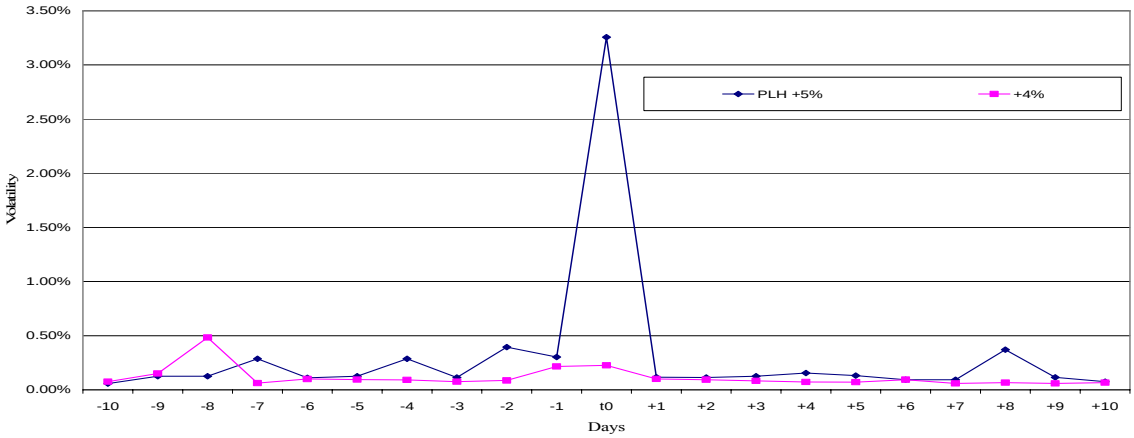
Panel B: for Banking Sectors



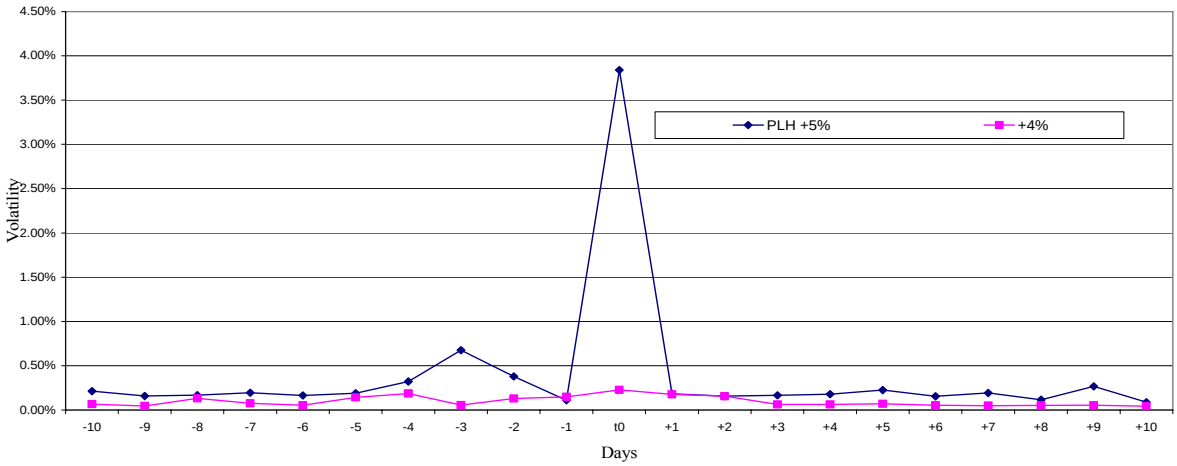
Panel C: for Insurance Sectors



Panel D: for Services Sectors



Panel E: for Industry Sectors



The second argument is based on the Spillover hypothesis. Bildik and Gulay (2003) find that the volatility of stock-hits during the post-limit period does not decrease as much as the volatility of the control group stocks. Table (2) indicates that on day +3 onward for the whole sample, the volatility of the stock-hits is larger than the volatility of the stocks in the control group, and the difference between them is significant at 5% level or less. However, there are no significant differences in the volatility of the stock-hits and those of the control group during the first two days after the event day. That is to say that the spillover hypothesis fails and, hence, it might be concluded that the price-limit technique is effective in reducing the volatility by providing a time-out to cool-off. This contradicting conclusion is very obvious in all sectors of ASE except the banking sector. In fact, there were no significant differences between the volatility of the stock-hits and those of the control stocks during all the post-limit days in the insurance and services sectors.

