

IMPACT OF THE INVESTMENT POLICY IN INFORMATION TECHNOLOGIES ON THE QUALITY OF THE TUNISIAN STOCK MARKET

Syrine Ben Romdhane
University of Tunis, Higher Institute of Management
BESTMOD-Lab
Email: srbenromdhane@gmail.com

Imen Kouki
University of Tunis, Higher Institute of Management
GEF2A-Lab
Email: imen_kouki@yahoo.fr

Mokhtar Kouki
University of Carthage
ESSAI-Lab
Email: mokhtar.kouki@essai.rnu.tn

ABSTRACT

The paper presents the use of the GARCH model and the GMM system method for the purpose of investigating the effects of technological investment on Tunisian stock market's trading volume and liquidity. This study contributes to the literature on financial development in two folds. First, it adds to the existing literature by providing empirical evidence on the advantages of IT' investments and its components in improving the quality of the trading mechanism. Second, this study will be helpful for financial authorities to implement the policies of their investments in automation and system development. We perform daily data from May 30, 2008, to December 31, 2018. The results suggest that there is a negative relationship between illiquidity ratio and investment, but a positive one with trading volume. Indeed, the automated system and the securities laws are efficient at long and not short term. Measuring the impact of

various categories of IT investments (hardware, software and training) on liquidity suggests that the training investment has a negative impact on illiquidity, but the effect is low. Finally, our results show that there is a lack in the implementation of investment policies in Tunisian financial market, suffering from many no strategies in investment. Indeed, the automated system of the stock market is obsolete, and the investment is allocated to maintain it and not to develop and improve the quality of the market.

Keys-words: Information Technology, Tunisian Stock Exchange, Liquidity, GARCH Method, GMM System Estimator.

JEL Classification : G12, G14, O32.

INTRODUCTION

The development of technology has boosted the financial markets to automate their trading activities, in particular, through information technologies (IT). Indeed, financial information is the key in the decision-making process, offering exciting benefits to investors, issuers and other market participants.

According to Yilmaz and al. (2015), since technological upgrades modernize the way financial assets are traded, investments in exchange infrastructures improve the strength of the link between investment and savers. Capital markets automation does not only benefit one of the players of the financial trading game, but also all the players in the sector gain from such technological breakthroughs. After the automation, investors were not entitled to go and deal directly with stock exchanges; they did not have to go to a stock broker's office or deal with the hassles of calling him/her on the phone. Initially, investors had to compete for the broker's time through regular and continuous access. The application of information technology allowed the investor to reach the information he/she requires any time anywhere.

Automation, IT use and the transparency, through technology decrease the cost incurred by intermediaries, and thereby not only enabling more efficient risk sharing, but also improving hedging strategies, liquidity, and efficiency of prices (Hendershott et al., 2011) and improve the market quality.

Different studies have already analyzed the impact of electronic trading on market quality and focused at the market level, i.e. measuring the change in market quality parameters like spread or volatility following exchange system updates (Riordan & Storkenmaier, 2012; Hendershott & Moulton, 2011; Al-Khouri & Al-Ghazawi, 2008; Ben Ouda & Hmaied, 1998). For instance, it has been found that spreads decrease after latency reducing IT-updates, thus market quality increases. Other researchers considered whether exchange operators gain a competitive advantage from the introduction of new exchange systems (Haferkorn & Zimmermann, 2015; Mata, Fuerst & Barney, 1995). Using generally a benchmarking approach against the closest competitor, these authors found

that exchange system overhauls significantly increase the attracted trading volume. They concluded that investments in enterprise systems provide benefits and lead to competitive advantages for the upgrading firm. However, and to the best of our knowledge, these studies do not consider the impact of technological investments on market dimensions. What is meant by technological investment here is an upgrade in trading systems through software, hardware and training.

So, to fill this gap, this paper investigates the effects of technological investment on trading activity, such as trading volume and liquidity. This paper contributes to the literature on financial development in two folds. First, it adds to the existing literature by providing empirical evidence on the advantages of IT' investments and its components in improving the quality of the trading mechanism. Second, this study will be helpful for financial authorities to implement the policies of their investments in automation and system development.

