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The effects of stock market crises shocks on market liquidity, market volatility and exchange rate volatility: Case of the Tunisian stock market

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Abstract

Purpose: This paper is conducted to investigate the response of market liquidity, market volatility and exchange rate volatility to stock market crises shocks.

Methodology: First, the CMAX approach is used to detect stock market crises. Then, the Vector Auto Regression (VAR) approach is applyed to study the transmission effect of stock market crises shocks on market liquidity, market volatility and exchange rate volatility.

Results: According to the empirical study based on evidence from Tunisia, we obtain the following results: The impulse response analysis underlines that there is a deterioration in market liquidity and market volatility in the months after the occurrence of stock market crises. In contrast, the response of EUR/TND exchange rate volatility to stock market crises shocks is not significant during the whole period. In addition, the variance decomposition results highlight that market liquidity and Tunindex index volatility are more sensitive to stock market crises shocks. However, stock market crises shocks explain a smaller portion of the EUR/TND exchange rate volatility.

Unique contribution to theory, policy and practice: This research contributes to this debate by investigating the impact of stock market crises shocks on liquidity market, volatility of stock returns and exchange rate volatility. A better understanding of these topics has become the key to investors, academics and policymakers.

Keywords : *Stock market crises, Market liquidity, Market volatility, Exchange rate volatility, VAR model.*

1 Introduction

The effects of stock market crises on liquidity and volatility in stock market and currency market have been a highly researched and debated topic in finance. Many researches have been done to assess the response of market liquidity, market volatility and exchange rate volatility to stock market crises shocks.

Market liquidity is an important factor affecting the decision of investors insofar as a liquid asset can be quickly bought and sold at lower trading cost. Wang & Chen (2012) support the view that many investors take into account the level of liquidity when they determine the risk of investing in a stock. They explain that higher liquidity market helps investors to carry out transactions without high price spread and at any time. Moreover, previous studies conclude that the transmission effects of the stock market crises leads to a decrease in stock market liquidity (Bordo, 2008; Rösch & Kaserer, 2013; Bessembinder et al., 2016; Adrian et al., 2017; Kaya & Engkuchik, 2017).

Other researches provide a broad analysis on the impact of stock market crises on volatility in stock market and currency market. Schwert (1990), Chakrabarti & Roll (2002) and Karunanayake et al. (2010) find evidence of an increase in stock return volatility immediately after the occurrence of financial crises. Besides, Fratzscher (2009), Melvin & Taylor (2009), Mbutor (2010) and Coudert et al. (2011) conclude that the financial crises cause highly volatile shocks across foreign exchange markets.

This research is motivated by insufficiency of empirical studies about the effects of stock market crises on market liquidity and volatility in stock market and currency market. Our paper contributes to this debate by investigating the impact of stock market crises shocks on liquidity market, volatility of stock returns and exchange rate volatility. A better understanding of these topics has become the key to investors, academics and policymakers.

The remainder of the paper is organized as follows. Section 2 exposes the literature review about the effects of stock market crises on market liquidity and volatility in stock market and currency market and presents the hypotheses. Section 3 describes the methodology and the data, specifies the episodes of stock market crises and defines the variables used in estimation. Section 4 reports and discusses the empirical results and a conclusion is in the final section.

2 Literature review and hypotheses development

Finance literature has been interested in investigating the transmission effects of stock market crises to markets behavior. Various researches studies have been conducted to explain the influence of stock market crises on market liquidity. Amihud & Mendelson (1986) argue that market liquidity reflects the cost of immediate execution of buy or sell order. According to Pastor & Stambaugh (2001), liquidity is described as the capacity of investors to swiftly trade massive quantities of assets at lower trading cost. Pastor & Stambaugh (2003) and Acharya & Pedersen (2005) explain that investors are encouraged to liquidate their assets in the period of economic recession. They argue that the lower liquidity level increases the trading cost. Rösch et al. (2013) conclude that higher liquidity can be illustrated by trading volume, decreasing transaction costs in the market.

Bernann et al. (1998) and Datar et al. (1998) use trading volume, turnover rate and bid-ask-spread as proxis for market liquidity. Amihud (2002) bases on another market liquidity measurement qualified as the Amihud illiquidity ratio. This ratio is calculated by

dividing the absolute return by the total trading volume of market or stock. Amihud (2002) stipulates that this ratio is negatively associated with returns.

Edelen (1999) proves that the excessive buying and selling of stocks by the investors induces a decline in liquidity during periods of financial turbulence. Bookstaber (2000) and Kyle & Xiong (2001) argue that traders suffer trading losses in the market due to the Russian crisis occurrence. Consequently, the investors are motivated to liquidate their positions in both markets. As a result, the market liquidity reduces and the asset return volatility increases. Bernardo & Welch (2004) and Morris & Shin (2004) show that traders are obliged to liquidate their asset because of negative shocks and the drop in stock market.