Our interpretation for the mixed results between the banking and the other sectors is that the banking sector in Jordan has witnessed a high volatility era during the study period 2004-2005. This is due to the huge capital inflows to Jordan from the neighbouring countries, mainly from Iraq. These funds entered the banking system, as interest-free demand deposits. Thus, the loanable funds have increased as well as the profitability and stock prices of the Jordanian banks. However, Basil II requirements have led to uncertainty in small-size banks, which in turn, increased their stock price volatility.

These findings might provide some explanation as why the banking sector has the highest price-limit hits ratio, in comparison with other sectors in ASE. Price-limit hits ratio is defined as the average number of upper and lower price-limit hits per stock. It is measured by dividing the number of price-limit hits in a sector by the number of companies listed in that sector. Using the data in table (1), it can be seen that price-limit hits ratio for banks is 9.2 hits per stock. While that of the manufacturing sector is 2.5, the services sector is 2.4 and the insurance sector is 1.7 hits. On average, there were 3.0 hits for each stock listed in both the first and second markets of ASE.

RESULTS ON LOWER LIMIT HITS

Table (3) reports the volatility in the daily returns around lower price limit hits of -5%, as well as, around the benchmark of price movement of -4%, for each sector as well as for the overall market. Also, the table reports the t-statistics according to Wilcoxon signed-rank test.

The results reported in the table are almost identical to those of the upper limit hits, reported in table (2), however, with less magnitude. Stocks-hit experiences their highest level of volatility on the day when stocks-hit reach their lowest daily price limits (day 0). The volatility of stocks-hit increased from 0.19% on day -10 to 0.23% on day -5 and jumps to 1.85% on day 0, then decrease significantly to 0.83% on day +1 and fluctuate down-ward significantly up to day +10 when it reaches 0.26%. Panel (A) in figure (2) shows the behavior of this volatility.

Sector-by-sector results in the same table reveal similar behavior, but different from those of the upper limit hits. The service sector has the highest volatility followed by the insurance sector and the manufacturing sector and, finally, the banking sector. The volatility of the banking and manufacturing sectors during post-limit-hit days are the most significant in comparison with the control group. But similar to those of the upper limit hits, none of the post-limit-hit day's volatility in the insurance and the service sectors is significant. Panels (B), (C), (D), and (E) in figure (2) show the behavior of volatility in the banking, insurance, services and industry sectors, respectively. In fact, movements in the daily returns volatility started on day -10, at which the difference from the control group was significant. But the movements eased afterward until day -5, then regained power up to the price-limit-hit day. The volatility relaxed significantly only during the post-limit hit day +1.