The remainder of this paper is structured as follows. Section 1 summarizes the relevant literature. Section 2 provides a brief description of the Tunisian stock market, its trading system and investments in IT. Section 3 represents data analysis and research methodology. Finally, section 4 illustrates empirical results. This section will be followed by a conclusion and recommendations.

1. A Brief Literature Review

A large body of literature has recognized the important role of technological change and the consequences of IT-investments on corporate performance. Al-Khoury and Al-Ghazawi (2008) investigated the impact of the electronic trading system (ETS) on the Amman Stock Exchange (ASE) with respect to volatility and liquidity before and after the implementation of the ETS, over the period from 2nd January, 1996 to 2nd January, 2004. They found that electronic trading seemed to decrease the volatility of the ASE and showed a positive effect on market liquidity, based on daily volume of trade. Their study found an increase in the relative volume of stocks after the adoption of the ETS. In their study, Naidu and Rozeff (1994) noted an increase of volatility and liquidity as well as an improvement in efficiency following the automation of the Singapore stock exchange. They advanced that automation speeds up the dissemination of prices, then volatility is likely to increase, especially when information is hitting the market. The study of Yilmaz and al. (2015) examines the effects of technological changes on liquidity of stock markets. Utilizing daily data of 361 stocks from 10 emerging market exchanges, a panel data regression analysis shows that technological upgrade decreases the bid-ask spread and increases trading activity. In other words, launching a more sophisticated trading platform contributes to the overall liquidity of the market. Riordan and Storckenmaier (2012) provide similar evidence from Europe. They examine the upgrade of the Deutsche Börse trading system with the release of Xetra 8.0., and show that decreasing latency leads to increased liquidity by decreasing bid-ask spreads while improving the efficiency of prices. Haferkorn and Zimmermann (2015) empirically analyzed the impact of exchange

system upgrades on the market share of the respective exchange. They found that exchanges depend on successful IT-systems as these ensure the core functionality of exchanges, i.e. bringing together buy and sell orders in an automatic manner. Especially due to the rise of new technologies like High-Frequency-Trending and ongoing fragmentation, exchanges are put more and more under pressure to invest into new systems. These authors analyzed if such investments help firms to gain a strategic advantage in comparison to their closest competitor and they found an increased relative trading volume on exchange systems.

The study of Omuchesi, Bosire and Muiro (2014) investigated the effect of the automation on stock market capitalization, liquidity, efficiency, returns and volatility of the Nairobi Securities Exchange (NSE). Two study periods were considered pre-automation period (January 2002 to June 2006) and post-automation period (July 2008 to December 2012). This study therefore provided information valuable to the existing and potential investors in evaluating their investment positions. It is of use to scholars through contribution to advance knowledge and research programs in finance and financial markets. The results indicated that automation of the NSE had a significant positive effect on market size, a significant negative effect on market liquidity, and no significant effect on market returns, market efficiency and price volatility at the NSE.

Moreover, capital market automation may not have an effect on security market performance. Critics of automation argue that electronic trading could lead to less efficient prices since judgmental aspects of trade execution are lost with automation, which could be particularly important in times of fast market movements. In fact, in their paper, Omuchesi, Bosire and Muiro (2014) examined the effect of automation on the efficiency of the Nairobi Securities Exchange. Their study concluded that the automation of the NSE had no significant effect on its efficiency. In contrast to Jarrett and Kyper (2005) finding that market returns are not random and can be used to predict future returns with a degree of accuracy, this study found no effects of the automation on the market efficiency. Market inefficiencies could have arisen if there were identifiable systematic and permanent variations in stock returns, in which case, those nonrandom variations were expected to decrease with increased trading activities occasioned by the automated trading system whereby new participants and instruments would be available. In this context, Freund and Pagano (2000) discussed the mechanics of automated trading systems and the benefits and disadvantages of implementing such systems and the effects of automation on price efficiency. They examined price efficiency before and after automation on the NYSE and the TSE. Although they found that automation is associated with an improvement in market efficiency on the TSE relative to the NYSE, they did not detect any changes in the nonrandom patterns in returns before and after automation, which leads them to conclude that automation has not changed price efficiency on the TSE. However, they pointed out that their results should be interpreted with caution since they rely on a relatively short sample. Mensah, Poma-Berko and Adom (2012) using the Unit Root Random Walk and the GARCH models found that the Ghana Stock Exchange (GSE) was weakly inefficient in both pre and post automation periods,

suggesting that the automation of the GSE did not yield the needed impact towards improving the efficiency of the exchange.

