The effect of electronic trading on market volatility and liquidity in emerging markets: Evidence from Amman Stock Exchange

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Practical applications

The study of the impact of electronic trading on volatility and liquidity is important for different parties and for different reasons. It is of concern to policy makers, domestic, as well as, foreign investors, corporations and other financial market participants. When a market is conceived as highly volatile, that volatility may act as a barrier to investing in that market. Poor liquidity and high volatility are considered to be the main reasons that prevent foreign institutional investors from investing in emerging markets. This reduces the capital flow to the market and affects the cost of capital for corporations. Poor liquidity and high volatility represent a serious concern for policy makers because they lead to financial instability. This creates uncertainty and negatively affects the growth potentials. In addition, stock prices and return volatility constrains economic growth and performance through their negative effect on consumer spending.

Abstract

This study investigates the impact of the electronic trading system (ETS) on market volatility and liquidity on the Amman Stock Exchange (ASE) before and after its implementation on 26th March, 2000. Using a sample of 34 companies, we collected data on closing prices, volume, and number of shares traded over the period from 2nd January, 1996 to 2nd January, 2004. The Generalized Autoregressive

Conditional Heteroskedasticity (GARCH) model was used to test the volatility level, while liquidity was examined by measuring the difference between the relative means of 'trading volume' in the two periods. Empirical results using the GARCH model with dummy variable show a reduction in volatility after the adoption of electronic trading. The persistence of the shocks to volatility, however, seemed to last for sometime in the future when the exchange moved to an

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ETS. Similar results were detected for each company separately. In addition, the adoption of electronic trading has improved the liquidity level of ASE. Journal of Derivatives & Hedge Funds (2008) 14, 222–236. doi:10.1057/jdhf.2008.21

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INTRODUCTION

Poor liquidity and high volatility are considered to be the main reasons that have prevented foreign institutional investors from investing in emerging markets.¹ The Amman Stock Exchange (ASE), like many emerging stock exchanges, underwent structural changes in its equity market. It liberalised its equity market, whereby foreign investors are now given the opportunity to invest in domestic securities up to 100 per cent in most of its companies. In addition, the ASE launched its electronic trading system (ETS) on 26th March, 2000. This allowed orders, which were executed purely based on price and volume, to be matched by a computerised system. This step was necessary to stimulate the financial market and to provide a new efficient source of financing. In addition, this reform in the market microstructure was considered essential to improving market liquidity by enhancing the market transparency, lowering operating costs, accelerating the process of order matching and execution, reducing the problems associated with human errors (more accuracy) in processing transactions, improving the ability to attract new pools of liquidity by providing remote access to investors, and by maintaining unexecuted orders in a consolidation order book, for possible matching with future orders.

Trading in automated auctions in stock markets, as well as in other financial markets, occurs through an electronic limit order book, without the need for physical exchanges or market makers. In the absence of market makers, automated auctions depend on public limit orders for liquidity. In a market such as the ASE, which is characterised by thin trading, small trades can induce large price movement and can increase trading costs and volatility. ASE, however, implemented a narrow ± 5 per cent limit on daily stock price movements. Therefore, price limit, along with electronic trading, is expected to enhance market liquidity. As Harris² shows, when traders use limit orders to buy stocks, they suffer from immediate losses if prices continue to fall. If price limits exist, however, the amount of losses will be limited, and limit order traders may be more willing to provide liquidity under normal conditions. Therefore, the change in liquidity on a thinly traded stock exchange that implements electronic trading along with narrow price limits over time can induce dynamic effects on trading costs and volatility, a fact that is not well understood and consequently affects trading behaviour and expected returns.

The evidence on the effect of electronic trading on liquidity and volatility in the literature is inconclusive. Schwartz,³ Naidu and Rozeff,⁴ Pagano and Roelle,⁵ and Freund and Pagano,⁶ among others, found that electronic trading has a positive impact on market liquidity and volatility. Other researchers such as Massimb and Philips⁷ and Biais *et al.*⁸ claim that ETSs eliminate the strategy-based informational advantages that market makers possess in the open-outcry trading pit. Furthermore, the liquidity suppliers face larger adverse information costs when submitting their orders, due to the possibility of trading with anonymous counterparts.