Table 3: Volatility in the Daily Returns around Lower Limit Price Hits

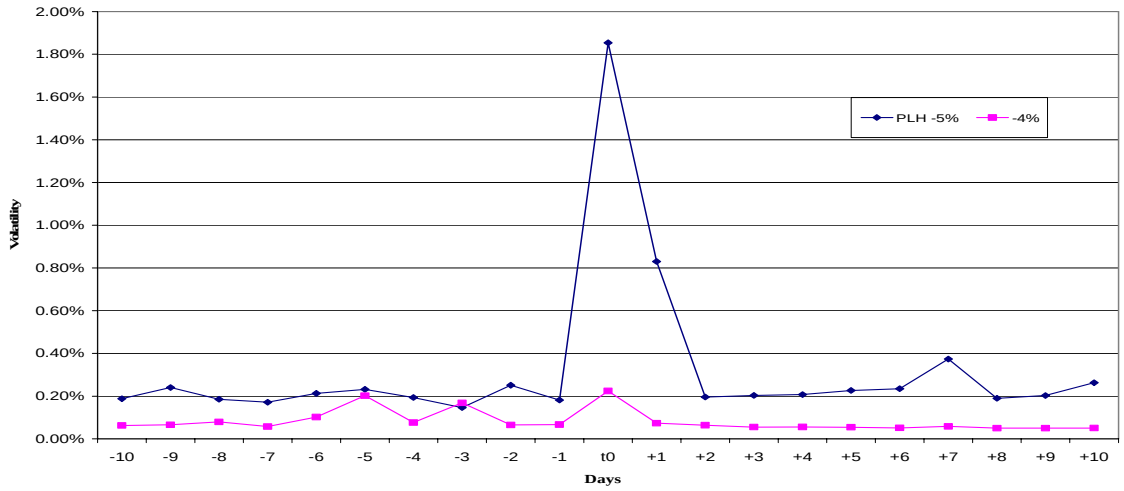
	ALL SECTORS			BANKS			INSURANCE		
Days	**PLH -5%**	**-4%**	**T-Value**	**PLH -5%**	**-4%**	**T-Value**	**PLH -5%**	**-4%**	**T-Value**
-10	**0.19%**	0.06%	-4.8705**	0.35%	0.05%	-4.4871**	**0.06%**	0.05%	-0.2699
-9	**0.24%**	0.07%	-3.2997**	0.54%	0.08%	-2.7043**	**0.03%**	0.05%	1.7391**
-8	**0.19%**	0.08%	-3.3030**	0.39%	0.07%	-4.3055**	**0.03%**	0.04%	0.6080
-7	**0.17%**	0.06%	-3.9868**	0.37%	0.07%	-3.3511**	**0.04%**	0.04%	0.0493
-6	**0.21%**	0.10%	-2.2657**	0.33%	0.31%	-0.1208	**0.02%**	0.08%	1.4443
-5	**0.23%**	0.20%	-0.2560	0.62%	0.10%	-2.8146**	**0.06%**	0.04%	-0.6696
-4	**0.19%**	0.08%	-2.9880**	0.44%	0.20%	-1.4607	**0.03%**	0.04%	0.9520
-3	**0.15%**	0.17%	0.3180	0.27%	0.27%	-0.0290	**0.03%**	0.23%	1.0922
-2	**0.25%**	0.07%	-2.6373**	0.60%	0.07%	-2.2084**	**0.02%**	0.05%	2.4323**
-1	**0.18%**	0.07%	-2.8808**	0.29%	0.09%	-2.6950**	**0.03%**	0.04%	0.2618
t0	**1.85%**	0.22%	-5.2449**	1.57%	0.22%	-3.9570**	**1.65%**	0.22%	-2.2153**
+1	**0.83%**	0.07%	-1.1616	0.35%	0.09%	-4.4154**	**0.04%**	0.06%	1.2031
+2	**0.20%**	0.06%	-5.2917**	0.38%	0.05%	-5.0741**	**0.04%**	0.05%	0.8040
+3	**0.20%**	0.06%	-5.1785**	0.39%	0.06%	-4.4920**	**0.05%**	0.04%	-0.7166
+4	**0.21%**	0.06%	-5.6114**	0.40%	0.05%	-5.0566**	**0.04%**	0.03%	-0.6395
+5	**0.23%**	0.05%	-3.4773**	0.54%	0.09%	-2.6761**	**0.02%**	0.03%	0.6144
+6	**0.23%**	0.05%	-5.4101**	0.42%	0.05%	-5.8161**	**0.05%**	0.03%	-1.2591
+7	**0.37%**	0.06%	-2.9689**	0.92%	0.08%	-2.3680**	**0.04%**	0.03%	-0.7530
+8	**0.19%**	0.05%	-6.0171**	0.40%	0.06%	-5.2155**	**0.04%**	0.04%	-0.2634
+9	**0.20%**	0.05%	-5.3211**	0.43%	0.13%	-3.0093**	**0.02%**	0.04%	1.0922
+10	**0.26%**	0.05%	-3.5553**	0.49%	0.05%	-2.6359**	**0.05%**	0.03%	-1.1385

