THE VALUE OF TRADING CONSOLIDATION: EVIDENCE FROM THE EXERCISE OF WARRANTS

YAKOV AMIHUD  
BENI LAUTERBACH  
HAIM MENDELSON
The Value of Trading Consolidation: Evidence from the Exercise of Warrants

Yakov Amihud, Beni Lauterbach and Haim Mendelson*

Revised May, 2002

Abstract

We study the effect of trading consolidation by examining the response of liquidity and stock price to the exercise of deep in-the-money corporate warrants. This enables a relatively clean test of the value of trading consolidation. The exercise at the warrant expiration is fully anticipated and has no information content. An effect can come from the value of trading consolidation that improves liquidity. Indeed, we find that liquidity and stock prices both increase significantly at warrant expiration. Further, the price increase is positively related to the pre-exercise extent of fragmentation, to post-exercise improvement in stock liquidity and to the proportional increase in the number of shares following the warrant exercise.

JEL Classification: G14

Keywords: Trading fragmentation; market microstructure; value of liquidity.

* Amihud, yamihud@stern.nyu.edu, Stern School of Business New York University. Lauterbach, lauteb@ashur.cc.biu.ac.il, School of Business Administration Bar Ilan University. Mendelson, haim@haim.stanford.edu, Graduate School of Business Stanford University. Amihud is Ira Leon Rennert Professor of Entrepreneurial Finance. We would like to thank an anonymous referee and the editor Jon Karpoff, for comments and suggestions that helped improve the paper. Financial support from the Israel Institute for Business Research of the Recanati Business School at Tel-Aviv University is gratefully acknowledged.
I. Introduction

The U.S. securities markets are characterized by multiple trading venues for the same, or closely-related, securities. The same stock may be traded on the New York Stock Exchange (NYSE), five Regional Exchanges, and alternative trading systems such as Instinet, Archipelago and ITG’s Posit. NASDAQ stocks are typically traded also on market-makers’ internal execution systems and on alternative trading systems like Instinet and Island. The Chicago Board of Trade and eSpeed trade closely-related futures contracts with the blessing of the Commodity Futures Trading Commission. Advocates of multiple trading venues argue that they encourage competition, put a downward pressure on the cost of trading, and enable new market mechanisms to emerge.

Several studies, however, show that fragmentation can hurt market performance. Cohen, Maier, Schwartz and Whitcomb (1982) study the effect of having, in addition to the main market, order execution in “satellite” markets off the exchange floor. They show that while off-exchange execution is beneficial for brokers, it can result in larger bid-ask spreads and greater price volatility than a consolidated market. Along similar lines, Cohen, Conroy and Maier (1985) show that in a fragmented market there is a lower chance that an order will find a trading counterpart, an increase in the expected time a limit order has to wait until it is executed, and a wider bid-ask spread. Mendelson (1987) shows that the overall gains from trade decline as the market becomes more fragmented. Thus, theory suggests that fragmentation reduces liquidity.

Is the fragmentation of trading actually harmful to liquidity and, consequently, does it lower stock values? The answer is important for the design and regulation of
securities markets. This issue took center stage since the Securities and Exchange Commission (SEC) pressured the NYSE to relax its Rule 390, which prohibited member firms from executing trades in NYSE-listed stocks off the Exchange floor.\(^2\) In 1980, the SEC enacted Rule 19c-3 that allows member firms to trade stocks off the exchange floor if they were listed after a cutoff date. More recently, this issue came up when Instinct applied for membership on a number of stock exchanges, which would have caused trading of the same security in two parallel systems.

The recent proliferation of electronic markets and trading platforms made market fragmentation more widespread, which led the SEC to issue a Concept Release examining the potentially harmful effects of fragmentation and ways to address them. In response, five major Wall Street brokers – Merrill Lynch & Co., Goldman, Sachs & Co., Morgan Stanley, Edward Jones and ABN Amro – joined to present a proposal to consolidate trading so fragmentation is avoided.

The consolidation/fragmentation debate is replayed in multiple countries and over time, with different outcomes. Because liquidity significantly affects the cost of capital (Amihud and Mendelson (1996)), the stakes are high, but the evidence is inconclusive. The U.S. regulatory approach is based on a tradition of inter-market competition, with broker/dealers and sophisticated investors deciding where to trade. Implicitly, this approach assumes that if consolidation were the efficient solution, one of the trading venues would emerge as a natural monopoly, absorbing the order flow from all other trading venues. Proponents of consolidation, however, argue that individual traders’

\(^1\) Island is an Electronic Communication Network (ECN) that serves as an electronic marketplace. In 2001, about 20% of NASDAQ volume was traded on Island.

decisions will not lead to the overall optimum because of externalities: “When traders
join the market, they certainly gain some surplus as a result; but they also increase the
surplus of all other traders by increasing the liquidity of the market (by providing traders
on the other side of the market the opportunity to trade with them),” and they have no
incentive to take these additional benefits into account (Mendelson (1982)). Thus, the
equilibrium outcome reflecting the choices of market participants may not maximize
overall welfare. Similarly, Hendershott and Mendelson (2000) show that when trading
takes place in multiple markets, liquidity often suffers as the bid-ask spread is set in a
“market of last resort.” These theoretical arguments, however, bear the burden of
empirical tests showing that consolidation can create value.

The empirical evidence on the effects of market fragmentation on trading costs is
mixed. Bessembinder and Kaufman (1997) study the effects of enacting Rule 19c-3,
comparing actual transaction costs for 300 NYSE-listed stocks that are also traded on
regional exchanges and on NASDAQ. They find that both the effective bid-ask spread
and the market-impact cost are larger for 19c-3 stocks. Lee (1993) analyzes the
execution prices of adjacent trades of stocks on the NYSE and off-board, in regional
exchanges and on NASDAQ. He finds that fragmentation has increased transaction costs
by 0.7 to 1 cents per share, on average. On the other hand, Neal (1987) finds that
multimarket trading and inter-market competition in options trading is beneficial:
American Stock Exchange (AMEX) options that are also traded in other markets enjoy
narrower bid-ask spreads than options that trade exclusively on the AMEX. Khan and
Baker (1993) examine cases where regional exchanges attract trades in listed stocks away
from the main exchanges (NYSE and AMEX). Their results are mixed: low-liquidity
stocks benefit from the competition of regional exchanges, whereas the liquidity of large, actively traded stocks is hurt by fragmentation.