This paper examines the volatility and the liquidity level in the ASE market before and after the implementation of the ETS. We use a sample of 34 companies listed on the ASE over the period from 2nd January, 1996 to 2nd January, 2004. The sample is then divided into two sub-periods: the Floor Trading Period, from 2nd January, 1996 to 25th March, 2000 and the Screen Trading Period, from 26th March, 2000 to 2nd January, 2004.

To capture the dynamics of price volatility, we implement the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model introduced by Bollerslev.⁹ Liquidity is examined by measuring the difference between the relative means of 'trading volume' over the two periods.

This paper proceeds as follows: the next section presents some basic institutional characteristics of the ASE and its trading mechanism, a brief review of the literature is laid out in the subsequent section, then the further section presents the data and methodology used in this study, and conclusions and recommendations are presented in the last section.

INSTITUTIONAL CHARACTERISTICS OF THE ASE

The capital market in Jordan

Long before the establishment of the Jordanian capital market in the late 1970s, shares of a few publicly held companies were traded over-the-counter in an irregular market. Corporate bonds were also being traded as early as the 1960s. To collect national savings, ensure quick and easy trading, and protect small investors, the Amman Financial Market was established in 1978. During the 1980s and early 1990s the market grew in an unbalanced way, and by the

mid-1990s a further restructuring of the market was required to increase its size and liquidity. The Jordanian government moved to upgrade the capital and presented a new Securities Law (Securities Law No. 23 of 1997). In March 1999, the ASE began its operation.

On 26th March, 2000, the ASE witnessed the implementation of an ETS. The ETS technology was provided by Paris Bourse. This system has put the ASE in line with modern security markets around the world and has provided a technical foundation for future development and growth.

The ASE has grown rapidly in size and importance both in terms of market capitalisation (MCAP) and MCAP as a percentage of GDP. Between 1978 and 2003, MCAP experienced growth from Jordan Dinar (JD) 286.12m in 1978 to JD 7,772.8m by the end of 2003. Traded volume also increased rapidly to reach 1,855.2m in 2003, especially in recent years due to the implementation of the ETS.

The trading volume (as a percentage of MCAP), however, did not increase as a proportion to MCAP. The general price index weighed by MCAP increased by more than four times, from 58.6 points in 1978 to 261.5 points in 2003. The ratio of MCAP to GDP, which is important for measuring the market in relation to the national economy, increased dramatically to 116.8 per cent by the end of 2003. Also, the number of listed companies jumped from 66 companies in 1978 to 161 in 2003.¹⁰

Table 1 shows the size and the importance of the ASE as compared to other Arab stock markets. The table presents selected indicators for 11 Arab stock markets for the year 2002, including the ASE. As the table shows, the ASE ranked second after Egypt in terms of the market

Table 1: Arab stock markets, selected indicators (2002)

<i>Stock market</i>	<i>No. of listed companies</i>	<i>MCAP (US\$ million)</i>	<i>MCAP as a % of GDP (%)</i>	<i>Value traded as a per cent of MCAP (%)</i>	<i>Value traded as a % of GDP (%)</i>
Bahrain	40	7,716.4	97.2	2.7	2.6
Egypt	1,150	26,338.7	29.3	24.5	7.2
Jordan	158	7,087.0	76.2	18.8	14.4
Kuwait	95	35,098.9	107.0	63.0	67.5
Lebanon	13	1,395.3	8.1	8.2	0.7
Morocco	55	8,564.2	23.0	16.8	3.9
Oman	140	5,268.1	26.2	11.0	2.9
Qatar	25	10,567.2	64.2	8.4	5.4
Saudi Arabia	68	74,851.4	40.1	41.4	16.6
Tunisia	46	2,125.7	10.0	11.6	1.6
United Arab Emirates	36	29,845.3	42.8	3.5	1.5

Source: Arab Monetary Fund, 2003, World Development Indicators.

size as measured by the number of listed companies (market breadth), but it is ranked eighth when we measure market size by MACP. Nevertheless, in terms of market depth and its importance in the national economy as measured by the ratio of MACP to GDP, the ASE was only exceeded by Kuwait and Bahrain. Although the ratio of trading value to MACP is 18.8 per cent (an indicator of the activity level in the market) and seems less impressive, the ASE ranks fourth among the Arab stock markets. In terms of value traded as a share of GDP (14.4 per cent), the ASE ranked third after Kuwait and Saudi Arabia. Compared to Arab markets, the ASE is relatively active, even though it is small in terms of size (as measured by MACP).