	SERVICES			INDUSTRY		
Days	**PLH -5%**	**-4%**	**T-Value**	**PLH -5%**	**-4%**	**T-Value**
-10	**0.11%**	0.09%	-0.4599	**0.14%**	0.05%	-3.1919**
-9	**0.06%**	0.06%	-0.2937	**0.18%**	0.07%	-2.2573**
-8	**0.07%**	0.06%	-0.4754	**0.14%**	0.11%	-0.5604
-7	**0.08%**	0.07%	-0.2692	**0.11%**	0.05%	-2.9288**
-6	**0.05%**	0.11%	1.4197	**0.26%**	0.06%	-1.9819**
-5	**0.08%**	0.22%	1.0143	**0.08%**	0.26%	0.8361
-4	**0.05%**	0.07%	1.3281	**0.13%**	0.07%	-2.1108**
-3	**0.12%**	0.09%	-0.4928	**0.10%**	0.20%	0.7164
-2	**0.07%**	0.08%	0.1683	**0.16%**	0.06%	-2.7457**
-1	**0.04%**	0.08%	1.8117**	**0.22%**	0.06%	-1.9253**
t0	**2.66%**	0.23%	-2.8054**	**1.63%**	0.22%	-2.6688**
+1	**2.85%**	0.08%	-0.9951	**0.16%**	0.07%	-2.0032**
+2	**0.07%**	0.08%	0.3870	**0.18%**	0.06%	-2.9574**
+3	**0.09%**	0.07%	-0.8351	**0.17%**	0.05%	-2.7244**
+4	**0.05%**	0.06%	0.8992	**0.20%**	0.06%	-3.1872**
+5	**0.07%**	0.06%	-0.1343	**0.15%**	0.05%	-2.6394**
+6	**0.08%**	0.07%	-0.2483	**0.24%**	0.04%	-2.8167**
+7	**0.11%**	0.08%	-0.5601	**0.22%**	0.05%	-2.1574**
+8	**0.04%**	0.06%	1.5373	**0.16%**	0.05%	-3.7664**
+9	**0.08%**	0.04%	-1.0758	**0.16%**	0.04%	-3.3639**
+10	**0.04%**	0.06%	2.0326**	**0.29%**	0.05%	-2.5491**

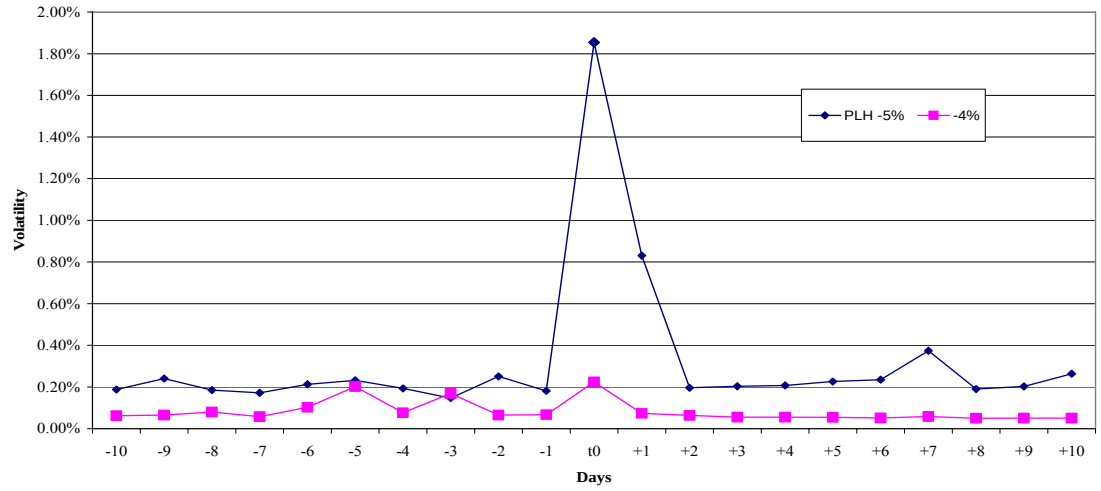
Note: Stocks are categorized into two groups (-5% and -4%) based on the level of their price movements on Day 0 . Stocks 5% denote stocks that reach their lower daily price limit (-). The main categories are presented for downward price movements. Each number (in %) in the table represents the volatility of daily returns at and around price limit hit for each sector during the period 1/1/2003 to 31/12/2004. T-value is computed according to Wilcoxon signed-rank test.

