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The contribution of market makers to liquidity and efficiency of options trading in electronic markets ☆

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Abstract

This paper examines the contribution of market makers to the liquidity and the efficiency of the options market in a unique setup of an order-driven computerized trading system, in which market makers and other participants operate under equitable conditions. The main findings are: (1) liquidity increased – a 60% increase in trading volume and a 35% decrease of bid–ask spreads; (2) the efficiency of shekel–euro options trading improved – deviations from put–call parity decreased significantly by 12%, and skewness decreased by about 30%. We also find that the net cost to the exchange is out weighted by the benefit to the trading public and that the presence of market makers encouraged trading between other participants far beyond their own trading.

JEL classification: G14; D23

Keywords: Market makers; Trading efficiency; Liquidity

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1. Introduction

In October 2002, a public committee in Israel recommended to introduce market making activity to the Tel Aviv Stock Exchange (TASE) electronic trading system, similar to that on the Euronext.[1] Given the thin trading of FX (shekel–euro) options, the TASE proposed incentives to market makers willing to trade these options by directly compensating three market makers for their commitments.[2] These commitments include an obligation to provide continuous bid–ask price quotations for a pre-determined period of time. Market making activity was launched in March 2004.

The purpose of this study is to examine the contribution of market making activity to the liquidity and the efficiency of options trading. Our empirical work is based on unique data that enables us to examine the issue under almost perfect 'laboratory' conditions for three main reasons: (1) up until March of 2004 there were no official market makers on the TASE; (2) in contrast to market making activity on NASDAQ and many other exchanges, these market makers do not have preferential access to the order book, and trading conditions are identical to all participants; and (3) our data allows us to examine the unique contribution of market makers by tracing their trading activities vis-à-vis other traders. This issue has not been addressed within the framework of an electronic order-driven options trading system.[3]

Examination of issues similar to those addressed in this paper is precipitated by proposed reforms to trading systems in various exchanges throughout the world. The common denominator of these reforms is the desire to improve trading systems and increase the liquidity of the securities listed on these exchanges. Numerous articles appearing in the financial economics literature lend both theoretical and empirical support to the importance of liquidity, and specifically, the impact of microstructure on market efficiency.

Some of these studies dealt with the impact of trading systems on the turnover, volatility and liquidity of the listed securities.[4] Others focused on the impact of continuous electronic trade on operational efficiency and the need for regulatory agencies to prepare for this new type of trading regime.[5] All studies concur that microstructure has a significant effect on market efficiency, which may be expressed by growth of trading volume, reduction of price volatility, an increase in liquidity or improved dissemination of information to investors.

Amihud and Mendelson (1986), for example, found that an increase in liquidity (measured by the bid–ask spread) has a positive impact on securities' prices. Sanger and McConnell (1996), Kadlec and McConnell (1994), Christie and Huang (1994),

[1] The Euronext includes the Paris, Amsterdam, Belgium, London and Lisbon stock exchanges.

[2] The decision to introduce incentives for shekel–euro options rather than other, more liquid options traded on the TASE, such as shekel–dollar or TA-25 Index options, stemmed from the low trading volumes of shekel–euro options.

[3] For example, the ISE in New York is the only exclusively electronic options market in the United States employing market makers. The ISE currently accounts for more than 30% of all US options trading.

[4] See, for example, Garbade and Silber (1979b), Amihud and Mendelson (1986, 1987, 1991), Domowitz and Wang (1994), Huang and Stoll (1996) and Amihud et al. (1997).

[5] See, for example, Becker et al. (1992) and Domowitz (1992).

Elyasiani et al. (2000) and others demonstrate that, subsequent to listing NASDAQ shares on the NYSE or AMEX exchanges, trading volumes and stock values increased. Similar results were obtained regarding the Tel Aviv Stock Exchange by Kalay et al. (2002). These studies argue that the change in trading systems constituted the primary reason for the improvement of share liquidity. Similar results were noted for bond trading as well, by Amihud and Mendelson (1991), Kamara (1994), and for options by Brenner et al. (2001).

The issue of the impact of trading systems on liquidity was also examined within the framework of the flow of limit orders by liquidity traders acting as market makers in certain securities. Brooks and Su (1997), for example found that NASDAQ and AMEX liquidity traders lower costs by reducing bid–ask spreads. Biais et al. (2000), who showed that the activity of market makers improves liquidity and reduces bid–ask spreads, attained similar results. These findings are consistent with the claims of Foucault et al. (2001) that the introduction of liquidity "providers" (i.e., market makers) to an order-driven market can contribute to that market's overall liquidity.

Although the impact of market makers on liquidity and trading efficiency was examined in a number of studies, it appears that none of them directly addressed the contribution of market makers to the liquidity and efficiency of options trading in electronic markets. Moreover, our data provide us a clean event that enables investigation of the issue under almost perfect 'laboratory' conditions. Also, these papers address this issue by using data on equities or futures contracts in an open outcry trading systems.