2. Tunisian Stock Market, Trading Systems and IT Investments

The new organization of the Tunisian stock market, as decided by Law N°94-117 dated November 14, 1994, has established a new redistribution of tasks and powers. It is based on a trilogy of institutions which are: a regulatory body (Financial Market Council, CMF), a body in charge of the management of the market (Stock Exchange of Tunis, BVMT) and a body in charge of deposit and clearing (Tunisie Clearing). Under this structure, the investment chain in the stock market starts with the transmission of a stock market order through a stock market intermediary and ends with the settlement of the transaction with the delivery of a security or the collection of its counter value. The various stages are performed by an electronic network between the three organizations (extract from the CMF Report, 2001). Since 1996, the Tunisian stock exchange (TSE) has been an electronic pure order driven market. It operates as a continuous market for the more actively traded stocks and a call auction (fixing) for the less liquid stocks.

2.1 Trading Systems in Tunisian Stock Market

Although created in 1969, the TSE started its expansion only about the Nineties with a rise in range into 2003. We conclude a sustained high growth and continuous of all the indicators and an increase in the performance. Different measures undertaken from 1999 to 2018 stimulated the development of the TSM and led to an important increase of the investor demand. Table 1 presents certain key figures related to the evolution of Tunis stock exchange.

Indeed, the volume of exchange increased from 881 million dinars (MD) in 1999 to 3 837 MD (for the whole market) and to 2 521 MD (for stock cote) in 2018. However, this demand was not accompanied by an equivalent increase in the stock offer. So, the Tunis stock market displayed a rise in its index (BVMT index) from 7 192 in 1999 to 7 272 MD at the end of 2018. The Tunindex index ended 2018 at 7 271.65 points, up 15.76% in the wake of increases of 14.45% in 2017 and 8.86% in 2016. The Tunindex20, made up of the 20 largest and most liquid stocks on the market, replicated the Tunindex trend almost identically. He finished the year with 3 248.56 points, up 15.09%.

Table 1. Evolution of Tunis stock market activity

Years	1999	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018
Market capitalization (in MD)	3328	3889	2842	3085	5491	8301	15282	13780	17324	19300	24398
Variation (%)	-	16.85	-26.92	8.55	78	51.17	84.09	-9.83	25.7	11.4	26.41
Trading volume (in millions)	41	58	43	43	143	260	308	293	325	340	332
Variation (%)	-	41.46	-25.86	-	232.5	81.81	18.46	-5%	10.92	4.61	-2.35
Trading value (in MD)	881	1814	1006	690	4606	4130	3836	2930	2596	2765	3837
Variation (%)	-	106	-44.54	-31.41	567	-10.33	-7.12	23.62	11.4	6.51	38.77
Tunindex index	1193	1442	1119	1331	2331	2892	5113	4580	5090	5489	7272
Variation (%)	-	20.87	-0.23	18.94	75.13	24.06	76.8	-10.42	11.13	7.84	32.48
Number of listed firms	44	44	46	44	48	50	56	59	77	79	82

Source: Authors' contribution with reference to yearly reports of Tunis Stock Exchange and National Institute of Statistics (INS) during the period 1999-2018.

At the end of 2018, the market capitalization increased by 2 528 MD, recording an increase of 11.57% to settle at 24 398 MD against 3 328 MD at the end of 1999. The increase in stock exchange capitalization in the last few years (especially from 2014) can be explained by the rise in the total value of the equity new issues and the initial public offering. The shareholders and the investors finally agree to take the risk to participate in the market and the companies accept to finance their development strategies by the financial market (Ben Khediri & Daadaa, 2011). Market capitalization experienced a significant increase between 2008 and 2010, but decreased throughout 2012. A considerable decrease in the listed companies' prices offset the positive impact on the market capitalization of twelve initial public offerings (IPOs) in 2013, which gained just 2.3% to reach 14 093 MD in 2013, against 13 780 MD in 2012. Following the Tunisian Revolution, the financial context was marked by a drop in bank liquidity.