Kyle & Xiong (2001), Garleanu & Pedersen (2007) and Brunnermeier & Pedersen (2009) document that the decline in stock market reduces market liquidity. Ang et al. (2006) suggest that the level of liquidity decreases after the drop in stock market. Bordo (2008) argues that market liquidity drops through the 2008-2009 financial crisis, leading to catastrophic effects. He suggests that central banks should reduce interest rates in order to flow the market with liquidity. Hameed et al. (2010) document that the fall in stock market is associated with a decrease in market liquidity, as financial intermediaries are faced with funding constraints. Chudik & Fratzscher (2012) suggest that the emerging market economies were more vulnerable to liquidity shocks during the subprime crisis in 2008 and the sovereign debt crisis in 2010. They put in evidence that those crises led to the occurrence of the flight-to-safety phenomenon.

Rösch & Kaserer (2013) investigate the growth of market liquidity during the financial crisis. They put in evidence that market liquidity diminishes as stock markets decrease. Adrian et al. (2017) detect a weak decline in bond market liquidity after the 2007-2009 financial crisis. Kaya & Engkuchik (2017) analyze the evolution of market liquidity through emerging and developed markets over the 1990's financial crises. On the one hand, they conclude that the market liquidity reduces in about half of the sample markets after the Thai crisis, the Hong Kong crisis, the Russian crisis and the Brazilian crisis. They explain that each crisis affects market liquidity measured as the turnover ratio in the country where the crisis originated and in other countries, suggesting that the liquidity level decreases after these financial crises. On the other hand, Kaya & Engkuchik (2017) provide evidence of the increase of market liquidity in the remainder of the sample markets. However, Bessembinder et al. (2016) put in evidence a decline in transaction costs after the occurence of 2007-2009 financial crisis.

Hypothesis 1. Stock market crises negatively influence market liquidity.

Additional evidence of the effect of stock market crises on market volatility is also provided by other studies including Christie (1982), Schwert (1990), Chakrabarti & Roll (2002) and Karunanayake et al. (2010). Christie (1982) shows that a decrease in stock prices leads to higher financial leverage, making the stock riskier and rising its volatility. Schwert (1990) suggests that down-markets are related to a rise in market volatility. Chakrabarti & Roll (2002) report an increase in stock return volatility in the East Asian and European stock markets directly after the occurrence of the 1997 Asian crisis. Karunanayake et al. (2010) show that the 1997 Asian financial crisis and the 2008 financial crisis are associated with an increase in stock return volatility. In contrast, Law (2006) put in evidence that the 1997 Asian financial crisis causes a decrease in stock return volatility.

Hypothesis 2. Stock market crises positively influence market volatility.

A considerable amount of research has been devoted to the investigation of the influence of stock market crises on exchange rate volatility. Fratzscher (2009), Melvin & Taylor (2009) and Mbutor (2010) conclude that the financial crisis of 2008 caused highly volatile shocks across foreign exchange markets. They explain that the exchange rate depreciated and became more volatile.

Coudert et al. (2011) explore the effect of the subprime crisis on the exchange rate volatility in 21 emerging countries from January 1994 to September 2009. They show that exchange rate has been characterized by greater volatility since the start of the financial crisis in July 2007 for most countries. Coudert et al. (2011) explain that the investors are obliged to sell their risky assets on emerging countries in local currencies because they faced enormous losses owing to the lack of liquidity.

Hypothesis 3. Stock market crises positively influence exchange rate volatility.

Other empirical evidence focuses on what triggers a stock market crisis on the interest rate behavior. Jobst & Kwapil (2008) show lower raise in lending rates after the occurrence of the financial crisis in July 2007. Taylor (2009) reports that the 2008 financial crisis causes an increase in the money market interest rates. Hristov et al. (2012) put in evidence that the expansion in interest rate spreads was caused by the occurrence of the 2008 financial crisis. Fouejieu (2013) investigates the effects of the 2008/2009 financial crisis on the global economy. He highlights that the real interest rate increased from 6% on average in 2003/2007 to 12% in 2009, the investment dropped, the unemployment went up and the GDP growth diminished from 6% in 2007 to 4% in 2008 and -0.08% in 2009. In contrast, Laubach & Williams (2015) document a drop in the natural interest rate since the emergence of the great recession. They explain there result by a decrease in the economic growth.

Hypothesis 4. Stock market crises positively influence interest rate.

A related research attempts to analyse the impact of financial crises on inflation. Borensztein & De Gregorio (1999) investigate the effect of the currency crises on inflation. They show higher level of inflation after the occurrence of the currency crises except for the 1992 EMS crisis. They explain that movements in the exchange rate exert an impact on inflation. However, Stock & Watson (2010) underline that the inflation declines in periods of recession in the United States from 1960 to 2010. Del Negro et al. (2014) put in evidence a fall in inflation since the emergence of the 2008 financial crisis.

Hypothesis 5. Stock market crises negatively influence inflation.

