Safer Margins for Option Trading: How Accuracy Promotes Efficiency

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Abstract

Margin requirements are designed to control the default risk inherent to commitments undertaken by option traders. Much like similar institutions, the Tel Aviv Stock Exchange (TASE) first adopted a system based on the Standard Portfolio Analysis of Risk (SPAN), which sets required levels of options margin according to the most pessimistic of 16 possible outcomes. Seeking to lower the probability of default without adversely affecting liquidity, the TASE switched in 2001 to a more detailed margin system based on the most pessimistic of 44 scenarios. This unique change provides us with an ideal laboratory for testing the impact of increased margining precision on the efficiency of option trading. Based on a sample of over 3 million transactions, we conclude that the more accurate pricing of default risk over the studied range leads to smaller implied standard deviation and deviations from put-call parity.

I. Introduction

Margin requirements limit the opportunity of traders to shift default risk to the exchange clearinghouse thereby promoting market efficiency through confidence in the financial integrity of traders and the institution behind them. Margin requirements are designed to control the default risk inherent to contractual commitments undertaken by option traders. Depending on the selected strategy, option trading may be exposed to a high credit risk due to the creation of a high-multiple leverage whereby a small change in the underlying asset price can induce a dramatic change in the price of the options themselves. The SPAN margining method is designed to cope with that risk by accounting for trader liability exposure under potential scenarios of different option trading strategies, including those of extreme financial risk.

The required margin represents a trade-off between two contradictory objectives, to decrease risk and to increase liquidity [Hardouvelis (1990)].[1] The larger the required margin, the lower the credit risk. But this benefit comes at a cost. A higher required margin is costlier for traders and

[1] See also Kupiec (1993, 1994, 1996, 1998).

leads to a thinner trade, which in turn decreases the options' liquidity. Liquidity can be increased by decreasing the required margin at the cost of a higher credit risk. The 16-scenario SPAN method developed in the U.S. and replicated in other exchanges, including Israel's Tel-Aviv Stock Exchange (TASE), was designed to balance the marginal cost of risk against that of illiquidity. The optimal size of the required margin is also a concern of the academic literature [See, for example, Kose, Kotichia, Narayanan, and Subrahmanyam (1997)].

The fate of SPAN-16 on the TASE took a unique course when experience suggested that, unlike stocks, the inherent exposure of option trading to a high leverage and related risk justifies a more accurate, more selective risk measurement. To this end, the margining method on the TASE was modified from SPAN-16 to the more detailed SPAN-44. The increased number of scenarios, each of a narrower price interval within the same price range, had the potential of a greater pricing accuracy, which may or may not lead to a larger total margin. Assuming an insignificant change in the cost of pricing itself, we test for a change in efficiency on the assumption that a greater margining precision will lower the clearinghouse risk of pricing errors and impart to traders more accurate, consistent incentives in choosing the size of transaction, its price, and its strategy. In short, we hypothesize that SPAN-44 will prove to be more economic.

Earlier studies examine the impact of margins separately on markets of stocks and derivatives. Following a comprehensive survey of theoretical models and empirical evidence, Kupiec (1998) describes earlier findings as contradictory and inconclusive.[2] Based on studies of stock trading, Garbade (1982) and Chowdry and Nanda (1998) claim that margin requirements promote instability in stock trading. In contrast, Schwert (1989), Salinger (1989), Kupiec (1989), Hsieh and Miller (1990), and Seguin and Jarrell (1993) conclude that margin requirements have no significant effects on the volatility of share prices or trading volume. Those results contradict Hardouvelis (1988, 1990) and Seguin (1990) who find that increased margin requirements lower

[2] See for example Kupiec (1998) and Kose, Kotichia, Narayanan, and Subrahmanyam (1997).

stock price volatility and lessen price deviation from fundamental value. According to Hardouvelis (1990), margining can be a useful tool for controlling spurious market volatility produced by speculators.

