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Price Limit and Financial Contagion: Protection or Illusion? The Tunisian Stock Exchange Case

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ABSTRACT: The aim of this paper is to analyze the role of the price limits system to secure the Tunisian stock market against the contagion by the current world-wide crisis. Initially, we try to show that the contagion observed in the Tunisian market is of psychological nature before analyzing the role played by the price limits to avoid a stock exchange crash. Our empirical investigation deals with the behavior of the Tunisian market around the downward price limits. Two methodologies are used: that of Kim and Rhee (1997), become impossible to circumvent in the studies being interested in the price limits and that standard event studies, applied to return and volume. Our results show that the price limits played a stabilizing part in the case of the price falls without undesirable effects, contrary to the results found on several other markets.

Keywords: price limits; event studies; financial contagion.
JEL Classifications: G01; G14; G15

1- Introduction

In the context of internationalization and financial globalization, the contagion in international financial crises became an omnipresent spectrum on the international scene. Generally, we evoke economic integration as a determinant factor of the contagion, as far as we estimate that the probability that a given country is in its turn touched by a crisis, is dependent on its level of integration in the worldwide economy.

In this logic, the Tunisian economy being slightly integrated in the worldwide economy, we could deduce from it a priori that Tunisia is safe from any contagion. The whole of the political discourses and the media articles appeared at the time of the crisis of the summer 2008 insisted on this fact. However, the course of the events showed that no country is saved from crisis and that the contagion struck all the countries without any exception because of a generalized distrust. More precisely, we could note that the crisis was propagated from a sphere to another (banking-stock exchange-real) and from a country to another, by borrowing various channels and at variable speeds. The comprehension of the transmission channels of the crisis (mechanism of the contagion) is capital to set up the suitable policies. For this reason, we can identify three factors of propagation of the crises such as, the common shocks, the trade and financial interdependences and the pure contagion. This classification corroborates the typology of Masson (1998, 1999), which identifies three forms of contagion:

- ✓ Monsoonal effect: a common factor influences at the same time two or several countries. Certain authors (Moser, 2003) talk about a fallacious contagion if the common shock influences two or several economies at the same time without any causal nexus.
- ✓ Normal interdependences, spillover effect or fundamentals-based contagion: a country is touched by a crisis because of the existence of a crisis in a third country with which it maintains trade or financial relations. Masson (1999) treated the trade channel whereas other researchers (Kaminsky and Reinhart (2000) and Broner and Gelos (2003)) were interested in the financial channel which is defined by the presence, in the related countries, of portfolio of stocks or loans emanating of a common third country.

- ✓ Pure Contagion: by elimination, Masson (1999) considers that if none of the already cited factors can explain a serial crisis, then we are in the presence of a pure contagion, which can be explained by financial panic, the loss of confidence, the increase in risk aversion or the mimetic behavior.

Kaminsky and Reinhart (2000) regard the first two forms as being "fundamentals-based" and the third as being a "true contagion". Forbes and Rigobon (2001) talk rather about a "shift contagion" in the sense that an economic link is reinforced or is created between two or several economies, following the propagation of the stress and financial panic.

The determination of a contagion typology is dependent on the chosen definition of contagion. Those which adopted a narrow definition of the contagion will be limited to the third form which is of a psychological nature contrary to the two first which are mechanical ones.

Ahluwalia (2000) distinguishes:

- the discriminating contagion, based on a judgment by the fundamental determinants (independently of the trade and financial channels), therefore on the perception of the economic resemblances by the investors who wake-up call to revise their perceptions of risk following the appearance of a crisis in a country which presents similarities or to the limit neighbor with their country,
- non-discriminating contagion which touches certain countries without apparent reason.

In this paper, we do not seek to reinforce the polemical debate on the definition of the contagion. We limit ourselves in fact, with a narrow definition, according to which the contagion is a variation of the link between markets during the crisis period, and we seek to establish a typology which enables us to identify the nature of the contagion which has affected the Tunisian stock market with the end of the year 2008.

The probability of the contamination of a given market depends on its degree of vulnerability and the set-up of policies adapted by the authorities. A precise knowledge of the form of the contagion is then capital to find the adequate policies: in the case of the common shocks and of the interdependence, it is necessary then to improve the fundamental determinants; in that of the pure contagion, less radical policies (less fundamental such as the injection of liquidities) can be adopted. It is clear that the authorities of the embryonic and emergent markets must be guarded against the crises by adopting a specific market microstructure (design) and protectionist regulation of market. Among the mechanisms used, there are mainly, the price limits which are limits of variation of the prices fixed by the authorities: they restrict and even prevent any transaction at a price higher than the maximum limit or lower than the minimal limit. The main reason called upon by the authorities of the markets, to justify the existence of such a mechanism, is that to avoid the movements of panic in the event of sharp decline of the prices.

The price limits can stabilize the markets only in the case of a psychological contagion. Whereas in the event of a degradation of fundamental and by admitting a certain degree of efficiency, even weak, the price limits do nothing but delay the process of price adjustment.

In the case of Tunis Stock Exchange, the price limits are used, among the mechanisms of regulation, by the authorities and are dissociated from those of other countries by the fact of being extremely tight (table 1). Our objective is to analyze the role played by the price limits system to secure the Tunisian stock market against the contagion by the last world-wide crisis. In this sense, we will initially try to show that the contagion observed in the Tunisian market is of psychological nature before analyzing the role played by the price limits to avoid a stock exchange crash.

Our aim is to show that the crisis of 2008 was started for exogenous reasons of the Tunisian economy and that thus, the tumble of the stock exchange prices could be limited with the adoption of price limits system.

In the second section we will discuss the various forms of the financial contagion on the stock markets before presenting the policies adopted by the Tunisian authorities to guard against the crisis. In the third, we will present our empirical investigation dealing with the behavior of the Tunisian market around the downward price limits. Two methodologies will be used: that of Kim and Rhee (1997), become impossible to circumvent in the studies being interested in the price limits and that standard event studies, applied to return and volume.

