APPLIED FINANCE LETTERS

VOLUME 10, 2021

# FINANCIAL RISKS AND STOCK MARKET CRASHES: AN EMPIRICAL ANALYSIS OF THE TUNISIAN STOCK MARKET

**HAIFA HAMMAMI[1]*, YOUNES BOUJELBENE[2]**

1. Faculty of Economics and Management of Sfax, Department of Finance, Tunisia
2. Faculty of Economics and Management of Sfax, Department of Applied Economics, Tunisia

* Faculty of Economics and Management of Sfax, Department of Finance, Road of Aerodrome Km 4, 1013-3018 Sfax, Tunisia. ✉ haifa_hammami83@yahoo.fr

## Abstract

This study aims to investigate the effect of financial risks on the stock market crash occurrence from 1999 to 2020. Using the windows method, we detect two stock market crises in the Tunisian stock market. Based on the probit model, we find evidence that low stock return risk, low EUR/TND exchange rate risk, high-interest rate risk, high credit risk and high liquidity risk increase the occurrence probability of stock market crashes. Our results suggest that the decrease in volatility, particularly in equity and exchange market, the increase in volatility in interest rate, the credit rating downgrades issued by Moody's and the low market liquidity contribute to crashes in the Tunisian stock market. In summary, financial risks, which are the market risks, the credit risk, and the liquidity risk, could be leading indicators of crashes in the Tunisian stock market.

**Keywords:** Stock market crashes; Liquidity risk; Credit risk; Market risks.

## 1. Introduction

Stock market crashes have been a topic of universal interest for both researchers and practitioners. Extensive literature in finance has concentrated on identifying the factors causing crises in the stock market. Previous studies conclude that financial and macro-economic indicators have played a significant role in causing stock market crashes (Mishkin, 1977; Fama, 1981; Reilly, 1997; Ottens et al., 2005; Coleman and Tettey, 2008; Khrawish et al., 2010; Berger and Pukthuanthong, 2012). Our framework differs from these empirical researches in that we analyse the effect of financial risks on stock market crises occurrence in addition to economic variables. Financial risks combine market risk, credit risk and liquidity risk.

The academic literature on stock market crises is well-established, starting with studies on liquidity risk by Geanakoplos (2003), Bernardo and Welch (2004), Brunnermeier and Pedersen (2009), Dick-Nielsen et al. (2012) and Fontaine et al. (2015), which conclude that high liquidity risk contributes to financial crises occurrence. Huang and Wang (2009) prove that the lack of liquidity supply decreases stock prices, leading to stock market crashes.

A rich literature on credit risk has also emerged. Janssen (2012) and Purnamasari et al. (2012) analyse the effect of credit risk on stock return. Other empirical studies concentrate on the interaction between market risk and stock return (Ryan and Worthington, 2004; Adjasi, 2006; Hyde, 2007; Mala and Reddy, 2007; Adjasi et al., 2011; Jawaid and Ul-Haq, 2012; Gulen and Ion, 2016).

Our main objective is to detect stock market crashes in the Tunisian stock market from 1999 to 2020 and empirically investigate the influence of financial risks on stock market crises.

The main contribution of our study is two-fold. First, our research is motivated by the insufficiency of empirical studies investigating the impact of financial risks: market risk, credit risk, and liquidity risk on stock market crash occurrences in emerging economies. Specifically, our analysis is a continuation of the initial surveys. It examines how financial risks explain stock market crises occurrence. Our research provides new empirical evidence by understanding the strong effects of market risk, credit risk and liquidity risk on stock market crises occurrence. Moreover, we extend the existing literature by presenting the key factors related to the emergence of stock market crises. Our paper provides a clear consensus on what causes a stock market crash and shows a significant relationship between financial risks and stock market crashes.

Second, our findings add new insights to investors and policymakers. In fact, investors need helpful information about market return, market liquidity, credit rating changes and currency market to make appropriate decisions when they buy or sell their stocks. Besides, understanding the strong effects of financial risks may lead policymakers to take appropriate measures to prevent the emergence of stock market crises.

Our paper is organised as follows: Section 2 outlines the literature relating stock market crises to financial risks and introduces the hypotheses. Section 3 presents the windows method used to identify stock market crises and the results obtained. Section 4 describes the methodology for modelling stock market crashes, the data and the measurement of financial risks and discusses our results. Section 5 concludes the empirical results.

## 2. Review of the literature and hypotheses

There is a great deal of interest in investigating the causes of stock market crashes occurrence. Financial theory focuses on financial risk as a critical factor of stock returns behaviour. Bhati and Sultan (2012) and Mehri (2015) suggest that financial risk influences stock returns. Kang and Kang (2009) and Aga et al. (2013) conclude that financial risks significantly affect stock returns. Berger and Pukthuanthong (2012) define their systemic risk measure the Fragility Index (FI) and find out that systemic risk is associated with the occurrence probability of international market crashes. They explain that a high level of systemic risk increases the emergence probability of a terrible market crash through various markets.