The disparity between margin requirements on options and underlying assets can be explained by their different relationship to financial leverage. As put by Figlewski (1984), margin on a stock is a loan, while margin on a stock's derivative is a performance bond. According to Kupiec (1998), increased margin requirements on options can increase volatility in the underlying share prices. Empirical margining studies conducted respectively by Fishe, Goldberg, Gosnell, and Shena (1990), Kupiec (1993), Hardouvelis and Kim (1995), and Day and Lewis (1997) fail to establish a systematic relationship between required futures margins and asset liquidity or price volatility in futures contracts written on U.S. indices of stocks, cash market assets, metal contracts, and crude oil. In contrast, Moser (1992) finds a significant negative correlation between the level of derivative margins and share price volatility in Germany. Theoretically, higher margin requirements should adversely affect trading volume since traders incur higher transaction costs. Yet, Fishe and Goldberg (1986) find that trading volume increases along with margin requirements, possibly as a result of a lower default probability. Hartzmak (1986) finds no significant relationship between the two variables, whereas Dutt and Wein (2002) find that the effect of increased margin requirements on trading volume is indeed negative, but only after controlling for price risk.

Can those findings be reconciled? Kose, Kotichia, Narayanan, and Subrahmanyam (1997) address some of the issues by theoretically treating the impact of margin requirements set on options *and* underlying stocks on trading in both markets. Under the benchmark assumption of no margin requirement on options, traders are shown to be active in both markets with a propensity to prefer stocks. With the introduction of margins to options, their built-in financial leverage invites a larger position. The authors show that the change in trader behavior is contingent on the relative margins placed on stocks and their options. They propose that market efficiency can be improved by setting the margins either high or low in both markets. Intuitively, informed traders of limited resources prefer to exploit their comparative advantage in the stock market but would settle for options, which offer a greater financial leverage and require a lower margin.

On July 1, 2001 the Tel Aviv Stock Exchange (TASE) modified the basis for calculating option margins by raising the number of risk scenarios from 16 to 44 in the hope that the greater accuracy of measuring default risk will lower the probability of default without adversely affecting liquidity. This unique event provides a laboratory for assessing the incremental efficiency of increased margining accuracy. Our findings extend those of Kupiec and White (1996) who rely on simulation to compare the SPAN system with the old Regulation-T Margining employed in the U.S. They conclude that both systems provide adequate protection against default risk, even though required margins under SPAN tend to be lower. Unlike their study, ours provides both simulation and empirical assessments of the effects of increased margining accuracy on trading efficiency in a given SPAN system. We compare the efficiency of the two margining regimes by estimating deviations from put-call parity and four additional indicators of efficiency – volatility of underlying asset prices, asymmetry in option pricing, trading volume, and bid-ask spread.

Consider the relationship between the volume of trade and the Bid-Ask spread. Empirical evidence shows that, other things held constant, an increase in volume would narrow the spread. In this paper we find evidence of no change in volume following the switch from SPAN-16 to SPAN-44, which suggests that the narrower spread is caused by more efficient trading. The same can be said about the decrease in volatility based on our finding that the risk measured by implied standard deviation decreases more than the historical standard deviation. Since the former type of volatility is more influenced by trading errors, part of which due to credit risk, this evidence too suggests an increase in trading efficiency. Referring to the lack of symmetry in option trading, the literature cites the phenomenon of a Smile (skewness) where the implied standard deviation in options that are deep-in-the-money or deep-out-of-the-money is higher than that of options merely at-the-money. A margining method relying on more precise scenarios, including extreme ones of double the standard deviation value, which account for a Smile or skewness, is likely to promote trading efficiency by pricing more precisely credit risk.

Our findings reveal that increased margining accuracy leads to increased efficiency as reflected by 1) a significantly lower implied price volatility and 2) smaller deviations from put-call price parity, but 3) no systematic decrease in trading volume or increase in bid-ask price spread – all this despite a frequent margin increase.

The remainder of the paper is organized as follows. Section 2 illustrates the principles underlying the SPAN-16 and SPAN-44 margining systems; Section 3 offers simulations aimed at defining the context of our empirical tests; Section 4 reports and analyzes the empirical tests; and Section 5 provides a summary and conclusions.

II. SPAN Margining System

Margin requirements are designed to ensure the contractual rights of option buyers. First introduced by the Chicago Mercantile Exchange (CME) in 1988,[3] the SPAN margining system is based on analysis of the client's portfolio risk. Previously, the CME relied on analysis of the individual option or its trading strategies (Sofianos [1988] and Kupiec and White [1996]). That system typically overstated the risk and required margin by failing to recognize the interaction of returns among various assets. The SPAN margining system was adopted by the TASE in August 1993.