Prior to the Revolution (2011), the TSE has recorded in 2008 the third best world performance, making for more than seven years a remarkable growth. We also detected the record of the TSE index (Tunindex) in 2010. The market capitalization, as well as trading value recorded a high growth rate. However, after the Revolution, they appear to register a negative growth rate. This can have an explanation in political instability resulting from terrorism and strikes (Jeribi, Fakhfekh & Jarbou, 2018). In 2012, the Tunindex noticed a decline for the third successive year, posting -10.42% compared to

2010. Hence, 2013 was marked by the introduction of 12 new companies to the stock exchange official list. However, the number of IPOs did not exceed 4 between the years 2008 and 2012. Between 1999 and 2018, the number of companies listed on the stock exchange increased by 38 firms to recover 82 in 2018. With this large number of firms, the TSM decided to modernize its microstructure and introduced an automated trading system: the SUPERCAC UNIX developed by EURONEXT. Securities listed on the BVMT were gradually transferred from the traditional system (quotation on panels) to the new electronic trading system.

2.2 Automated Trading System and IT Investments

As computing power has become exponentially more powerful and comparatively inexpensive, technology has transformed the TSE. Computerized systems have provided unprecedented opportunities for innovation and competition in market operations, speed and accuracy in processing trades, and creation of advanced portfolio and risk management techniques. In addition, technology has dramatically increased investor access to securities prices and other information. In fact, the TSE identified the operational advantages derived from automation and the application of the automated trading system (ATS) as electronic matching of orders, internet trading facilities, enhancing internationalization of the stock market' multiple prices for an order, quick order execution prices and volume levels available in real time. Automation of the TSE also improved market data or information, online report of prices, higher volume of trade and index, online corporate reporting, transparency of dealings and fairness in establishing order priority. All these operational advantages of automation were to translate into improved market performance measurable in terms of market liquidity, volatility, size and efficiency.

The project of migration to a new quotation platform has been initiated to adopt state-of-the-art technology to accompany the market development, to comply with international standards, and to meet investors' needs. The new quotation platform Optiq, developed by Euronext and implemented in close collaboration with the TSE, is a major technological transformation that radically changes the performance and speed of order processing and trading. It is developed based on high availability and fault tolerance technology. Thanks to its integrated modules, most market operations processes will be highly automated and meticulously supervised. The new Optiq platform can handle a wide range of financial products (stocks, bonds, derivatives, exchange-traded funds, etc.).

As for Tunisie Clearing, central securities depository and manager of the Settlement/Delivery system and corporate actions on the Tunisian market, for several years has been preparing a new information system which will automate processing with custodial account holders (BVMT, 2020). The migration to the new platform involves a multidimensional transformation. Indeed, in addition to the regulatory changes deriving from this technological evolution, functional and organizational rules have been adopted

to improve liquidity and the level of transparency and fairness of the market. Also this migration requires huge investments in IT.

Table 2 shows, firstly, that IT investment in the TSM is highly fluctuating. Secondly, it presents the weight of hardware (HA), software (SO) and services (TM: training and maintenance) investments in total IT investments over the 1999-2018 period, and it shows that TSM organizations give more importance to tangible investments than to intangible and service-related investments over the whole studied period. In this context, it is interesting to note that Tunisian financial market does not invest in hardware, software and services in the same way each year. In fact, the year when the market decides to invest the most in hardware (software), the weight of software (hardware) investment in total IT investments will be low, while that of investments in training and maintenance is quite high. The reverse will be undertaken the following year. This shows that the financial market attaches more importance to the training of its executives in the use of new equipment (software), a training that requires a significant budget.