The international evidence on the effects of multiple listing is similarly inconclusive. Pagano and Roell (1993) find that the bid-ask spreads on French stocks traded in London narrow after the opening of the Paris Bourse, their home market, and widen again after the Bourse closes. Yet, opposite results appear for Italian stocks traded in both Milan and London, where the fragmentation of trading between the two markets is associated with wider bid-ask spreads (Pagano and Roell (1990)). Fang (1997) examines the price effect of dual listing - listing on the Hong Kong Stock Exchange of stocks that have been already traded on the Shanghai Stock Exchange. Comparing the pre-listing prices of the dually-listed stocks to their prices 40 days after the dual listing (controlling for the market effect), he finds that the prices of the dually-listed stocks decline as a result of the dual listing.

The above results provide only partial and indirect tests of the effect of trading fragmentation. For example, because of institutional differences between the markets being compared, the effects of fragmentation may be confounded with the effects of the institutional framework. Furthermore, most of the above studies do not directly address the core issue of the value effect of trading consolidation: is it valuable, and why?\(^3\)

A pure test of the effects of fragmentation would artificially segregate trading in a security into two versions of the security, say \(A\) and \(B\), using the same trading mechanism in the same market, and then convert all \(B\)'s into \(A\)'s. If the consolidation of trading in the two identical securities leads to an increase in \(A\)'s price, this would support the

---

\(^3\) Amihud and Mendelson (1986) show that liquidity has a positive value effect, providing a link between measures of liquidity and value.
hypothesis that the consolidation of trading is valuable (or, conversely, that fragmentation is harmful). In seeking to conduct such an experiment, we note that fragmentation of trading can occur even within a single market, when similar securities are traded side by side. Suppose a company has two classes of shares traded in the market, which are identical in every respect but are traded separately. If the two classes are merged at some point, we can directly study the effects of consolidation on stock values.

This paper comes close to performing a “pure” test of the value effects of consolidation. We study two practically identical securities that are traded side-by-side in the same market: a stock and a warrant on the stock that is deep in the money at expiration. On the day of the warrant expiration, the formerly fragmented trading in these two almost identical securities is completely consolidated. The company issues additional shares against the warrants, and from then on there is a single equity claim, with a larger float, that is traded in the market. Since the exercise of the warrant is fully anticipated, there should not be any information-related effect on stock price. However, if the consolidation of trading is valuable for liquidity reasons, we should find a positive effect of consolidation on the stock price on the exercise day.

Having multiple versions of the same security trading in the same market reduces liquidity because the order flow is fragmented. As a result, the price impact of a given order flow is larger, trading in each security is thinner, and liquidity is lower. The exact way in which fragmentation affects market performance depends on the market’s trading mechanism.

Our study examines 123 warrant exercises on the Tel-Aviv Stock Exchange (TASE) during 1992-97. Sixty-seven percent of the sample stocks and all warrants were
traded once a day in a computerized Call Auction that resembles the “clearing house” mechanism analyzed by Mendelson (1987). The rest of our stocks, comprising larger and relatively heavily traded stocks, were traded more frequently using the Variable-Price Mechanism. Under the Variable Price Mechanism (hereafter VPM), trading opened with a call auction and proceeded with a series of sequential trading sessions in a trading arena which resembles a trading pit. There were no designated market-makers or specialists, and no measurable bid-ask spread (see Amihud, Mendelson and Lauterbach (1997)).

In the trading environment we study, traders could not take advantage of the liquidity available in one security when they traded in the other. Orders for each security (stock or warrant) were separate, and in many cases traders could rebalance their portfolios, in light of the executions they received, only on the following trading day. The extent of this problem was lessened for stocks that traded using the VPM. While VPM trading was not continuous, some offsetting and rebalancing trades were possible on the same day. Mendelson (1987) shows that in this environment, fragmentation between markets (or between versions of the same security) reduces the trading volume and the quality of price signals as well as the expected gains from trade.\(^4\) Thus, upon consolidation, both liquidity and value should increase. However, the benefits of consolidation can be different for securities that have traded beforehand under different methods, because the extent of fragmentation is more severe in the once-a-day call auction than it is under the. We examine these differences empirically.

Following the consolidation of trading in the two equity claims as a result of

\(^4\) Indeed, there could be differences between the underlying stock price and the price implied by the warrant’s price on the same day, since the two prices were set separately. Evidence on price differences between practically identical securities is presented in Lauterbach and Wohl (2001). They find that on most
warrant exercise, we find that the liquidity of the stock improves, attesting to the beneficial effect of consolidation. In addition, stock prices appreciate by 1.27%, on average, on the warrant expiration. This price increase, which is highly statistically significant, may appear inconsistent with market efficiency, since the warrant expiration is an anticipated event and the warrants are deep in the money. However, in order to gain from the price increase, an investor would have to buy the stock before the expiration and sell later, incurring transaction costs whose magnitude would eliminate most (if not all) of the gain from the price increase on the warrant expiration day. Therefore, the anticipated price appreciation on the warrant expiration day was bounded by transaction costs.\textsuperscript{5}

A loosely related literature examines the effect of options expiration on the behavior of the underlying stock price.\textsuperscript{6} But options are claims on existing shares, so their exercise does not broaden the market for shares. And, when options expire, new options series are generated on the same underlying stock, hence the trading of the stock and the option remains separate. In contrast, warrants are claims on new shares, so their

\textsuperscript{5} These costs include brokerage fee, illiquidity cost and the cost of holding an unhedged risky position (see below).