The main inputs of the SPAN system are the scan ranges of price and price volatility of the assets underlying the derivative. Our empirical study focuses on European options written on the TA-25 stock price index (hereafter the Index) composed of 25 companies of the largest capitalization on the Exchange. The Exchange sets a fixed scan range for the price and price

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[3] SPAN is a registered trademark of the CME. For an extensive explanation of the SPAN margining system, see Kupiec (1994).

volatility of the Index as measured by its standard deviation. The standard deviation of implied volatility is averaged across eight options that include two types (call and put), two conditions (in-the-money and out-of-the-money), and two maturity series (expiration within the coming month and the month that follows).

Under the SPAN-16 system, call and put values are calculated by applying the Black-Scholes (1973) model to 16 scenarios. Those scenarios are defined by positive and negative Index changes within a set *price* scan range of 16% (not to be confused with the 16 scenarios) with price intervals set at 1/3 of this range, and a scan range of *price volatility* set at intervals of 1/5 of the Index standard deviation. For example, at the Index price of 450, the scan range is 72 = (0.16)450 and each interval, representing a separate scenario, is 24 = (1/3)72 in each direction. Required margins are calculated at each interval for two standard deviations, each of which representing a discrete scenario. Thus, if the standard deviation is 25%, margin requirements are calculated for each price scenario under the assumption of a rising standard deviation 30% = 25% + (1/5)25% and a falling standard deviation 20% = 25% − (1/5)25%. Two extreme cases of the sharpest price movements (twice the scan range for prices and their standard deviation) are also introduced. For those scenarios, only 35% of the option's theoretical value is applied to reflect a lower probability. This procedure accounts for deep-out-of-the-money options that would otherwise fall outside the scan range.

After setting the theoretical value of each of the options held by the client in each of the scenarios, the most pessimistic outcome is identified and used as a basis for setting the minimum margin that must be deposited with the clearinghouse broker. Appendix Table A1 displays the scenarios calculated under SPAN-16.

Insert Table 1

Table 1 shows the calculation of margin requirements for a strategy involving a long position of two calls with a strike price of 460, and a short position of two calls with strike prices of 450 and 470. After calculating the Black-Scholes value of the entire position using SPAN-16, the margin is set according to the least favorable Scenario 2, indicating a minimum collateral deposit of $181.[4]

Of a similar structure, the modified SPAN-44 margining system defines 44 scenarios with measuring intervals of 1/10, instead of the wider original intervals of 1/3 under the fewer 16 scenarios. The scan range of the price Index and its volatility remain unchanged at 16% and 1/5 of the standard deviation, respectively. See Appendix Table A2 for the calculation of scenarios under SPAN-44.

A comparison between Appendix Tables A1 and A2 shows how the change from SPAN-16 to SPAN-44 generated more precise results by dividing each scan range into smaller intervals between scenarios, each of which has unique margin requirements. Some of the scenarios overlap: SPAN-16 scenarios 1, 2, 11, 12, 13, 14, 15, and 16 in Table A1 are, respectively, identical to SPAN-44 scenarios 1, 2, 3 9, 40, 41, 42, 43, and 44 in Table A2.

III. Margining Precision and Margin Levels: A Simulation

Using simulation based on transaction data, we next explore effects of changing the margining systems on margin levels for three option strategies – “Butterfly,” “Condor,” and a combination of two call options written at strike price X and one call option purchased at strike price Y where Y>X. Our simulation is carried out in two stages. In the first stage, we sample under each strategy two opposite cases – one in which the margin requirements of SPAN-44 are higher than those of SPAN-16, and one in which the opposite is true. In both cases, we assume a standard deviation of 23% with an annual interest rate of 6% at various Index prices. These strategies were selected for their sensitivity to margin requirements. Specifically, the SPAN method takes into consideration only the options held in the investor’s portfolio, not holdings of the underlying real asset. Consistently, if the investor sells a Call or a Put option, the required margin is based on the extreme scenario. This is not an informative case since, as shown in Table 1, the extreme

[4] This outcome is also presented in Figure 1:1a (16 scenarios) below.

scenarios under SPAN-16 and SPAN-44 are similar in this case. Likewise, a Covered Call and a Protective Put associated with a purchase or sale of the underlying asset have no effect on the margin calculation under the two methods. In the same vein, the sale of a Straddle is not an interesting case because the required margin is based on the extreme scenario of a Short Call or a Short Put. Only in a complex strategy, such as Butterfly, the required margin under SPAN-44 can vary from that under SPAN-16.