Table 1. Price limits of some stock exchanges

Country	Price limits
Bengladesh	7,5–20%
Belgium	5–10%
China	10%
South korea	15%
Ecuador	10-20%
Spain	10%
Finland	15%
France	10-20%
Italy	10-20%
Japan	10-60%
Malaysia	30%
Mexico	10%
Philippines	40% for the downward
Portugal	15%
Romania	15%
Czech	5%
Tunisia	6,09%

Source: Extract from Chung and Gan (2005)

2- Contagion Forms and Policies adopted by Tunisian Authorities

While referring to two studies ((Moser (2003) and Lowell, Neu and Tong (1998)), we will analyze, in a first paragraph, the nature of the contagion which touched the Tunisian market before discussing the policies adopted by the Tunisian authorities to limit the effects of the financial contagion.

2-1 Contagion forms

Moser (2003) elaborate a general framework, allowing the establishment of a typology of the contagion forms, concerning all the spheres. Since our interest is limited to the stock market we adopted only the approaches which are attached to it. Moser (2003) distinguishes two mechanisms in a pure contagion, namely the informational effect and the domino effect.

The informational effect takes place when a crisis in a given country triggers another crisis in other countries; in this case, the investors consider the first crisis as a signal which pushes them to readjust their information and thus their anticipations concerning other countries. Several reasons can explain an evaluation readjustment of fundamentals without any modification of the latter:

- ✓ The signal extraction failures: in situation of incomplete information, the release of a crisis in a country can reveal relevant information for the investors of other countries, which lead them to revise their anticipations concerning the fundamentals of the latter. Two cases can have the same effect: the fictitious interdependence and the lump together hypothesis. In the first situation, the investors suppose wrongly, the existence of an interdependence of fundamentals or at least, over-estimate the level of this interdependence. Whereas in the second case, the investors suppose that the countries similar to the country attacked by the crisis, will encounter the same problems; they go then, interpret wrongly the shocks specific to a country by taking them for common shocks. In both case, a crisis in a given country leads to an inefficient revision of the fundamentals in the other countries and to a bad evaluation of the assets.
- ✓ The wake-up call: the investors will revise their anticipations concerning the fundamentals, following the release of a crisis in another country. Contrary to the assumption of the signal extraction failure, the investors will pay more attention to the real risks and their readjustments will be done in the good direction.
- ✓ Expectations interaction: this argument is based on the group psychology and finds its sense in the self-fulfilling expectations phenomenon of the financial crises or in the failures of coordination between the investors in the presence of multiple equilibrium. The contagion emerges when a crisis in a given country will act as a sunspot variable which pushes the

investors to coordinate their anticipations concerning the crisis equilibrium. A crisis in a country will make the investors lose their confidence in the markets and the (international) investments in general.

The second effect of the pure contagion, called domino effect, appears when a crisis in a given country creates some another elsewhere, because of financial connections and in particular because of portfolio readjustment of certain investors, due to some liquidity constraints. In this case, a crisis on a given market, can force the investors to get rid of part of their investments in healthy markets so, to free liquidity which will be useful on the touched market either, to cover additional margin call or, to satisfy the repurchases, in the case of the investment funds. The massive sale of the assets in the markets initially unaffected by the crisis can generate a sharp decline of the prices and a possible collapse.

The analysis of the transactions carried out by the foreigners on Tunis Stock Exchange during the period of the crisis, shows us that there was a massive exit from some foreigners but which were limited only to some assets, whereas the price fall touched the entirety of stocks. The Tunisian authorities affirmed that the floating foreign participation before the crisis, accounted for only 3% of the total market capitalization, of which a part only is expatriate during the year 2008. The market capitalization held by the foreigners fell during the year 2008 to pass from 28% to 24, 74% (including 22% of strategic participations). It is true that most of the trading volume (33%) were carried out by foreigners, but there were as well sales as purchases[1].

Consequently, the domino effect can explain only a part of the decrease of some Tunis Stock Exchange assets (7 assets were possibly touched by this effect, namely TPR, TL, ARTES, BH, Poulina, BIAT and SOMOCER). What is it then about the informational effect?

The assumption of a wake-up call is initially to be rejected, since the financial performances of the listed companies increased in 80% of cases during year 2008 compared with 2007. Even during the first quarter of 2009, the financial performances of 45 companies increased compared to the first quarter of the year 2008 against only 5 falls. We deduce from it that the investors did not revise their anticipations downward following a signal given by other markets, more especially as at the time of the crisis the listed companies (following the directives of the market authorities) did not cease publishing information concerning their activities and indicating that their prospects concerning the future were optimistic.

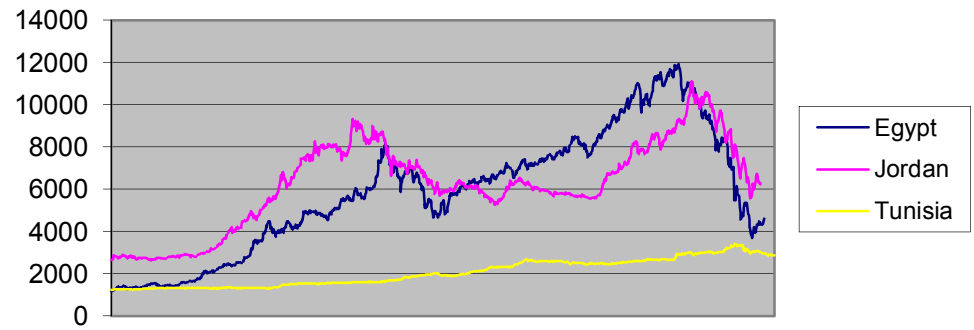
We thus retain the two remaining assumptions namely the signal extraction failure and expectation interactions. Let us note that with regard to the first assumption, we keep only the explanation by the fictitious interdependence since the lump together hypothesis cannot be valid, being given the state of mind dominating before the crisis: the Tunisian investors did not see any link between Tunis's Stock Exchange and the European or Arab stock exchanges. Moreover, the examination of the graph (1) shows us that no correlation exists between Tunis Stock Exchange and the other markets during the five last years.