\textsuperscript{6} Studies of options expiration present mixed results on the value effect. Klemkosky (1978) finds negative abnormal returns on the underlying stock in the week before the expiration of options listed on the Chicago Board Options Exchange that is partially reversed in the subsequent week. Officer and Trennepohl (1981) find significantly negative abnormal returns on the Thursday and Friday preceding expiration, a negative (insignificant) return on the Monday following expiration, and a significantly positive partial adjustment on Tuesday. Pope and Yadav (1992) find similar, albeit smaller, effects in the UK, and Bhattacharya (1987) finds no evidence of abnormal price behavior of bond futures contracts either before or after the date of option expiration. However, Bhattacharya (1987) finds evidence of increased price and volume volatilities prior to option expiration. With respect to the effects of option listing, Sorescu (2000) finds that prior to 1981, option listing increased the price of the underlying, consistent with earlier studies, whereas since 1981, option listing have been associated with negative abnormal returns for the underlying. Danielson and Sorescu (2001) show that the price effect of option introductions is cross-sectionally related to contemporaneous increases in the level of short interest of the underlying stock, and suggest that changes in the price and short interest around option introductions reflect a reduction in the short sale constraints affecting the underlying.
exercise increases the number of shares traded and leaves only one active market for the security.

In what follows, we present tests on how the consolidation of trading, following the warrants’ expiration, affects stock liquidity and stock prices. We describe the data in Section II and the effects of the exercise on the underlying stock trading volume and liquidity in Section III. Section IV tests the effects of the warrant exercise on stock value, and Section V presents our concluding remarks.

II. Data and Institutional Background

A. Data

To test the effect of consolidation on stock values, we collect data from the Tel Aviv Stock Exchange (TASE), where companies commonly issue warrants. Most companies that go public issue packages consisting of stocks and warrants. For example, 81% of all IPOs in Israel between 11/1989 and 11/1993 were unit IPOs that included warrants (see Amihud, Hauser and Kirsh (2002)). Warrants constituted a considerable part of the equity value: in our sample of companies, warrants are 18% of the outstanding shares of stock (see below).\(^7\) Most of the companies in our sample that have warrants are small and trading in their stock is thin. When the warrants are exercised, there is a sizable increase in the number of shares traded and a meaningful change in liquidity.

Our sample consists of all the warrants that were exercised on the TASE over the 1992-1997 period, except for three warrants for which data were missing. There are 153

\(^7\) Green (1984) shows that warrants reduce agency costs by reducing risk incentives in the presence of risky debt. Schultz (1993) proposes that issuing warrants at the IPO can help solve some agency problems in young entrepreneurial firms.
warrants that were exercisable as of three days before expiration, i.e., they were in the money (the stock price exceeded the exercise price). However, since we want to consider the consolidation of two identical securities into one, we have to confine our study to those warrants that are practically substitutes of the stock. To do that, we confine the study to warrants whose price sensitivity to stock price exceeds 0.995. We approximate the warrant price sensitivity using $\Delta (= \partial C/\partial S)$ of the Black-Scholes call option model, using representative parameters for our sample stocks and period: $\sigma = 0.40$ (annual), $r = 0.13$ (annual), and $T = 3$ days. We choose $T = 3$ days since, by the TASE rules, warrants cease trading two days before expiration, and individual investors have to notify their broker of their intention to exercise their warrants no later than two days before expiration (institutional investors can notify their intention by the expiration day). We obtain that our choice criterion is satisfied for $S/X \geq 1.10$. We thus set the cutoff at $S/X = 1.10$, that is, we include in our study cases for which the stock price is 10% higher than the warrant exercise price three days before expiration. There are 123 warrants that qualify; the distribution of their “moneyness” is shown in Table 1 by the variable INMONEY, the ratio of stock price three days before expiration to the exercise price.

**INSERT TABLE 1**

Data on the warrants and general trading statistics are collected from TASE publications, mainly *This Month in the Exchange, Daily Stock Prices*, and *Marketability Guide* (all in Hebrew). Data on stock prices and trading volumes are obtained from the

---

8 For example, $\Delta = 0.996$ for $S/X = 1.10$ but only 0.918 for $S/X = 1.05$. Another way to look at it: if
database of *Tochna Lainyan*, a leading stock data dissemination company in Israel.

B. Trading Mechanisms

All warrants and most stocks traded on the TASE by the Call Auction method. Before the auction, traders submit market and limit orders to the TASE, which electronically communicated the excess demand or supply for each stock and warrant at the previous day’s closing price. Traders could observe these excess demand/supply values and submit additional orders in the opposite direction (only). That is, after the TASE announced the initial excess demand (supply), traders could submit sell (buy) orders only. The process was then repeated one more time. Finally, the TASE computed the new equilibrium prices that were announced simultaneously for all stocks and warrants.

Given this trading structure, traders would often remain with a residual demand to trade, which could be satisfied only on the following day’s Call Auction. Further, arbitrage appears impossible, and price gaps emerge between the warrants and the underlying stocks that were traded separately. Thus, the fragmentation of trade brought about several problems, which increased the explicit and implicit costs of trading.

The problems of fragmentation were partly mitigated for the more heavily traded stocks that were traded by the Variable-Price Mechanism (VPM). These stocks opened with a call auction (as above), and then proceeded with a series of sequential trading sessions in a trading arena resembling a pit. In each session, stocks were announced in a predetermined order, and traders could execute bilateral trades until the market cleared.

\[ X = \$100, \text{ the option premium is } \$0.11 \text{ for } S = \$110, S = \$111 \text{ and } S = \$200, \text{ but it is much higher, } \$0.29, \text{ for } S = \$105. \]
Since some intra-day adjustments were possible when the stock was traded by the VPM, we expect the costs of fragmentation to be smaller for VPM stocks.

III. Trading Volumes and Changes in Stock Liquidity

A. Pre-exercise Fragmentation

Warrants constituted a sizable proportion of the equity of companies that had them. We calculate two measures of their importance. The first is $RATWS$, the ratio of warrants to shares of stock on the warrants’ expiration day for each company. The second is $VOLRWS$, the ratio of the average daily trading volume of warrants to the average daily trading volume of the stock in the three quarters preceding the quarter when the warrants expired. (Volume is in monetary units.) The data are presented in Table 1.

The extent of fragmentation due to the existence of warrants on the stock is substantial. Warrants, when exercised, become a considerable proportion of their firms’ equity. In our sample, the average ratio of warrants to shares of stock ($RATWS$) is 18%, with a minimum of 7.6% and a maximum of 50.4%.