Table 2. Investments in IT in Tunisian stock market during the period (1999-2018)

Years	Variation of total IT investment (%)	Variation of investment in HA (%)	Variation of investment in SO (%)	Variation of investment in TM (%)	Investment in HA / Total IT investment (%)	Investment in SO / Total IT investment (%)	Investment in TM / Total IT investment (%)
1999	-	-	-	-	70,77	5,64	23,59
2000	45,13	46,74	0	51,09	71,55	3,89	24,56
2001	3,18	3,95	18,18	-1,44	72,09	4,45	23,46
2002	12,33	4,28	61,54	27,74	66,92	6,40	26,68
2003	-31,10	-54,21	47,62	8,00	44,47	13,72	41,81
2004	-7,52	-23,88	85,48	-20,63	36,60	27,51	35,89
2005	-28,95	-30,72	-97,39	25,33	35,69	1,01	63,30
2006	177,10	150,00	131,00	-13,83	32,20	48,12	19,68
2007	72,54	24,53	143,43	-22,22	23,24	67,89	8,87
2008	-64,86	-33,94	-89,42	42,06	43,69	20,44	35,87
2009	-12,22	-11,47	-48,04	7,26	44,06	12,10	43,84
2010	96,12	145,60	445,28	-50,00	55,18	33,64	11,18
2011	-46,92	-54,43	-68,17	54,17	47,37	20,18	32,46
2012	17,76	9,26	33,70	20,27	43,95	22,91	33,15
2013	-3,35	8,05	-23,58	-4,49	49,13	18,11	32,76
2014	5,59	-6,27	79,79	-17,65	43,61	30,84	25,55
2015	25,73	42,26	-20,71	53,57	49,35	19,45	31,20
2016	0,44	1,18	56,72	-35,81	49,71	30,35	19,94
2017	-17,05	-50,00	38,10	-18,84	29,97	50,52	19,51
2018	48,08	130,81	6,9	27,68	46,71	36,47	16,82

Source: Authors' contribution

3. Methodology and Data

This section describes our variables, data sources and methodology.

3.1 Methodology

To achieve the objective of this study, we estimate the following model:

$$Y_t = \beta_0 + \beta_1 Y_{t-p} + \beta_2 IT_t + \beta_3 IT_{t-q} + \beta_4 size_t + \varepsilon_t \quad (1)$$

Where Y is a measure of the liquidity such as the trading volume (TV) or the illiquidity ratio (Illiq). IT is the investment in technology. We decompose this variable into three components: hard, soft and training. The $size$ is related to the capitalization of the market. To carry out our econometric estimates, we use two methods. We use the GARCH for the illiquidity ratio, while the GMM system method is used for trading volume.

3.2 Data

We perform data over the period 2008-2018. First, we collect daily data from the stock market (BVMT). We consider the period from May 30, 2008 to December 31, 2018, i.e., 2631 observation dates. It consisted of daily reports issued by the market on closing prices and volume of trade. The daily index return is calculated as the first difference of the logarithmic close-to-close prices. For the trading volume is calculated as the daily average of all stock trading volume. While the illiquidity ratio, we take the Amihud (2002) illiquidity ratio.

The Amihud illiquidity ratio is computed as follow:

$$Illiq = \frac{|RETURN_j|}{TV_j} \quad (2)$$

$RETURN_j$ is the absolute value of daily stock return, and TV_j is the daily transaction volume.

On other side, in order to assess the effect of investment policies on liquidity, we extract data of technology investment from Tunisian financial market. We have annual data related to the investment in hard, soft and training in the automated system of stock market and in law securities of financial regulation. Finally, we use the size of the market measured by the annual logarithm of market capitalization. We expect a negative association between market sizes and illiquidity. Table 3 presents the summary statistics of the data used in this study. First, the distribution of the return and illiquidity ratio exhibits excess kurtosis. This is consistent with the existence of the fat tails of the distributions and Jarque-Bera test that decisively reject normality of the distribution. The trading volume shows a kurtosis greater than 3 (three) implying non-normal distribution. On the other side, the trading volume and illiquidity ratio distribution seem to be right asymmetric while left asymmetric for the return.

Table 3. Descriptive statistics

Statistic	RETURN	Illiq	LnTV
Mean	0.066625	0.036707	9.741506
Median	0.070000	0.024898	9.675430
Maximum	4.190000	0.513029	14.21681
Minimum	-4.880000	0.000000	6.935546
Std. Dev.	0.558964	0.041940	0.919060
Skewness	-0.692336	3.680659	0.558961
Kurtosis	15.69394	24.97786	3.704587
Jarque-Bera	17874.73	58892.25	191.4266
Sum	175.2900	96.57600	25629.90
Sum Sq. Dev.	821.7206	4.626071	2221.485
Observations	2631	2631	2631

Notes: RETURN is value of stock return, Illiq is illiquidity ratio, and LnTV is the natural logarithm of trading volume.

