This paper studies the trading behavior of derivative warrant issuer on the Taiwan Stock Exchange and its relationship to stock price. The issuer is the major liquidity provider on the warrant market and helps increase the liquidity of the underlying. The issuer does not trade like a scalper or a position trader. It makes market. Although overall it’s inventory of the underlying stock decreases as the inventory of warrant increases, it does not quickly adjust the underlying inventory as an option market maker would. Since it is difficult to hedge the gamma risk of issuing warrant and continuous hedge based on delta is impractical, taking a view (speculating) on the direction of price movement is a way of hedging gamma risk. In addition, the issue premium is the main source of the issuer’s profit. Since in practice the issuer sets a higher premium than the volatility of the underlying stock warrants, high premium allows the issuer to trade more aggressively (speculate more) on the secondary market. The issuer’s profit is significantly negatively related to the degree of overpricing of warrant. And the degree of overpricing does not seem to hamper the liquidity of the secondary market. Thus, there is no need to regulate issue premium. Actually, higher degree of overpricing induces the issuer to buy back warrant, which helps the warrant and underlying market to be efficient because the issuer’s trade is often picked off by informed traders. In this regard, higher premium on the primary market leads to more efficient secondary market. Finally, the fact that the issuer is the only trader on the short side gives the issuer more incentive to buy back warrant than to sell warrant. This is the reason why the issuer’s warrant buy is more susceptible to be picked off by informed traders, but the issuer’s warrant sell is not. The issuer has higher incentive to sell warrant after stock price drops significantly.

Key words: derivative warrant, trading behavior, liquidity, option, private information

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Derivative warrants are common in Asia and Europe and sometimes more popular than stock options. Derivative warrants and options are identical in terms of their contractual characteristics. However, their trading mechanisms are quite different. Derivative warrant is traded like stock with limited supply set by the issuer. So the outstanding amount of derivative warrant is fixed. Thus, it is not possible to sell warrant without already having warrant in hands. In addition, since the derivative warrant is issued by investment bank that is not the issuer of the underlying stock, the issuer is the only party that is obligated to deliver in the event of warrant exercise. Hence, in order to lock in profits or to reduce risk the issuer has an incentive to buy warrant to reduce the number of outstanding warrant.

In contrast, the open interest of options is in principle unlimited. Traders can short and long options without a position in hands. Market makers cannot directly influence the size of open interest. In addition, market makers of options presumably have better profit prospects when open interest is high. Because of these reasons, it is conceivable that warrant traders could behave quite differently

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1 In Hong Kong, Singapore, Australia, Taiwan, and Germany derivative warrants are heavily traded. In Hong Kong derivative warrants are actually more liquid than options with the same underlying (Duan and Yan (1999)). In Taiwan, derivative warrants are quite liquid as well (See Chow, Lee, Lee, Liu and Chen, (2000)). Derivative warrants are usually issued by investment banks for the purpose of making trading and issuing profits. The underlying stocks of the derivative warrants are not the stocks of the issuers. In contrast, equity warrants, which are common in the US,
from options traders.

To our knowledge all major options exchanges around the world have designated market makers. But there are no designated market makers on warrant markets. Although the issuer of derivative warrant is the presumed market maker, they could conceivably behave quite differently from an options market maker for several reasons. Firstly, if the issuer of warrant makes the market, it is out of its interest in maintaining a market that has potential for future issues. The options market maker makes market to earn short-term trading profits. Secondly, the options market maker usually has to keep a constant presence on the market by posting two-way quotes, but the warrant issuer does not have to. The warrant issuer supplies liquidity by submitting limit orders like other traders would. Thirdly, when the issuer buys the warrant, the outstanding number of warrant is reduced. However, the open position of options is not necessarily affected by the trading of options market maker. Fourthly, the warrant issuer can reduce its risk by buying warrant, i.e., reducing the outstanding amount of warrant, but the options market maker needs to keep a minimum presence on the market as required by the exchange. Fifthly, the warrant issuer has to “market” its warrants, while the option market maker does not have to. To the extent that the subscribers of warrant are the customers of the issuer the are issued by the firms of the underlying stocks for financing purpose.
relationship between the issuer and the investors is different from that between
options market makers and public traders.

This paper attempts to study the trading behavior of Taiwan’s warrant issuer. The
study is interesting in several aspects. One, since derivative warrants are popular in
many markets, studying the trading behavior of warrant issuer will give clue to the
design of trading mechanism that fosters the growth of warrant market.