3 Methodology

First, we use the CMAX approach to identify stock market crises. Then, we apply the Vector Auto Regression (VAR) model to analyze the transmission effect of stock market crises shocks on market liquidity, market volatility and exchange rate volatility. We aim to characterize the dynamic influence of the stock market crises shocks on the endogenous variables. For this end, we present the impulse response functions and the variance decompositions. The impulse response functions define the response of an endogenous variable to a shock over time. While, the variance decompositions determine the contributions of the shocks to the variance of the n-period ahead forecast error for each endogenous variable.

3.1 Econometric model and data

The VAR approach considers each variable as endogenous variable as a function of the lagged values of all endogenous variables in the system. The model VAR is written as:

$$Y_t = A_0 + A_1 Y_{t-1} + A_2 Y_{t-2} + ... + A_p Y_{t-p} + \varepsilon_t \quad (3.1)$$

Where $y_{1,t}$, $y_{2,t}$, ..., $y_{k,t}$ are stationary and $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, ..., $\varepsilon_{k,t}$ are error terms. The time period that was analyzed is from January 1999 to February 2020.

The data is gathered from the Central Bank of Tunisia, the Tunisian Stock Exchange and the National Institute of Statistics.

3.2 Identifying the episodes of stock market crises

We focus on the shocks stemming from the occurrence of stock market crises. For this end, we use the CMAX approach developed by Patel & Sarkar (1998) to detect stock market crises in Tunisia from January 1999 to February 2020. This approach defines a crisis indicator, the $CMAX_t$, which corresponds to the ratio of the stock market index at time t to the maximum stock market index level for the period T (set to twenty-four months).

Patel & Sarkar (1998) explain that the indicator $CMAX_t$ equals 1 if the prices rise during the preceding period, indicating a bullish market. When the stock market index declines, the indicator $CMAX_t$ gets to 0. A stock market crisis is identified when the indicator $CMAX_t$ exceeds the threshold. The threshold is defined as following:

$$Threshold_t = \overline{CMAX}_t - 1.5\sigma_t \quad (3.2)$$

As shown in Table 1, two stock market crises are detected for the TUNINDEX index from January 1999 to February 2020: the first crisis is from May 2001 to March 2003 and the second crisis is from September 2010 to May 2011.

TABLE 1 Detection of stock market crises through the CMAX method

The crisis beginning	The trough date	Price decline to trough
May 2001	March 2003	-26.80 %
September 2010	May 2011	-24.75 %

3.3 Variables used in estimation

In this study, we use a list of financial and economic variables such as, the ratio of liquidity (Amihud illiquidity ratio), the ratio of liquidity (Martin Liquidity Index), the Tunindex index volatility, the EUR/TND exchange rate volatility, the interest rate and the inflation.

We introduce the Amihud illiquidity ratio developed by Amihud (2002) and the Martin Liquidity Index (MLI) proposed by Martin (1975) as our market liquidity measures.

The Amihud illiquidity ratio 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. According to Amihud (2002), the Amihud illiquidity ratio is negatively associated with stock returns.

The Martin Liquidity Index (MLI) is calculated as the following ratio:

$$MLI_i = \sum_{t=1}^{I} \frac{(P_t - P_{t-1})^2}{V_t} \tag{3.3}$$

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. Martin (1975) argues that a low value of *MLI* reflects a high level of stock return liquidity.

Moreover, we integrate Tunindex index volatility as a proxy of market volatility. Tunindex index volatility is measured by calculating the standard deviation of daily returns of Tunindex index for each month. A high market volatility is an indicator of a decline in stock market.

Besides, we incorporate in this analysis the EUR/TND exchange rate volatility which is equal to the standard deviation of 12 monthly exchange rate.

Furthermore, we employ two control variables, such as the inflation and the 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. In addition, we use monthly interest rate. The interest rate is equal to the Money Market Average (TMM). Table 2 presents the descriptive statistics of the financial and economic variables.

TABLE 2 Descriptive statistics of the variables used in estimation

	Mean	*Maximum*	*Minimum*	*Standard deviation*
Stock market crises	0.118110	1.000000	0.000000	0.323376
Ratio of liquidity (Amihud illiquidity ratio)	$5.11\ 10^{-6}$	$6.12\ 10^{-5}$	$2.63\ 10^{-8}$	$1.03\ 10^{-5}$
Ratio of liquidity (MLI)	0.000309	0.006594	$3.66\ 10^{-8}$	0.000672
Tunindex index volatility	0.093582	0.170642	0.034658	0.032662
EUR/TND exchange rate volatility	0.074606	0.214238	0.009755	0.046452
Interest rate (TMM)	0.052051	0.079000	0.031600	0.009834
Inflation	0.037681	0.071021	0.009222	0.014655

4 Empirical results

To verify that our data is stationary, the KPSS test is used to check for a unit root. The results of the KPSS unit root test appear in Table 3. From Table 3, we conclude that all variables are stationary at the 5% level.

TABLE 3 Results of the stationarity (unit root) test

Variables	Calculated values of the KPSS test	Critical value of the KPSS test at the 5% level
Stock market crises	0.331651**	0.463
Ratio of liquidity (Amihud illiquidity ratio)	0.067571**	0.146
Ratio of liquidity (MLI)	0.114162**	0.463
Tunindex index volatility	0.165763**	0.463
EUR/TND exchange rate volatility	0.029393**	0.463
Interest rate (TMM)	0.344341**	0.463
Inflation	0.040508**	0.146

Note: **Denotes that all variables are stationary at the 5% level.