Mayhew (2002) addresses the effect of competition and market structure on equities and options listed on multiple exchanges. His paper finds that cross-listed options have narrower quoted spreads than those of options listed on a single exchange. He also finds that options traded under designated primary market makers have narrower spreads than those traded in an open outcry trading system. However, these latter results seem to be robust regarding quoted spreads but not effective spreads. Mayhew's findings rely on a comparison between options traded with market makers and those traded without market makers. His results are subject to a potential selection bias of the control group and may be affected by the fact that the securities examined trade under different trading systems. In contrast to this study, our study is based on a clean event that allows a direct test of the impact of market makers on the liquidity and trading efficiency of options. More specifically, we investigate the issue of options traded in electronic trading system rather than open outcry system. The trading system was not altered with the introduction of market makers. Also, unlike Mayhew's findings, we find that the effective spreads, rather then quoted spreads, became narrower following the introduction of market makers.

Nimalendran and Petrlla (2003) investigated the impact of specialist intervention in equities trading on market quality and trading costs, liquidity and price discovery. They study a unique arrangement in Italy in which the Italian Stock Exchange give traders the choice to trade under a pure order-driven trading system or a hybrid trading system that allowed for specialist intervention. They find that specialist-based system offers lower execution costs, greater depth and liquidity. There are several important differences between this paper and ours. While their paper deals with equity instruments, ours deals with options. More importantly, Nimalendran and Petrlla (2003) admit that their research design suffers from a potential bias because their sample selection could favour finding that the specialist-based system performs more efficiently.

In Haan (2001) and Mann et al. (2003) the issue examined differs from ours. These studies investigate the value of liquidity providers in trading of equities. Their findings rely on a controlled experiment on stocks traded in the Euronext-Paris, where securities can trade either with or without liquidity providers. Specifically, they find that share prices increase following the introduction of liquidity providers, especially for less liquid stocks. Prices increase in spite of the fact that there is no significant change in liquidity. In our paper, we find that market makers had significant contribution to liquidity.

Nevmyvanka et al. (2004) attempt to establish an analytical foundation for electronic market making. Unlike most studies that model human market making activity, they address the issue of normative automation of market making. They demonstrate that, for non-predictive strategies, market making allows more expedient updates as well as narrower spreads. Their paper differs from ours because its focus is on electronic rather than human market making activities. Nevertheless, to a large extent our paper supports the theory suggested in their paper.

Tse and Zabotina's (2004) appear to address the same issue addressed in our paper. Their paper, however, differs from ours in several respects. First, it deals with interest swap futures and not options. Second, their sample is based on designated market makers in an open outcry rather than electronic trading system. Third, in their sample there were voluntary market makers that operated in the market prior to the designation of official market makers. In contrast, in Israel, there was no market making activity, voluntary or otherwise, in the shekel–euro options market prior to the appointment of market makers.

Finally, unlike all these studies, our data allows us also to test the hypothesis that the presence of market makers has a spillover effect, as it encourages trading among other participants far beyond their own trading. It also allows to compare the net cost to the TASE that sponsors market makers with the benefits to the trading public.

The paper is organized in four sections. In the next section, we survey the TASE options market, the sample data and methodology. In Section 3 we present the empirical findings. Section 4 summarizes the paper.

2. Data and methodology

2.1. TASE trading system

The TASE trading system in options and futures contracts is a fully automated order-driven electronic trading system. It is a single-stage trading system, which opens at 9:30 in the morning and closes at 17:00. Three types of orders can be submitted: (1) Limit order (LMT), orders with maximum/minimum price limits. Execution priority for these orders are determined by the limit and the time the orders are received by the TASE; (2) fill or kill (FOK) orders, limit orders that are cancelled if they are not executed in full; and (3) immediate or cancel (IOC), orders for either full or partial immediate execution. In the case of partial execution, the unfilled portion is cancelled and deleted from the order book.

Throughout the trading day, investors can view the order book at three levels of aggregate demand (buy orders) at the best price, and three levels of aggregate supply (sell orders) at the best price. The difference between the best buying price and the best selling price constitutes the bid–ask spread. All matched orders are executed immediately. Price (highest priority) and time of arrival (second priority) determine execution priority. The price and amount traded in each transaction conforms to the investors' orders. Price is determined by matching buy and sell orders in the order book and no limitations are placed on possible price fluctuations.[6]

Options trading on the TASE began in August 1993, initially on the TA-25 (the 25 most highly capitalized firms on the TASE) share index. In April 1994, trade on shekel–dollar exchange rate options was launched. Over the years, the volume of trade in these derivatives flourished and a number of other products were introduced. These newer derivatives, such as options on the TA banking index, have not enjoyed the success of their predecessors and trade has been thin or none. The TA-25 and shekel–dollar options currently continue to command the lion's share of trading volume, with an average daily volume of over 160,000 contracts.