Two, much has been done on the effects of listing or trading of options on the
underlying market. But little is done to understand the mechanism through which
options trading affects the underlying market. Our analysis would help the general
understanding of the mechanism that facilitates the trading of warrants to affect the
price and liquidity of the underlying asset. In addition, by comparing the trading
mechanism of warrants to that of options our finding can shed light on how options
market affects the underlying.

We use the trade-by-trade data to analyze the trading behavior of the warrant
issuer and its impacts on the underlying and the warrant market. A part of our

\footnote{2 So far only call warrants have been issued in Taiwan. Because the securities firms are prohibited
from selling stocks short, it is difficult for them to issue put warrants.}

\footnote{3 Chan, Chung and Johnson (1995) find different intraday patterns of bid-ask spreads for actively traded
CBOE options and for their NYSE-traded underlying stocks. Fedenia and Gramatikos (1992) show that options
listing significantly affects the spreads on the underlying stocks. Gjerde and Saettem (1995) show that on the
Norwegian markets option listing is associated with a temporary price increase on the introduction day and a
substantial decline in the bid-ask spreads of the underlying stocks. There are quite a few other studies on the
impacts of the introduction of options on the price of the underlying stocks. See, e.g., Treneophol and Dukes (1979),
Damodaran and Lim (1991), and Chamberlain, Cheung, and Kwan (1993). Very little is done on the same issue with
respect to warrant. Alkeback and Hagelin (1998) find that the introduction of equity warrant has no}

Two hypotheses about the effects of options trades on stock prices are investigated by Vijh (1990) and Berkman (1996). The first one can be called the information hypothesis. Market makers’ orders or quotes can be picked-off by informed investors who prefer to trade options to take advantage of their private information. Consequently, the stock price after the option trade would change significantly.

The second hypothesis can be called the inventory hypothesis. Options traders adjust their stock inventory after the option trades to hedge the risk exposure of options. As a result, the stock price after the options trade need not change significantly.

Vijh (1990) finds that large options trades are not informative about future stock prices. Neither does he find significant price effects of large option trades due to inventory adjustment. Berkman (1996) distinguishes between the large trades of public limit orders and those of designated market makers. He finds that for both effect on the price of the underlying stock.
limit order trades and market-maker trades investors tend to buy calls after a rise in
the stock price, and tend to sell call after a fall in the stock price. After market
makers trade, the option quotes tend to return to their pretrade level and there is a
weak temporary effect on the stock price. This finding is consistent with the
hypothesis that inventory control by market makers spills over to the stock exchange.
However, the public limit orders are picked-off after adverse change in the underlying
stock price and the trades have significant impacts on stock prices.

Vijh (1990) studies options trades on the CBOE that has a multiple dealers
system. Similarly, Berkman studies the options trades on the European Options
Exchange (EOE) that also has multiple designated market makers. On both the
CBOE and the EOE market makers not only compete with each other but also with
orders in the limit order book. On the Taiwan Stock Exchange (TSEC) there are no
designated market makers. The warrant issuer competes with other orders in the
limit order book.

Easley, O’ Hara and Srinivas (1998) find that particular option volumes lead
stock price change, consistent with option markets being a venue for
information-based trading. Stock prices also lead option volumes, which is induced
by hedge-related trading in options. Option volumes respond to stock price changes
with lags of between twenty and thirty minutes, but option volumes affect stock price
changes much more rapidly. They suggest that the direction of the effect is not straightforward because information is not the only factor influencing stock and option market short-term movements.

The warrant issuer is not like the options market maker that tries to balance the buy and sell trades constantly. The warrant issuer’s incentive to buy and sell is asymmetric. For the issuer to collect the premium, the warrants are issued to investors before the secondary market trading starts. After the secondary market trading starts, the issuer has a stronger incentive to buy than to sell warrant because having fewer warrants outstanding reduces the risk exposure of the issuer and helps the issuer to lock in the issue profit. However, the issuer could not completely abstain from selling warrants on the secondary market for it is expected to provide liquidity. We thus expect the impact of the issuer’s buy trade to have more significant impact on stock prices than the sell trade. This is because when the issuer is more willing to buy than sell warrant, its buy orders are more likely to be picked-off by informed investors.