The ratio of trading volume in the warrant to trading volume in the stock ($VOLRWS$) is quite high prior to the warrant exercise. The warrant trading volume is 46.9% of the stock trading volume (see Table 1). This is noteworthy since the warrant price is lower than the share price, and warrants comprise only 18% of the shares of stock.

There are a number of explanations for the higher turnover of warrants. First, in the TASE, the public holds only a third of the stock, the rest being held by insiders who rarely trade. In contrast, public investors hold most warrants. For example, on December
2000, insiders held 33.8% of the warrants, an exact reverse of the holdings of stock.\footnote{The data source on stock holding is Hahodesh Babursa (This Month in the TASE), various issues. We thank Kobi Abramov of the TASE for providing us with data on warrants’ ownership.} Thus, while warrants constitute 18% of the shares of stock, they represent a much larger proportion of the float in the company’s equity claims.

Second, warrants provide a convenient way of leveraging the investment in the stock. In Israel, leveraging via warrants is less costly (in terms of transaction costs, fees and monitoring efforts) than taking a bank or broker loan and investing in the stock. Hence, investors who wish to leverage may prefer the warrants to the stock.

Third, the high turnover of warrants relative to that of stocks may reflect induced “arbitrage” trading between warrants and the underlying stock in response to changes in their relative prices. This raises the turnover of warrants relative to stock, since the quantity outstanding of warrants is smaller. Pure arbitrage, however, is limited in Israel because of the trading mechanism limitations described in II.B above, and because of various regulations that make it difficult and (relative to the U.S.) expensive to short-sell securities. Thus, the term “arbitrage trading” in this paper refers primarily to (risky) switching activity between warrant and stock.

**B. Post-exercise Changes in Liquidity**

We expect an increase in the liquidity of the underlying stock after the warrants are exercised. A commonly used measure of illiquidity is the stock’s bid-ask spread. However, there are no market-makers quoting bid and ask prices on the TASE and most stocks in our sample traded in a once-a-day call auction. Therefore, bid-ask spreads are not available. Instead, we use two variables that proxy for liquidity.
1. Trading volume

The first measure of liquidity is the stock’s trading volume. We expect the trading volume in the stock to rise, since trading that has previously taken place in warrants partially shifts to the stock, raising the stock’s liquidity. We calculate the change in the relative trading volume in the stock as follows. Let $DVOL_j$ denote the change in the trading volume of stock $j$ relative to the market volume:

$$ DVOL_j = \log(VOL_j^A/VOL_m^A) - \log(VOL_j^B/VOL_m^B), $$

where $VOL$ is the average daily volume (in monetary units) and $j$ and $m$ indicate stock $j$ and the market, respectively. “$A$” indicates the period of 200 days following the expiration window, days (+11, +210), “$B$” indicates the period of 200 days before the expiration window (days −210, −11), and the expiration window consists of the 20 days straddling the expiration day.

**INSERT TABLE 2**

The trading volume in the stock rises after the warrant exercise. The average $DVOL$ is 0.115 with $t = 1.96$. This increase in average stock volume is insignificantly different from the average increase in number of shares following the warrant exercise. The average increase in the stock trading volume is, however, significantly smaller than the extent of trading in the warrants relative to trading in the stock during the period before the warrant expiration. This reflects the advantages of warrant trading over trading the underlying stock, as discussed earlier. The evidence that stock trading
volume rises less than the pre-exercise warrant trading volume may also reflect the elimination of arbitrage trading between the warrant and the stock.

2. Implicit spread

The second measure of liquidity is based on Roll (1984), who shows that the implicit bid-ask spread, \( \text{SPREAD}_j \), can be calculated using the autocovariance of stock returns, \( \text{COV}_j = \text{Cov}(R_{j,t}, R_{j,t+1}) \), as:

\[
2 \cdot \sqrt{-\text{COV}_j}.
\]

(2)

In this context, the implicit spread reflects the transitory price impacts of temporary excess demand and supply, which cause the price to bounce between the bid and the ask. Such bounces generate a negative \( \text{COV}_j \), even when the “true” price of the stock is serially uncorrelated.

We calculate the \( \text{COV}_j \) of each stock \( j \) from daily returns over 200 days before (“B”) and 200 days after (“A”) the warrant expiration window. The change in the return autocovariance,

\[
\text{DCOV}_j = \text{COV}^A_j - \text{COV}^B_j,
\]

(3)

can be used as an estimate of the change in liquidity. If stock liquidity improves, the stock’s implicit bid-ask spread decreases and \( \text{DCOV} \) should be positive. Indeed, the results in Table 2 show that the mean \( \text{DCOV} \) is 0.0684 with \( t = 3.50 \), highly significant.\(^{10}\)

\(\text{\textsuperscript{10}We find, like Roll (1984), that for many stocks } \text{COV}_j > 0. \text{Roll (1984) points out that } \text{COV}_j \text{ may be positive due to “inefficiency-induced positive dependence” in daily returns (p. 1134). Amihud and Mendelson (1987) model this dependence using a lagged price-adjustment model. In their model, the \text{“true” (log) price on day } t, P^*_t, \text{ adjusts only partially to the intrinsic (log) value, } V_t, P^*_t = P_{t-1} + g (V_t - P_{t-1}), \text{ and the observed price on day } t, P_t, \text{ is related to the \text{“true” price } P^*_t \text{ by } P_t = P^*_t + u_t, \text{ where } u_t = S \text{ or } -S \text{ with equal probabilities, reflecting the bid-ask bounce (} S \text{ is half the bid-ask spread). The intrinsic stock value } V_t, \text{ evolves as a random walk with a constant positive drift and innovations } e_t, \text{ Var}(e_t) = v'. \text{ From this, } \text{COV} = \frac{g}{2(2-g)} \cdot \{(1-g) \cdot v' - S^2\}. \text{ If } 0 < g \leq 1, \text{ it is possible to have } \text{COV} > 0. \text{ Absent more information, we cannot calculate the necessary parameters } g, v' \text{ and } S \text{ -- from the observed return variances and covariances. Schultz (2000) proposes the use of transaction-by-transaction data to estimate the implicit spread. Unfortunately, most stocks in our sample were traded by the Call Auction method, which results in}\} \)
Further, $DCOV$ is positive for 63.4% of the sample, and this proportion is significantly higher than 50% ($t = 2.98$). These results show that liquidity, as measured by $COV$, improves significantly following the warrants’ exercise.