Trading systems

Before implementing the ETS on the ASE in 2000, brokers used white boards to sell and buy

and to track trading activities. They bought and sold stocks using the ‘open outcry’ system, gesturing and calling out stock prices to potential buyers. The system was faulty, inefficient, and laborious — and it limited trading volume.

Currently, the ASE has a fully automated trading system and implements an automated limit order book system. All Public Shareholding Companies are traded electronically and brokers can trade on the system remotely. All transactions take place through stockbrokers. Brokers place buy and sell orders into the trading system, which in turn matches those orders to generate a trade. The highest limit price of all buy orders for a particular stock is considered the best bid price of the stock, and the lowest limit price of all sell orders for a particular stock is considered the best ask price of the stock. The trading mechanism at the ASE is continuous and strict price and time priority rules are applied.

Trading days in the ASE market are from Sunday to Thursday in three trading sessions. The pre-opening phase is from 9:30am to 10:00am, and in this phase buy and sell orders are entered without any match. The system selects the suitable price and during this phase prices are displayed and orders can either be modified or cancelled. The continuous session operates from 10:00am to 12:00pm, and in this phase an order is matched between traders against existing orders and then executed. The unexecuted orders are added to the list of orders waiting for the execution to be made based on time priorities and determined price. The last phase is the block phase from 12:00pm to 12:15pm, and in this phase the ending closing prices are determined. The ASE has set the daily price limit by a narrow ± 5 per cent to avoid excessive volatility in share prices as a protection for small investors.

Transaction costs in ASE

The costs associated with trading securities may have an impact on trading activities and investors' portfolio returns. There are two types of trading costs: explicit cost (commissions, fees, and taxes) and implicit costs (marketability and opportunity costs). Commissions are one of the main costs of dealing on the ASE and are set up by the Jordan Securities Commission (JSC). The commission for trading securities on the ASE varies between 0.0054 and 0.0074 of the value of traded shares and 0.0008 and 0.001 of the value of traded bonds. These commissions are paid to brokers (between 0.004 and 0.006 of the value traded) and to the major market authorities (JSC (0.0005), ASE (0.0006), and SDC (0.0003) (JSC, 2002).

LITERATURE REVIEW

Automated systems in financial markets should attract more investors, since traders in automated systems have more access to broader information, which leads to better market transparency as compared to what the floor trading system offers. Automated systems, consequently, increase trading volume and improve market liquidity and the price discovery process.^{4,11,12}

The critics of electronic trading, however, claim that liquidity providers in automated systems face a larger information cost when submitting their orders to the limit order book because of the possibility of trading with unidentified counterparts, as compared to floor trading. They state that screen trading is unable to provide the same liquidity as floor trading systems.^{7,8} Therefore, the issue of the effect of electronic trading on market liquidity and volatility is still unresolved and the results differ from one exchange sitting to another.

Naidu and Rozeff⁴ measured the market quality before and after the introduction of an ETS on the Singapore Stock Exchange using daily data. They found an increase in volatility and liquidity, in addition to an improvement in market efficiency. Sioud and Hamied¹² also found similar results on the Tunisian Stock Exchange (TSE). The researchers examined the impact of transfer to automation on liquidity, volatility, stock returns, and market efficiency. Using daily closing prices and trading volumes on a sample of 20 stocks traded in the TSE they found a positive impact for the transfer of electronic trading on liquidity, volatility, and market efficiency. Using intraday data on stock index future contracts on the Swedish Stock Exchange for the period from 31st July, 1995 to 23rd February, 1996, Coppejans *et al.*¹³ found

that increasing liquidity reduced volatility, and that volatility shocks reduced liquidity over the short period and consequently led to a decrease in price efficiency. Additionally, Green *et al.*¹⁴ examined the impact of the introduction of a screen trading system to the Mumbai Stock Exchange on the market microstructure. Using daily closing prices for the 69 most liquid shares (A) and 83 of the least liquid shares (B), they found an increase in market liquidity in the automated system and the effect was higher for the most liquid shares. Moreover, there was an improvement in the efficiency in both shares, but the improvement was more pronounced in the least liquid shares. Additionally, the volatility of the market was reduced. They showed that automation of the system improved the market microstructure for both shares (A and B), but that the improvement was more obvious for the least liquid shares.