4. Results

Our main object is to examine the impact of investment policies on liquidity. The hypothesis is to assume a positive impact of investment on liquidity so we have to find a negative relationship between illiquidity ratio and investment but a positive one with trading volume.

Indeed, the investment on the stock market, such as in hardware, software and training, has to improve market liquidity by accelerating information process, lowering operating costs, reducing the human errors in processing transactions and consequently enhancing the market transparency, efficiency and quality. Moreover, the financial market regulators should implement securities laws in order to improve transparency informational efficiency, fairness and enforce the market quality. Hence, the enforcement of securities laws is enforced by the investment policies. First, as increasing in investment, securities laws will prevent certain illegal trading practices, such as insider trading and protect small investors. Also, financial market regulations force listed firms to disclose all financial and accounting information. This disclosure will limit information asymmetry and agency problems for traders.

The results of the equation (1) are summarized in tables (4, 5). First, we test the impact of the total investment on illiquidity and trading volume (table 4). For instance, we find a positive impact of the current and the previous year total investment on illiquidity but the investment of the two previous years has a negative impact. However, for the trading volume, only the two years' investment has a positive effect. Hence, the investment policies improve the quality of the market through the liquidity and trading volume in the long term but deteriorate in the short term. So, automated system and the securities laws are efficient for the long and not for the short term.

Table 4. Results of the estimation total investment

	Illiq	TV
C	-0.02199* (-2.885065)	-6.649629* (-6.288901)
Illiq(-1)	0.176002* (9.514911)	
Illiq(-2)	0.059091 (3.697306)	
TV(-1)		0.281107* (9.329443)
TV(-2)		0.167681* (5.928226)
Size	0.013521* (4.568847)	0.611117** (1.854386)
IT	0.066001* (3.418178)	0.320849 (0.486026)
IT(-1)	0.048838** (2.435188)	-0.275678 (-0.548673)
IT(-2)	-0.114579* (-16.58522)	1.644086* (8.263574)
GARCH	5.231883* (8.905810)	
C		0.000150 (13.57708)
RESID(-1)^2		0.170967* (18.23180)
RESID(-1)^2*(RESID(-1)<0)		-0.544771* (-18.37732)
GARCH(-1)		0.875058* (94.56104)
Number of obs.	2629	2629

Notes: (*), (**), (***) indicate that the variables are significant at the 1%, 5%, 10% levels respectively. Illiq is the illiquidity ratio, Illiq(-1) and Illiq(-2) present the one and the two previous years illiquidity ratio respectively, TV is the trading volume, TV(-1) and TV(-2) present the one and the two previous years trading volume respectively, IT is the total investment on technology, IT(-1) and IT(-2) present the one and the two previous years investment on technology respectively.

On the other side, when we decompose the total investment into investment on stock market and financial regulation, the results are mitigated. For instance, we find only a positive effect on trading volume and not on illiquidity. So, we can advance that the increase in trading volume is due to the information process and not the liquidity effect. Indeed, and according to microstructure theory (Kyle, 1985; Admati & Pfleiderer, 1988) the trading volume may increase to both information and liquidity shocks. Hence, an automated system attracts more investors with easy access to broader information and consequently increasing the trading volume.

Regarding the investment on financial regulation, there is no impact on trading volume but a positive effect on illiquidity ratio. In other words, as we increase the investment,

the market becomes more illiquid. So, we interpret these results as implying that the securities laws to enhance the market efficiency are not fully enforced. Hence, unethical trading practices, such as insider trading or illicit strategies conducted by institutional investors, are not well controlled by the regulators. So, these investors try to influence the price through their informational advantage. As a result, the market is still illiquid. In addition, the enforcement of regulation, through investment policies, are not beneficial for the minority and potential investors, as they may notice that the quality of this information is low in relation to the private information held by insiders.