The model VAR requires the detection of the optimal lag length of p. In this research, one lag has been chosen on the basis of Akaike information criterion (AIC), Schwarz information criterion (SC), sequential modified likelihood ratio (LR) test, final prediction error (FPE) and Hannan-Quinn information criterion (HQ) (See Table 4).

TABLE 4 Selection of lag length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	6566.801	NA	1.63e-32	-53.33171	-53.23197	-53.29155
1	8252.223	3261.223	2.71e-38	-66.63596	-65.83800*	-66.31466*
2	8308.404	105.5111	2.56e-38	-66.69434	-65.19816	-66.09190
3	8391.925	152.1040	1.94e-38	-66.97500	-64.78061	-66.09142
4	8451.062	104.3300	1.79e-38	-67.05741	-64.16480	-65.89269
5	8510.067	100.7404*	1.66e-38*	-67.13875*	-63.54793	-65.69290
6	8546.005	59.31311	1.87e-38	-67.03256	-62.74352	-65.30557
7	8587.333	65.85614	2.02e-38	-66.97019	-61.98293	-64.96205
8	8623.377	55.38464	2.29e-38	-66.86486	-61.17938	-64.57558

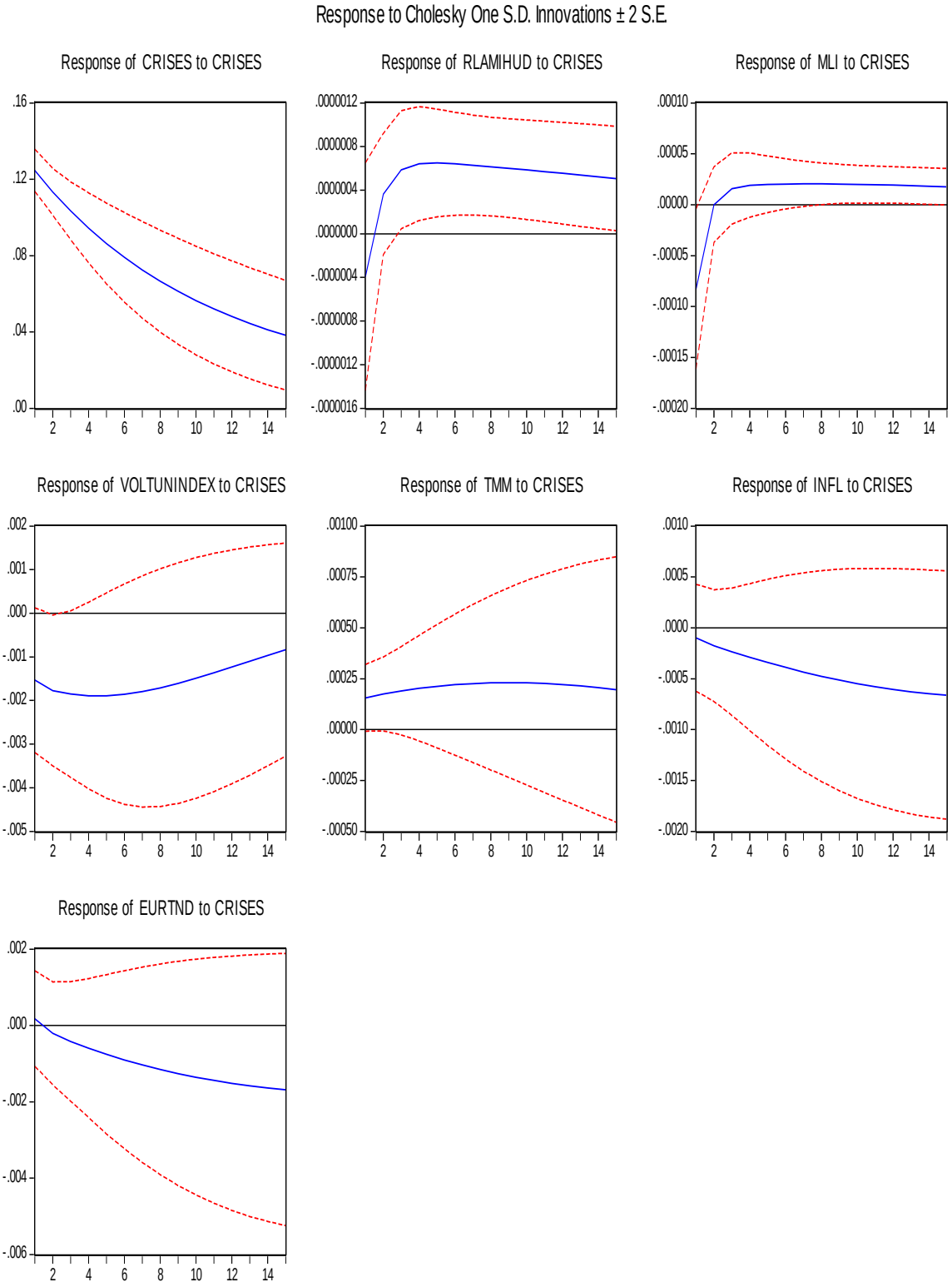
Note: NA: non-available value.