Other papers in the literature tackled the issue of the effect of electronic trading on transaction costs. Theissen¹⁵ compared the transaction cost on the floor of the Frankfurt Stock Exchange with the ETS, using the DAX index over 44 trading days. He found that the cost was greater using the ETS as compared to the floor trading system. His analysis of the bid/ask spread in the two trading systems revealed that the floor trading system was relatively more competitive for the less liquid stocks. Therefore, electronic trading offered low spread for liquid stocks. These results are confirmed by Venkataraman,¹⁶ who compared the execution cost for common stocks of similar firms in an automated trading system (Paris Bourse) with the floor-based system (New York Stock Exchange (NYSE)). His results indicated that the execution costs are higher on the Paris Bourse than on the NYSE after controlling for differences in adverse

selection, relative tick size, and economic attributes across samples. Additional evidence of high transaction costs when electronic trading is implemented is provided by Omet and Khasawneh.¹⁷ They measured the determinant of execution costs on the ASE using daily closing prices, trading volume, and highest buy prices, as well as lowest sell prices. Their sample covered 13 listed companies for 15 weeks following the implementation of electronic trading. The study showed a high transaction cost on ASE market, and the trading volume was the major determinant of this cost.

Domowitz *et al.*¹⁸ examined the relationship between liquidity, volatility, and transaction costs for 42 countries over the period from September 1992 to December 1998. After controlling for volatility and MCAP, they found variation in trading costs between different countries. Trading costs in emerging markets were higher than those in other markets. They showed that the increase in volatility, acting through costs, reduced portfolio expected return and reduced turnover. Furthermore, they found an inverse relationship between trading costs and turnover.

The study by Taylor *et al.*¹⁹ tested the effect of electronic trading on transaction cost and the trade speed faced by the arbitrage trading of the FTSE100 spot and futures contracts on the London Stock Exchange. They documented a significant reduction in the transaction costs faced by arbitrageurs after the introduction of ETS. Moreover, the study found that futures markets were less affected by shocks than spot markets in the pre-electronic period. Both markets, however, appeared to be equally affected in the post electronic period.

Recently, Gilbert and Rijken²⁰ examined the bid/ask spread of the FTSE100 before and after the exchange moved from a floor trading system

to an ETS. Using a complete 'tick data record' relating to FTSE100 contract over the sample 13-month period, they found that the bid/ask spread of the FTSE100 was smaller after the move from a floor trading system to an ETS. Their results showed a narrower effective spread, which was due to the increase in competition among traders and the decline in tick-level volatility.

Therefore, from the review of the few relevant papers in the literature, we can infer three observations: first, there was an agreement on the positive impact of electronic trading on market liquidity. The positive impact, however, was more pronounced for more liquid securities. Secondly, there was no consensus on the effect of electronic trading on volatility. This inconclusive result on volatility levels might be due to the differences in price limits set by diverse markets. Finally, there was an agreement that transaction costs increase after the implementation of electronic trading. The increase in transaction costs, however, was more pronounced for emerging markets, which are considered less liquid than developed markets.

DATA, METHODOLOGY, AND EMPIRICAL RESULTS

Data

At the beginning of 2004, there were 161 Jordanian companies listed on the ASE and distributed among four sectors: banking, insurance, services, and industry. To discover the effect of the automation system on volatility and liquidity on the ASE market, we chose a sample based on the 'number of trading days' to acquire the most active companies in the ASE. We divided the sample period into two sub-periods: the Floor Trading Period, from 2nd January,

1996 to 25th March, 2000 and the Screen Trading Period, from 26th March, 2000 to 2nd January, 2004.

The sample chosen fulfils the following conditions:

- (1) companies listed on the ASE market during the two periods of this study;
- (2) all companies share the same fiscal year, ending on 31st December of each year;
- (3) companies with trading days equal to or greater than 60 per cent of the total trading days of the study periods; and
- (4) companies with no change in position (eg mergers, stock split, suspension of trade).

Given these restrictions, a sample of 34 companies listed on the ASE satisfied our conditions. The study samples included companies from different sectors: banking (29 per cent of the sample), services (20 per cent), and industry (51 per cent). None of the insurance companies, however, satisfied our criteria.

The data for this study was obtained from the Department of Research and International Relationship of the ASE market. It consisted of daily reports issued by the ASE market on closing prices, volume of trade, and the number of shares traded.