Since selling warrants increases the issuer’s risk exposure, the issuer should be more cautious on the sell side than on the buy side. The issuer tends to sell more when it feels less risky to do so. Since the likelihood of warrant exercise declines with stock price, the situation that would make the issuer more willing to sell warrants
is when the stock price falls. If the warrant sell is a response to stock price drop, it is less likely to be informative about future stock prices.

Of course, our hypothesis hinges on the assumption that the issuer cannot continuously hedge its risk exposure. Jameson and Wilhelm (1992) show that risks associated with the inability to rebalance an option position continuously and uncertainty about the return volatility of the underlying stock account for a statistically and economically significant proportion of the bid-ask spreads quoted for a sample of Chicago Board Options Exchange options. Our empirical analysis indicates that the warrant issuer does not attempt to continuously hedge its issue risk.

If the issuer continuously hedges its risk, we should have the following observations. It is more common that two warrant trades are offsetting each other than on the same side of transaction; or a warrant (stock) trade is followed by a stock (warrant) trade on the opposite side of the transaction. In addition, the time span between two trades should be short so that the price risk is low. However, we find that it is much more common to have two consecutive warrant trades that are on the same side of transaction than two warrant trades that are on the different side of the transaction. The ratio of the former case to the latter case is about 5 to 1. When two consecutive warrant trades are in opposite directions, the average time span between them is about 11 minutes. Moreover, of all the two consecutive issuer’s
trades we observed, there is only about 12% of the time when the issuer has a warrant (stock) trade followed by a stock (warrant) trade on the opposite direction of transaction. The average time between a warrant trade and a stock trade in opposite direction is about 7 minutes.

Our analysis shows that there are significant stock price decreases after the issuer buys warrant, and there is no significant stock price change before the issuer’s trade. This finding is consistent with our hypothesis that the issuer’s warrant buy is picked off by informed traders and is informative about future stock price. There is no significant stock price change after the issuer sells warrant, but there are significant stock price decreases before the issuer’s trade. The finding implies that the issuer’s warrant sell is induced by the decline in stock price, which is hedge-based for the purpose of providing liquidity. However, we do not find significant association between the issuer’s stock trade and the warrant price before and after the issuer’s stock trade.

The issuer is the significant liquidity provider on the warrant market. About 40% of warrant trading is attributed to the issuer’s trades. In addition, the issuer contributes about 4% of the liquidity to the underlying stock market. The issuer does not trade like a scalper on the options market because it trades only on 60% of the trading days. It does not behave like a position trader either for the time between
trades is about seven minutes, longer than one would expect for arbitrage trades.

Neither does it trade *strictly* like a designated market maker. Although it provides
liquidity on the warrant market, it does not attempt to manage its inventory risk
continuously in the fashion described by Jameson and Wilhelm (1992). Over the life
of the warrant the issuer does manage its inventory risk, but discretely allowing a long
period of time before completing the hedge. The issuer’s inventory of warrant and
the underlying stock is negatively related in the long-run (quarterly), but the sort-term
weekly correlation between them is not consistently negative. In addition, our
finding reveals that the issuer does not try to offset its inventory risk immediately
after it makes market in the warrant market. It frequently trades warrant (stock) in
one direction consecutively and wait for about eight minutes on average to have the
next trade.

There could be several reasons for the issuer not to hedge conservatively.

Warrant is not like option having a series of many similar contracts that differ only by
exercise price and maturity date and having puts as well as calls traded simultaneously.
As a result, it is difficult to hedge the gamma risk of issuing warrant. Since
continuous hedge based on delta is impractical, taking a view (speculating) on the
direction of price movement is a way of hedging gamma risk.

In addition, the issue premium is the main source of the issuer’s profit. Since in
practice the issuer sets a higher premium than the volatility of the underlying stock warrants, high premium allows the issuer to trade more aggressively (speculate more) on the secondary market.

Warrant is first derivative product that is traded on the centralized exchange in Taiwan. Before it was introduced in 1997 policy makers were primarily concerned about the impact on the underlying market of the secondary market trading of warrant and the pricing of warrant on the primary market. The authority was particularly anxious about whether or not the issue premium would be fair to investors. Although never implemented, there was a proposal that would require the pricing model of the issuer to be approved by the stock exchange before the warrant could be issued.