To go in depth in our analysis, we take into account the components of investment policies, such as hardware, software and training. As shown in table 5, and except the training component, we confirm our previous results of the absence of investment of stock market illiquidity. For instance, the training investment has a negative impact on illiquidity but the effect is low. Indeed, the investment on training could improve the liquidity by 0.1%. In other hands, all the components of stock market investments may increase the trading volume and hence confirm the easy access to broader information.

Table 5. Results of the estimation

	Illiq	TV	Illiq	TV	Illiq	TV
C	-0.024528* (-2.956357)	1.961859* (3.955620)	-0.013344*** (-0.013344)	1.964521* (4.109761)	-0.031981* (-3.789648)	1.361581* (2.692549)
LnIlliq(-1)	0.170423* (9.207156)		0.178056* (9.351717)		0.175039* (9.180702)	
LnIlliq(-2)	0.054376* (3.325471)		0.059759* (3.468782)		0.059999* (3.501359)	
LnTV (-1)		0.373336* (17.24862)		0.388560* (17.88808)		0.433711* (20.93502)
LnTV(-2)		0.229401* (8.790722)		0.243719* (9.434408)		0.288513* (11.80818)
Size	0.013811* (4.191194)	-0.542660* (-2.891484)	0.012737* (3.871088)	-0.221569 (-1.295915)	0.015041* (5.815311)	0.378965* (2.790795)
CMF	0.001174** (2.222893)	0.641425* (8.569351)				
BVMT	-0.000365 (-0.44422)	-0.004060 (-0.118407)				
Hard-BVMT			0.000576 (1.054166)	0.222035* (5.953335)		
Soft-BVMT			-0.000404 (-1.201219)	0.147019* (6.418537)		
Train-BVMT			-0.001586* (-3.868798)	0.164353* (6.470643)		
Hard-CMF					0.000543*** (1.284059)	0.023957 (1.122178)
Soft-CMF					0.000765*** (1.334911)	-0.026416 (-1.493978)

Train-CMF					0.000716*** (2.658613)	0.059652 (1.606451)
GARCH	5.066019* (9.033460)		5.249757* (8.880563)		5.013657* (8.651581)	
Variance equatop						
C	0.000168* (15.19192)		0.000152* (13.94836)		0.000162* (15.12013)	
RESID(-1)^2	0.176030* (17.46512)		0.165312* (17.03328)		0.168882* (17.81204)	
RESID(-1)^2*(RESID(-1)<0)	-0.577461* (-18.66000)		-0.550777* (-18.43428)		-0.570140* (-18.11853)	
GARCH(-1)	0.863080* (92.96236)		0.877689* (90.13119)		0.871112* (95.45321)	
Number of obs.	2629	2629	2629	2629	2629	2629

Notes: (*), (**), (***) indicate that the variables are significant at the 1%, 5%, 10% levels respectively. Illiq is the illiquidity ratio, LnIlliq(-1) and LnIlliq(-2) present the one and the two previous years normal logarithm of illiquidity ratio respectively; TV is the trading volume, LnTV(-1) and LnTV(-2) present the one and the two previous years normal logarithm of trading volume respectively; IT is the total investment on technology; IT(-1) and IT(-2) present the one and the two previous years investment on technology respectively; *Size* is related to the capitalization of the market; CMF and BVMT represent the total amount invested in information technology by CMF and BVMT respectively; Hard-BVMT, Soft-BVMT and Train-BVMT represent the total amount invested by BVMT in Hardware, Software and Training respectively; Hard-CMF, Soft-CMF and Train-CMF represent the total amount invested by CMF in Hardware, Software and Training respectively.

Our results show that there is a lack in the implementation of investment policies in financial markets, suffering from many no strategies in investment and confirmed by the directors of financial markets. Indeed, the automated system of the stock market is obsolete, and the investment is allocated to maintain it and not to develop and improve the quality of the market. On the one hand, the financial regulators didn't implement some new financial products, such as options, futures, etc. So, there is no diversification for the investors. Also, only 4 hours working per day for the market which could not be sufficient for the investors to deal in the market and have easy access to broader information and hence a weak enforcement of securities laws. On the other hand, since the spring revolution in 2011, Tunisia is suffering from political instability which is the main factor that affects the growth of the economy and so the investment and development of the financial market. So, we can attribute that the investment is only allocated to fix the automated system and regulations and not to reinforce the quality of the market.