Figure 2: Daily Returns Volatility around Lower Price Limit Hits

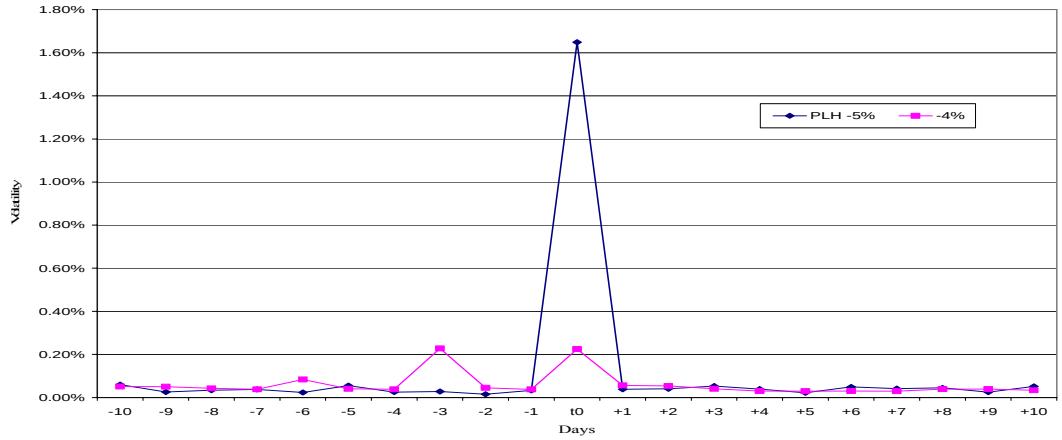
Panel A: for All Sectors



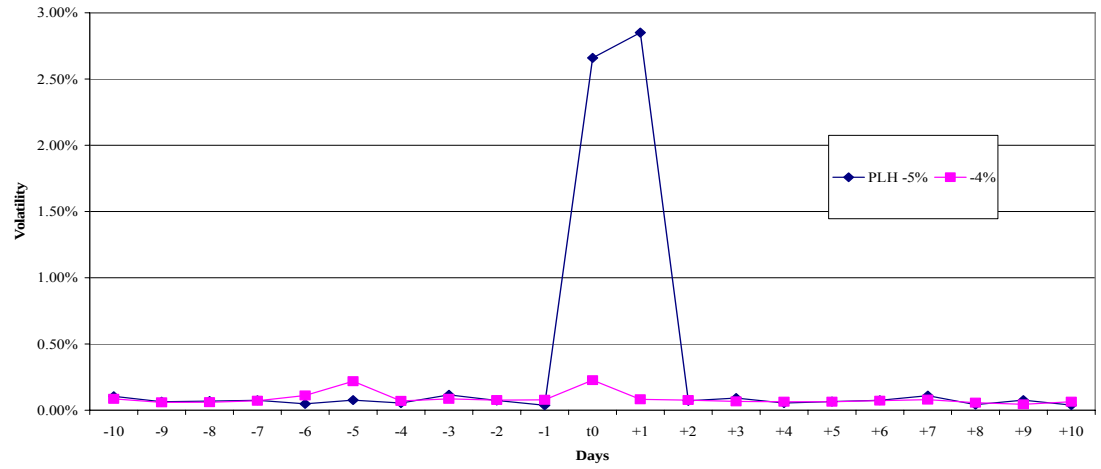
Panel B: for Banking Sectors



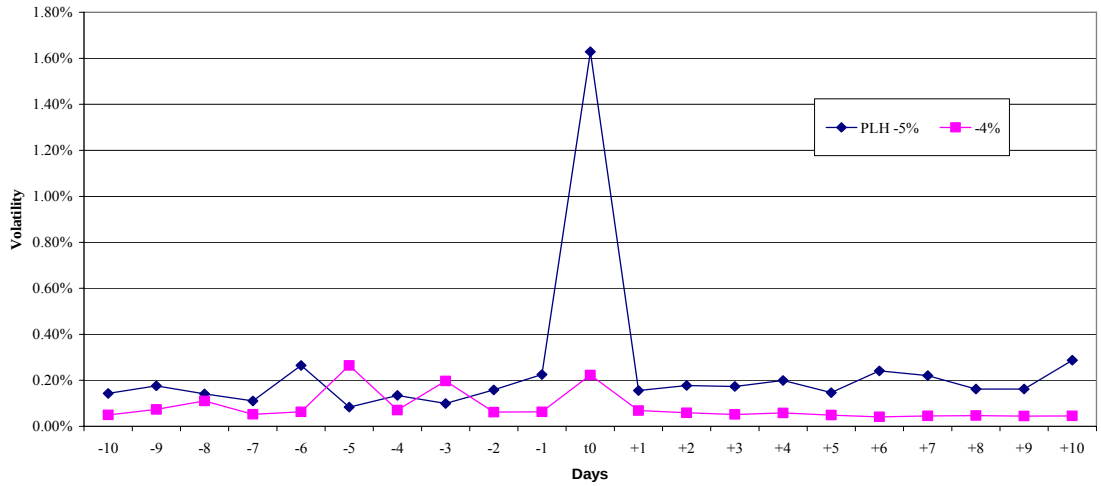
Panel C: for Insurance Sectors



Panel D: for Services Sectors



Panel E: for Industry Sectors



SUMMARY AND CONCLUSION

This paper empirically investigated the behavior of daily stock return volatility around the price limit hits for a sample of 159 (189) securities listed in ASE for the years 2004 (2005). It investigates whether daily return volatility for stock that hit hits price limits are lower (higher) in the post limit hit period than in the pre limit hit period, which is consistent with the overreaction hypothesis (volatility spill over hypothesis).

The methodology employed was based first on identifying the days where the high (low) price matches its previous day's closing price plus (minus) the price limit, and then on measuring the price volatility around the days, when price hits the limit. Our results indicate that stocks-hit experiences their highest level of volatility on the day when stock-hits reached their upper daily price limits of 5% (day 0), and decreases significantly one day after the hit. Similar results are found when stock hits reach their lower daily price limits of -5%, however with less magnitude. Results on sectors reveal that the banking sector has the highest volatility, and its volatility is the most significant during post limit hit days in comparison to the other sectors when the stock-hits reach their upper daily price