2.2. *Shekel–euro options*

Options on shekel–euro exchange rates were introduced to the TASE in 2001. Despite the relatively healthy volume of international trade between Israel and the "euro bloc" countries, exceeding $400 million daily, the turnover of shekel–euro options remains comparatively low. Prior to the introduction of market makers, daily volume averaged only 1962 contracts. Since market makers began operating in this market, the daily average number of contracts increased to 3165. The rules governing market making activity are summarized below.

2.2.1. *Qualifications and obligations of market makers*

An applicant undertakes to act as market maker for a period of at least three months and to simultaneously submit buy and sell orders as prescribed by the TASE. Trading activity within the framework of market making obligations is conducted solely through the market maker's own account. Market makers must quote bid and ask prices on derivatives on all days the option is traded and they are obligated to provide price quotes throughout 80% or more of the trading day.[7] They are also exempt from providing quotations on days in which the underlying asset is not traded. At least 10 options are required per order, selected from a series of the closest exercise date, and five options from the next exercise date. Market makers are also obligated not to exceed a maximum spread of eight price ticks for series with the

[6] For full details on trading rules, see TASE regulations (Chapter 6), instructions as per Section 3.

[7] Initially, the TASE intended to require continuous quotations, but settled for less to lower the risks market makers may encounter. Note that shekel–euro futures contracts hardly trade (less then 1 contract a day on average).

closest exercise date, and 10 price ticks for the exercise date after that. Finally, they must quote prices for calls and puts for at least four of seven of the following striking prices: (1) the striking price closest to the current price of the underlying asset; (2) three striking prices above that of the underlying asset; (3) three striking prices below that of the underlying asset.

2.2.2. Auditing market makers

The TASE operates an automated auditing system to validate market maker compliance to their commitments and publishes periodic reports on market making activity, at least once in a month. In the event that a market maker is unable to meet its commitments, the authorization to engage in market making is revoked and cannot be renewed within the coming year.

2.2.3. Publication

The TASE publishes the following information: a list of market makers for each relevant security; notification on the initiation or cessation of market making activity by a market maker; and notification of the initiation or cessation of market making activity for a specific security.

2.2.4. Compensation for market makers

In order to encourage market making activity, the TASE has instituted a system of incentives, which includes: rebates on trading and clearance fees; a fixed monthly payment of NIS 8000 (approximately \$1800); and a variable monthly payment of \$0.05 for each transaction in which it partakes as market maker in which the other party to the transaction is not itself a market maker. This payment is made to each market maker for each derivative above the first 6000 contracts each month. Given these payments and the reported change in the trading volume of contracts, and given that trading and clearance fees came to 10 cents a contract from each side, we estimated that net cost of this program to the TASE approximated \$3700 a month during the sample period.[8] Of that, market makers gained approximately

[8] Based on these figures, and the fact that the average daily volume (number of contracts) following the change, without market makers, was 2332 and that with market makers (exempted from trading fees) was 702, the TASE paid a total of \$25,826 ($=4 * 3 * 8000/4.5 + 702 * 0.1 * 64$) where the NIS/\$ was about 4.5 in the four months (64 days) following the introduction of market makers to the TASE. During this period the revenues to the TASE, through these fees, were \$36,019 ($=64 * [2332 * 2 + 131 * 2 + 702] * 0.1$). The '2' signifies that the 10 cents fee was charged by the TASE from both: the seller and the buyer, and the '131' signify the number of contracts between market makers that are not exempted from fees. These figures are now compared with the TASE revenues from euro–shekel options, in the four months preceding the change. During this four-month period, the revenues to the TASE were \$25,114 ($=64 * 1962 * 2 * 0.1$). Hence, the revenues of the TASE increased by \$10,905 (=\$36,019 − \$25114). Since the cost to the TASE were \$25,826, the monthly net cost to the TASE came to \$3730 ([=\$25,826 − \$10,905]/4). The breakeven of 4300 contracts a day was computed based on the need to increase revenues by approximately \$14,920 ($=3730 * 4$) in a four-month (64 days) period, and the 10 cents fee charged by the TASE from each side in any transaction. That is, if the daily average number of contracts would increase by 1166 contracts ($=14920/64/0.2$), the breakeven level can be achieved at a daily average number of contracts of 4330 ($=1166 + 3164$).

$1100 from lower trading fees. Based on these figures we find that the breakeven point, the point at which net costs for the TASE are zero, is achieved at an average daily turnover of 4300 contracts. Any increase in the average number of contracts beyond this figure would generate positive revenues to the TASE. We also estimated the dollar benefit to the investment community by estimating the impact of lower effective spreads to investors. We find that the 35% decrease in the bid–ask spread lowered annualized execution costs to investors by about 3 million dollars. That is, the net cost to the TASE sponsoring market makers is far out weighted by the benefit to the trading public. Specifically, we find that for every dollar spent by the exchange, there are $67 (= 30,000,000/(14920 * 3)) benefits to the public trading in this market. It should be noted that starting from August of 2003, the TASE suspended payments to two market makers because both were too passive.[9]

2.3. Data and methodology

The data set employed in this study includes all intra-day trading data for the four months prior to the introduction of market makers in March 2004 and the four months subsequent to their debut on the TASE. At that time, there were only four options contracts on the TASE – the shekel–euro, the shekel–dollar, the TA-25 share index and the TA Banking Index option. Market maker incentives were established solely for shekel–euro option trading, given their thin trading. In other words, prior to the introduction of shekel–euro market making arrangements, there was no market making activity on the TASE. In addition, the introduction of incentives for official market makers was the only change in the eight-month period that would have affected liquidity of the options market. Hence, the inception of shekel–euro market making represents a uniquely "clean" event.