3. The Relation of Liquidity Changes to Fragmentation

We attribute the increase in liquidity to the consolidation of trading, brought about by the warrant exercise. If so, the increase in liquidity should be positively related to the degree of fragmentation before the warrant expiration. To test this proposition, we estimate the models:

\[(4.1) \quad DLIQUIDITY_j = \gamma_0 + \gamma_1 VOLRWS_j + u_j \]

\[(4.2) \quad DLIQUIDITY_j = \gamma_0 + \gamma_1 RATWS_j + u_j . \]

For $DLIQUIDITY_j$ we use $DVOL_j$ or $DCOV_j$, our measures of the change in stock liquidity at the warrant expiration. The right hand side variables are measures of fragmentation prior to the expiration. $VOLRWS_j$ is the ratio of the trading volume of warrants to that of the stock in the three quarters before expiration, and $RATWS_j$ is the ratio of the number of warrants to the number of shares of stock outstanding. After the warrants are exercised, they are converted into shares of stock. Thus, our hypothesis is that in both models $\gamma_1 > 0$.

The estimation results of these models, presented in Table 2, strongly support our hypothesis. The consolidation of previously fragmented trading leads to significant improvement in liquidity, measured by $DVOL_j$ or $DCOV_j$. And, the greater the

---

a single (aggregate) transaction per day. For stocks that traded under the VPM, the transaction data are not available.
fragmentation before the warrants' expiration, the greater the improvement in liquidity afterwards.

IV. The Effect of Warrant Exercise on Stock Values

A. Hypotheses

As discussed in the Introduction, theory suggests that the consolidation of trading may increase liquidity and thereby stock values. In general, there is a tradeoff between the costs of fragmentation and the benefits of inter-market competition. However, in the case at hand, both the underlying stocks and the warrants are traded in the same market. Hence, inter-market competition does not exist, which enables us to directly examine the costs of fragmentation. Note that while each investor acts on his or her own in a way that is individually optimal, all investors collectively bear the costs of fragmentation. These costs are like a negative externality that no single investor will endeavor to correct on his or her own (see Amihud and Mendelson (1996) for a discussion).

Our main test is whether stock prices are affected by the consolidation of trading. Given that the warrant exercise on the expiration day has no information content (we include only warrants that are deep in the money prior to expiration), our conservative null hypothesis is that the abnormal return on the stock is zero. Against this null, the first alternative hypothesis is:

\[ H1: \text{ Stock prices should rise if fragmentation of trading is harmful and consolidation of trading is beneficial. } \]

Hypothesis \( H1 \) can be reasoned as follows. On the expiration day, the number of shares increases and there is a consolidation of trading in the two securities – the stock
and the warrant – that had previously been traded separately. The ensuing improvement in liquidity should bring about a higher stock price (Amihud and Mendelson (1986), Brennan and Subrahmanyam (1996), Amihud, Mendelson and Lauterbach (1997)).

It could, however, be argued that warrants offer individuals flexibility and cheap leverage whose elimination, upon warrant exercise, reduces investors’ welfare and weakens public interest in the stock (recall from Table 1 that warrant trading has a special appeal for investors).\(^{11}\) We therefore consider a second alternative hypothesis:

\textbf{H2:} Stock prices should decline because of the elimination of trading opportunities afforded by warrants.

In fact, it could well be that both effects are present. Then, the results will show which effect is stronger.

\section*{B. Estimation Results}

To test these hypotheses, we calculate the abnormal returns,\(^{12}\)

\begin{equation}
AR_{jt} = R_{jt} - RM^S_t,
\end{equation}

where \(R_{jt}\) is the return on stock \(j\) on day \(t\), and \(RM^S_t\) is the return on the market size-based index \(S\) on day \(t\). For the forty large stocks in our sample that have traded on the semi-continuous variable-price method we use as benchmark \(RM^S_t\), the value-weighted TASE index. For the 83 smaller stocks that have traded under the Call Auction mechanism we

\(^{11}\) We are not aware of a theoretical body of research that directly predicts that this should affect the stock price. Yet, such an effect is plausible.

\(^{12}\) See Brown and Warner (1980, 1985) on this method of calculating the abnormal return. In our case it appears inappropriate to employ the conventional market model methodology and estimate the market model parameters in the period before the expiration. This is because in some cases a warrant enters our sample of exercised warrants after a rise in the price of the underlying stock before the warrant expiration.
use as $RM^5$, the *Yeter* index that includes all stocks traded by this mechanism.\textsuperscript{13} Our abnormal returns are best perceived as size-adjusted because the value-weighted TASE index is dominated by large stocks, and the *Yeter* index comprises the smaller stocks (that traded only once a day in the Call Auction).

When the stock trades by the Call Auction, which gives traders a single trading opportunity per day, the execution of nontrivial trading strategies may require an extra day. Thus, for stocks traded by this mechanism, it is possible that the price adjustment starts a day before the warrant exercise, namely on Day $-1$. In contrast, when the stock trades by the VPM, traders have more degrees of freedom, as they can sequence their trades so that undesirable stock positions are unwound later on the same day. When studying the price effect, we thus allow for a two-day adjustment period (Days $-1$ and 0), expecting a weaker Day $-1$ effect for the forty larger stocks that traded under the VPM.

The two-day cumulative abnormal return is defined as $CAR_j = AR_{j,-1} + AR_{j,0}$.

**INSERT TABLE 3**

Table 3 reports that the mean $CAR$ is +1.275% with a $t$-statistic of 2.98, highly significant. The median is higher, 1.379%. Over 60% of the stocks have a positive $CAR$, significantly different from a chance result. The results thus strongly support hypothesis $H1$ against the null. Importantly, the price increase at the time of the warrant exercise is not transitory and it is not reversed: the average cumulative abnormal return over days (+1,+10) is +0.52% ($t = 0.70$). Also noteworthy, the pre-exercise $CAR(-10,-2)$ is $-0.04\%$.