CONCLUSION

This paper investigates the effects of technological investment on trading activity, such as trading volume and liquidity of Tunisian stock market. This analysis is motivated by the need for greater insights into how the IT' investments and its components is improving the quality of the trading mechanism. Also, it provides a better understanding for financial authorities to implement the policies of their investments in automation and system development. Our findings confirm that automated systems and the securities laws improve the quality of the market through the liquidity and trading volume in the long term. However, in the short term, automated system attracts the insider trading.

Our findings have strong policy implications as they underscore the need to adapt some aspects of financial regulation and investment policy to increase the quality of the market.

References

- Admati, A. R. and Pfleiderer, P. (1988). A Theory of Intraday Patterns: Volume and Price Variability. *The Review of Financial Studies*, 1(1), 3-40.
- Al-Khoury, R. and Al-Ghazawi, N. (2008). The effect of electronic trading on market volatility and liquidity in emerging markets: Evidence from Amman Stock Exchange. *Journal of Derivatives & Hedge Funds*, 14(3/4), 222-236.
- Amihud, Y. (2002). Illiquidity and stock returns: Cross-section and time-series effects. *Journal of Financial Markets*, 5, 31-56.
- Ben Khediri, K. and Daadaa, W. (2011). Stock Trading and Capital Structure in Tunisian Stock Exchange. *Journal of Business Studies Quarterly*, 3(2), 10-24
- Ben Ouda, O. and Hmaied, D. (1998). The Impact of Automation on Liquidity, Volatility, Stock Returns and Efficiency: Evidence from the Tunisian Stock Market. Working Paper 0222, Economic Research Forum, 1-14.
- Freund, W. C. and Pagano, M. S. (2000). Market Efficiency in Specialist Markets Before and After Automation. *Financial Review*, 35(3), 79-104.
- Haferkorn, M. and Zimmermann, K. (2015). Strategic Competitive Advantages Through Enterprise Systems: The Case of Exchange Systems. Conference Paper *in* Lecture Notes in Business Information Processing, January 2015.
- Hendershott, T. and Moulton, P.C. (2011). Automation, speed, and stock market quality: the NYSE's hybrid. *Journal of Financial Markets*, 14(4), 568-604.

- Hendershott, T., Jones, C.M. and Menkveld, A.J. (2011). Does algorithmic trading improve liquidity? *Journal of Finance*, 66 (1), 1-33.
- Jarrett, J. E. and Kyper, E. (2005). Daily Variation, Capital Market Efficiency and Predicting Stock Market Returns. *Management Research News*, 28(8), 34-47.
- Jeribi, A., Fakhfekh, M. and Jarboui, A. (2018). Tunisian revolution and stock market volatility: evidence from FIEGARCH model. *Managerial Finance*, 41(10), 1112-1135.
- Kyle, A. (1985). Continuous Auctions and Insider Trading. *Econometrica*, 53, 1315-1335.
- Mata, F.J., Fuerst, W.L. and Barney, J.B. (1995). Information Technology and Sustained Competitive Advantage: A Resource-Based Analysis. *MIS Quarterly*, 19, 487-505.
- Mensah, J. T., Pomaa-Berko, M. and Adom, P. K. (2012). Does Automation Improve Stock Market Efficiency? Evidence from Ghana, MPRA Paper No. 43642, posted 08 Jan 2013.
- Naidu, G.N. and Rozeff, M.S. (1994). Volume, Volatility, Liquidity and Efficiency of the Singapore Stock Exchange before and after Automation. *Pacific-Basin Finance Journal*, 2 (1), 23-42.
- Omuchesi, J. A., Bosire, M. and Muiru, M. (2014). The Effect of Automation on Stock Market Efficiency: A Case of Nairobi Securities Exchange. *Research Journal of Finance and Accounting*, 5 (17), 71-79.
- Riordan, R. and Storckenmaier, A. (2012). Latency, liquidity and price discovery. *Journal of Financial Markets*, 15 (4), 416-437.
- Yilmaz, M. K., Erdem, O., Eraslan, V. and Arik, E. (2015). Technology upgrades in emerging equity markets: Effects on liquidity and trading activity. *Finance Research Letters*, 14, 87-92.