Insert Figure 1

Results are displayed by six graphs in Figure 1, each incorporating observations from all scenarios under both systems. Graphs 1a, 1c, and 1e offer examples in which the required margin of SPAN 44 is greater than that of SPAN-16; graphs 1b, 1d, and 1f offer examples of the opposite margin relationship. These examples provide initial evidence that SPAN-44 is a more precise margining method, a conclusion further examined below.

The second stage of our comparison consists of a simulation based on transaction data collected during three months surrounding the date of system change – the month of May before the event, followed by July and August after the event. For each day, we calculate margin levels and simulate various strike prices for each of the three strategies – at the prevailing price Index, above the Index, and below the Index – 530 simulations in total. Table 2 summarizes our key findings. The standard deviation we use in calculating the options' margin is measured in the same method used by the TASE clearing house to measure the price volatility of the underlying asset, the TASE-25 index. This is done by calculating the average implied standard deviation of eight options, two call options and two put options of the next maturity date, and a similar set of four of the following maturity date. The mean implied standard deviation of the eight options is used by Exchange members to calculate the minimum margin required of traders. It should be noted that the estimated standard deviation is independent of the price interval. Furthermore, the fat tails in our simulation are taken into account in the same manner as under the procedure followed by the Exchange, using the scenario-based SPAN method. This includes the allowance of a standard deviation that is twice the estimated value, the SPAN treatment of the Smile and Fat-Tails problems**.**

Insert Table 2

The first finding revealed by Table 2 is that the switch to SPAN-44 leads to higher margin requirements in 76% of the cases. Requirements are lower only in 7% of the cases and unchanged in 18%. In interpreting these results, we bear in mind that the strategies used in this comparison were selected *because* of their expected strong influence on margin requirements. Given the equivalence of key scenarios, differences would be small or negligible had we used instead strategies like uncovered puts and calls, straddles, or strangles. Although legitimate, this finding overstates the difference between the two systems.

The second finding is that margin requirements set by SPAN-44 are, on average, 20% higher than those set by SPAN-16. Furthermore, in cases where the required margins of SPAN-44 are lower, the difference between the two margin levels averages only 3%.

The third finding is that these results are not affected either by the month, or by whether and to what extent the options are in-the-money, out-of-the-money, or at-the-money.

IV. Empirical Findings

A. Data

Data include all transactions in options and their underlying asset, the TA-25 Stock Index, during the month of June 2001, just before the system changeover date, and the month of July, just after that change.[5] The overall sample consists of 3,029,877 put and call transactions, 1,525,703 in June and 1,504,174 in July. For each day, the average implied standard deviation (ISD) and bid-ask spread (BA%) reflect all transactions on that day, where:

[5] The empirical tests were replicated using data from the extended period of two quarters (rather than two months) surrounding the changeover date. The results did not differ from those presented here.

$$BA\% = 100\left[{(Ask - Bid)} \Big/ {(Ask + Bid)/2} \right]$$

The effective bid-ask spread on shares comprising the TA-25 in June and July 2001 was calculated for each transaction just before it was conducted. In addition, daily data were collected on options' trading volume and number of open-interest positions. Interest rates are based on the yield-to-maturity of 3-month domestic T-Bills. Trading figures include all transactions for all possible expiration periods – one month, two months, and three months.

B. Findings

Increased trading efficiency. Table 3 summarizes all empirical test results. In the first test, we estimate the effect of the switch from SPAN 16 to SPAN 44 on trading efficiency. Efficiency is defined by the extent of price deviation from put-call parity. Deviation is measured by the absolute ratio between the TA-25 Price Index (S) and the equilibrium price predicted by the put-call parity (S*):

$$\frac{S}{S^*} - 1 = \left| \frac{S}{C - P + Xe^{-rT}} - 1 \right|$$

where P and C are the put and call prices, X is the striking price, T is the number of years to expiration, and r is the annual yield to maturity on 3-month T-Bills. Only options traded within 30 seconds of each other were paired. Test results show that the increase in margining accuracy was associated with a decrease the ratio S/S*-1 from approximately 0.25% to 0.19%, a change significant at the 0.05 level. This result establishes causality between margining accuracy and market efficiency consistent with the theoretical claim of Kose et al. (1997) and the expectations of those implementing the margining change on the TASE.