On the basis of this data, we conduct an event study to examine changes in liquidity, volatility and their impact on the efficiency of options trading. The data comprises all transactions in shekel–euro options. The sample includes 12,910 (12,037) put and call transactions, of which 3311 (3028) were concluded in the four-month period prior to the debut of market making activity and 9599 (9009) in the four months subsequent to this event. Sundays have been excluded because there is no trade in the underlying asset on Sundays and market makers are not required to operate on these days. We found, however, that in the period preceding market maker participation, the average volume of trade on Sundays did not differ significantly from Sunday volume following their introduction. At times, a very small number of contracts (as little as three) were traded on Sundays.

The implied standard deviation (ISD) for each transaction was calculated using the Black and Scholes model. Bid–ask spreads were calculated as follows:

[9] The three market makers were appointed by the TASE as of March 2004 and commenced operations that day. All three operated during our sample period. One of them was responsible for over 55% of the transactions. Since August 2004 (out of our sample period), when one market maker remained active, volume remained at the same level of approximately 3000 contracts a day implying that since then an average daily volume of 3200 contracts represents the break even point.

$$\mathrm{BA} = \frac{\mathrm{Ask} - \mathrm{Bid}}{(\mathrm{Ask} + \mathrm{Bid})/2}.$$

Trading figures include all transactions for all possible exercise dates as well as daily figures for turnover and number of open positions. Bid–ask spreads on shekel–euro options were derived from the effective selling and buying prices recorded in the order book immediately prior to the time the transaction was completed. Absent of direct trading of the shekel–euro, we multiplied the effective cross rates between the shekel–dollar rate and the euro–dollar, as do traders. The spread between buying and selling prices was derived accordingly. Interest rates were inferred from rates on three-month Israeli treasury bills.

The first hypothesis of our study is that the introduction of market makers contributes to option liquidity and lowers the implied standard deviation (ISD). Liquidity is measured by trading volume and by bid–ask spreads. We expect turnover to increase and bid–ask spreads to decrease. As a result, we also expect a decline in implied standard deviations. The latter stems from the assumption inherent in the Black–Scholes model that the options and their underlying assets are highly liquid. Hence, if at least one of them becomes more liquid, the illiquidity premium will shrink and ISDs will decline accordingly (Brenner et al. (2001)).

The second hypothesis is that market makers contribute to market efficiency. Market efficiency is measured in two ways. The first is by calculating the deviations from put–call parity prices (*%diff*). Specifically, we calculate the relative difference between the actual underlying asset price indicator (S) and the implied put–call parity equilibrium price (S^*) as follows:

$$\%diff = \frac{S}{S^*} - 1,$$

where, S^* is inferred from $C - P = S\mathrm{e}^{r*T} - X\mathrm{e}^{-rT}$, P and C denote put and call prices respectively, X denotes the striking price, T is the time to expiration and r and r^* represent the annualized yield to maturity on three-month treasury bills, and euro–dollar interest rates, respectively. Options are paired only if they trade within two minutes from each other. When we examined the deviation for options trading at shorter intervals, the results were similar. Also, given the possibility that the price of the underlying asset (S) changed, we calculated the deviation according to the spot exchange rate at the beginning of this time interval (S_0), at the end of the interval (S_1) and the average of the two exchange rates (S_A). The hypothesis is that market making activity reduces these discrepancies. This reduction is linked to the increase in option turnover and the decrease of transaction costs, such as the bid–ask spread.

The second indicator for efficiency is linked to the skewness phenomena of option prices at various striking prices and the calculation of implied standard deviations. The hypothesis is that skewness will decrease. Since skewness represents different ISDs for options bearing different striking prices for the same underlying asset, it is possible that under the Black–Scholes (1973) assumptions, skewness may be related to market efficiency, inter alia, due to increased liquidity and lower transactions costs. That is, we test the hypothesis that one of the benefits stemming from increased liquidity is minimizing the well known phenomena of skewness because of lower transactions costs. To test this, we calculated the average ISDs for options in the sample with $\delta \cong -0.25$ (deltas ranging between -0.35 and -0.15) in order to compare it with that of options with $\delta \cong +0.25$ (deltas ranging between 0.15 and 0.35). Skewness (SK) was measured as follows: $\mathrm{SK} = \mathrm{ISD}_{\delta\cong-0.25} - \mathrm{ISD}_{\delta\cong0.25}$.