In the following section, we will present the impulse responses of the variables to stock market crises shocks using the VAR model. Besides, we will study the variance decompositions.

4.1 Impulse responses

The primary step is to analyse the impulse responses of each variable to stock market crises shocks at most of fifteen months horizon as shown in Figures 1, 2, 3, 4, 5, 6 and 7.

Figures 1, 2, 3, 4, 5, 6 and 7 Responses to stock market crises shocks



Where *CRISES* is the stock market crises, *RLAMHUD* is the ratio of liquidity (Amihud illiquidity ratio), *MLI* is the ratio of liquidity (MLI), *VOLTUNINDEX* is the Tunindex index volatility, *EURTND* is the EUR/TND exchange rate volatility, *TMM* is the interest rate and *INFL* is the inflation.

From Figure 1, we observe that stock market crises positively and significantly react to their own shocks and the effect of the shocks decreases in the long period. Figure 2 and 3 depict the impulse responses of liquidity market to stock market crises shocks using two liquidity indicators, such as the Amihud illiquidity ratio and the Martin Liquidity Index (MLI). We conclude that Amihud illiquidity ratio and the Martin Liquidity Index (MLI) positively and significantly respond to the shocks of stock market crises, during a period, respectively, from three months to fifteen months and from seven months to fifteen months. These results are consistent with the fact that stock market crises negatively affect these markets' liquidity levels. These findings support the existence of a decline in market liquidity after the occurrence of stock market crises. An alternative interpretation of our result is that stock market crises occurrence is accompagnied by changes in behaviour of market participants, decreasing market liquidity. Thus, the decline in stock prices raises the risk aversion of investors, influencing their trading behavior. Moreover, higher risk aversion leads market participants to reduce their transaction volumes, increasing the transaction costs and turning down their returns when they buy or sell. Consequently, the market liquidity falls. An other explanation of our result is that the higher uncertainty about economic and monetary policy causes the increase in market volatility, affecting the investors expectation of the asset price, their confidence in their forecasts and their sensitivity to market information. As a result, market liquidity drops and price becomes more volatile as the degree of traders' risk-aversion raises.

Our empirical result falls in line with the empirical evidence of Bookstaber (2000), Kyle & Xiong (2001), Bordo (2008), Chudik & Fratzscher (2012), Rösch & Kaserer (2013), Adrian et al. (2017) and Kaya & Engkuchik (2017) who put in evidence that market liquidity decreases through the financial crises. Besides, our empirical analysis is consistent with the empirical evidence of Kyle & Xiong (2001), Ang et al. (2006), Garleanu & Pedersen (2007), Brunnermeier & Pedersen (2009), Hameed et al. (2010) and Viswanathan (2010) who document that the decline in stock market reduces market liquidity. Conversely, the research of Bessembinder et al. (2016) seems contradictory to ours because, according to these authors, transaction costs fall after the occurence of financial crisis.

Furthermore, Figure 4 highlights that stock market crises shocks negatively and significantly affect the Tunindex index volatility during a period ranging from two months to three months. The effects were proven to be small but significant. This means that stock market crises are followed by a financial stability, thus investors form rational expectation of the asset price when risk is low. Consequently, market volatility falls. Our result confirms the suggestion in Law (2006) who emphasizes that the 1997 financial crisis led to a decrease in stock return volatility. However, our findings are inconsistent with the results of Chakrabarti & Roll (2002) and Karunanayake et al. (2010) which highlight that the financial crises are accompagnied by an increase in market volatility.

After examining the relation between stock market crises and the market liquidity and market volatility, we turn our attention to the interaction between the economic variables and stock market crises shocks. From Figure 5, it appears that the interest rate positively and significantly responds to the shocks of stock market crises and the effect of the shocks reduces at the end of two months. This means that in spite of the stock market crashes occurrence, the interest rate continue to increase. One possible explanation of this result is the lower level of

market liquidity conducts investors to raise the liquidity risk premium, increasing their required interest rate. Therefore, the Central Bank did not react by introducing appropriate decisions and pursuing policies in order to reduce the interest rate. Besides, when stock prices decline, the supply of credit falls while precautionary savings rise, leading to an expansion in interest rate. In this line, several papers have recently argued that the financial crises cause a rise in the interest rate (Jobst & Kwapil, 2008; Taylor, 2009; Hristov et al., 2012; Fouejieu, 2013).