### 2.1 Relationship between market risk and stock market crashes

Some studies in the existing literature focus on the interaction between market risk and stock returns. Volatility in the equity market has become a mutual interest for investors and policymakers. Ryan and Worthington (2004) study bank stock return volatility using market risk, interest rate risk and foreign exchange risk over the 1996 - 2001 period. Their results indicate that market risk, short- and medium-term interest rate risk are the determinants of bank stock returns. Hyde (2007) documents that market risk significantly influences stock returns.

Officer (1973) proves that stock return volatility was at similar levels before and after the period of depression. Schwert (1989a) and Hamilton and Lin (1996) conclude that high stock market volatility is observed during a recession. Schwert (1989b) studies the stock return volatility around the 1987 crisis and shows higher market volatility during the crash and lower market volatility before the crisis of 1987.

Mala and Reddy (2007) find that high stock market volatility induces investors to demand a higher risk premium, increasing capital cost. Consequently, investment declines and economic growth

slows down. Gulen and Ion (2016) put in evidence that the increase in stock return volatility has led to uncertainties in the policy. As a result, investment, output and employment decrease.

Adrian and Shin (2013) conclude that low stock return volatility leads financial institutions to take riskier positions and increase their balance sheet leverage, contributing to financial crises occurrence. Besides, financial intermediaries seek higher yields in low stock return volatility periods. As a consequence, they lend and reallocate from safer to riskier assets. In addition, Adrian and Shin (2013) prove that high stock return volatility could increase the financial crisis occurrence, as it reflects uncertainty about future cash flow.

Based on the current literature, we test the following hypothesis:
Hypothesis 1. Higher stock return risk increases the occurrence of stock market crises.

A considerable amount of research has been devoted to investigating the influence of exchange rate volatility on stock market crises occurrence. Branson (1983) and Frankel (1983) demonstrate that exchange rate volatility affects stock prices movements. They clarify that the exchange rate decrease encourages the investors to move funds from domestic stocks towards foreign stocks, declining stock prices. Khoo (1994) shows that stock returns are significantly related to exchange rate movements. Adjasi et al. (2011) analyse the impact of exchange rate movements on stock market returns in seven African countries. Their empirical findings indicate that in the long run, the drop-in exchange rate increases the stock market returns in some countries and in the short-run, the decrease in exchange rate reduces stock market returns.

Adjasi (2006) examines the effect of exchange rate volatility on stock returns during the 1951-2005 period. Its empirical evidence indicates that exchange rate volatility negatively affects stock returns. Sekmen (2011) studies the impact of exchange rate volatility on stock returns for the U.S. stock market from 1980 to 2008. The empirical analysis demonstrates that exchange rate volatility negatively influences U.S. stock returns.

Choi et al. (1992) investigate the relationship between exchange rate risk and stock returns. They find that stock returns are significantly related to exchange rate risk. Jawaid and Ul-Haq (2012) show that the effect of exchange rate risk on commercial banks stock returns is significant. However, Jorion (1991) and Bodnar and Gentry (1993) report an insignificant link between exchange rate risk and stock returns.

Hence the following hypothesis is presented:
Hypothesis 2. A rise in exchange rate risk increases the occurrence of stock market crashes.

Interest rate risk remains an important subject for researchers and regulators. Joseph and Vezos (2006) demonstrate that interest rate risk is a relevant financial factor affecting stock returns. Their empirical evidence shows that the stock returns are highly responsive to interest rate movements. Massomeh and Al Nasser (2017) analyse the link between interest rate volatility and stock market performance for 12 emerging economies over the period 1980-2011. The empirical evidence reveals a significant relationship between interest rate volatility and the stock market in the short-run for 12 emerging economies. However, their results indicate a significant link between the two variables only for 9 emerging economies in the long run. Banerjee and Adhikarys (2009) report an insignificant relationship between interest rate movements and the stock market return.

Based on the current literature, we investigate the following hypothesis:
Hypothesis 3. A rise in interest rate risk increases the occurrence of stock market crashes.

Interest rate is considered an important indicator that influences stock market returns. Mishkin (1977) points out that interest rate is negatively associated with stock returns. He explains that a low-interest rate induces higher capital flows to the stock market, increasing stock returns. However, a high-

interest rate incites people to increase their savings in banks, thus decreasing the flow of capital to the stock market. Thorbecke (1997) suggests that a drop in interest rates encourages people to take out more loans at a lower cost of borrowing. As a result, an expansionary monetary policy seeks to amplify economic growth, increasing investment in the stock market. In addition, a decline in interest rate conducts investors to transfer their money from the bond market to the equity market. Other studies, such as Coleman and Tettey (2008) and Khrawish et al. (2010), prove that interest rates are negatively linked to stock market returns.

Hence the following hypothesis is tested:
Hypothesis 4. A high-interest rate increases the stock market crises occurrence.

## 2.2 Relationship between credit risk and stock market crises

Credit risk is one of the most important forms of financial risk that the stock market confronts. Naser et al. (2011) analyse the influence of credit and exchange rate risks on stock return volatility in Australia. Their results show a significant relationship between credit risk and exchange rate risk and stock return volatility. Janssen (2012) explores the influence of credit risk on stock returns from 2004 to 2012. The finding reveals that there is no significant link between excess returns on stocks and credit spreads. Purnamasari et al. (2012) find that credit risk is insignificantly related to stock returns.