3. Findings

Table 1 summarizes some key figures regarding the underlying asset, shekel–euro, and trading volume of other options traded on the TASE (shekel–dollar and TA-25 stock index). It appears that the trading volume of other options, and the historical volatility (HSD) of the shekel–euro, estimated by the GARCH (1,1) model, did not change during the sample period. The importance of the former figure is to ascertain that the introduction of market makers to the shekel–euro options was the only change to the TASE during the sample period that could explain a change in shekel–euro option performance. The importance of the non-significant change of HSD (which remained at a level the 9% (annualized) level) is to highlight the significant reduction of the implied standard deviations (ISDs) from 11.4% to 10.5%. This reduction of the ISDs inferred from the Black–Scholes model is positively related to liquidity. This is because one of the model's basic assumptions is that both the option and the underlying asset are highly liquid. In the absence of adequate liquidity, the ability to hedge positions or capitalize on arbitrage opportunities is plagued with uncertainty. Hence, improved liquidity causes a reduction in illiquidity premiums and a corresponding decline in ISDs (see Brenner et al., 2001). These points are further discussed below.

Panel A of Table 2 presents the main findings with respect to the contribution of market making to liquidity. The first important finding is that, on average, the daily number of shekel–euro contracts leaped from 1962 prior to the initiation of market making activities to 3165 contracts since its inception, an increase of 60%. Fig. 1 illustrates the increase in trading volume in the four months preceding and following the change. This increase in volume is significant for "in- at- and out-of-the-money" short-term options. Long-term options experienced statistically insignificant volume increases, indicating that market makers are more active in short-term options.

The increase in turnover is also reflected in a significant increase in the average number of daily transactions – tripling from 46 to 141 transactions in all options (at-, in- and out-of-the-money, short-term and long-term options).[10] Examination of open interest figures tells a similar story. There was a significant increase in the open interest from 18,278 contracts a day to 27,136 contracts a day. These changes in trading activity came at a time when there were no significant shifts in foreign

[10] The greater change in the number of transactions relative to the change in the volume indicates that, on the one hand, following the introduction of market makers, total volume increased but, on the other hand, the size (number of contracts) of each transaction declined.

Table 1
Description of data

	Period 1 – before		Period 2 – after		p-Value
	Mean	SD	Mean	SD	
Underlying asset (shekel–euro)					
Bid–ask spread (×100)	0.2604	0.0419	0.2521	0.0416	0.000
Historical standard deviation (HSD)	0.0899	0.0151	0.0952	0.0156	0.223
Implied standard deviation (ISD)	0.1136	0.0267	0.1053	0.0191	0.000
Trading volume of options on TASE (daily average number of contracts)					
Shekel–dollar options	31,939	18,488	30,467	26,070	0.355
TA-25 index options	136,783	42,338	130,073	54,517	0.191
Shekel–euro options	1962	2239	3165	2315	0.002

This table displays figures of bid–ask spreads of the underlying exchange rate, historical standard deviation (HSD) derived from the GARCH (1, 1) model, and the implied standard deviation (ISD). Standard deviation figures are annualized by multiplying the daily standard deviation by the root of the number of trading days in the year. Period 1 relates to trading data for the four months preceding the introduction of market makers, while period 2 relates to the four months following the event.

trade with the euro bloc and there was no increase in the turnover in options traded on other underlying assets. On the contrary, the daily turnover of shekel–dollar options declined slightly from 32,000 contracts on average to 30,500 and average daily trading volume on TA-25 options fell from 136,000 contracts to 130,000 (Table 1). During this time, the average daily volume of transactions involving Euros, deceased insignificantly from 409 million to 401 million.[11] We also find that these improvements occurred in spite of the fact that market making was responsible for only 15% of the trading volume. This suggests a spillover effect, i.e. the presence of market makers encourages trading among other participants far beyond their own trading. One possible explanation is that, investors previously reluctant to trade shekel–euro options because of an often empty order book, were no longer afraid to trade these options subsequent to the appearance of market makers in the market.

The second important finding is that effective bid–ask spreads (BA) declined significantly by approximately 35% from 10.96% on average to 7.15% (Fig. 2). The decrease in BA is significant for all options, albeit to a lesser extent for out-of-the-money options. This reduction came during a period when the decline of BA on the shekel–euro underlying asset was significant as well. Although the reduction in the BA of the underlying asset, shekel–euro, was negligible, 0.0083%, we also tested the incremental effect of market making on the options BA by examining the ratio of the daily average of the options BA to that of the shekel–euro. The results of

[11] Unfortunately, the only data that we could obtain was from the Bank of Israel on the total foreign trade (in all currencies) and the percentage of Euro trading out of it. Based on these figures, we estimated the average daily trading volume of foreign exchange transactions before and after the introduction of market makers to the market. Based on these findings and the fact the BA spreads did not change significantly between the two periods, we conclude that the increased volume is due to the introduction of market makers rather than "other factors" that may to influence the change in market activity.