Lowell, Neu and Tong (1998) present four models of financial contagion:

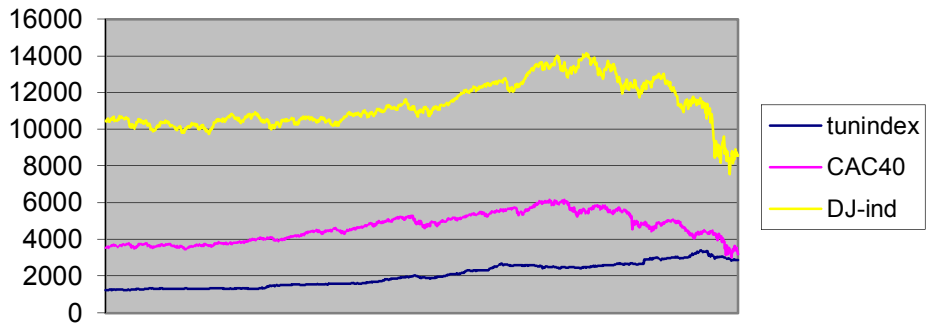
- ✓ The economic links model: the crisis in a country affects the fundamentals in other countries.
- ✓ The heightened awareness: this form of contagion can appear in the case of the existence of a difference between the information held by the investors and the fundamentals. From the moment that there is a crisis in a country, the investors will revise downward their anticipations in the other countries. Failing to adopt adequate policies, a precise reporting and a good analysis can reduce the exposure to such a contagion. This model merges with the assumption of wake-up call of Moser (2003).
- ✓ Portfolio adjustment model: the needs for liquidity of an investor following a crisis in a given country oblige it to sell its assets in other countries, which will make them sink in crisis.
- ✓ Mimetic behavior model: the investors of a given country will imitate other investors touched by the crisis in another country without the fact that the fundamentals of the first country being poor, as supposes the second model.

[1] The acquisitions amounted to 610 million dinars while sales were 685 million dinars in 2008.

Graph 1a: Evolution of indexes of three arab stock exchanges (2004-2008)



Graph 1b: Evolution of Tunindex, CAC40 and DJ-ind (2004-2008)



By using this typology, the model of the mimetic behavior reflects the contagion observed in the Tunisian market. Indeed, we can reject the model of economic link by analyzing the structure of the listed companies on the Tunisian market[2]. The great majority of the companies of the financial sector, in particular the banking sector, have a very limited link with outside and are held to respect the prohibitions of access to the international markets, dictated by the law. For the companies other than banking, their activities are directed overall towards the local market: if one excludes two of them (ICF and ALKIMIA), the export activities for those which have some, hardly exceed 20% of total turnover. Consequently, the models of awareness and those of portfolio adjustment cannot be plausible.

2-2 Policies

Tunis Stock Exchange shows certain structural characteristics likely to make it vulnerable to stock exchange crises: a recent financial liberalization, a weak market capitalization, a limited number of listed companies and a prevalence of some assets. On the other hand, other specificities play a moderating role, if not protective against the stock market crises: the mean level of the price earning ratio (*PER)* which was only 12,9 at the beginning of the 2008, against a PER of 30 in Morocco, the almost systematic devaluation of the local currency limiting the flows of foreign assets, the prohibition

[2]The IMF have revised the growth of the Tunisian economy downward with a half during the year 2009, whereas the Tunisian market index have not ceased to go upward in the period.

of the short sales and the absence of derivatives that limit the leverage and dissuade foreign speculators.

According to Lowell, Neu and Tong (1998), the markets characterized by small investors are vulnerable to the contagion because this type of investors is exposed more to panic and the rumors. In Tunisia, the stock exchange authorities tried to control the foreign capital while seeking to attract them: although the Tunisian market is rather a market of small investors, we observed at the time of the new IPOs, the priority was offered to institutional - including foreigners - who devoted the greater part of the newly issued securities. Other side, aware from the 1997 Asian crisis, the risks of contagion induced by the existence of foreign investors, the Stock Exchange authorities tried to frame them in order to limit their adverse effects. Thus, to avoid the stock exchange panics and crashes, they implemented a system of price limits with of the very tight thresholds as well as a suspension system trading (with an absolute discretionary power).

In addition to these regulatory precautions that existed long before the crisis of 2008, the Tunisian authorities have conducted two series of measures to stem the contagion even the crisis.

The first series is designed to counteract the pure contagion and includes the following decisions:

- ✓ A communication policy by the political authorities wanting to be reassuring about the economic situation of the country and using the various mass media.
- ✓ The limitation of the possibilities of giving orders via Internet.
- ✓ The creation of two public hedge funds intended to stabilize the stock exchange prices by the injection of liquidities on the market which would make it possible to compensate for the leak movements of the foreign assets.
- ✓ The call to the companies to be aggressive in terms of financial reporting, mainly by increasing the amount of public information, which is likely to reduce the information cost and thus to limit the effects of rumor and in particular panic. In this sense, 31 volunteers communications were recorded in 2008, whereas traditionally the companies listed on Tunis Stock Exchange are rather stingy in terms of communication: in previous years, the Financial Market Council has frequently had to remind the order listed companies to publish in time, the quarterly information, yet mandatory.
- ✓ The creation in 2009 of a Broker Guarantee funds in order to protect the depositors in the event of bankruptcy of an intermediary.

The second set of measures aim at the fundamentals. There are:

- ✓ Protection measures of the companies which are really exposed to the crisis and this on an economic plan.
- ✓ Policy of reducing interest rates, during 2009, with a view of reviving the economy.

Thus, apart from the provisions existing before the crisis, the authorities have tried, at the time of the start of the crisis, to adopt policies which aim mainly the psychology of the investors and the reduction of the information asymmetry followed by policies aiming at the economic sphere.

3- Tunisian Market Reaction to Downward Price Limits in Times of Crisis

After the stock exchange crisis of October 1987 and the report of Brady (1988), several markets throughout the world adopted a system of quotations interruption, in particular the price limits, which are limiting prices forced by the stock exchange authorities to reduce the daily variations of the prices. In such case, a transaction can be carried out only if the price belongs with a pre-established interval; in the opposite case, the transaction is blocked for a certain period or until the end of the day.

The price limits are used to reduce the information asymmetry. They provides the investors more time to evaluate new information and the intermediaries the possibility to consult their customers during the periods of strong turbulence; so rational decisions and an overreaction reduction are expected. They also limit the great price changes due to the speculation and panic, in the case of downward trend.