We find that the correlation between the extent of overpricing of the issue premium benchmarked against the Black-Scholes theoretical price and the total profit is significantly negative. And the degree of overpricing does not seem to hamper the liquidity of the secondary market. Thus, our finding provides a new insight on the regulation of a market maker’s (underwriter’s) issue premium. Since higher degree of overpricing does not result in higher profit or less secondary market liquidity, there is no need to regulate issue premium. Actually, the issuer’s warrant buy seems to be picked off often by informed traders. Higher degree of overpricing induces the
issuer to buy back warrant premium, which helps the warrant and underlying market to be efficient because private information is revealed through the issuer’s trade. In this regard, higher premium leads to more efficient secondary market.

Finally, our finding about the issuer’s role in providing liquidity has implication for the secondary market pricing of warrants as well. Jameson and Wilhelm (1992) show that risks associated with the inability to rebalance an option position continuously and uncertainty about the return volatility of the underlying stock each account for a statistically and economically significant proportion of the bid-ask spreads quoted for a sample of Chicago Board Options Exchange options. They suggest that the risks may influence the theoretical bounds on option prices.

Brenner, Eldor and Hauser (2001) find that illiquidity (on the options market) affects the value of currency options. Nontradable options issued by the Central Bank of Israel are priced about 21% less than the exchange traded options listed on the Tel-Aviv Stock Exchange. The reason is that the central bank options can be replicated by the exchange-traded options only at a substantial transaction cost. On the TSEC the warrant issuer is the only market maker of the warrant. Since the issuer can significantly affect the liquidity of the warrant, the pricing of warrant on the secondary market is related to the issuer’s trading behavior.

The remainder of the paper is organized as follows. Section I introduces the
market mechanism of the primary and secondary market of the Taiwan Stock Exchange (TSEC). Section II explains the characteristics and the handling of our data. Testable hypotheses and testing methodology are discussed in Section III. We present our empirical results in Section IV. Section V concludes the paper.

I. Market Micro-Structure of Derivative Warrants and Their Underlying Stocks on the TSEC

A. The Primary Market of Warrants

Derivative warrants have been traded on the TSEC since September of 1997. All the warrants on the TSEC are issued by securities firms. One unit of warrant is exercised for one underlying share. Warrants on the same underlying stock can be issued more than once by the same issuer and different issuers. But the total number of outstanding warrants cannot exceed 20% of the amount of outstanding shares of the underlying stock. The number of shares of any issue has to be no less than 20 millions. The issuer has to apply for the approval of the Securities and Futures Commission (SFC) to issue new warrants. Afterwards it usually takes more than 10 days for the issuer to place the warrants to interested buyers. The issuer is allowed to keep as much as 20% of the whole issue as inventory for the purpose of making the market for the warrants. Since more than 80% of the issue has to be purchased by investors, for it to be considered by the SFC as qualified for secondary market trading,
sometimes the issuer has to recruit involuntary buyers by promising to buy back the warrant at a price the same as or higher than the issue price. That is the reason why in the first few weeks of secondary market trading the issuer sometimes buys much more than sells warrant.

B. The Secondary Market

Warrants are traded on the TSEC. The trading mechanism for warrants and the underlying stocks are identical. In essence, warrants are traded just like stocks. The TSEC is an electronic, order driven, call market without designated market makers. The market liquidity is provided by public limit orders. Except for the proprietary traders of securities firms (dealers) who can submit orders directly to the TSEC, all traders must submit orders to the TSEC through their brokers. In terms of the rules for engaging on the secondary market trading the warrant issuer is treated with the same status as a dealer.

The TSEC matches orders according to the price-time priority rules that conform to the trading mechanism of a call market. The TSEC relies on the call mechanism for determining transaction prices throughout the trading day. For the opening call between 8:30 and 9:00 A.M. orders can be submitted to the TSEC. At 9:00 A.M. the first call is conducted. After the open orders are matched about every 4 to 50 seconds throughout the trading day. Basically, in between two calls orders are
sequentially accepted by the computer and matched to maximize the trading volume.

If after a call a sufficient number of orders have entered the system so that a transaction price can be determined, the TSEC will conduct another call immediately. However, there can be only two back-to-back calls like this. So the duration of a call period can vary from few seconds to approximately 50 seconds. After the second all, the computer would wait for as long as 50 seconds to initiate another call, depending on the order flow.

After each call the transaction price, transaction volume, the highest bid price and the lowest ask price among unmatched orders are released to the public. At the close the exchange conducts the last call for each stock. Remaining orders after the last call are removed from the book.