While several empirical studies of credit risk have been concerned with credit rating changes and have analysed their impact on the stock market. The empirical evidence from Kaminsky and Schmukler (2002), Brooks et al. (2004), Martell (2005), Ferreira and Gama (2007), and Arezki et al. (2011) suggest that credit rating downgrades have a significant effect on the stock market and credit rating upgrades have limited effect. Hill and Faff (2010) find evidence that the reaction of financial markets to credit rating changes is more excessive during periods of crises. Afonso et al. (2012) study the effect of sovereign credit rating announcement on the stock market. They show that only negative credit rating signals have a significant impact on the stock market. Alsakka et al. (2017) suggest that the stock market reacts significantly to negative credit rating announcements issued by Standard and Poor's.

Based on the current literature, we postulate the following hypothesis:
Hypothesis 5. A rise in credit risk increases the occurrence of stock market crashes.

## 2.3 Relationship between liquidity risk and stock market crises

The relationship between liquidity risk and stock returns has been a subject of study for researchers over a long period. Gibson and Mougeot (2004) define market liquidity as the number of traded shares in the S&P 500 Index and show that stock returns are associated with the fluctuations in market liquidity. Moreover, they demonstrate that the October '87 Crash does not influence systematic liquidity risk. Huang and Wang (2009) demonstrate that the lack of liquidity supply negatively affects stock prices, causing stock market crashes.

Geanakoplos (2003), Bernardo and Welch (2004), and Brunnermeier and Pedersen (2009) provide evidence that high liquidity risk contributes to financial crises occurrence. Dick-Nielsen et al. (2012) demonstrate that a higher level of liquidity risk characterises the 2008 crisis. Fontaine et al. (2015) conclude that the decrease in stock returns is related to higher liquidity risk. Mehri (2015) studies the impact of financial risks on stock returns. The analysis sheds further light on the negative relationship between credit risk and capital risk on stock returns. However, the liquidity risk has an insignificant effect on stock returns.

Hence the following hypothesis is examined:

Hypothesis 6. A higher level of liquidity risk contributes to stock market crises occurrence.

### 2.4 Relationship between inflation and stock market crises

Fama (1981) shows a negative relationship between inflation and asset prices. Schwartz (1995) suggests that the higher inflation raises the inflation volatility and, therefore, the uncertainty. The uncertainty can increase the preference for safe assets. Reilly (1997) demonstrates that inflation is negatively related to stock prices. He explains that the increase in product costs induces firms to decrease their own selling prices. Consequently, the expected money flows reduce, thus decreasing stock prices.

Based on the current literature, we assume the following hypothesis:
Hypothesis 7. A rise in inflation increases the occurrence of stock market crises.

As stated above, we investigate the seven hypotheses to draw meaningful insights into the determinants of stock market crises occurrence.

## 3 Detecting stock market crises

The first step of our research consists of detecting stock market crises from January 1999 to February 2020. We use the windows method proposed by Mishkin and White (2002). These authors define a stock market crash as a decline of 20% in the stock market index over windows of one day, two days, five days, one month, three months and one year. The crashes of October 1929 and October 1987 are used as benchmarks to detect stock market crashes.

According to Mishkin and White (2002), we identify two stock market crashes for the TUNINDEX index from January 1999 to February 2020 using the twenty-four months window (see Table 1): the first crisis is from May 2001 to March 2003, and the second crisis is from September 2010 to May 2011. These stock market crashes are broadly consistent with the events occurring over the period.

**Table 1:** Detection of stock market crashes through the windows method

| The crisis beginning | The trough date | The recovery date | Price decline to trough |
|---|---|---|---|
| May 2001 | March 2003 | 4 years | -26.80 % |
| September 2010 | May 2011 | 5 months | -24.75 % |

**Note:** Table 1 defines the stock market crises that occurred during our sample period.

The first crisis occurred in May 2001 and reached a trough twenty-two months later in March 2003. It was characterised by a decrease of 26.8 per cent relative to the previous historical maximum level, but it took longer to recover about four years. The second stock market crisis of 2011 began in September 2010, and the TUNINDEX index decreased by 24.75 per cent relative to the previous historical maximum level.

## 4 Modelling stock market crashes

### 4.1 Methodology: A probit analysis of stock market crashes

The second step of our study consists of analysing the effect of financial risks on stock market crashes occurrence. To this end, we follow the probit model proposed by Kamnisky et al. (1997) to investigate the role of market risk, credit risk and liquidity risk in triggering stock market crises. In probit regression, the dependent variable is binary and can take only two values. The binary dependent variable called "a crisis indicator" equals to:

equals to: $I_t = \begin{cases} 1 \text{ for the crisis periods,} \\ 0 \text{ otherwise.} \end{cases}$

The probit model can be expressed as in (1):

$$\Pr(crisis_i = 1 | x_i, \beta) = 1 - \theta(-x'_i \beta) = \theta(x'_i \beta) \quad (1)$$

where $\theta$ represents the cumulative distribution of a standard normal random variable and $x_i$ is the vector of explanatory variables for crises.