The introduction of the price limits was primarily studied within the framework of the future markets, as we can note it through a review of the formal models preaching the setup of price limits:

- ✓ Brennan (1986) found theoretically that the price limits are partial substitutes with the calls for markup whose cost is exorbitant. He concludes that the price limits reduce the total transaction costs and reduce the risk of defect of the contracts.
- ✓ Kodres and O' Brien (1994) developed a model to examine the effects of the price limits on the futures markets. They conclude that the price limits allow a better division of the risks when the fluctuations of price are due to information concerning the fundamentals of the company.
- ✓ Kim and Park (2010) found that the authorities used the price limits more to oppose the manipulators than to limit volatility. According to them, the authorities would seek in fact to camouflage their real intentions, so that the price limits are regarded as an official consent of the existence of handling.

Theoretically thus, the price limits are founded with an aim of calming the markets and of avoiding the excessive movements of price, i.e. to reduce overreaction and volatility. However, as point out it in particular Wong, Liu and Zeng (2009), several theoretical and empirical studies revealed negative effects:

- ✓ Fama (1989), Lehmann (1989) and Lee, Ready and Seguin (1994) maintain that price limits delay information integration in prices so new equilibrium cannot be reach at time. (Delayed price discovery).
- ✓ Kuhn, Kurserk and Locke (1991), Kim and Rhee (1997) and Kim (2001) claim that the price limits increase the volatility of the daily prices which follow the hitting limit. (volatility spillover effect)
- ✓ Tesler (1989), Fama (1989) and Kim and Rhee (1997) maintain that the price limits can interfere with the trading activity implying illiquidity and thus an intensification of the trading volume in the days following the limit hitting. (trading interference effect)
- ✓ Subrahmanyam (1994), Cho, Russel, Tiao and Tsay (2003): found that the price limits play a magnet role by attracting the prices, by causing an intensification of trading and by increasing volatility before the hitting limit. (magnet effect)
- ✓ Chen (1993), McDonald and Michayluk (2003) claim that "large hands" can use the price limits to handle the not-informed investors. While pushing the prices to converge to the price limits during one or few days, many investors will be attracted and will think that an opportunity comes up. These imply an overreaction and a volatility increase.

In what follows, we will test the first three assumptions of the undesirable effects of the price limits. We can dismiss the last assumption in the Tunisian context for the lower price limits because of the prohibition of short sale whereas to test the assumption of the magnet effect we need intra-day data. With this intention, we will use the nonparametric methodology of Kim and Rhee (1997). We will have then resort to the standard event studies methodology to study the market reaction at price-limit-hit, in terms of price and volume.

3-1 Data

The study period is spread out between the 01-09-2008 and 31-12-2008. A daily frequency was selected for the various tests. We used a database published by the BVMT that we adjusted to take account of the changes in the company's share capital (capital increase, splits and dividend distributions). We retained in our sample only the stocks listed on continuous, because those with fixing quotation suffer of illiquidity although they are exposed to highly frequent price limits.

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. We also eliminated the stocks that are new listed. On the whole, the sample comprises 21 stocks.

According to the table 2 which recapitulates the number of downward price limits of our sample for each year, we note that the year 2008 is touched by the downward price limits in spite of the fact that from 03-12-2007, the maximum downward limits passed by decision of the Stock Exchange, from 4,5% to 5,91%. The price limits noted in 2005 and 2006 touched some stocks for several times, whereas in 2008, the majority of the stocks reached price limits at least once, in particular during the day of 06-10-2008.

Table 2. Downward price limits of stocks listed on continuous

Year	Total
2005	43
2006	34
2007	2
2008	50

3-2 Non-parametric Approach

3-2-1 Kim & Rhee (1997) non-parametric methodology

Let Pi,t the adjusted closing price of asset i at the moment t. The return $R_{i,t}$ can be defined as the logarithm of the difference between the closing prices for two successive transaction days:

$$R_{it} = \text{Log } P_{i,t} - \text{Log } P_{i,t-1} \quad (1)$$

To identify the moment of the crossing of limits, we used the Official Bulletins of the BVMT where the downward price limits are announced by the letter B. Normally, the lower limit ($S_{dow}(i,t)$) is reached when the closing price crosses the closing price of the day before, less the maximum allowable downward price movement:

$$P_{i,t} = S_{dow}(i,t) \leq P_{i,t-1} * (1 - dow) \quad (2)$$

With dow, the maximum percentage falls. As from the 03-12-2007, this fall cannot be identified any more a priori, but we can know his maximum value which is equal to 5.91%.

For reasons of comparison, the stocks which did not reach the limits 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 S_{dow} and it is noted $Stock_{0.90}$. The second group, noted $Stock_{0.80}$, is composed of the stocks which reached at least 80% of the authorized maximum fall and to the more 90%. The use of the $Stock_{0.80}$ group is used to show that the difference between the group of stocks that reach price limits and groups of $Stock_{0.90}$ is not due to the difference between the variations of the prices during day zero, if no difference is found between the two groups, $Stock_{0.90}$ and $Stock_{0.80}$.

3-2-1-1 Hypothesis of the volatility spillover

We choose a 21 days window centered at the date of price limits and it's for $t = -10$ **to** $t = +10$. To avoid the stepping of the limits, we eliminated all the successive limits as well as the limits outdistanced one period lower than 20 days. The same step was adopted for the assets which reach the limits of 90% and of 80% of the authorized maximum variation.

Two measurements of the volatility are used:

$$Vol_{i,t} = (R_{i,t})^2 \quad (3)$$

Where $R_{i,t}$ is the calculated return with the closing prices for two successive days.

Another measurement, $\mathbf{Vol_{i,t}}$ using the highest prices and the low one of the day are defined as follows:

$$Vol_{i,t} = \left[\frac{High_{i,t} - Low_{i,t}}{0.5(High_{i,t} + Low_{i,t})}\right] \quad (4)$$

Where $High_{i,t}$, is the highest price of asset i the day t and $Low_{i,t}$ the lowest price.

In the event of downward price limits we estimated the lowest price by the crossed lower limit. On the other hand, if the asset is price limited throughout the day volatility would be equal to zero what skews downward the estimated volatility the day of price-limit-hit.