Figure 6 shows that the response of the inflation to the stock market crises shocks is not significant during the whole period. An alternative interpretation of our analysis is that the stock market crises do not cause any disruptions in the evolution of the inflation and do not harm economic activity. Our result is inconsistent to the suggestions in Borensztein & De Gregorio (1999) who underline higher level of inflation as soon as the occurrence of the currency crises and the empirical evidence of Del Negro et al. (2014) who put in evidence a fall in inflation since the emergence of the 2008 financial crisis.

From Figure 7, we observe that the response of the EUR/TND exchange rate volatility insignificantly reacts to stock market crises shocks during the whole period. This probably reflects the fact that a fall in Tunindex index does not generate an interruption in the EUR/TND exchange rate volatility. Consequently, stock market crises do not influence volatility in exchange market. Our results reveal that the Tunisian stock market crises is accompagnied by stable EUR/TND exchange rate volatility and the behaviour of investors does not change towards their risky assets on emerging countries in local currencies. Our empirical evidence contradicts the results of Fratzscher (2009), Melvin & Taylor (2009), Mbutor (2010) and Coudert et al. (2011) who conclude that the 2008 financial crisis causes highly volatile shocks across foreign exchange markets.

4.2 Variance decompositions

The secondary step consists in investigating the variance decomposition in order to analyse the proportion of the forecast variance of variables which can be explained by shocks to stock market crises. Tables 5, 6, 7, 8, 9, 10 and 11 present the variance decompositions for all variables at a forecast horizon of 15 months. Table 5 displays the variance decomposition results for the stock market crises and underlines that most of the variance of the forecast errors are attributable to its own shocks (95.73%) and a small fraction is due to Tunindex index volatility shocks (1.64%), liquidity ratio (Martin Liquidity Index) shocks (1.19%), liquidity ratio (Amihud illiquidity ratio) shocks (0.44%), EUR/TND exchange rate volatility shocks (0.42%), inflation shocks (0.4%) and interest rate shocks (0.2%).

TABLE 5 Variance decomposition for stock market crises

Period	S.E.	Stock market crises	Ratio of liquidity (Amihud illiquidity ratio)	Ratio of liquidity (MLI)	Tunindex index volatility	Interest rate	Inflation	EUR/TND exchange rate volatility
1	0.124671	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.168562	99.89976	0.035322	0.012572	0.022312	0.001621	0.020574	0.007842
5	0.236302	99.28819	0.183437	0.056064	0.240703	0.020156	0.135536	0.075911
10	0.283299	97.57106	0.339871	0.522905	0.902833	0.090384	0.318357	0.254594
15	0.303983	95.72754	0.439943	1.185658	1.638726	0.195122	0.397627	0.415381

The results from Table 6 consider that 79.67 percent portion of liquidity ratio (Amihud illiquidity ratio) is explained by its own innovative shocks while innovative shocks of stock market crises contribute to liquidity ratio (Amihud illiquidity ratio) by 5.15 percent. In this context, market liquidity decreases to $2.10736\ 10^{-5}$ and $1.1262\ 10^{-6}$, respectively after the occurrence of the crises in March 2003 and May 2011. Our empirical analysis confirms the evidence in Bookstaber (2000), Kyle & Xiong (2001), Bordo (2008), Chudik & Fratzscher (2012), Rösch & Kaserer (2013), Adrian et al. (2017) and Kaya & Engkuchik (2017) who underline that stock market crises negatively influence market liquidity. A small fraction is due to Martin Liquidity Index (4.75%), Tunindex index volatility shocks (3.76%), inflation shocks (3.73%), interest rate shocks (1.75%) and EUR/TND exchange rate volatility shocks (1.19%).

TABLE 6 Variance decomposition for ratio of liquidity (Amihud illiquidity ratio)

Period	S.E.	Stock market crises	Ratio of liquidity (Amihud illiquidity ratio)	Ratio of liquidity (Martin Liquidity Index)	Tunindex index volatility	Interest rate	Inflation	EUR/TND exchange rate volatility
1	8.30E-06	0.224686	99.77531	0.000000	0.000000	0.000000	0.000000	0.000000
2	8.65E-06	0.384781	98.59120	0.116938	0.163545	0.062154	0.591590	0.089795
5	8.96E-06	1.828122	92.15013	1.351705	1.096984	0.426372	2.627783	0.518899
10	9.38E-06	3.814734	84.35028	3.375221	2.620928	1.101381	3.732787	1.004664
15	9.66E-06	5.150512	79.67354	4.747443	3.757088	1.754867	3.721556	1.194990

The results of the variance decomposition for liquidity ratio (Martin Liquidity Index) are presented in Table 7 and provide clear evidence that most of the variance is due to liquidity ratio (Amihud illiquidity ratio) shocks (55.58%) and to its own shocks (37.17%). The role of stock market crises, Tunindex index volatility, interest rate, EUR/TND exchange

rate volatility and inflation are less important. These variables by their shocks contribute to liquidity ratio (Martin Liquidity Index) by 2.66 per cent, 2.3 per cent, 1.49 percent, 0.41 percent and 0.38 percent, respectively. We observe that the 2003 and 2011 stock market crises entail the drop in market liquidity measured by liquidity ratio (Martin Liquidity Index) to 4.44 10^{-4} and 1.44 10^{-4}, respectively. Our further analysis confirms that stock market crises negatively affect the market liquidity.