Methodology and empirical results

The methodology used will be divided into two parts. The first part introduces the methodology applied for testing the market volatility, while the second part explains the methodology used for testing market liquidity.

Part one: Testing market volatility

Volatility can be simply defined as the variability of security price during a given period. In a

model of asset valuations such as the Capital Asset Pricing Model and Arbitrage Pricing Model, volatility is associated with risk, measured by the standard deviation or its squared (variance) under normal probability. In this study, volatility is measured by applying the GARCH model developed by Bollerslev.⁹ This model is capable of capturing the leptokurtosis, skewness, and volatility clustering in our time series.

The general GARCH (p, q) model for stock return at time t (r_t) is characterised by the following equation:

$$Y_t = X_t\beta + \varepsilon_t \quad (1)$$

$$r_t = \beta_0 + \sum_{i=1}^t \beta_i r_{t-i} + \varepsilon_t, \varepsilon_t / \psi_{t-1} \approx N(0, h_t) \quad (2)$$

$$h_t = \omega + \sum_{i=1}^p \gamma_i \varepsilon_{t-i}^2 + \sum_{j=1}^q \delta_j h_{t-j} \quad (3)$$

where $p \geq 0, q \geq 0$

$$\gamma_0 \geq 0, \quad \gamma_i \geq 0, \quad i = 1, \dots, p$$

$$\delta_j \geq 0, \quad j = 1, \dots, q$$

where ε_t is a zero mean, serially uncorrelated error term, with a normal distribution conditional on past information, and h_t is the conditional variance of the error term, which is a function of three terms: the mean ω , the news about volatility from the previous period measured by the lag squared residual from the mean equation ε_{t-1} the (ARCH term), and the last period's forecast variance h_{t-1} (the GARCH term). The estimate of γ_i shows the impact of current news on the conditional variance process, and the estimate of δ_j shows the persistence of volatility to a shock, or, alternatively, the impact of old news on volatility.

Engle and Bollerslev²¹ showed that volatility persistence is measured by the sum of γ and δ , $(\gamma + \delta)$. They proved that if the sum is equal to 1, the GARCH process becomes an integrated GARCH (IGARCH) process and subsequently this sum should be less than 1 in order to have a stationary variance. If the sum is less than unity, the effect of the shocks will decay over time. Nevertheless, if the summation value is greater than unity, volatility will increase with time.

In this study, a dummy variable (D) will be added to the conditional variance equation for the structural change. The dummy variable will be used to capture the effect of electronic trading on the market volatility of the ASE. It takes the value of 0 during the Floor Trading Period, before 26th March, 2000, and the value of 1 during the Screen Trading Period, after 26th March, 2000.

Therefore, the conditional variance equation becomes

$$h_t = \omega + \sum_{i=1}^p \gamma_i \varepsilon_{t-i}^2 + \sum_{j=1}^q \delta_j h_{t-j} + \eta D \quad (4)$$

If the dummy variable in equation (4) is statistically significant, the electronic trading process will have an impact on market volatility. The positive coefficient of the dummy variable (η) suggests that the transfer to an ETS will possibly increase volatility. Otherwise, it suggests that the transfer will reduce the amount of volatility.

To carry out the analysis, we formed a return index from our 34 sample firms, and employed the volatility analysis on this index. Before applying the GARCH model, we started by analysing whether the data in the time series was normally distributed. Table 2 provides descriptive statistics for the daily return index

Table 2: Summary statistics for return series for the study sample

	Study sample index ^a
Mean	−0.003731
Standard deviation	0.929496
Skewness	−6.786905
Kurtosis	295.7623
JB test	2.54E+08
Observation	2,083
ADF test ^b	−127.0259
The optimal lag	(3)

Notes: Normality test, which follows a chi-squared distribution, with 2 degrees of freedom. Critical range of skewness for return series are ± 0.0869 and ± 0.074 , respectively. The critical value for the kurtosis for return series are ± 3.1737 and ± 3.1738 , respectively.

^aGenerated series by return equation.

^bCorresponding to the critical value of 1 per cent.

formed by the study sample, and Figure 1 graphs the distribution of return index.

It is clear from the table that our return data is not normally distributed. The coefficient of skewness indicates that the return is skewed to the left. In addition, the distribution has a flatter tail than the normal distribution, and is leptokurtic. The Jarque–Bera (JB) test for normality is rejected at the 1 per cent level.