Volatilities are calculated for the three groups ($Stock_{hit}$ (stocks that reach the limits), $Stock_{0.80}$, $Stock_{0.90}$) during the 21 days window and are then compared by using the Wilcoxon signed rank test by for the two samples. If the assumption of *spillover* is validated, that would indicate a higher volatility for the stocks which hit the limits (normally after the price- limit-hit day)

3-2-1-2 Hypothesis of trading interference

The same window and the same Wilcoxon test are used here, but they are applied to a proxy of trading volume instead of volatility. We eliminate from our sample the stocks which have a high number of no trading days. We adopt an approach different from that of Kim and Rhee (1997) who used the day-to-day change of turnover ratio.

Initially we took as measures of turnover, the ratio of the number of asset traded during one day on the total number of his share outstanding. In the second time, we reported daily volume in dinars on the average of volume during all the period in order to obtain a standardized value. When we met an excessively raised volume, we regarded them as aberrant values and treated them in an *ad hoc* fashion, by replacing them by an arbitrary value of 100000 dinars, value which corresponds to the floor of a block transaction. A 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 volume of the group $stock_{hit}$ is higher than that of the two other groups before and after date zero.

3-2-1-3 Hypothesis of delayed price adjustment

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

$O_{i,t}$ the opening price of asset i the day t and $p_{i,t}$, the closing price of asset i the day t.

Then the return of asset i between the opening and the closing, the day t, can be written as follows:

$$R^{d}_{i,t} = Log\left(\frac{p_{i,t}}{O_{i,t}}\right) \quad (5)$$

And the return between the closing day t and the opening of the day (t+1) is equal to:

$$R^{d}_{i,(t+1)} = Log\left(\frac{O_{i,(t+1)}}{p_{i,t}}\right) \quad (6)$$

Consequently, the return between the opening of the day t and the opening of the day (t+1) are:

$$R^{o}_{i,t,t+1} = R^{d}_{i,t} + R^{n}_{i,t+1} \quad (7)$$

The empirical analysis of the combinations $[R^{d}_{i,t}, R^{n}_{i,t+1}]$ during the hit price day (t=0) permit to detect 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 possible cases of combinations $[R^{d}_{i,t}, R^{n}_{i,t+1}]$ such the following $\{[+,+],[+,-],[+,0],[0,+],[0,-],[0,0],[-,+],[-,-],[-,0]\}$.

For the lower limit, the cases $\{[-,-],[0,-]\}$ is regarded as a continuation of the prices, the cases $\{[-,-],[0,+],[-,+],[+,+],[+,0]\}$ announces a reversal of trend whereas the two cases $\{[-,0],[0,0]\}$ reflects a situation without change.

As far as we use the closing price and not on the highest prices and the lowest ones of the day $\{[+,-],[+,0],[+,+]\}$ is not possible configurations when the lower limit is attained.

The calculation of the frequencies of the various remaining configurations for the three groups of stocks will make it possible to operate comparisons. The assumption of delayed price discovery will be validated if we find more continuation of tendency for the $Stock_{hit}$ group compared to the two other groups. This would imply that the price limits prevent the prices from reaching equilibrium the hit day. A nonparametric standard binomial test is used to test the statistical significance of the difference between the two groups $Stock_{hit}$ and $Stock_{0.90}$.

3-2-2 Results and interpretations

3-2-2-1 Spillover hypothesis

The results of table 3 do not confirm the assumption of *spillover* when we use the squared return as a volatility measure. For the three groups, we found that volatility reached its maximum day zero, which is completely normal since the return is with its maximum this day there. Moreover, the group made up of the price limited assets presents the highest maximum followed by the assets of the $Stock_{0.90}$group.

We cannot really affirm the presence of the persistence of volatility after the hit-price-day since, as of the following day, volatility returned on its normal level. On the contrary, we cannot reject the assumption of stabilization of volatility since for the stocks belonging to the two other groups it took two days and not one so that volatility is stabilized. Our results thus are completely opposed to those of Kim and Rhee (1997), Tooma (2004) and Nath (2005) on the respectively Japanese, Egyptian and Indian markets.

In addition, we observed an increase in volatility the day before the hit, for the assets of the $Stock_{hit}$ group, contrary to the two other groups, which can be explained by the concern and fear felt by the investors during the crisis period.

The use of the relative difference between the highest and the lowest prices of the day provides a little different results (table 4): the volatility of $Stock_{hit}$ group reached its maximum the day following the trading halt day to return the day after on its normal level whereas for the two other groups, no significant growth of volatility is noted during all the period of event. However, even these results cannot confirm the spillover assumption.

Table 3. The volatility spillover

	$Stock_{hit}$	$Stock_{0.90}$	$Stock_{0.80}$
-10	0,25502427	0,230395	0,86131798
-9	0,13303276	0,26460335	0,4826164
-8	0,13303276	0,10001824	0,12997939
-7	0,61235907	0,25873294	0,3046447
-6	0,31812616	0,22817842	0,23628998
-5	0,25208446	0,25843975	0,18560741
-4	0,48286655	0,22925294	0,21376631
-3	0,22393751	0,29752592	0,27484839
-2	0,51532077	0,6594615	0,30245188
-1	1,0880502	0,29724867	0,83755004
0	6,00704617	>>1,65274018	1,22458563
1	2,87507559	>>0,58391363	0,35228615
2	0,27712223	0,51296065	0,7084107
3	0,37949403	0,22665435	0,16167695
4	0,96333877	0,10231079	0,30422672
5	0,5198334	>0,16223446	0,12639279
6	0,96697776	0,13581766	0,02105226
7	0,32229838	0,26621387	0,26734156
8	1,16985093	0,11153338	0,03459431
9	0,07856328	0,18122904	0,2001847
10	0,14101697	0,08090203	0,35882171

Volatility $=(Rit)^{\wedge 2}$

Ri,t denotes the daily return of stock i on day t, >> (>)indicate that the left-hand figure is greater than the right-hand figure at 1%(5%) level of significance using the Wilcoxon signed –rank test.