Table 2
The impact of market makers on the volume, bid–ask spread and depth

	Degree in the money			Time to expiration		All sample
	Out	At	In	Short	Long	
Panel A – All transactions						
Volume (number of contracts)						
Period 1 – before	490	1014	458	1119	843	1962
Period 2 – after	956	1425	783	2212	952	3164
p-value	(0.002)	(0.000)	(0.016)	(0.000)	(0.607)	(0.002)
Number of daily transactions						
Period 1 – before	11	21	14	12	34	46
Period 2 – after	36	64	41	35	106	141
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Options bid–ask spread (×100)						
Period 1 – before	13.88	10.65	8.99	11.41	9.94	10.96
Period 2 – after	11.69	7.01	3.85	7.54	5.92	7.15
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Options bid–ask spread/euro–shekel bid–ask spread						
Period 1 – before	54.29	41.93	35.46	44.66	39.56	43.10
Period 2 – after	47.82	28.20	15.93	17.85	30.69	29.13
p-value	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Depth (×100)						
Period 1 – before	5.11	2.70	2.89	3.54	2.09	3.24
Period 2 – after	3.38	2.58	1.85	2.63	2.39	2.57
p-value	(0.000)	(0.305)	(0.000)	(0.000)	(0.324)	(0.000)
Panel B – All transactions excluding those with market makers						
Volume (number of contracts)						
Period 1 – before	490	1014	458	1119	843	1962
Period 2 – after	825	1224	634	1899	785	2684
p-value	(0.013)	(0.203)	(0.215)	(0.002)	(0.401)	
Number of daily transactions						
Period 1 – before	11	21	14	34	12	46
Period 2 – after	27	47	26	78	22	100
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Options bid–ask spread (×100)						
Period 1 – before	13.88	10.65	8.99	11.41	9.94	10.96
Period 2 – after	10.19	6.59	4.69	7.16	6.98	7.13
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Options bid–ask spread/euro–shekel bid–ask spread						
Period 1 – before	54.29	41.93	35.46	44.66	39.56	43.10
Period 2 – after	41.15	26.58	19.40	29.14	28.14	28.96
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Depth (×100)						
Period 1 – before	5.11	2.66	2.89	3.60	2.09	3.24
Period 2 – after	3.80	3.00	2.16	3.14	2.58	3.04
p-value	(0.008)	(0.375)	(0.021)	(0.038)	(0.382)	(0.175)

This table displays the major findings concerning the impact of market making activity on trading volume, on open interest, the number of transactions, bid–ask spreads and depth. Period 1 relates to trading data for the four months preceding the introduction of market makers, while period 2 relates to the four months following this event. Bid–ask spreads were calculated as follows:

$$\mathrm{BA} = \frac{\mathrm{Ask} - \mathrm{Bid}}{(\mathrm{Ask} + \mathrm{Bid})/2}.$$

Depth is calculated by the ratio of the percentage change of option prices relative to the volume (number of contracts) in each transaction. The lower this ratio is, the higher the depth. The p-values reported are of t tests, testing the hypothesis that volume is significantly larger in period 2 relative to period 1, and the hypothesis that the bid–ask spread decreased significantly in period 2.

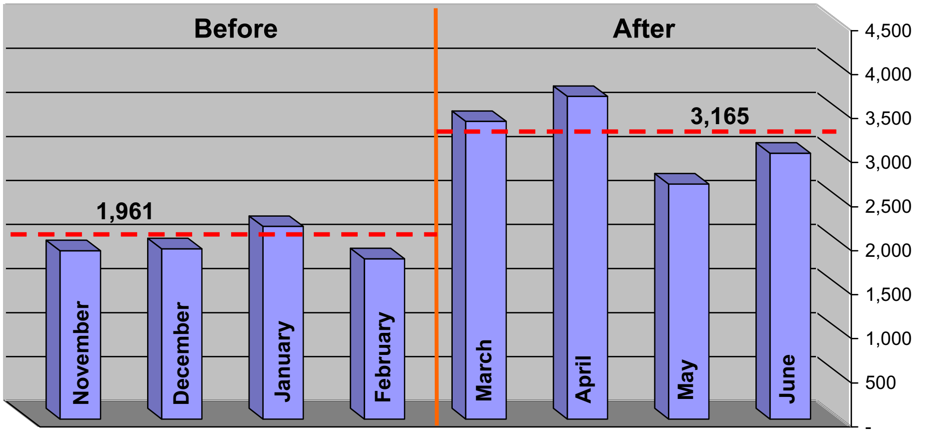

Fig. 1. Average daily turnover prior and subsequent to the introduction of market makers on the TASE (number of contracts).