Insert Table 3

No decrease of trading liquidity or volume. The observed positive effect on trading efficiency was not accompanied by decreased market liquidity, either in the option market or in the market for the underlying stocks comprising the TA-25 Index – and this despite an increase in margin requirements. As those who modified the system hoped for, we find that the change in margining did not adversely affect the trading volume or the number of open positions. Similarly, bid-ask spreads of the options and underlying assets remained unchanged. These findings are consistent with the proposition that increased margin requirements, in and of itself, has contradictory effects on efficiency, especially if the higher margin is not associated with a greater margining accuracy.

Decreased implied volatility. Despite unchanging trading volume and liquidity, the average implied standard deviation (ISD) fell by 3.8%, from 24.56% to 20.77% (below 0.000 significance level). During the same period, the historical standard deviation (HSD) fell only by 1.2%, from 20.78% to 19.54% (0.036 significance level).[6] These findings support claims by Hardouvelis (1988) and Seguin (1990) that increased margin requirements has a positive effect on market stability as measured by a reduction in trading uncertainty. A possible explanation for the lower stock price volatility under SPAN-44 is a stricter, more frequent enforcement due to narrower margin intervals. The larger intervals of SPAN-16 offered greater opportunities for gaming the system.

Accurate pricing lowers risk. The final test is designed to determine the extent to which deviations from put-call parity, our measure of efficiency, is affected by the underlying stock Index price volatility. The following regression (based on data from June-July 2001) indicates a significant positive correlation:[7]

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[6] Historical daily standard deviation (HSD) is estimated using the GARCH (1, 1) model based on daily data of the TA-25 Index from the beginning of April to the end of September, 2001. On the basis of this model, we estimated annual standard deviations by multiplying the daily figure by the square root of the number of trading days in 2001. In addition, since the decision of the TASE to replace SPAN-16 by SPAN-44 was made on June7, 2001, we estimated the changes in ISDs and HSDs in May 2001 as well, two months before the system was changed. The results were essentially the same. On average, ISDs were approximately 24.76% in May compared with 24.56% in June. HSDs came out 21.81% in May compared with 20.77% in June. The insignificant difference (0.17 p-value) indicates that the change was felt only after it went into effect on July 1, 2001.

[7] Here too, the results were essentially the same after extending the sampling period to the two quarters surrounding the date on which the change in the system was initiated.

$$\left(S/S^* - 1\right)_t = -0.0954 + 1.3987 ISD_t + \varepsilon_t$$

(p-value) (0.498) (0.028) $R^2 = 11.5\%$

A similar result is obtained when the independent variable is controlled for the historical daily standard deviation of the stock Index over the same period (HSD_1):

$$\left(S/S^* - 1\right)_t = 0.1846 + 1.4596(ISD_t - HSD_t) + \varepsilon_t$$

(p-value) (0.000) (0.047) $R^2 = 9.5\%$

These results suggest that improved accuracy in margining and the resulting increase in margin levels had a positive effect on the efficiency of option trading mainly through reduced uncertainty. Efficiency increased despite the apparent absence of improved liquidity in the options market or the market for the underlying stock Index.

V. Summary and Conclusions

This paper seeks to determine whether increased margining accuracy can improve the efficiency of option trading by lowering the probability of default without provoking a fully offsetting effect of decreased liquidity. The empirical tests are based on a unique event that took place on the TASE involving an increase in the number of scenarios used in calculating default risk under a U.S.-style SPAN margining system. Efficiency is measured, *inter alia*, by implied volatility, deviations from put-call parity, and liquidity. Supported by a large data set of option transactions and underlying stock price index surrounding this event, our tests show that a switch from the 16-scenario to the 44-scenario SPAN led to increased efficiency by the first two criteria without decreasing efficiency by the third criterion despite generally higher margin requirements.

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Table 1

SPAN-16: Sample Calculation of Margin Requirements

This comprehensive example illustrates the SPAN margining system using the following parameters: (1) TA-25 index – 450; (2) scan range – 16%; (3) TA-25 annual standard deviation – 25%; (4) interest rate – 6% per annum; (5) days to option exercise – 16. The investor is assume to be short in two Calls (450, 470), and long in two Calls (460). For each scenario, the value of each option is calculated according to the B-S model. For scenarios 15 and 16, the B-S result is multiplied by 0.35. Margin requirements are based on the option values of various scenarios. In this example, Scenario 2 represents the worse case, which determines the margin requirement of $181.