3-2-2-2 Trading interference hypothesis

Once the moment that certain stocks are not daily exchanged, we preferred to analyze the rate of rotation rather than the growth of rotation rate. Not only, the elimination of the days of no transaction can bias the results, but in more we think that the use of growth rate is prone to criticisms: it can bring us to erroneous conclusions since it is normal that following a big raise of return one day t, we find a brutal fall the following day.

The presented results in table 5 show that the exchange is on its lowest level the limit day whereas the next day, it returns on its normal level. Such a result can be explained by price limits which lasted a long time preventing the investors from trading. The investors not being precipitated the following day to readjust their portfolio, we conclude from it contrary to Kim and Rhee (1997), that the assumption of trading interference was not validated.

For the assets belonging to the $Stock_{0.90}$ group, the trading reached its maximum day zero, which is not the case of the assets belonging to $Stock_{0.80}$. We noted that the trading activity during the event period largely increased for the $Stock_{0.80}$ group, whereas it is on the same level for the two other groups, which calls into question any linear relation between volume and the return.

Table 4. The volatility spillover

	$Stock_{hit}$	$Stock_{0.90}$	$Stock_{0\cdot80}$
-10	17,4927114	29,0912938	19,1005302
-9	13,4886573	24,7390785	25,8181486
-8	14,8148148	25,5556732	26,5678382
-7	22,6904376	21,9178688	23,5233788
-6	20,4498978	25,192883	19,8494927
-5	23,8095238	21,594625	18,4415072
-4	18,0761782	22,1704095	20,3473117
-3	24,9554367	27,1675261	25,9456185
-2	13,4228188	26,0366983	24,4078947
-1	15,7480315	24,6108228	27,0612561
0	53,4124629	>>29,9526045	30,3780958
1	78,8979336	>29,2831413	23,4432234
2	30,4568528	28,8369658	26,9735659
3	26,6666667	19,0417579	24,6826975
4	22,5988701	16,685545	29,8446871
5	25,477707	18,8319681	24,298354
6	25,5754476	>16,9121999	21,2827602
7	17,9104478	18,1246781	20,5101675
8	28,0701754	15,9051383	10,1465894
9	26,7686424	23,1617302	17,2377252
10	24,3902439	22,9469352	27,4797816

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

>> (>) indicate that the left-hand figure is greater than the right-hand figure at 1%(5%) level of significance using the Wilcoxon signed –rank test.

Table 5. Trading interference

	$Stock_{hit}$	$Stock_{0\cdot90}$	$Stock_{0\cdot80}$
-10	2,04142345	0,35413589	2,2251969
-9	1,20629426	0,90586545	<2,78586032
-8	0,83943525	0,52576112	1,54245788
-7	1,33386485	0,58869942	1,28039653
-6	0,92467728	0,38331062	1,14360852
-5	1,06521845	0,79903558	<1,55370124
-4	0,59992008	0,38145746	1,34861903
-3	0,82124471	0,54151062	1,82272706
-2	0,51764769	0,31528023	2,43005789
-1	0,62888078	0,99214431	1,45093022
0	0,88413778	0,81220373	1,67582795
1	1,87593761	1,07685427	1,10581248
2	0,54107791	1,07034882	2,61326317
3	0,57167821	0,56872122	2,1232673
4	0,82036525	0,37517469	0,59989041
5	0,79391443	0,34855442	0,79043378
6	1,23867132	0,5052049	1,31673071
7	0,54846586	0,78139269	1,42644921
8	0,84657715	1,1579193	0,72332926
9	0,71228322	0,42255023	0,95530018
10	0,92136273	0,56234647	1,95647014

>> (>)indicate that the left-hand figure is greater than the right-hand figure at 1%(5%) level of significance using the Wilcoxon signed –rank test.

The results found with our second measurement of the rotation rate arrive at the same conclusions concerning the rejection of the assumption of the trading interference and the importance of exchange level of the $Stock_{0.80}$ group compared to the two other groups.

3-2-2-3 Delayed price adjustment hypothesis

Table 6 presents the frequency of continuation, inversion and stagnation of the closing prices for the three groups of stocks.

For the stocks which reach their limit prices, the frequency of continuation is about 72%, that of reversal, 28%. Whereas for the stocks belonging to the group $Stock_{0.90}$ ($Stock_{0.80}$), the frequency of continuation is only of the order of 60% (63%), thus being able to confirm the assumption of adjustment delay of the prices. However, the nonparametric binomial test used does not reject the assumption of equality of the continuation frequency for the three groups. The only significant difference that we found is at the level of the no change frequency, since the stocks that reach their limits vary more than the stocks belonging to the $Stock_{0.80}$ group. This result is charged to the great fluctuations of price and not to the price limits since there is no difference between the stocks that reach their limits and the stocks belonging to the $Stock_{0.90}$ group.

Since the reversal trend is not the most frequently configuration observed for the price that reach their limit prices, we cannot affirm that the price limits limited overreaction of the investors.

By taking again the approach above, but by keeping this time in the sample the successive limit days, not to underestimate the frequency of continuation of price, we find results very close to the precedents. This is probably explained by the scarcity of the successive price limits in our data.

Table 6. Delayed price adjustment

Panel A	The frequency of price changes for the three groups of stocks		
	Hit	Stock0.90	Stock0.80
minus-minus	0,73333333	0,6	0,66666667
minus-plus	0,26666667	0,4	0,11111111
minus-zero	0	0	0,22222222
zero-plus	0	0	0
zero-minus	0	0	0
zero-zero	0	0	0
continuation	0,73333333	0,6	0,66666667
reversal	0,26666667	0,4	0,11111111
No change	0	0	0,22222222

Panel B: The results of binomial test statistic		
situation	hit-0,9	hit-0,8
continuation	0,13333333	0,06666667
	(-1,05409255)	(0,54772256)
reversal	-0,13333333	0,15555556
	(-1,05409255)	(1,91702895)
No change		-0,22222222
		(-2,07019668)
Z-value based on binomial test statistic is given in parentheses		

3-3. Classical approach

3-3-1 Event study methodology

We will use the traditional methodology to analyze the abnormal return and volume around the downward price limits. Several generating models and two statistical tests of which one is nonparametric were used.