## 4.2 Data description and financial risks measurements

We use monthly data for the period beginning in January 1999 and ending in February 2020. Our data were obtained from the Central Bank of Tunisia, the Tunisian Stock Exchange and the National Institute of Statistics.

We define the measurements of the following financial risks.

**Table 2:** Moody's ratings and the numerical scale defined

| | Rating | Scale |
|---|---|---|
| **Investment** | Aaa | 20 |
| | Aa1 | 19 |
| | Aa2 | 18 |
| | Aa3 | 17 |
| | A1 | 16 |
| | A2 | 15 |
| | A3 | 14 |
| | Baa1 | 13 |
| | Baa2 | 12 |
| | Baa3 | 11 |
| **Speculative** | Ba1 | 20 |
| | Ba2 | 19 |
| | Ba3 | 18 |
| | B1 | 17 |
| | B2 | 16 |
| | B3 | 15 |
| | Caa1 | 14 |
| | Caa2 | 13 |
| | Caa3 | 12 |
| | Ca | 11 |
| | C | 2 |
| | D | 1 |
| | WR | - |

**Note:** In table 2, we convert the categorical scale (Aaa,..., C, D) of Moody's ratings into a numerical scale formed by 20 categories.

Credit risk: The proxy used to measure credit risk is the credit rating changes issued by Moody's. Following Williams et al. (2013) and Alsakka et al. (2014), we transform the categorical scale (Aaa,..., C, D) of Moody's ratings into a numerical scale formed by 20 categories as specified in table 2. We define an index that takes values from 1 to 20. The highest value is related to higher credit quality, thus a lower probability of default. This index, as developed by Hill and Faff (2010), is measured according to adding (subtracting) 0.5 points to the current rating, when a positive (negative) watchlist is issued or adding (substructing) 0.25 points when a positive (negative) outlook is published.

*Liquidity risk:* We define two proxies to measure liquidity risk. Based on Amihud (2002) empirical study, we include the first measure of liquidity, which is defined as the liquidity ratio of $\left|P_t - P_{t-1}\right| / V_t$. Where $P_t$ is the monthly stock price index at the month $t$, $P_{t-1}$ is the monthly stock price index at the month $t-1$ and $V_t$ is the number of traded shares in TUNINDEX during a month.

The second liquidity measure used in this analysis is the Market Efficiency Coefficient (MEC) developed by Hasbrouck and Schwartz (1988).

$$MEC = \frac{Var(R_t)}{(n * Var(R_t / n))} \qquad (2)$$

Where $Var(R_t)$ is the variance of stock market return in the long period, $Var(R_t / n)$ is the variance of stock market return in a short period, and $n$ is equal to the number of under periods by which we divided the long period. The Market Efficiency Coefficient (MEC), which is greater than 1, reflects a good level of liquidity, suggesting that short term stock market volatility is lower than its long-term stock market volatility. However, if the Market Efficiency Coefficient (MEC) is less than 1, stock market liquidity is low.

Interest rate risk: We incorporate interest rate volatility as a proxy of interest rate risk. The interest rate volatility is calculated as the standard deviation of 12 monthly interest rate.

EUR/TND exchange rate risk: To measure the EUR/TND exchange rate risk, we use the EUR/TND exchange rate volatility in this analysis equal to the standard deviation of 12 monthly exchange rate.

Tunindex index risk: We introduce Tunindex index volatility as a proxy of stock return risk. Tunindex index volatility is measured by calculating the standard deviation of 12 monthly Tunindex index.

We employ two control variables, such as inflation and interest rate. The inflation is calculated as $\left(\frac{CPI_t}{CPI_{t-12}} - 1\right) * 100$. The $CPI_t$ is equal to the price index at the month $t$. Also, we use a monthly interest rate. The interest rate is equal to the Money Market Average (TMM).

The explanatory variables incorporated in the model are the Tunindex index volatility, the credit rating changes, the liquidity ratio, the Market Efficiency Coefficient (MEC), the EUR/TND exchange rate volatility, interest rate volatility, interest rate and inflation. These variables are introduced in the model in several stages to see if they could help investors estimate the occurrence probability of stock market crises.

## 4.3 Empirical results and discussion

We estimate our models on the full sample period from January 1999 to February 2020. The results of our regressions appear in table 3.

**Table 3:** Regression results on monthly sample

| **Models** | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| **Estimations Period** | | **1999 M1-2020 M2** | |
| Tunindex index volatility | -8.425218** | -7.889621* | -7.763519* |
| Credit rating changes | -0.888966*** | -0.823819*** | |
| Liquidity ratio | -43389.40*** | -37748.93*** | -39186.75*** |
| Market Efficiency Coefficient (MEC) | | -0.021525 | -0.019197 |
| EUR/TND exchange rate volatility | | | -16.34923** |
| Interest rate volatility | | 75.07187 | 220.9875*** |
| Interest rate | | 56.94046*** | 27.34715* |
| Inflation | | | -42.82199*** |
| Constant | 9.949340*** | 6.139324** | -0.279030 |
| $R^2$ Mc Fadden | 0.433451 | 0.502777 | 0.426513 |
| LR stat (p-value) | 0.000000 | 0.000000 | 0.000000 |

**Note:** Table 3 presents the results of our regressions. In this table, (***), (**), (*) indicate that the test is significant at respectively 1%, 5%, and 10% level.