The TSEC has a daily price limit of 7% for the underlying stocks. The price limit for the warrant is the actual dollar amount of the price limit for the stock. Suppose that an underlying stock closes at NT$ 100 on the previous business day. Then the range of price change today is NT$ 14 (NT$ 7 up plus NT$ 7 down) for both the warrant and stock. Since the price of warrant is usually much lower than the stock, the actual price limit for the warrant is much less stringent than the stock. In addition, except for the open price that is allowed to reach the daily price limit, all subsequent trades on the underlying stocks are imposed an intraday two-tick price
limit that mandates the transaction price to move within two ticks of the price determined in the previous call. But warrants are not constrained by the two-tick limit.

Only limit orders are allowed on the TSEC. To secure matching priority, traders need to submit limit orders hitting the daily price limits (limit orders with prices beyond the price limits are not accepted by the computer). This type of price-limit orders can achieve the effect of market orders. For this reason, Taiwan’s practitioners call these orders market orders. Thus, on the TSEC traders can aggressively submit market orders to enhance the probability of trade and yet have some price protection due to the call mechanism and the intraday price limit (for stocks only). In the case of stock trading unless the previous transaction price is within two ticks of the daily price limit, market orders would not be matched at the daily price limit. Thus, traders who prefer trade immediacy would place market orders. However, dealers and warrant issuers can only submit limit orders, which puts the issuers at a disadvantageous position relative to other traders in securing execution immediacy.

Except for the transaction cost the warrant issuer does not have any regulatory advantage over other traders. All the traders on the TSEC have the same access to

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4 If market orders are allowed, according to Schwartz (1991), they are equivalent to limit orders written at the highest allowable call price for buy orders and the lowest allowable call price for sell
the trade information and intraday news release. All traders are subject to a
transaction tax of 3% of the transaction amount on the sell side only. Brokerage fee
for buy and sell is 0.1425% respectively and is charged to non-dealer traders only.
So there is no brokerage fee for the warrant issuer. Instead, the is a transaction fee
levied by the TSEC. For the warrant issuer it is 0.015% on each side of trade.

II. Data

We employ the data of warrants and their underlying stocks that are listed between
September of 1997 and July of 1999. We only include the warrants that are listed
and mature during the sample period. There are 15 plain vanilla warrants and 4
warrants for which the underlying asset is a portfolio of stocks (portfolio warrants).
To focus on the trading behavior of the issuer of warrant that is more like
exchange-traded stock options, we exclude the four portfolio warrants. In addition,
three vanilla warrants issued by the same securities firm have overlapping life. Since
we need to relate the issuer’s trading of the underlying stock to a particular warrant in
order to study the issuer’s trading behavior and the profitability of trading and our data
do not allow us to do so, the three warrants are excluded from our sample.

We have access to the tick-by-tick transaction data of the TSEC. Since the
orders.
TSEC is completely automated, the transaction data are complete. The transactions are recorded at the time when they occur in the system. Our data allow us to identify the issuer’s transaction and to trace its entire trading history.

Table I reports the issue information about the sample warrants. The theoretical price of the warrant is calculated using the Black-Scholes formula for a call option. The volatility input in the formula is the annualized standard deviation of the daily returns over the period one year prior to the issue date. We calculate the percentage of overpricing of the warrant by dividing the difference between the issue premium and the theoretical price by the theoretical price. Table I shows that all the warrants are issued at the money and mature in one year. The number of shares issued is either 20 million or 22 million shares, invariant to the number of shares outstanding of the underlying stock. Except for one warrant, all the warrants are overpriced, some as much as by 50%.

III. Testable Hypotheses

A. The Trading Behavior of Warrant Issuer

On an option market like CBOE three types of traders make the market: scalpers, position traders and designated market makers. A scalper makes a two-sided market

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5 According to Mayhew (forthcoming) after 1987 CBOE started to list some options under a Designated Primary Marketmaker (DPM). In 1991 the Pacific Exchange began to assign options to a
by making bids and offers. The scalper trades frequently during the day hoping to make very short-term profits without carrying inventory overnight. They manage risk by shedding positions quickly even at a loss. As Najarian (1992, p. 9) puts it, “….if the trader would not have established the trade at the current prices, the trade would be eliminated, even if it meant taking a loss. In this way the scalpers would turn over their inventory on a more regular basis and thus, free capital for other trades.” So scalpers are short-term speculators.