limit. However, when the stock-hits reach its lower daily price limit, the service sector has the highest volatility as compared to the other sectors in the industry. Therefore, our results are consistent with the overreaction hypothesis and that the price-limit technique is effective in reducing the volatility by providing a time-out to cool-off.

REFERENCES

Arak, M. and Cook, R.E. (1997) "Do Daily Price Limits Act as Magnets? The Case of Treasury Bond Futures", *Journal of Financial Services Research,* vol. 12(1), p. 5-20.

Bidlik, Recep and Guzhan Gulay (2003) "Effects of Price Limits on Stock Markets: Evidence from Istanbul Stock Exchange", *Draft Paper*.

Brandt, M. and T. Wu (2002) "Cross-Sectional Tests of Deterministic Volatility Functions", *Journal of Empirical Finance*, vol. 9, p. 525-550.

Brennan, Michael (1986) "A Theory of Price Limits in Future Markets", *Journal of Financial Economics*, vol. 16, p. 213-233.

Chan, Soon Huat, Kenneth Kim and S. Ghon Rhee (2005) "Price Limit Performance: Evidence from Transactions Data and the Limit Order Book", Journal of Empirical Finance, vol. 12(2), p. 269-290.

Chen, Haiwei, (1998) "Price Limits, Overreaction, and Price Resolution in Futures Markets"*, Journal of Futures Markets* vol. 18, p. 243-263.

Chernov, M., A. Gallant E. Ghysels and G. Tauchen (2003) "Alternative Models for Stock Price Dynamics", *Journal of Econometrics*, vol. 116, p. 225-257.

Cho, D., J. Russell, G. Tiao and Ruey Tsay (2003) "The Magnet Effect of Price Limits: Evidence from High-Frequency Data on Taiwan Stock Exchange", *Journal of Empirical Finance*, vol. 10, p. 133-168.