We construct three models that incorporate market, credit and liquidity risks in addition to the control variables.

We focus on detecting the presence of the endogeneity problem and robustness checks in our empirical analysis. First, we use the Likelihood Ratio test to control the endogeneity problem. As shown in table 3, we find the absence of the endogeneity problem based on the LR stat (p-value). Second, using a set of exhaustive robustness checks, we test the heteroskedasticity and the autocorrelation problems. One of the assumptions of the probit model, the sample is homoskedastic. In this case, we do not need to adjust for heteroskedasticity. As a result, there is no heteroskedasticity problem. For checking the autocorrelation problem, we use the correlogram of residuals. We put in evidence the absence of the autocorrelation problem. Thus, the deficiency of heteroskedasticity and autocorrelation problems suggests that our robust regression results still stand.

### 4.3.1 Results of Model (1)

To investigate the relative roles of financial risks in the occurrence probability of stock market crashes, the first empirical model incorporates Tunindex index volatility as a proxy of stock return risk, credit rating changes as a proxy of credit risk and liquidity ratio as a proxy of liquidity risk.

As shown in Table 3, higher tunindex index volatility is negatively and significantly related to the occurrence probability of stock market crises. In this sense, lower stock return volatility leads to the occurrence of crises in the Tunisian stock market. Our result implies that the low degree of stock market volatility induces investors to demand a higher risk premium, increasing the cost of capital. Consequently, investment declines, implying the decrease in stock prices. Besides, our result can be explained by the fact that a low risk in stock return encourages economic agents to take excessive risk in their investment, and thus, causes stock market crises.

Furthermore, low stock market volatility over a prolonged period induces higher risk-taking and leads to riskier investments. As a result, banks will support loan losses, causing a crisis in the stock market.

This result is consistent with the empirical evidence of Adrian and Shin (2013). Their findings reveal that low stock return volatility is positively and significantly related to financial crises occurrence. Conversely, the studies of Schwert (1989a and 1989b) and Hamilton and Lin (1996) seem contradictory to ours because, according to these authors, the high stock market volatility is observed during crises.

In addition, we notice that credit rating upgrades have a negative and significant impact on the occurrence probability of stock market crises. Therefore, this result supports the hypothesis that credit rating changes present relevant market information to investors. Hence, it is believed that agencies have access to private information. Consequently, credit rating downgrades issued by Moody's lead to the decrease in stock returns, causing crises in the stock market. This implies that investors perceive the credit rating downgrades as deterioration in the expectations of the cash flow. As a result, the investors react to credit rating changes and decrease their investment in periods of credit rating downgrades, causing stock market crises. Our result demonstrates that high credit risk is positively associated with the occurrence probability of crises in the stock market.

This result corroborates with the empirical results of Hill and Faff (2010) and Alsakka et al. (2017), who support the evidence that financial markets react significantly to credit rating changes during periods of crises. Besides, this result is consistent with the studies of Kaminsky and Schmukler (2002), Arezki et al. (2011) and Afonso et al. (2012), who suggest that credit rating downgrades have a significant effect on the stock market.

Furthermore, the liquidity ratio is negatively and significantly related to the occurrence probability of stock market crises. This result indicates that low market liquidity causes crises in the Tunisian stock market. Consequently, high liquidity risk contributes to a decrease in stock returns, triggering stock market crises. Our finding shows that an increase in liquidity risk leads to the occurrence of stock market crises. Our result is consistent with the empirical analyses of Geanakoplos (2003), Bernardo and Welch (2004), Brunnermeier and Pedersen (2009), Dick-Nielsen et al. (2012) and Fontaine et al. (2015), who conclude that high liquidity risk contributes to the occurrence of financial crises. Moreover, our analysis corroborates with the empirical evidence of Huang and Wang (2009), who underlines that the shortage of liquidity brings about the decrease in stock prices, which in turn causes stock market crashes.

In conclusion, it appears that low stock returns risk, high credit risk and high liquidity risk lead to stock market crashes occurrence.

### 4.3.2 Results of Model (2)

In model (2), we include, rather than the variables of model (1), a second proxy to liquidity risks, such as the Market Efficiency Coefficient (MEC), the interest rate volatility as a proxy of interest rate risk and the interest rate as a control variable. The results indicate that all explanatory variables are significant at 1%, 5% and 10% level, with the exception of the Market Efficiency Coefficient (MEC) and the interest rate volatility. The results obtained in model (2) can be summarised as follows. We conclude that low stock returns risk, high credit risk, high liquidity risk and high-interest rate increase the occurrence probability of stock market crises. Hence, stock return risk, credit risk and liquidity risk are found to be determinant in explaining stock market crises.

The empirical findings show that the interest rate has a positive and significant impact on the occurrence probability of stock market crises. This manifests that a high interest rate leads to a drop in stock returns, causing stock market crises. Our result is in accordance with the studies of Mishkin (1977), Thorbecke (1997), Coleman and Tettey (2008) and Khrawish et al. (2010), which demonstrate a significant negative relationship between interest rates and stock returns.