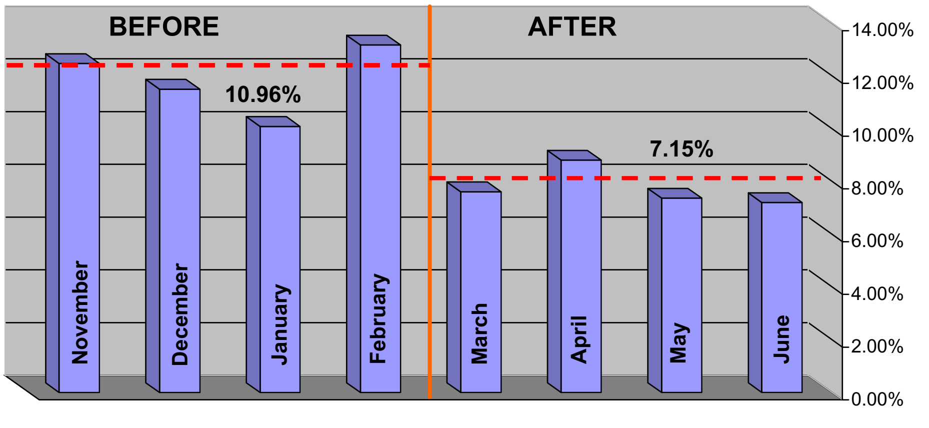

Fig. 2. Average daily bid–ask spreads prior and subsequent to the introduction of market makers on the TASE.

this test indicate a significant decline in the BA of all options. These results are especially notable because they came at a time in which the volatility (measured by HSD) of the shekel–euro foreign exchange rate (HSD) did not change significantly.

The third finding is that market makers had a marginal positive impact on market depth. We examined changes in the depth of the order book by estimating the ratio of absolute percentage change of option prices relative to the volume (number of contracts) of each transaction. This measure of depth, suggested by Kyle (1985) and others, claims that the lower the ratio, the deeper the market. We find that there is a significant increase in depth following the introduction of market makers for in-and out-of-the-money options and an insignificant increase for at-the-money options.[12] We conclude, therefore, that the improvement in depth is marginal. One possible explanation for these results is that the increased turnover was accompanied by a greater increase in the number of transactions. That is, the average size of each transaction decreased following the introduction of market makers. An alternative possible explanation is that market makers are relatively passive in their activities.

We also examined the effect of tick size on the bid–ask spread. Tick size for shekel–euro options is 10 basis points for option prices exceeding 200 shekels and five basis points for prices lower then 200 shekels. We find that the average ratio of tick size to the transaction price is 2.36%. This figure is significantly lower than the average effective bid–ask spreads of 7.15% in the second period, and 10.96% in the first period. More importantly, we also find that in only 6% of the transactions, the effective bid–ask spreads equalled the tick size. This suggests that tick size rarely constituted an effective barrier to lower bid–ask spreads.

Overall, these results support Foucault et al.'s (2001) theoretical model that the introduction of liquidity providers (i.e., market makers) to an order-driven market can contribute to liquidity. They are also consistent with the findings of Haan (2001) and Mann et al. (2003) on illiquid stocks in the Euronext, and Tse and Zabotina (2004) findings on interest swap futures in the CBOT and others.

The results reported so far are reinforced by a more in-depth analysis of the unique contribution of market makers to liquidity and bid–ask spreads. This analysis includes tracking all transactions in which market makers were engaged and differentiating them from transactions in which they were not involved. The results are displayed in panel B of Table 2. The figures presented here exclude all transactions with market makers. We find that market makers were involved in only 15% of all shekel–euro option transactions. Only 4% were between the market makers themselves. Even when these transactions are excluded, trading volume increased significantly by 37% and bid–ask spreads declined by 35% – equivalent to the reduction found when market makers were not excluded. These findings indicate that the designated market makers seem to be passive and that the effective BA of transactions involving market makers do not significantly differ from those between other investors. This finding supports the hypothesis that the presence of market makers motivates investor participation, that transcends the specific contribution of market making activity.

Finally, we present findings with respect to the contribution of market makers to market efficiency. The major finding is that deviations from put–call parity prices decreased by an average rate of 12% from 0.176% to 0.155%. This reduction was not uniform for all options traded, however. When we categorized the sample by the price of the underlying asset and by time-to-maturity, we found that post-market making deviations from put–call parity prices are significantly smaller only for at-the-money options. Results for all other categories were statistically insignificant.

[12] When we used a second measure for depth by estimating the quantity demanded or supplied that was not cleared in any transaction (based on the three layers of demand and supply revealed to all investors), we found that there was no significant change to our findings.

Naturally, one possible explanation is that the majority of the observations used to estimate the deviations from put–call parity were at-the-money options. Another possible explanation is that market makers are more active in at-the-money-options (Table 3).