To study whether the logarithm of stock returns of the sample index is stationary, we applied the Augmented Dickey–Fuller (ADF) test statistics (1981). The unit root test strongly rejected the hypothesis of non-stationary, indicating that the return series displayed a degree of time dependency. In addition, we tested for the autocorrelation in the study index. We found Durbin–Watson statistics to be

Figure 1: Sample index normal distribution

1.830654, which is approximately 2 of the critical value. Therefore, we rejected the hypothesis of autocorrelation in the data.

Table 3 presents the results of GARCH_(1,1) model for the sample index for the period from 2nd January, 1996 to 2nd January, 2004. The results indicated that ARCH and GARCH terms coefficients (γ, δ), respectively, are highly significant and positive. The significance of δ parameter in the model indicated a tendency of shocks to persist. The $\gamma + \delta$ in the return index of our sample is equal to 0.962002, which is less than unity. Nevertheless, it is very close to 1, which indicated that volatility persistence to shock will last in the future.

To capture the effect of the ETS on the volatility of the ASE market, we added a dummy variable to the conditional variance equation. This variable takes a value of 0 for the period before the adoption of ETS, and a value of 1 for the period after the adoption of ETS.

Table 3 presents the results on the coefficient of the dummy variable. For our index, the coefficient of the dummy variable is negative and significant, which indicates that the ETS reduces market volatility.

Table 3: Full sample results with/without dummy variable (study index)

<i>Model</i>	γ^a	δ^a	$\gamma+\delta$	η	<i>AIC</i> ^b	<i>SIC</i> ^b
GARCH _(1,1)	0.037047 (0.0000)	0.924955 (0.0000)	0.962002		2.561486	2.562003
GARCH _(Dummy)	0.039532 (0.0000)	0.919831 (0.0000)	0.959363	−0.00455 (0.0000)	2.555245	2.555891

^aCorrespond to a significant value at 1 per cent level. Parentheses include *p*-values.

^bAIC (Akiake Information Criteria), SIC (Schwarz's order Information Criteria); the number of optimal lag structure of the conditional variance equations is determined according to SIC and AIC.

Table 4: Two sub-sample results before and after electronic trading (examining on GARCH_(1,1) model)

<i>GARCH_(1,1) model</i>	γ^a	δ^a	$\gamma+\delta$	<i>AIC</i>	<i>SIC</i>
Before electronic trading (2nd January, 1996–25th March, 2000)	0.232103 (0.0000)	0.456999 (0.0000)	0.689102	2.445694	2.446589
After electronic trading (26th March, 2000–2nd January, 2004)	0.013341 (0.0000)	0.981481 (0.0000)	0.994822	2.61634	2.617412

^aCorrespond to a significant value at 1 per cent level. Parentheses include *p*-values.

The Akiake Information Criteria (AIC) and Schwarz's order Information Criteria (SIC), which determine the optimal lag structure in the GARCH model, are also determined. The results indicate that the optimal lag from the use of AIC and SIC criteria was (3) lags for the index.

In addition to testing the effect of electronic trading on liquidity and volatility by introducing a dummy variable, we reapplied the GARCH model to both periods (before electronic trading and after electronic trading) to compare the volatility in the two periods. Table 4 presents the results of the two sub-samples and examines the behaviour of the parameters in the GARCH equation.

The term γ , which represents the lagged squared error term relating to changes in the price from the previous day, decreased to 0.0133 after the implementation of the ETS. If we assume that the market is efficient, the changes in prices probably suggests that information that reached the market was being more efficiently utilised after the implementation of electronic trading as compared to the period before.

The coefficient on δ , which reflects the lagged variance error term and the tendency of shocks to persist over time, could be considered as reflecting the impact of 'old news' on volatility. In Table 4, δ shows an increase from 0.456999 to 0.981481. This indicates an increase in the

shocks of volatility after the adoption of the ETS. In other words, ‘old news’ has less impact on today’s price changes.

The values of volatility persistence, increased to 0.994822 during the period of the ETS, as compared to the period before the ETS when they were 0.689102. This indicates a tendency of volatility response to shocks to display a long memory within the ETS. These results were also confirmed when we applied the same methodology to each company separately (results are not shown in the paper).