### 4.3.3 Results of Model (3)

The following model (3) is used to analyse whether market risk variables exert an impact on crashes occurrence probability. Market risk variables are stock returns risk, EUR/TND exchange rate risk and interest rate risk, and two proxies to measure liquidity risks, such as the liquidity ratio and the Market Efficiency Coefficient (MEC). The control variables correspond to the interest rate and inflation. As reported in Table 3, all market risk variables are significantly related to the occurrence probability of stock market crises. Our result shows that low stock return risk, low exchange rate risk and high interest rate risk are considered the key factors that lead to an increase in the occurrence probability of stock market crises.

As illustrated in Table 3, low exchange rate volatility exerts a positive and significant impact on the stock market crashes occurrence, suggesting that low EUR/TND exchange rate changes can affect the investors' wealth by generating losses based on the net foreign position. As a result, the investors' investment drops, decreasing stock returns and causing stock market crises. Besides, investors' perception of the future economic growth changes in a period of low exchange rate risk. They assume that the fluctuation of the exchange rate is fueled by economic instability, affecting the competitiveness of firms in the domestic stock market. Consequently, their profits will decrease, which in turn causes a decline in the domestic stock market. Besides, the investors tend to sell risky assets, including domestic currencies, which may trigger stock market crises.

We conclude that the exchange rate risk could be another important determinant of stock market crisis occurrence. Our results confirm the empirical evidence of Choi et al. (1992) and Jawaid and Ul-Haq (2012), which find that stock returns are significantly related to exchange rate risk and the empirical analyses of Branson (1983), Frankel (1983), Khoo (1994) and Adjasi et al. (2011) which show that stock returns are significantly related to exchange rate movements. However, our findings are inconsistent with the results of Adjasi (2006) and Sekmen (2011), which indicate that high exchange rate volatility negatively affects stock returns and with the analyses of Jorion (1991) and Bodnar and Gentry (1993), which report an insignificant link between exchange rate risk and stock returns.

Furthermore, our results reveal that both the interest rate and their volatility have a positive and significant effect on the occurrence probability of stock market crashes. In other words, high interest rate and high interest rate volatility are positively related to the stock market crises occurrence. Our findings suggest that high volatility in interest rate represents an important source of risk for investors' activity and can affect their investment. We conclude that large interest rate fluctuations reflect economic uncertainty; consequently, consumer spending and investment decline and borrowing becomes more difficult and expensive. As a result, stock prices drop, causing stock market crises.

One explanation for this latter result may be that an increase in interest rate decreases the present value of a firm's future cash flows, implying the drop in stock prices. Another explanation, a higher interest rate stimulates the capital inflow. Thereby, the exchange rate drops. As a result, stock returns decrease. Besides, the significant and positive effect can be interpreted as an increase in interest rates discourages people from taking out loans, decreasing investment in the stock market. In addition, a rise in interest rate leads people to transfer their money from the equity market to the bond market, implying the decline in stock prices.

Our results align with the empirical evidence of Joseph and Vezos (2006) and Massomeh and Al Nasser (2017), which highlight a significant effect of interest rate volatility on the stock market and show that interest rate risk is a relevant financial factor affecting the value of common stocks. Moreover, our findings corroborate with the results of Mishkin (1977), Thorbecke (1997), Coleman and Tettey (2008) and Khrawish et al. (2010), which demonstrate that interest rate is negatively related to the stock prices.

Besides, inflation is negatively and significantly related to the occurrence probability of stock market crises. Our result suggests that low inflation leads to a decrease in stock prices, causing stock market

crises. Our empirical analysis reveals that despite the decrease in inflation, people anticipate a weaker expected economic activity and uncertainty about the future monetary policy, which increase the risk premium of the investors and thus, decrease asset prices. Our finding is inconsistent with Fama's (1981) and Reilly (1997) results, which suggest a negative relationship between inflation and asset prices.

## 5 Conclusion

The present study was conducted to identify Tunisian stock market crises and to examine their determinants, focusing on the financial risks. Firstly, we find that the Tunisian stock market crisis occurred in March 2003 and in May 2011 using the windows method.

Secondly, we combine market risk variables, such as stock return risk, EUR/TND exchange rate risk and interest rate risk, with the credit risk and the liquidity risk based on the probit model. The empirical findings of our study highlight that low stock return risk, low exchange rate risk, high interest rate risk, high credit risk and high liquidity risk lead to stock market crashes occurrence. In other words, the decrease in volatility, particularly in equity and exchange market, the increase in volatility in interest rate, the credit rating downgrades issued by Moody's and the low market liquidity contribute to crashes in the Tunisian stock market. In summary, financial risks, which are the market risk, the credit risk, and the liquidity risk, could be leading indicators of Tunisian stock market crises.

Our research has important implications for the literature focused on the causes of stock market crashes occurrence. Studying the effect of market risk, credit risk, and liquidity risk on the occurrence of stock market crises could provide helpful information to investors, academics and policymakers. Therefore, policymakers need to introduce appropriate measures and pursue policies to prevent the occurrence of stock market crashes.