The improvement of market efficiency is also reflected in a reduction in the level of asymmetry in the distribution of option returns (skewness). We find that the skewness declined by a rate of 30% from SK = 0.0024 to SK = 0.0017. The importance of this test emanates from the hypothesized relationship between skewness and market efficiency, according to which the increased efficiency is positively correlated with increased liquidity and decreased transaction costs. Hence, we raise the hypothesis that since skewness represents the ISDs of various options written on the same underlying asset, it is possible that under the Black–Scholes (1973) assumptions, skewness may be related to market efficiency, inter alia, due to increased liquidity and lower transactions costs. That is, one of the benefits of increasing liquidity is

Table 3
The impact of market makers on the efficiency of options trading

	Period 1 – before			Period 2 – after			p-Value
	N	Mean	SD	N	Mean	SD	
Panel A – Trading efficiency as per deviations from put–call parity and skewness							
$(S_0/S^* - 1) * 100$	579	0.1728	0.1805	1761	0.1501	0.1050	0.000
$(S_1/S^* - 1) * 100$	579	0.1794	0.1795	1761	0.1613	0.1242	0.003
$(S_A/S^* - 1) * 100$	579	0.1758	0.1794	1761	0.1552	0.1101	0.001
$(S_A/S^* - 1) * 100$ *partitioned by*							
At-the-money	359	0.2065	0.2062	1160	0.1675	0.1041	0.000
In- and out-of-the-money	220	0.1257	0.1065	691	0.1334	0.1202	0.300
Short	384	0.1437	0.1769	1647	0.1388	0.1025	0.238
Long	195	0.2390	0.1675	204	0.2835	0.0979	0.001

Panel B – Skewness

ISDs in period 1			ISDs in period 2		
SK	$\delta \cong 0.25$	$\delta \cong -0.25$	SK	$\delta \cong 0.25$	$\delta \cong -0.25$
0.0024	0.1096	0.1121	0.0017	0.1035	0.1052

This table displays the main findings concerning the impact of market making activity on the deviations from put–call parity prices and on the skewness of implied standard deviations. Period 1 relates to trading data for the four months preceding the introduction of market makers while period 2 relates to the four months subsequent to this event. The deviation from put–call parity prices was calculated on the basis of at-the-money options as follows:

$$\frac{S}{S^*} - 1 = \frac{S}{[C - P + Xe^{-rT}]e^{r^*T}} - 1.$$

We paired options traded at intervals of no more than two minutes. Given that the price of the underlying asset (S) may have changed, we calculated the deviation according to the spot exchange rate at the beginning of this time interval (S_0), at the end of the interval (S_1), and the average of the two exchange rates (S_A). The skewness of implied standard deviations was measured as follows: $\mathrm{SK} = \mathrm{ISD}_{\delta\cong-0.25} - \mathrm{ISD}_{\delta\cong0.25}$. Short (long) options are those with time to expiration less (more) then a month.

minimizing skewness because of lower transactions costs. We estimated the following regression to test the effect of transaction costs on skewness,

$$\underset{(p-\text{value}=)}{\text{SK}} = \underset{(0.876)}{-0.00064} - \underset{(0.011)}{0.0106}\text{Period} + \underset{(0.006)}{6.34}\ \text{BA} \quad R^2 = 25.7\%,$$

where SK denotes the daily skewness, Period is a dummy variable that equals '0' in the first period and '1' in the second period, and BA is the average relative bid–ask spread (in percent) calculated each day.[13] The results of this regression indicate that the reduction in skewness between the two periods is significant (p-value = 0.011).[14] The positive and significant coefficient of the bid–ask spreads (BA) demonstrates that the lower transaction costs in the second period had a positive impact on market efficiency to the extent that the skweness phenomena has been minimized. One possible explanation is that the bid–ask spreads are higher in out-of-the-money options and lower for in-the-money options. Indeed we find that average bid–ask spreads of out-of-the-money options declined to 11.69% in the second period compared with that of in-the-money options which declined to 3.85%.

4. Summary

In March, 2004 market makers became active in shekel–euro options trading with the encouragement of the TASE to improve the liquidity of this market. Until that time, market makers were foreign to the options market on the TASE. The introduction of market making activity enabled us to examine the contribution made by market makers on option liquidity and market efficiency under almost perfect 'laboratory' conditions, in a market employing an electronic trading system which places market makers on equal footing with other investors. We found that the introduction of market makers had a positive affect on both option liquidity and market efficiency. Our major findings include: (1) option turnover increased by approximately 60%; (2) the bid–ask spread decreased by approximately 35%; (3) deviation from put–call parity prices decreased significantly by a rate of approximately 12%; (4) and the skewness of the distribution of returns decreased by a rate of approximately 30%; and (5) the net cost to the TASE sponsoring market makers is far out weighted by the benefit to the trading public – for every dollar spent by the exchange, there are $67 benefits to the public trading in this market. We also found that these improvements are in spite of the fact that market makers were responsible for only 15% of the trading volume, indicating that their presence encourages trading among other participants far beyond than their own trading.

[13] Days in which there were no observations with options having deltas both between 0.15 and 0.4 and between −0.4 and −0.15, were excluded.

[14] When we ran this regression only with the dummy variable that represents the two periods, we found that its coefficient is about 0.007 (the difference between SK = 0.0024 in the first period and SK = 0.0017 second period) and significantly different from zero.

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