3-3-1-1 Return generator models

The abnormal return ex-post $RA_{i,t}$ is defined as being the difference between the observed return of company i with the day t and its expected return generated by a particular model.

$$AR_{i,t} = R_{i,t} - E(R_{i,t}) \quad (8)$$

$R_{i,t}$ is the return of stock i at the moment t calculated as follows:

$$R_{i,t} = \frac{(p_{i,t} - p_{i,(t-1)})}{p_{i,(t-1)}} \quad (9)$$

$p_{i,t}$,is the closing price of stock i at the moment t, adjusted of the changes in the company's share capital.

The logarithmic form of the return was also used.

The model of the return adjusted by the average

$$E(R_{i,t}) = \bar{R}_{i,t} \quad (10)$$

With $\bar{R}_{i,t}$ is the mean daily return calculated during the estimation period.

$$\bar{R}_{i,t} = \frac{\sum_{t=105}^{-6} R_{i,t}}{100} \quad (11)$$

Market movement Adjusted return model

Whatever the asset i, $E(R_{i,t}) = R_{m,t}$ (12)

$R_{m,t}$, is the market return at the date t, estimate by TUNINDEX return.

This model, called also the market index model, is a particular case of the CAPM where all the assets have the same systematic risk equal to the unit.

The market model

$$E(R_{i,t}) = \hat{\alpha} + \hat{\beta} R_{m,t} \quad (13)$$

$\hat{\alpha}$ and $\hat{\beta}$ are the estimators obtained of the regression of $R_{i,t}$ on $R_{m,t}$ over the period of estimation covering 100 days right before the event period.

The estimator of Scholes and Williams (1977) is:

$$\beta_i = \frac{\beta_i^{+1} + \beta_i^{0} + \beta_i^{-1}}{1 + 2\rho_1} \quad (14)$$

With β_i^{+1} , β_i^{0} and β_i^{-1} are advanced, current and delayed betas.

ρ_1 , the coefficient of correlation of order 1 of TUNINDEX return

The cumulated abnormal return (CAR) is calculated as follows

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} RA_{i,t} \quad (15)$$

3-3-1-2 Volume generator models

$V_{i,t}$, is the trading volume of asset i at the date t calculated as being the number of shares traded the day t on the number of outstanding shares.

Abnormal volume is calculated by the difference between volume of the stocks and a standard:

$$VA_{i,t} = V_{i,t} - K_{i,t} \quad (16)$$

Three models comparable with those used for the return were retained.

The mean adjusted model

$$K_{i,t} = \frac{\sum_{t=105}^{-6} V_{i,t}}{100} \quad (17)$$

The market index model

$$K_{i,t} = V_{m,t} \quad (18)$$

Where $V_{m,t}$ is the iso-weighted average return of the market.

The market model

$$V_{i,t} = \hat{\mu}_i + \hat{\lambda} V_{m,t} \quad (19)$$

$\hat{\mu}_i$ and $\hat{\lambda}$ are the estimators obtained of the regression of $V_{i,t}$ on $V_{m,t}$ over the period of estimation which is spread out over 100 days and preceding the event period.

3-3-1-3 The statistical tests

The two tests were used as well for the return as for volume

The student test

The statistics of Student t are given by:

$$t = \frac{RAM_t}{\sigma(RAM_t)} \quad (20)$$

$$RAM_t = \frac{1}{n}\sum_{i=1}^{n} RA_{i,t} \quad (21)$$

n: number of the stocks in the sample

$$\sigma^2(RAM_t) = \frac{1}{T-1}\sum_{t=1}^{T}(RAM_t - \overline{RAM})^2 \quad (22)$$

$$\overline{RAM} = \frac{1}{T}\sum_{t=1}^{T} RAM_t \quad (23)$$

T is the number of observations composing the estimation period and which is equal to 100 days in our case.

The sign test

This test checks if the abnormal return are positive than negative during the period of event. It is based on the fraction of the positive abnormal returns during the event period, noted p under the null assumption and if the distribution of the returns is symmetrical, the expected value of p would be of 0,5. The statistic $Z = 2\sqrt{N(p-0.5)}$ follows a standardized normal distribution.

3-3-2.Results and interpretations

3-3-2-1 The return

The analysis of the results provided by the various generating models of the return shows us that the price limits played a stabilizing part of the market since the prices did not crumble and on the contrary the following day the market was readjusted with the rise by recovering part of the loss of the day before. The use of the logarithm of the returns does not affect the found results regardless of the generating model of the return used.

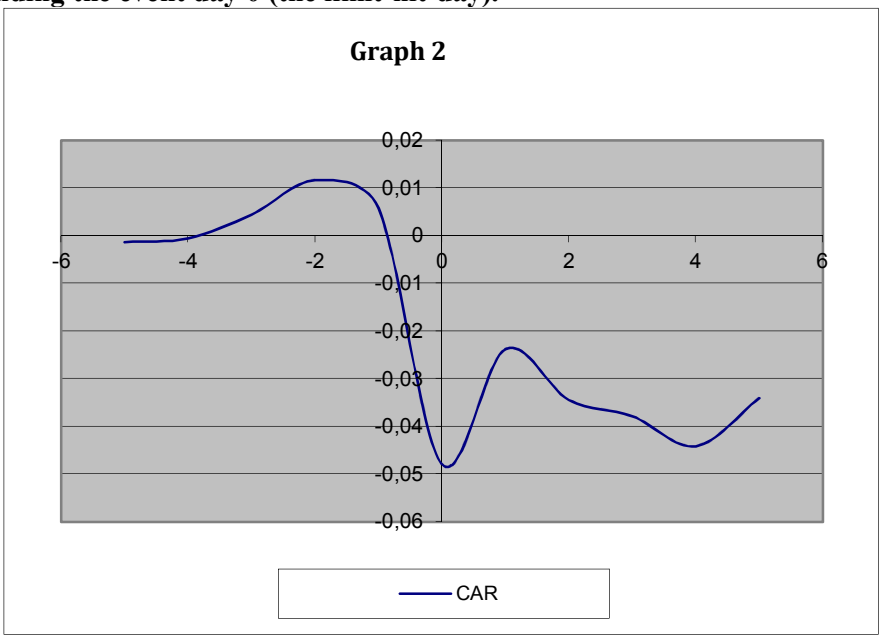
The derived results are more or less sensitive to the two tests which we used. In fact, the reaction after the limit-hit-day is considered to be significant by the Student test but is not valid according to the sign test. In the same way the adjusted average model provides us a result different from that of the other models with regard to the sign and the significance of the returns of the days plus two and plus five since we find a negative reaction which is significant in the first case and a positive reaction in the second case which does not appear for the other models.