\textsuperscript{13} The *Yeter* index is a value-weighted index of all stocks that do not trade under the VPM. The market value of *Yeter* stocks was about a fifth of the total market value of TASE stocks. The *Yeter* index started in
(t = -0.05).

The estimated CAR may understate the value of consolidation. The exercise of warrants eliminates a convenient way for leveraged purchase of the stock, which may have been valued by investors. Then, CAR reflects the net result of the two effects described in H1 and H2. It is thus likely that the true value of trading consolidation exceeds our estimated CAR of about 1.3%.

Market efficiency considerations also suggest that our CAR is underestimated. Recall that the exercise of deep in the money warrants is an anticipated event whose exact date is known in advance. If the CAR on expiration were large, investors could profit from the anticipated price increase by buying the stock before the warrant expiration day and selling it afterwards, earning an excess return during the holding period. Thus, market efficiency requires that the price increase on warrant expiration is bounded by the round-trip transaction costs. If there were an anticipated price appreciation that exceeds the transaction cost, investors would trade to profit from it and the excess return would be eliminated.\footnote{Gains from dividend capture trading strategies by investors with advantageous tax status on ex dividend days, which is an anticipated event, are argued to be bounded by transaction costs; see Kalay (1982). Malatesta and Thompson (1985) discuss the price effects of partially anticipated events. We just measure the residual effect. Estimating the full value effect of consolidation requires following the stock over a long period before and after the warrant entered into the money, a task that is infeasible due to data unavailability.}

Transaction costs in the TASE included the following: (a) brokerage fees that ranged during the period under study between 1% for individual investors and 0.4% for portfolio managers (for "round trip" transaction); (b) cost of illiquidity, reflected by market impact of orders (including an implicit bid-ask spread); and (c) risk premium of holding an unhedged position in the stock.
The \textit{CAR} at the consolidation of trading is expected to be higher for smaller, less liquid stocks for two reasons. First, the lower the liquidity of the stock, the greater the benefit from the improvement in liquidity following the exercise of warrants. Second, illiquidity costs (item (b) above) are larger for less liquid stocks. Since the price increase at the anticipated event – the warrant expiration – is bounded by the transaction costs, there is more room for appreciation in the price of less liquid stocks.

The evidence in Table 3 is consistent with our predictions. The average \textit{CAR} for the 83 smaller stocks (traded in the Call Auction) is 1.67\%, much higher than the average \textit{CAR} of 0.45\% for the larger stocks that are traded by the VPM. Further, the average excess return of the larger and more frequently traded stocks on Day \text{-1} is \text{-0.07\%}. Thus, the larger stocks that are traded by the VPM react only on the expiration day. In contrast, the smaller stocks, traded by the Call Auction method, have an average excess return of 0.69\% (\text{t=1.91}) on day \text{-1}, and of 0.98\% (\text{t=2.70}) on day 0. Evidently, these small stocks react on Day \text{-1} in addition to Day 0.

The above results are consistent with our discussion of the relationship between the trading mechanism and the speed of price adjustment. When the stock is traded by the Call Auction method, traders may need two days to implement their trading strategies – one for the initial implementation and one for unwinding excess positions. In contrast, the VPM enables traders to implement their strategies in a single day, using the multiple trading rounds in the stock on Day 0.

Hypothesis \textit{H1} posits that the rise in stock price is due to the increase in stock liquidity upon the consolidation of trading following the warrant expiration. We test this by examining the relation between \textit{CAR}, and variables that reflect the liquidity benefits of
trading consolidation. Our hypothesis is

**H3:** \( CAR_j \) is an increasing function of the liquidity benefits from consolidation.

This hypothesis is tested by the model

\[
(6) \quad CAR_j = \delta_0 + \delta_2 DL\text{LIQUIDITY}_j + \nu_j.
\]

\( DL\text{LIQUIDITY}_j = DVOL_j \) or \( DCOV_j \) or both. Hypothesis H3 suggests that \( \delta_2 > 0 \), while the null is \( \delta_2 = 0 \). The change in liquidity of the underlying stock is proxied by the same variables used in Section 2. Our first variable is the increase in the stock trading volume, \( DVOL_j \). If investors anticipate that the consolidation of trading between the warrants and the stock improves liquidity, the increase in stock price should be an increasing function of the increase in its trading volume. The second measure is Roll’s estimate of the decrease in the squared half bid-ask spread, \( DCOV_j \); see equations (2) and (3).

**INSERT TABLE 4**

Our hypothesis that \( \delta_2 > 0 \) is supported by the estimation results in Table 4. For \( DVOL_j \) we obtain that \( \delta_2 = 1.790 \) with a \( t \)-statistic of 2.47, and for \( DCOV_j \), we obtain \( \delta_2 = 3.652 \) with \( t = 2.17 \); both coefficients are statistically significant. When we include both variables in the equation, both remain significant although the significance of \( DCOV_j \) is marginal.

We also consider the change in trading volume of the firm’s equity claims in excess of the increase in the number of shares following the warrant exercise:

\[
(7) \quad DVOL\text{RAT}_j = DVOL_j - \log(l + RATWS_j).
\]

\( DVOL\text{RAT}_j \) is the difference between the relative change in the stock’s trading volume,
$DVOL_j$ and $RATWS_j$, the relative increase in the number of shares of stock that results from the warrant exercise. Since the number of shares of stock naturally increases after the warrant exercise, it may be expected that the trading volume in the shares would increase as well. However, this is not necessarily true if part of the trading volume in the shares before the warrant expiration is due to arbitrage (or switching) transactions between the stock and the warrant. We obtain that the mean of $DVOLRAT_j$ is -0.046 with $t = 0.82$, insignificantly different from zero, and the median is -0.122, implying that for most stocks, the trading volume increases by less than the increase in the number of shares of stock after the warrant exercise, although this change is insignificantly different from zero. This reflects the fact that part of the trading volume before the warrant exercise was due to arbitrage trading. Still, the stock liquidity rose, as shown in Table 2.