Part two: Testing market liquidity

This study examined liquidity by using the trading volume as a proxy for liquidity. Other things being held constant, we expected that the trading volume of a given security was an increasing function of its liquidity. Consequently, an increase in the trading volume of a stock after its transfer to the new ETS reflected an increase in its liquidity, and in its transparency.

Liquidity on the ASE market could not be measured by a bid/ask spread because of the unavailability of the required data. Therefore, the measure of liquidity in this study is through ‘trading volume’, in which it is considered to be the main determinant of market liquidity.

Two empirical tests were employed to examine the liquidity of the market.

First, we calculate the relative volume of each stock in the sample VR_{it} on a daily basis.

$$VR_{it} = \frac{\log(V_{it})}{\log(V_{Mt})} \quad (5)$$

where V_{it} is the cumulative stock’s volume on day t and V_{Mt} is the cumulative market volume on day t .

After we calculated the daily relative volume, we averaged across the 34 stocks of the sample,

Figure 2: Market relative volume time series before and after automation

Figure 3: The mean of market relative volume before and after automation

for every day t , using the following equation:

$$VR_{mt} = \frac{1}{34} \sum_{i=1}^N VR_{it} \quad (6)$$

Table 5 illustrates the sum of the averaged relative volume for each stock and their mean.

The resulting average in time series is presented in Figure 2. This figure shows the relative volume in time series through the two sub-periods, that is, before automation and after automation, for the study sample, which consists of 34 companies. It is worth noting that the

Table 5: The sum of relative volume of each stock and their mean

Number	Stock	Before automation	After automation
		$\sum Rv_{it}$	$\sum Rv_{it}$
1	Arab Bank	800.3584787	821.7334299
2	Jordan National Bank	462.3287567	591.1781283
3	Bank of Jordan	388.4220797	591.3205559
4	Industrial Developments Bank	319.9704992	540.4562733
5	The Housing Bank	658.3193188	613.458496
6	Jordan Kuwait Bank	341.3303914	510.9811121
7	Jordan Gulf Bank	532.8928684	374.9826858
8	Jordan Islamic Investment	440.9508569	628.6949166
9	Jordan Investment & Finance Bank	299.4965028	370.5356295
10	Philadelphia Bank	253.6599339	450.275049
11	Bait el mall	279.8499848	406.5415861
12	Jordanian Electric Power	488.9298969	712.2410938
13	Jordan Press Foundations/ALRA'I	218.3781262	509.0421353
14	Arab International for Investment and Education	406.6114999	411.6132386
15	Al-Zaraqa for Education and Investment	449.8606387	539.925841
16	Unified Cop. for Org. Tran.	358.1210752	473.5291691
17	The Jordan Cement Factory	704.2308061	644.4768635
18	Jordan Phosphate Mines	339.1695302	599.2816573
19	Arab Potash	477.9167114	529.2883905
20	The Industrial Commercial & Agricultural	284.15362	518.6826462
21	Arab Pharmaceutical Manufacturing	683.4214728	690.9737336
22	Jordan Ceramic Factory	183.4917903	401.6633691
23	Dar al Dawa Development & Investment	568.180818	719.5588325
24	Arab Aluminum Industry	279.1986632	399.2686648
25	Universal Chemical Industry	242.4372141	354.4709614
26	National Cable & Wire Manufacturing	338.1355524	567.1737094
27	Jordan Slpho-Chemical	422.2450532	395.2788044
28	Arab Center for Pharmaceuticals & Chemicals	355.2037828	365.5836982
29	Universal Modern Industry	601.6095478	457.7486239
30	Industrial Resources	358.8870379	415.754144
31	New Cables	545.9063808	572.6772144
32	Union Chemical Vegetables & Oil Industry	235.9582358	302.6072251
33	National Colerain	361.2800954	401.4071043
34	Jordan Steel	312.9714839	717.9779485
Mean relative volume (Rv_{it})		411.585	517.658