TABLE 7 Variance decomposition for ratio of liquidity (Martin Liquidity Index)

Period	S.E.	Stock market crises	Ratio of liquidity (Amihud illiquidity ratio)	Ratio of liquidity (Martin Liquidity Index)	Tunindex index volatility	Interest rate	Inflation	EUR/TND exchange rate volatility
1	0.000629	1.735951	60.12717	38.13687	0.000000	0.000000	0.000000	0.000000
2	0.000636	1.697031	60.07800	37.77655	0.195162	0.085203	0.104389	0.063658
5	0.000644	1.900240	58.63728	37.52399	0.928091	0.444609	0.305715	0.260068
10	0.000655	2.316109	56.77733	37.37309	1.798834	1.006308	0.332168	0.396164
15	0.000662	2.663079	55.58169	37.16807	2.299176	1.494374	0.381705	0.411904

It is seen from Table 8 that the variance decomposition for Tunindex index volatility is attributable to its own shocks (46.95%), liquidity ratio (Martin Liquidity Index) shocks (38.89%), EUR/TND exchange rate volatility shocks (4.84%) and stock market crises shocks (4.16%). We demonstrate that changes in market volatility is explained by the occurrence of the stock market crises. We observe that the Tunindex index volatility decreased to 5.37% and 13.89% as a result of the stock market crises occurrence in Tunisia in 2003 and 2011, respectively. We conclude that stock market crises emergence exerts a significant impact on market volatility. Our result supports the evidence of Law (2006) who emphasizes that the 1997 financial crisis is accompagnied by a drop in stock return volatility. However, a small fraction is attributable to liquidity ratio (Amihud illiquidity ratio) shocks (2.08%), inflation shocks (1.97%) and interest rate shocks (1.11%).

TABLE 8 Variance decomposition for Tunindex index volatility

Period	S.E.	Stock market crises	Ratio of liquidity (Amihud illiquidity ratio)	Ratio of liquidity (Martin Liquidity Index)	Tunindex index volatility	Interest rate	Inflation	EUR/TND exchange rate volatility
1	0.013253	1.340501	5.282359	36.70691	56.67023	0.000000	0.000000	0.000000
2	0.018216	1.657020	4.103187	40.62803	53.46616	0.006265	0.085457	0.053882
5	0.025050	2.563616	2.769729	42.49754	50.93461	0.087797	0.557729	0.588981
10	0.028613	3.722017	2.241105	40.80864	48.86599	0.459093	1.441834	2.461319
15	0.029695	4.161157	2.084631	38.88925	46.95206	1.109978	1.965272	4.837658

The results documented in Table 9 show that most of the variance decomposition for the interest rate is attributable to its own shocks (69.12%). Besides, the variance decomposition for the interest rate reveals that inflation significantly attributes to interest rate by 16.98 percent through its innovative shocks. The liquidity ratio (Martin Liquidity Index) and the Tunindex index volatility explain, respectively, 5.39 percent and 3.04 percent portion of interest rate by their innovations. However, the contribution of EUR/TND exchange rate volatility, stock market crises and liquidity ratio (Amihud illiquidity ratio) to interest rate are, respectively, 2.67 percent, 2.01 percent and 0.8 percent. These results imply that stock market crises play a key role in explaining the interest rate behaviour. As a result of the occurrence of stock market crises in 2003 and 2011, the interest rate is increased to 5,81% and 4,51%, respectively. Our results are similar to those of Jobst & Kwapil (2008), Taylor (2009), Hristov et al. (2012) and Fouejieu (2013) who find evidence that financial crises entail the rise in the interest rate.

TABLE 9 Variance decomposition for interest rate

Period	S.E.	Stock market crises	Ratio of liquidity (Amihud illiquidity ratio)	Ratio of liquidity (Martin Liquidity Index)	Tunindex index volatility	Interest rate	Inflation	EUR/TND exchange rate volatility
1	0.001307	1.419931	0.806261	3.261340	0.226954	94.28551	0.000000	0.000000
2	0.001867	1.574017	1.065781	3.839266	0.562923	92.70643	0.244388	0.007197
5	0.003046	1.911051	1.251628	5.303630	1.724813	87.04571	2.617085	0.146078
10	0.004520	2.131417	1.054797	6.027099	2.923006	77.39974	9.477222	0.986724
15	0.005742	2.010165	0.798050	5.389687	3.035308	69.12015	16.98068	2.665959

Table 10 underlines that most of the variance decomposition for inflation is due to its own shocks (83.64%) and to liquidity ratio (Martin Liquidity Index) shocks (6.31%). However, a small fraction is attributable to Tunindex index volatility shocks (3.22%),

EUR/TND exchange rate volatility shocks (2.62%), stock market crises shocks (2.34%), liquidity ratio (Amihud illiquidity ratio) shocks (1.30%) and interest rate shocks (0.57%). We observe that 2003 and 2011 stock market crises occurrence leads to a drop in inflation to 1,28% and 2,66%, respectively. Our result confirms that stock market crises occurrence negatively influences the inflation as shown in Stock & Watson (2010) and Del Negro et al. (2014).