Using $DVOLRAT_j$ as a measure of liquidity in model (6), we obtain that $\delta_2 = 1.691$ with $t = 2.24$, statistically significant. This is consistent with the liquidity hypothesis: $CAR_j$ is positively related to the excess increase in stock volume, $DVOLRAT_j$. Including both measures of liquidity, $DVOLRAT_j$ and $DCOV_j$ in the same model, we obtain that both have a positive and significant effect on $CAR_j$ although the significance of $DCOV_j$ is weaker.

Last, we test whether the pre-exercise fragmentation in the trading of the firm’s equity claims affects the stock price increase at the time of warrant expiration, when the firm’s equity claims are consolidated. The greater the former fragmentation, the greater should be the price increase. We test this proposition by estimating the model:

\begin{equation}
CAR_j = \delta_0 + \delta_2 RATWS_j + \nu_j,
\end{equation}

where $RATWS_j$, the ratio of the number of warrants to shares of stock before the warrant
expiration, is a measure of pre-exercise fragmentation in the trading of the firm’s equity claim. Our hypothesis is that in (8), \( \delta_2 > 0 \). Consistent with our hypothesis on the value of consolidation, we find that \( \delta_2 = 6.154 \) with a t-statistic of 2.11, significant (see Table 4). The stock price increase at the exercise of the warrants appears positively related to the extent of fragmentation beforehand.

V. Conclusions and Discussion

This paper presents tests of the hypothesis that consolidation of trading in securities is valuable. The tests are quite clean of informational effect, in that they focus on an event that is fully anticipated: the exercise of warrants that are outstanding on a publicly traded stock. The warrants included in our sample are deep in the money prior to the expiration day, hence their exercise is quite certain. Therefore, any price change at the warrants’ exercise can be attributed to the effect of the consolidation of trading in two equity claims – warrant and stock – that were traded separately beforehand.

The results show that the average two-day cumulative abnormal return on the warrant expiration is positive, \( 1.27\% \), and highly statistically significant. Importantly, the \( CAR \) is positively related to variables that reflect the degree of trading consolidation. It is an increasing function of the proportion of new shares added as a result of the exercise of the warrants, and it increases in changes in the liquidity of the stock following the warrant exercise. Our results are obtained for the TASE, whose market mechanism affords additional insights into the fragmentation problem. Our evidence shows that when the trading mechanism enables continuous trading and rebalancing, the loss (benefit) from fragmentation (consolidation) is much smaller than when stock trades in a
single daily call auction. It is also likely that the cost of fragmentation is substantially reduced under advanced trading systems, since electronic on-screen trading enables traders to quickly move between markets and securities at low cost.

Our evidence relates to the ongoing debate on the value of consolidation. The U.S. regulatory regime encourages competition among exchanges and trading systems and, indeed, the same security is often traded in multiple venues. While there is always some transparency across markets (for example, execution prices are communicated market-wide, and orders can be routed across markets), in most cases not all information is fully transparent (for example, bids and offers are not always communicated market-wide, and markets and market-makers typically do not share their entire order books even when they do provide some information to others). Absent cross-market transparency, theoretical studies suggest that fragmentation is costly.

The fact that multiple trading venues for the same security often\textsuperscript{15} survive flies in the face of the proposition that exchanges are natural monopolies, and raises questions regarding the value of consolidation. On the other hand, it is well known (cf. Mendelson (1987), Amihud and Mendelson (1996), Hendershott and Mendelson (2000)) that the equilibrium achieved across multiple trading venues need not be efficient. This, coupled with the fact that securities market structure has a significant effect on the cost of capital (Amihud and Mendelson (1986)), makes it important to study empirically whether market consolidation creates value. This study shows the answer is affirmative, that is, consolidation generates value, at least in the context of the Tel Aviv Stock Exchange.

The TASE provides a clean experimental setting for studying the value of
consolidation; but as with all such experiments, our results do not fully resolve the issue. In particular, the Call Auction market mechanism on the TASE creates informational fragmentation that can result in a full day's delay in execution. Our results show that the value of consolidation is reduced under the VPM, where trading is semi-continuous, suggesting that the value of consolidation may be low in other continuous markets. Thus, while our results for the TASE support the theoretical framework, care has to be exercised in applying it to different markets. We hope researchers will seek similar settings in other markets to examine to what extent our results are sensitive to the particular institutional arrangements of the TASE.

The evidence presented here has additional implications for the design of corporate securities. Amihud and Mendelson (1988) proposed that firms should balance the advantage of having a number of different securities with different payoff patterns, which offer investors a greater choice, against the cost of lower liquidity that fragmentation might entail. For example, warrants have attractive features that provide equity investors an expanded menu of payoffs and can help them control agency costs (cf. Schultz (1993). However, our study shows that corporate management must also consider the costs of illiquidity due to possible fragmentation.

15 But not always: Neal (1987) shows that when an option is listed on two markets, there is a period of competition between them, and after a while one market prevails and trading concentrates almost entirely in that market.
References


Table 1

Descriptive statistics on the sample warrants and the extent of trading fragmentation

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>INMONEY</td>
<td>2.390</td>
<td>1.660</td>
<td>1.102</td>
<td>15.244</td>
</tr>
<tr>
<td>RATWS</td>
<td>0.181</td>
<td>0.150</td>
<td>0.0076</td>
<td>0.504</td>
</tr>
<tr>
<td>VOLWS</td>
<td>0.469</td>
<td>0.398</td>
<td>0.031</td>
<td>1.652</td>
</tr>
</tbody>
</table>

INMONEY equals stock price divided by the warrant exercise price, three days before expiration. Our sample includes only warrants for which INMONEY > 1.10.

RATWS is the ratio of number of shares of stock that warrant holders obtain upon warrant exercise to number of shares of stock outstanding (before the exercise).

VOLWS is the ratio of the average daily trading volume (in monetary units) of warrants to that of the stock during the three quarters preceding the quarter when the warrants expired.