It is clear that the market did not anticipate at least the timing of the price fall since during the period pre-trading halts the tendency was much more with the rise and thus the abrupt reaction of the market can be explained only by panic since no fundamental information appeared at this period.

During the day of the 06-10-2008, the majority of the stocks reached their downward limits during the trading session and the transactions were blocked the remainder of the day and we make us believe that the fall was inevitable the following days but the minds were calmed and the following day the market reacted to the rise.

By observing the CAR curve after the trading halts (graph 2), we find that the market recovered the integrality of its losses according to the market model and part of its losses according to the other models. Considering the assets illiquidity we think that a correction of the Scholes and Williams (1977) type for example is essential to correct bias of estimated beta. The results found with such a correction are very similar to those of the market model except for the width of readjustment of the prices after the price limits. And thus we retain the assumption of a partial readjustment which is most plausible following the revaluation and with the change of the risk perception by the Tunisian investors. We used the mean adjusted model to generate the normal return.

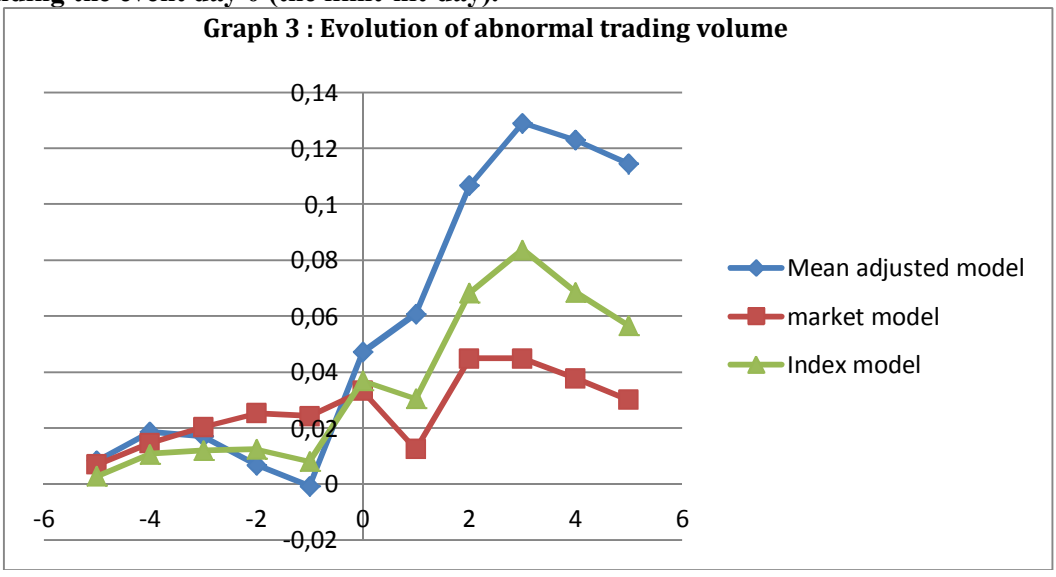
Graph 2. The evolution of the Cumulative Abnormal Return during a 11-day period surrounding the event day 0 (the limit-hit-day).



3-3-2-2 The trading volume

The reaction of the market in terms of volume is not significant the limit day although it was higher than the other days according to the average model. Moreover no significant reaction was retained except for that of the second day after the trading halt calculated by the market model and which coincides with a price fall. The observation of the graph 3 shows us an increase mitigated in the exchange activity right after the limit day and besides insignificant according to the Student test. Whereas the sign test indicates a significant decrease to us the following days the price limit what proves that the exchange activity was reduced for the majority of the stocks whereas the average increased for certain days. This contradiction between the sign of the average and that of the test statistics of the sign reflects the absence of a clear tendency and the reaction heterogeneity of the assets in our sample. We used three models to generate the normal trading volume.

Graph 3. The evolution of the abnormal trading volume mean during a 11-day period surrounding the event day 0 (the limit-hit-day).



These results especially confirm the rejection of the assumption of trading interference that the shortly after the limit day a fall of the trading activity is noted according to the index model and the market model.

The use of a generating model of normal volume is much more problematic than for the return but the results found in our study are more or less convergent as for the conclusions which we can draw. As a conclusion we can affirm that the price limits played a capital role to avoid the tumble of the stock prices during the summer 2008. But this was not possible that with other united policies aiming at the reduction of the information asymmetry.

4. Conclusion

On the basis of the Forbes and Rigobon (2001) report: "*there is no consensus on exactly what constitutes contagion or how it should be defined"*, we are not attached find a final definition of this concept and chose the narrow definition according to which the contagion is a variation of the link between the markets during the crisis period.

The principal transmission channels of crises listed in the literature are the trade channel, the financial channel, and the similarities between the economies, the coordinated policies and the geographical proximity. For our part, we think that the contagion which touched the Tunisian market used another channel: mass media! The Tunisian authorities thus could avoid the worst by adopting a communication policy whose aim was to reassure the households as for the economic situation and stock exchange in the country and to avoid the psychosis which reigned elsewhere. All the official statements and the analyses diffused on all the media supports during this period, converged in this direction. However, and in spite of these efforts, Tunis Stock Exchange lived one period of nervousness of several weeks, before falling abruptly 06-10-2008; this fall nevertheless was blocked by the price limits and the market thus could find its calm as of the following day. Our results show that the price limits played a stabilizing part in the case of the price falls without undesirable effects, contrary to the results found on several other markets.

This contagion had several effects on the market such an increase in the systematic risk of the market, a modification of the behavior of the investors who do not perceive any more the risk of the same manner and became more averse, and a possible revision with the downward anticipations concerning the future prospects for some listed companies. The conjugation of these three effects generated a fall in the prices of the Tunisian actions during the last quarters of the year 2008.

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