TABLE 10 Variance decomposition for inflation

Period	S.E.	Stock market crises	Ratio of liquidity (Amihud illiquidity ratio)	Ratio of liquidity (Martin Liquidity Index)	Tunindex index volatility	Interest rate	Inflation	EUR/TND exchange rate volatility
1	0.004176	0.056108	0.210315	0.022048	0.283272	1.446904	97.98135	0.000000
2	0.005753	0.124234	0.419185	0.295116	0.157361	1.314234	97.64442	0.045449
5	0.008446	0.416858	0.746541	1.464853	0.299605	1.008736	95.62344	0.439965
10	0.010741	1.240006	1.077326	3.936794	1.557714	0.695069	89.96732	1.525776
15	0.012020	2.344283	1.300212	6.309937	3.217596	0.565817	83.63998	2.622173

As shown in Table 11, we report that most of the variance decomposition for EUR/TND exchange rate volatility is due to its own shocks (88.99%), to liquidity ratio (Martin Liquidity Index) shocks (4.36%) and to Tunindex index volatility shocks (3.86%). However, the innovative shocks of stock market crises, liquidity ratio (Amihud illiquidity ratio), inflation and interest rate explain a small portion of EUR/TND exchange rate volatility. We conclude the lack of effect of stock market crises on EUR/TND exchange rate volatility. In this context, we observe that EUR/TND exchange rate volatility falls to 2,43% and 6,25%, respectively, as a result of the 2003 and 2011 stock market crises occurrence.

Our further analysis is inconsistent to the findings of Fratzscher (2009), Melvin & Taylor (2009), Mbutor (2010) and Coudert et al. (2011) who put in evidence that the 2008 financial crisis causes highly volatile shocks across foreign exchange markets.

TABLE 11 Variance decomposition for EUR/TND exchange rate volatility

Period	S.E.	Stock market crises	Ratio of liquidity (Amihud illiquidity ratio)	Ratio of liquidity (Martin Liquidity Index)	Tunindex index volatility	Interest rate	Inflation	EUR/TND exchange rate volatility
1	0.009964	0.031651	0.034800	0.106798	0.648915	0.131889	0.002193	99.04375
2	0.013950	0.038738	0.153202	0.549381	0.896479	0.118883	0.012757	98.23056
5	0.021328	0.259968	0.288969	1.743019	1.607949	0.110294	0.069580	95.92022
10	0.028510	0.964709	0.406355	3.195019	2.799230	0.109977	0.204613	92.32010
15	0.033064	1.850893	0.495894	4.359137	3.860149	0.113399	0.331949	88.98858

5 Conclusion

In this research, we analyze the response of market liquidity, market volatility and exchange rate volatility to stock market crises shocks using the Vector Auto Regression (VAR) approach. The impulse response analysis put in evidence, on the one hand, that the occurrence of stock market crises negatively affects the market liquidity and the market volatility. An interpretation of our result is that the drop in Tunindex index reduces the market liquidity measured by Amihud illiquidity ratio and Martin Liquidity Index and diminishes the market volatility. Overall, the evidence reports that stock market crises occurrence increases the risk aversion of investors, reducing their transaction volumes. Consequently, the transaction costs raise, decreasing the market liquidity. Besides, the stock market crises occurrence negatively affects the participants market confidence.

On the other hand, the interest rate raises because of the emergence of stock market crises in 2003 and 2011. We argue as a possible explanation for our results that the drop in market liquidity leads investors to increase the liquidity risk premium, consequently their required interest rate increases. Moreover, the supply of credit decreases as a result of the stock market crises occurrence, increasing the interest rate.

In contrast, the effect of the stock market crises shocks is not significant on the EUR/TND exchange rate volatility and the inflation. Our results confirm that stock market crises do not cause any disruptions in the currency market and the economic activity.

Besides, the variance decomposition results confirm that the stock market crises shocks explain a larger proportion of the variability in market liquidity and market volatility. On the contrary, the exchange rate volatility, the interest rate and the inflation are less sensitive to Tunisian stock market crises shocks.

The main contribution of this study is two-fold. First, our study is motivated by insufficiency of empirical researches investigating the impact of stock market crises on emerging economies. Specifically, our paper extends previous researches by examining how market liquidity, market volatility and exchange rate volatility are related to stock market crises occurrence. Our research provides a new empirical evidence by understanding the strong effects of stock market crises on market liquidity and volatility in stock and currency markets.

Second, our findings add new insights to investors, academics and policymakers. Hence, investors need to useful informations about financial market to make appropriate decisions when they buy or sell their stocks. They take into account the level of liquidity when they determine the risk of investing in a stock. Besides, understanding the strong effects of stock market crises occurrence may lead policymakers to take appropriate measures aiming at preventing the emergence of stock market crises and minimizing their impacts.

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