**Acknowledgements**
We would like to thank Professors Najla Bouaziz and Khalil Mhadebi, the editor and two anonymous reviewers, for their many insightful and helpful comments and suggestions.

## References

Adjasi, C.K.D., 2006. Are exporting firms really productive? Evidence from Ghana. African Journal of Business and Economics Research 2&3, 78-97.

Adjasi, C.K.D., Biekpe, B.N., Osei, K.A., 2011. Stock prices and exchange rate dynamics in selected African countries: a bivariate analysis. African Journal of Economic and Management Studies 2, 143-164.

Adrian, T., Shin, H.S., 2013. Procyclical leverage and Value-At-Risk. Working Paper No. 18943, National Bureau of Economic Research, 1-41.

Afonso, A., Furceri, D., Gomes, P., 2012. Sovereign credit ratings and financial markets linkages: application to European data. Journal of International Money and Finance 31, 606–638.

Aga, B.S., Mogadam, V.F., Samadiyan, B., 2013. Relationship between liquidity and stock returns in companies in Tehran stock exchange. Applied Mathematics and Engineering, Management and Technology 1, 278-285.

Alsakka, R., Gwilym, O., Nhung Vu, T., 2014. The sovereign-bank rating channel and rating agencies' downgrades during the European debt crisis. Journal of International Money and Finance 49, 235-257.

Alsakka, R., Gwilym, O., Vu, H., 2017. Differences of opinion in sovereign credit signals during the European crisis. European Journal of Finance 23, 1–26.

Amihud, Y., 2002. Illiquidity and stock returns: cross-section and time-series effects. Journal of Financial Markets 5, 31-56.

Arezki, R., Candelon, B., Sy, A., 2011. Sovereign ratings news and financial markets spillovers: Evidence from the European debt crisis. IMF Working Paper, No. 11/68.

Banerjee, P.K., Adhikary, B.K., 2009. Dynamic effects of changes in interest rates and exchange rates on the stock market return in Bangladesh. Ritsumeikan Journal of Asia Pacific Studies 25, 119-133.

Berger, D., Pukthuanthong, K. 2012. Market fragility and international market crashes. Journal of Financial Economics, 105, 565-580.

Bernardo, A., Welch, I., 2004. Liquidity and financial market runs. Quarterly Journal of Economics 119, 135–158.

Bhati, V., Sultan, J., 2012. Leverage risk, financial crisis and stock returns: A comparison among islamic, conventional and social responsible stocks. Islamic Economic Studies 20, 87-143.

Bodnar, G.M., Gentry, W.M., 1993. Exchange rate exposure and industry characteristics: evidence from Canada, Japan, and the USA. Journal of International Money and Finance 12, 29-45.

Branson, W.H., 1983. Macroeconomic determinants of real exchange risk in managing foreign exchange risk, in: Herring, R.J., (ed.), Cambridge University Press, Cambridge MA.

Brooks, R., Faff, R., Hillier, D., Hillier, J., 2004. The national market impact of sovereign rating changes. Journal of Banking and Finance 28, 233–250.

Brunnermeier, M., Pedersen, L., 2009. Market liquidity and funding liquidity. Review of Financial Studies 22, 2201–2238.

Choi, J.J., Elyasiani, E., Kopecky, K. J., 1992. The sensitivity of bank stock returns to market, interest and exchange rate risks. Journal of Banking and Finance 16, 983-1004.

Coleman, A. K., Tettey, K.F.A., 2008. Impact of macroeconomic indicators on stock market performance: The case of the Ghana stock exchange. Journal of Risk Finance 9, 365- 378.

Dick-Nielsen, J., Feldhutter, P., Lando, D., 2012. Corporate bond liquidity before and after the onset of the subprime crisis. Journal of Financial Economics 103, 471–492.

Fama, E., 1981. Stock returns, real activity, inflation, and money. American Economic Review 71, 545–565.

Ferreira, M., Gama, P., 2007. Does sovereign debt ratings news spill over to international stock markets? Journal of Banking and Finance 31, 3162–3182.

Fontaine, J.S., Garcia, R., Gungor, S., 2015. Funding liquidity, market liquidity and the cross-section of stock returns. Bank of Canada Working Paper, No. 2015-12, Bank of Canada, Ottawa.

Frankel, J.A., 1983. Monetary and portfolio balance models of exchange rate determination, in economic interdependence and flexible exchange rates, in: Bhandari, J.S., Putnam, B.H., (Eds.), Economic Interdependence and Flexible Exchange Rates, MIT Press, Cambridge MA, pp.84-115.

Geanakoplos, J., 2003. Liquidity, default and crashes: endogenous contracts in general equilibrium, in: Dewatripont, M., Hansen, L.P., Turnovsky, S.J. (Eds.), Advances in economics and econometrics: Theory and applications II, Econometric Society Monographs: Eighth World Congress, pp.170–205. Cambridge University Press, Cambridge.

Gibson, R., Mougeot, N., 2004. The pricing of systematic liquidity risk: Empirical evidence from the US stock market. Journal of Banking and Finance 28, 157-178.