Scenario	TA-25 Index	Std. Dev. (%)	"Short" Call (450)	"Long" 2Call (460)	"Short" Call (470)	Total
1.	450	30	-1,186	1,504	-448	-130
2.	450	20	-811	798	-168	**-181**
3.	474	30	-2,826	4,166	-1,461	-121
4.	474	20	-2,605	3,528	-1,077	-154
5.	426	30	-313	324	-78	-67
6.	426	20	-93	56	-7	-44
7.	498	30	-4,979	8,112	-3,194	-61
8.	498	20	-4,922	7,880	-2,991	-33
9.	402	30	-43	34	-6	-15
10.	402	20	-2	0	0	-2
11.	522	30	-7,326	12,626	-5,379	-19
12.	522	20	-7,318	12,642	-5,327	-3
13.	378	30	-2	2	0	-0
14.	378	20	0	0	0	0
15.	594	50	-5,083	9,473	-4,391	-1
16.	306	50	0	0	0	0

Table 2

Required Margins: SPAN-16 vs. SPAN-44

This table presents the results of 530 simulations based on transaction data of the three months surrounding the system changeover date – June before the change, and July-August after the change. For each trading day, we calculate the margin levels and simulate striking prices under three strategies: at the prevailing Index price, above that price, and below that price. The strategies are: "Butterfly," "Condor," and a combination of writing two calls at the striking price X, and purchasing a call at striking price Y where Y>X.

		Cases of higher margin level:		
		SPAN 44	SPAN 16	No Difference
Total	**All Observations**	**402**	**35**	**93**
By expiration date	Long portfolios	217	18	53
	Short portfolios	185	17	40
By extent of in- or out-of-the money	Out-of-the-money	144	13	20
	At-the-money	127	7	42
	In-the-money	131	15	31
By month	June 2001	127	8	35
	July 2001	129	12	30
	August 2001	146	15	28

Table 3

The Impact of Switching from SPAN-16 to SPAN-44

This table summarizes the effects of changing the margining system on trading volume, deviation from put-call parity, bid–ask spread (BA%) on options and shares, number of open positions, implied standard deviation (ISD), and skewness of ISD distributions. Period 1 refers to trading data in the month preceding the change; Period 2 refers to the month immediately following the change. The historical daily standard deviation (HSD) is estimated using the GARCH (1, 1) model and based on daily data of the TA-25 stock Index from the beginning of April 2001 until the end of September 2001. Annual standard deviations are calculated by multiplying the daily figure by the square root of the number of trading days in 2001. The deviation from put-call parity prices is calculated on the basis of at-the-money options as follows:

$$\frac{S}{S*} - 1 = \left| \frac{S}{C - P + Xe^{-rT}} - 1 \right|$$

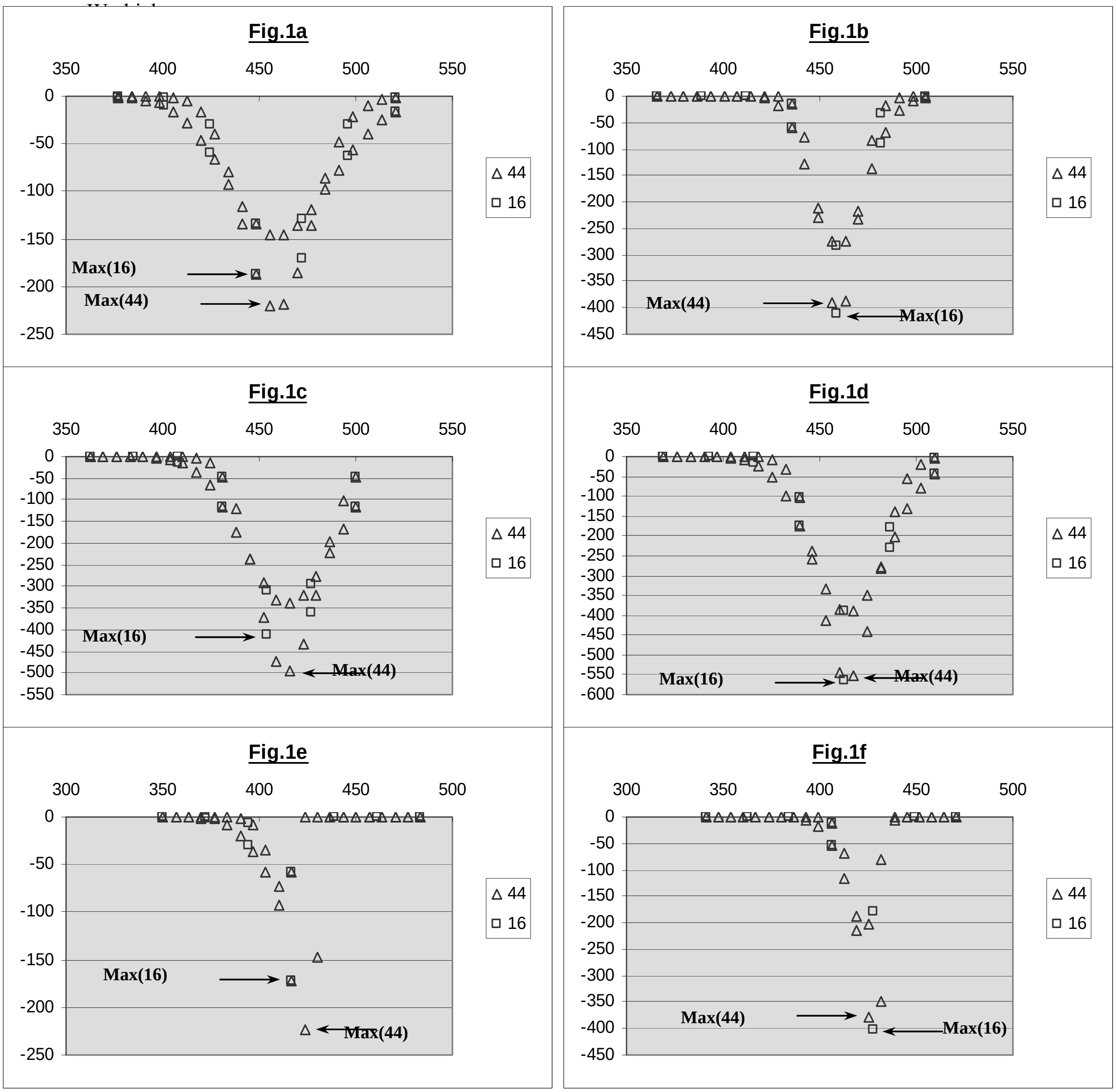
In this table, the daily average of each parameter (22 observations in the month preceding the change, and 21 observations in the month following the change) is presented on the basis of average trading volume for each trading day. Daily averages are derived from intra-day data.

	Period 1 – Before Change	Period 2 – After Change	p-value
Trading Efficiency by:			
100(S/S*-1)	0.2513	0.1921	0.054
Liquidity by:			
Bid-Ask Spread (BA%)			
TA-25 stocks	0.4549	0.4339	0.387
Options- entire sample	3.2374	3.2325	0.851
At-the-money options	2.5186	2.6327	0.624
Trading volume (No. of contracts)	109,193	105,179	0.571
Open interest (No. of contracts)	367,065	348,962	0.504
Uncertainty by:			
Implied standard deviation – TA-25	0.2456	0.2078	0.000
Historical standard deviation – TA-25	0.2077	0.1954	0.036

Figure 1

Margin Requirements for Various Trading Strategies

This table displays graphic representations of three trading strategies: "Butterfly" (Fig. 1a, 1b), "Condor" (Fig. 1c, 1d), and a combination of two calls written at strike price X, and one call purchased at strike price Y where Y>X (Fig.1e, 1f). For each of these strategies, we plot cases in which SPAN-44 renders comparatively higher margin requirements than SPAN-16, and cases in which the opposite holds. Figures 1a, 1b, and 1e offer examples in which SPAN-44 leads to higher margin requirements, while Figures 1b, 1d, and 1f are counter-examples where SPAN-16 renders higher margin levels than SPAN-44. Margin requirements for each method are indicated on each of the graphs.



APPENDIX

Table A1: The Scenarios under SPAN-16 (Replaced July 1, 2001)

In this table, S stands for the TA-25 stock price Index and M for its volatility coefficient. Sigma denotes the annual standard deviation, and α the volatility coefficient of the standard deviation as set by the TASE. For the sample period, M = 0.16 and $\alpha = (1/5)\sigma$.