Table 6: Change in the daily averaged relative volume for each stock

<i>Number</i>	<i>Stock</i>	$VR_i(b)$	$VR_i(a)$	ΔVR_i
1	Arab Bank	0.846	0.850	0.004
2	Jordan National Bank	0.640	0.676	0.04
3	Bank of Jordan	0.566	0.693	0.13
4	Industrial Developments Bank	0.590	0.643	0.05
5	The Housing Bank	0.669	0.720	0.051
6	Jordan Kuwait Bank	0.549	0.583	0.03
7	Jordan Gulf Bank	0.638	0.572	-0.07
8	Jordan Islamic Investment	0.639	0.664	0.02
9	Jordan Investment & Finance Bank	0.548	0.546	-0.002
10	Philadelphia Bank	0.620	0.600	-0.02
11	Beit el mall	0.481	0.534	0.05
12	Jordanian Electric Power	0.702	0.734	0.03
13	Jordan Press Foundations/ALRA'I	0.579	0.641	0.062
14	Arab International for Investment and Education	0.554	0.640	0.09
15	Al-Zaraqa for Education and Investment	0.551	0.617	0.07
16	Unified Cop. for Org. Tran.	0.592	0.571	-0.02
17	The Jordan Cement Factory	0.671	0.740	0.069
18	Jordan Phosphate Mines	0.632	0.648	0.02
19	Arab Potash	0.660	0.670	0.01
20	The Industrial Commercial & Agricultural	0.505	0.584	0.08
21	Arab Pharmaceutical Manufacturing	0.719	0.730	0.011
22	Jordan Ceramic Factory	0.540	0.550	0.01
23	Dar al Daw Development & Investment	0.668	0.744	0.08
24	Arab Aluminum Industry	0.550	0.570	0.02
25	Universal Chemical Industry	0.520	0.528	0.01
26	National Cable & Wire Manufacturing	0.589	0.624	0.03
27	Jordan Slpho-Chemical	0.542	0.512	-0.03
28	Arab Center for Pharmaceuticals & Chemicals	0.579	0.546	-0.03
29	Universal Modern Industry	0.578	0.634	0.056
30	Industrial Resources	0.540	0.603	0.06
31	New Cables	0.600	0.642	0.04
32	Union Chemical Vegetables & Oil Industry	0.504	0.554	0.05
33	National Colerain	0.580	0.596	0.016
34	Jordan Steel	0.626	0.757	0.13
	Mean	0.599	0.633	0.034
	Standard deviation	0.079	0.073	0.043
	Change in Vi positive			85.3%
	T-statistic			1.835

transfer to the automated system caused a parallel shift in the time series and that it had a positive effect on the amount of relative volume for each stock.

Additionally, Table 5 shows the mean relative volume for the period before automation as 411,584, but after the transfer to the automation systems it was 517,658.

Figure 3 shows the differences in the relative means for the two periods. We observed a large gap in the mean of the relative volume, which is an indicator of the increase in market liquidity.

In the second test, as equation (7) shows, we defined the change in the relative volume for each stock_{*i*} as

$$\Delta VR_i = VR_i(a) - VR_i(b) \quad (7)$$

where VR_i is the average daily relative volume on stock i , $VR_i(b)$ before $VR_i(b)$ and $VR_i(a)$ after $VR_i(a)$ the transfer to the automation system. The results are presented in Table 6.

The change in the relative volume was positive for 85.3 per cent of the transferred stocks. A high percentage of the stocks in the sample, which represent the ASE market, confirmed an increase in the sum of the trading volume after the transfer to the automation system, and that positive change indicated an improvement in liquidity in total.

Moreover, the mean for the change in the average daily relative volume was 0.034, and the t -statistic for testing the equality of means between the two series was 1.835.

These findings imply that an automation system on the ASE has a positive effect on market liquidity, as indicated by an increase in trading volume.

SUMMARY AND CONCLUSIONS

This study investigated the impact of the ETS on the 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. The GARCH model, developed by Bollerslev,⁹ was used to test the volatility level on the ASE. Furthermore, the study examined the liquidity of the ASE by testing the behaviour of 'trading volume'.

Empirical results were similar to what most of the researchers have found on other exchanges. Electronic trading seemed to decrease the volatility of the ASE. The persistence of the shocks to volatility, however, seemed to last for sometime in the future when the exchange moved to an ETS. Similar results were detected for each company separately.

In addition, the ETS showed a positive effect on market liquidity, based on daily volume of trade, as the major determinant of market liquidity. The study found an increase in the relative volume of stocks after the adoption of the ETS. The change in the relative volume was positive for 85.3 per cent of the study sample. Investors are mainly interested in the market mechanism, stability, and market liquidity. Therefore, supportive studies should find an interaction between liquidity, volatility, and expected returns in the market.

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