Gulen, H., Ion, M., 2016. Policy uncertainty and corporate investment. Review of Financial Studies 29, 523-564.

Hamilton, J.D., Lin, G., 1996. Stock market volatility and the business cycle. Journal of Applied Econometrics 11, 573–593.

Hasbrouck, J., Schwartz, R., 1988. Liquidity and execution costs in equity markets. Journal of Portfolio Management 14, 10-17.

Hill, P., Faff, R., 2010. The market impact of relative agency activity in the sovereign ratings market. Journal of Business Finance and Accounting 37, 1309-1347.

Huang, J., Wang, J., 2009. Liquidity and market crashes. The Review of Financial Studies, 22, 2607-2643.

Hyde, S., 2007. The response of industry stock returns to market, exchange rate and interest rate risks. Manchester Business School Working Paper, No. 9679, pp.1-20.

Janssen, L., 2012. The Effect of Credit Risk on Stock Returns, Tilburg University, Netherlands.

Jawaid, S.T., Ul-Haq, A., 2012. Effects of interest rate, exchange rate and their volatilities on stock prices: Evidence from banking industry of Pakistan. Theoretical and Applied Economics 19, 153-166.

Jorion, P., 1991. The pricing of exchange rate risk in the stock market. Journal of Financial and Quantitative Analysis 26, 363-376.

Joseph, N.A., Vezos, P., 2006. The sensitivity of US bank's stock returns to interest rate and exchange rate changes. Managerial Finance 32, 182-199.

Kaminsky, G., Lizondo, S., Reinhart, C.M., 1997. Leading indicators of currency crises. IMF Working Paper, No. 97/79, pp.1-43.

Kaminsky, G., Schmukler, S., 2002. Emerging market instability: do sovereign ratings affect country risk and stock returns? World Bank Economic Review 16, 171–195.

Kang, C., Kang, H.G., 2009. The effect of credit risk on stock returns. Journal of Economic Research 14, 49-67.

Khoo, A., 1994. Estimation of foreign exchange exposure: an application to mining companies in Australia. Journal of International Money and Finance 13, 342-363.

Khrawish, H.A., Siam, W.Z., Jaradat, M., 2010. The relationships between stock market capitalisation rate and interest rate: Evidence from Jordan. Business and Economic Horizons 2, 60-66.

Mala, R., Reddy, M., 2007. Measuring stock market volatility in an emerging Economy. International Research Journal of Finance and Economics 2007, 126-133.

Martell, R., 2005. The effect of sovereign credit rating changes on emerging stock markets. Working Paper, Purdue University.

Massomeh, H., Al Nasser, O.M., 2017. The impact of interest rate volatility on stock market development: Evidence from emerging markets. The journal of Developing Areas 51, 301-313.

Mehri, A.B., 2015. The effects of financial risks on the relationship between earnings and stock returns. International Journal of Organizational Leadership 4, 154-169.

Mishkin, F., 1977. What depressed the consumer? The household balance sheet and the 1973-1975 recession. Brookings Papers on Economic Activity 1, 123-164.

Mishkin, F., White, E., 2002. US Stock market crashes and their aftermath: Implications for monetary policy. NBER Working Papers, No. 8992.

Naser, S., Mohammad, E., Mohammad, R.H., Akbar, A.T., 2011. Designing and identifying the model to investigate the effect of credit and exchange risk on stock returns of banks (GARCH Approach). Australian Journal of Basic and Applied Sciences 5, 1519-1532.

Officer, R.R., 1973. The variability of the market factor of New York Stock Exchange. Journal of Business 46, 434-453.

Ottens, D., Lambregts, E., Poelhekke, S., 2005. Credit booms in emerging market economies: a recipe for banking crises? Working Paper, No. 046, De Nederlandsche Bank NV.

Purnamasari, K., Herdjiono, I., Setiawan, E., 2012. Financial risk, growth, earnings and stock returns relationship: The case of Indonesia. International Review of Business Research Papers 8, 79-93.

Reilly, F., 1997. The impact of inflation on roe, growth and stock prices. Financial Services Review 6, 1–17.

Ryan, S., Worthington, A., 2004. Market, interest rate and foreign exchange rate risk in Australian banking: A GARCH-M approach. International Journal of Applied Business and Economic Research 2, 81-103.

Schwartz, A., 1995. Why financial stability depends on price stability? Economic Affairs 15, 21–25.

Schwert, G.W., 1989a. Why does stock market volatility change over time? Journal of Finance 44, 1115-1153.

Schwert, G.W., 1989b. Stock volatility and the crash of 87. Working Paper, No. 2954, pp.1-32.

Sekmen, F., 2011. Exchange rate volatility and stock returns for the U.S. African Journal of Business Management 5, 9659-9664.

Thorbecke, W., 1997. On stock market returns and monetary policy. Journal of Finance 52, 635-654.

Williams, J., Calice, G., Chen, J., 2013. Liquidity spillovers in sovereign bond and CDS markets: An analysis of the Eurozone sovereign debt crisis.

Journal of Economic Behavior and Organization 85, 122-143.