Scenario No.	Scenario Index	Scenario Standard Deviation
1.	S	$\sigma + \alpha$
2.	S	$\sigma - \alpha$
3.	S[1 + (1/3)M]	$\sigma + \alpha$
4.	S[1 + (1/3)M]	$\sigma - \alpha$
5.	S[1 − (1/3)M]	$\sigma + \alpha$
6.	S[1 − (1/3)M]	$\sigma - \alpha$
7.	S[1 + (2/3)M]	$\sigma + \alpha$
8.	S[1 + (2/3)M]	$\sigma - \alpha$
9.	S[1 − (2/3)M]	$\sigma + \alpha$
10.	S[1 − (2/3)M]	$\sigma - \alpha$
11.	S(1 + M)	$\sigma + \alpha$
12.	S(1 + M)	$\sigma - \alpha$
13.	S(1 − M)	$\sigma + \alpha$
14.	S(1 − M)	$\sigma - \alpha$
15.[+]	S(1 + 2M)	2σ
16.[+]	S(1 − 2M)	2σ

[+] Extreme scenarios.

Table A2: The scenarios under SPAN-44 (beginning July 1, 2001)

In this table, S stands for the TA-25 stock price Index and M for its volatility coefficient. Sigma denotes the annual standard deviation, and α the volatility coefficient of the standard deviation as set by the TASE. For the sample period, M = 0.16 and α = (1/5)σ.

Scenario No.	Scenario Index	Scenario Standard Deviation
1.	S	$\sigma + \alpha$
2.	S	$\sigma - \alpha$
3.	S(1 + 0.1M)	$\sigma + \alpha$
4.	S(1 + 0.1M)	$\sigma - \alpha$
5.	S(1 − 0.1M)	$\sigma + \alpha$
6.	S(1 − 0.1M)	$\sigma - \alpha$
7.	S(1 + 0.2M)	$\sigma + \alpha$
8.	S(1 + 0.2M)	$\sigma - \alpha$
9.	S(1 − 0.2M)	$\sigma + \alpha$
10.	S(1 − 0.2M)	$\sigma - \alpha$
11.	S(1 + 0.3M)	$\sigma + \alpha$
12.	S(1 + 0.3M)	$\sigma - \alpha$
13.	S(1 − 0.3M)	$\sigma + \alpha$
14.	S(1 − 0.3M)	$\sigma - \alpha$
15.	S(1 + 0.4M)	$\sigma + \alpha$
16.	S(1 + 0.4M)	$\sigma - \alpha$
17.	S(1 − 0.4M)	$\sigma + \alpha$
18.	S(1 − 0.4M)	$\sigma - \alpha$
19.	S(1 + 0.5M)	$\sigma + \alpha$
20.	S(1 + 0.5M)	$\sigma - \alpha$
21.	S(1 − 0.5M)	$\sigma + \alpha$
22.	S(1 − 0.5M)	$\sigma - \alpha$
23.	S(1 + 0.6M)	$\sigma + \alpha$
24.	S(1 + 0.6M)	$\sigma - \alpha$
25.	S(1 − 0.6M)	$\sigma + \alpha$
26.	S(1 − 0.6M)	$\sigma - \alpha$
27.	S(1 + 0.7M)	$\sigma + \alpha$
28.	S(1 + 0.7M)	$\sigma - \alpha$
29.	S(1 − 0.7M)	$\sigma + \alpha$
30.	S(1 − 0.7M)	$\sigma - \alpha$
31.	S(1 + 0.8M)	$\sigma + \alpha$
32.	S(1 + 0.8M)	$\sigma - \alpha$
33.	S(1 − 0.8M)	$\sigma + \alpha$
34.	S(1 − 0.8M)	$\sigma - \alpha$
35.	S(1 + 0.9M)	$\sigma + \alpha$
36.	S(1 + 0.9M)	$\sigma - \alpha$
37.	S(1 − 0.9M)	$\sigma + \alpha$
38.	S(1 − 0.9M)	$\sigma - \alpha$
39.	S(1 + M)	$\sigma + \alpha$
40.	S(1 + M)	$\sigma - \alpha$
41.	S(1 − M)	$\sigma + \alpha$
42.	S(1 − M)	$\sigma - \alpha$
43. $^{+}$	S(1 + 2M)	2σ
44. $^{+}$	S(1 − 2M)	2σ

$^{+}$ Extreme scenarios.