The sample comprises 123 warrants over the period 1992-1997.
Table 2
Changes in stock liquidity following the warrant exercise

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Mean</th>
<th>Regression estimation results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Constant</td>
</tr>
<tr>
<td>$DVOL_j$ = log($VOL_j^A/VOL_m^A$) - log($VOL_j^B/VOL_m^B$). $VOL$ is the average daily volume (in monetary units), and $j$ and $m$ indicate stock $j$ and the market, respectively. “A” indicates the period of 200 days after the warrant expiration, days 11 to +210, and “B” indicates the period of 200 days before expiration, days -210 to -11.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$DCOV$ = COV$^A$ - COV$^B$, where COV is the first order autocovariance of daily stock returns (multiplied by 1000). Roll (1984) proposes that SPREAD$=2\sqrt{-COV}$. Thus, $DCOV$ represents the reduction in the bid-ask spread.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$VOLWS$ is the ratio of the average daily trading volume (in monetary units) of warrants to that of the stock during the three quarters preceding the quarter when the warrants expired.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$RATWS$ is the ratio of number of shares of stock that warrant holders obtain upon warrant exercise to number of shares of stock outstanding (before the exercise).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The sample comprises 123 warrant exercises over the period 1992-1997.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The estimated models are</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4.1) $DLIQUIDITY_j = \gamma_0 + \gamma_1 VOLWS_j + \epsilon_j$, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4.2) $DLIQUIDITY_j = \gamma_0 + \gamma_1 RATWS_j + \epsilon_j$,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>where $DLIQUIDITY_j = DVOL_j$ or $DCOV$.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t$-statistics are in parentheses. The $t$-statistics of the regression coefficients are calculated using robust estimation of the standard errors, following White (1980).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 3
Cumulative Abnormal Returns (CAR) on stocks at the expiration of their deep in the money warrants

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean</th>
<th>Median</th>
<th>Proportion positive</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>All stocks N = 123</td>
<td>1.275%</td>
<td>1.379%</td>
<td>0.618 (2.61)*</td>
<td>-12.650%</td>
<td>15.741%</td>
</tr>
<tr>
<td>Large stocks N = 40</td>
<td>0.450%</td>
<td>0.441%</td>
<td>0.575 (0.95)</td>
<td>-9.705%</td>
<td>8.513%</td>
</tr>
<tr>
<td>Small stocks (Yeter) N = 83</td>
<td>1.672% (2.97)*</td>
<td>1.436%</td>
<td>0.639 (2.52)#</td>
<td>-12.650%</td>
<td>15.741%</td>
</tr>
</tbody>
</table>

The abnormal return (size-adjusted) is estimated as $AR_{jt} = R_{jt} - RM^N_{jt}$, where $R_{jt}$ is the return on stock $j$ on day $t$, and $RM^N_{jt}$ is the return on the benchmark size-based portfolio on day $t$. For large stocks, traded using the Variable Price Mechanism, $RM^N_{jt}$ is the value-weighted TASE index, and for small stocks, traded in a single daily Call Auction, $RM^N_{jt}$ is the index of all stocks traded via the Call Auction - the Yeter index. The cumulative abnormal return is defined as $CAR_j = AR_{j,t-1} + AR_{j,0}$, where day 0 is the warrant expiration day.

Warrants are included if the stock price is at least 10% above the exercise price on day -3. The sample comprises 123 warrant exercises over the period 1992-1997.

* $t$-statistic of the null hypothesis that the mean CAR equals zero.
# $t$-statistic of the null hypothesis that the proportion of positive CARs equals 0.50.
Table 4
Determinants of the cumulative abnormal return (CAR) on warrant expiration

<table>
<thead>
<tr>
<th></th>
<th>Model (6)</th>
<th>Model (6)</th>
<th>Model (6)</th>
<th>Model (6)</th>
<th>Model (6)</th>
<th>Model (8)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>1.070 (2.42)</td>
<td>1.025 (2.28)</td>
<td>0.877 (1.97)</td>
<td>1.352 (3.27)</td>
<td>1.126 (2.60)</td>
<td>0.161 (0.23)</td>
</tr>
<tr>
<td><strong>DVOL</strong></td>
<td>1.790 (2.47)</td>
<td></td>
<td>1.664 (2.31)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DCOV</strong></td>
<td></td>
<td>3.652 (2.17)</td>
<td>3.027 (1.67)</td>
<td></td>
<td></td>
<td>3.239 (1.84)</td>
</tr>
<tr>
<td><strong>DVOLRAT</strong></td>
<td></td>
<td></td>
<td></td>
<td>1.691 (2.24)</td>
<td>1.590 (2.16)</td>
<td></td>
</tr>
<tr>
<td><strong>RATWS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.154 (2.11)</td>
</tr>
<tr>
<td><strong>R^2</strong></td>
<td>0.060</td>
<td>0.028</td>
<td>0.079</td>
<td>0.050</td>
<td>0.071</td>
<td>0.030</td>
</tr>
</tbody>
</table>

The dependent variable is CAR, the size-adjusted cumulative abnormal return over days (-1,0), where day 0 is the warrant expiration day.

\[ DVOL_j = \log(VOL_j^t/VOL_m^t) - \log(VOL_j^B/VOL_m^B) \]

VOL is the average daily volume (in Israeli currency) and j and m indicate stock j and the market, respectively. “t” indicates the period of 200 days after the warrant expiration, days +11 to +210, and “B” indicates the period of 200 days before expiration, days −210 to −11.

\[ DCOV = COV^j - COV^B \]

DCOV is the first order autocovariance of daily stock returns (multiplied by 1000). Roll (1984) proposes that \( SPREAD_j = 2 \cdot \sqrt{-COV_j} \). Thus, DCOV represents the reduction in the bid-ask spread.

**RATWS** is the ratio of number of shares of stock that warrant holders obtain upon warrant exercise to number of shares of stock outstanding (before the exercise).

\[ DVOLRAT_j = DVOL_j - \log(1 + RATWS_j) \]

DVOLRAT is the excess of the post-exercise increase in the stock trading volume over the post-exercise increase in number of shares.

The sample comprises 123 warrant exercises over the period 1992-1997.

\( t \)-statistics are calculated using robust estimation of the standard errors, following White (1980).