Chung, J and Li Gan (2004) "Estimating the Effect of Price Limit Hitting Days", *Econometric Journal*, vol. 8, p. 79-96.

Gay, G., J. Kale, R. Kolb, and T. Noe (1994) "(Micron) Fads in Asset Prices: Evidence from the Futures Market", *Journal of Futures Markets*, vol. 6, p. 637–659.

Goetzmann, W., R. Ibboston and L. Peng (2001) "A New Historical Database for the NYSE 1815 to 1925: Performance and Predictability", *Journal of Financial Markets*, vol. 4, p. 1-32.

Hair, Jr., Joseph F., Rolph E. Anderson, Ronald L. Tatham and William C. Black (1998) *Multivariate Data Analysis*, 5th Edition, Prentice Hall, USA.

Harris, L. (1998) "Optimal Order Submission Strategies in Some Stylized Trading Problems", *Financial Markets, Institutions and Instruments*, vol. 7(2).

Hopewell, Michael H. and Arthur L. Schwartz (1978) "Temporary Trading Suspensions in Individual NYSE Securities", *Journal of Finance*, vol. 33, p. 1355-1374.

Huang, Y.-S., T.-W. Fu, and M.-C. Ke (2001): "Daily Price Limits and Stock Price Behaviour: Evidence from the Taiwan Stock Exchange," *International Review of Economics and Finance*, vol. 10, p. 263–288.

Kaizoji, T., S. Bornholdt and Y. Fujiwara (2002) "Dynamics of Price and Trading Volume in a Spin Model of Stock Markets with Heterogeneous Agents", *Physica A*, vol. 316, p. 441-452.

Kim, K.A. and Rhee, S.G. (1997) "Price Limit Performance: Evidence from the Tokyo Stock Exchange", *Journal of Finance,* vol. 52(2), p. 885-901.

Kodres, L.E. and D.P. O'Brien (1994) "The Existence of Pareto Superior Price Limits", *American Economic Review,* vol. 84, p. 919-932.

Lee, S.B. and K.J. Kim (1995) "The Effect of Price Limits on Stock Price Volatility: Empirical Evidence from Korea"', *Journal of Business Finance & Accounting*, 22, p. 257-267.

Lee, C.M.C., Ready, M.J., Seguin, P.J. (1994) "Volume, Volatility, and New York Stock Exchange Trading Halts", *Journal of Finance,* vol. 49(1), p. 183-214.

Lehmann, Bruce N. (1989) "Commentary: Volatility, Price Resolutions and Effectiveness of Price Limits", *Journal of Financial Services Research*, vol. 3, p. 205-209.

Liesenfeld, Roman (2001) "A Generalized Bivariate Mixture Model for Stock Price Volatility and Trading Volume", *Journal of Econometrics*, vol. 104, p. 141-178.

Ma, C. K., W. H. Dare, and D. R. Donaldson (1990): "Testing Rationality in Futures Markets", *Journal of Futures Markets*, vol. 11, p. 137–152.

Ma, C.K., R.P. Rao and R.S. Sears (1989) "Volatility, Price Resolutions and Effectiveness of Price Limits", *Journal of Financial Services Research*, vol. 3, p. 165-199.

Maslov, Sergei (2000) "Simple Model of a Limit Order-Driven Market", *Physica A*, vol. 278, p. 571-578.

Miller, M.H. (1989) "Comment: Volatility, Price Resolutions and Effectiveness of Price Limits", *Journal of Financial Services Research*, vol. 3, 201-203.

Newbold, Paul (1991) *Statistics for Business and Economics*, 3rd Edition, Prentice-Hall International, USA.

Remer, R. and R. Mahnke (2004) "Application of Heston Model and its Solution to German DAX Data", *Physica A*, vol. 344, p. 236-239.

Subrahmanyam, A. (1994) "Circuit breakers and Market Volatility: a Theoretical Perspective", *Journal of Finance,* vol. 49, p. 237-254.

BIOGRAPHY

Ritab S. Al-Khouri is a professor of finance at Yarmouk University, Jordan
Moh'd M. Ajlouni is the Chairman of the Department of Banking and Finance at the Yarmouk University, Jordan.