Position traders, instead, are more like arbitragers. They tend to have greater capital base than scalpers, which allows them to establish and hold large positions. They search for disparities in option pricing and then create an arbitrage between one or more option classes and the underlying stock or futures contract. Their trading edge relies on their ability to manage the risk of their arbitrage positions. They do not aim to sell premium to make a quick profit.

Unlike scalpers and position traders who do not necessarily maintain the market at all times the designated market makers are required to maintain a two-sided market constantly. For the designated market maker the benefit of bearing the stringent market making responsibility is usually the guarantee of participation in the market, fee discount and reduction in the margin requirement for writing options. The

Lead Market Maker (LMM). The AMEX and PHLX trade options under a specialist structure resembling that used in stock markets. The responsibilities of DPM are quite similar to LMM and
designated market maker makes profits from the quoted spread. To make money he
must be skillful in assembling a hedged position in the underlying stock. Jameson
and Wilhelm (1992) find that uncertainty about the return volatility of the underlying
stock accounts for a significant portion of the bid-ask spreads of CBOE options.

The trading behavior of the three types of market makers exhibits distinct
features. Since a scalper speculates on short-term option price movement without
holding a hedged position in the underlying stock, he primarily trades on the options
markets only. In addition, the trades are frequent and in small size.

A position trader arbitrages by trading both option and the underlying stock
simultaneously to make profits arising from mispricing. Given that arbitrage
opportunity only appears momentarily and the profit margin is slim, the position trader
usually trades in large size. In addition, the time it takes to unwind the arbitrage
positions depends on when the expected convergence of asset prices occurs. So a
position trader does not trade as frequently as a scalper.

Since a designated market maker needs to meet the minimum requirement of
trade participation and to maintain a constant presence on the market, not only does he
trades frequently, but he also trades more evenly than a scalper. The size per trade of
a designated market maker should be smaller than that of a position trader. In

specialists.
addition, the designated market maker hedges his option risk by actively trading on the underlying stock. But the key to the success of risk management relies as much on the simultaneous trading on the option and stock market as on the skill to rebalance position when necessary.

The warrant issuer sells the warrant to investors on the primary market, so it is the only trader on the short side on the secondary market. In principle, as long as the issuer manages its inventory of the underlying stock well enough to limit its risk exposure to the price change of the stock and warrant, the issuer can make profits from the issue premium. Thus, unlike the market makers on the options market, the warrant issuer does not need to make profits from secondary market trading. However, the warrant investors expect the issuer to provide liquidity on the secondary market, otherwise they would not be willing to purchase warrant on the primary market. So the issuer would not abstain from trading on the secondary market for fear of losing its future business. As a result, the issuer would make market only when it deems necessary. Therefore, we expect the issuer to provide liquidity on the secondary market. However, it may not be present on the market as a designated market maker would be. In addition, because its profit is made on the primary market, there is not obvious motivation or advantage for it to provide liquidity like a scalper. But whether or not the warrant issuer would sometimes behave like a
position trader depends on if it aims to take advantage of arbitrage opportunity.

Again, the issuer does not seem to necessarily possess superior ability in this area compared to other traders.

B. The Effect of the Warrant Issuer’s Trading on the Price of Warrants and the Underlying Stocks

Extant literature on the relationship between the trading of options and the price of the underlying stock tends to rest on the possibility that higher leverage of options contract might induce informed traders to transact options rather than stocks. 6

Although earlier literature emphasizes on the relationship between option price and stock price (e.g., Manaster and Rendleman (1982) and Bhattacharya (1987)), recent literature focuses more on the relationship between option trades and stock price. As Easley, O’ Hara and Srinivas (1998) put it: “….option trades (rather than option prices) may first reflect information due to the fact that option pricing models need the stock price and volatility to determine the options price, but the new information would not yet have been incorporated into stock prices. The asymmetry of information and the preference of trading venues would thus cause option transactions to convey information to market participants of impending changes in stock and option prices.”

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There are a few reasons for the warrant issuer’s trade to be particularly informative for the future stock prices. The warrant issuer is expected to provide liquidity on the secondary market. As it does so, its limit orders are susceptible to be picked-off by informed traders. Berkman (1996) argues that limit orders are more easily to become the prey of informed traders than the quotes of designated market makers. Unless the warrant issuer behaves like a designated market maker, we would expect its limit orders to have significant impacts on future stock prices.

In addition, the warrant issuer is the only trader on the short side and its primary revenue source is the issue premium, so it has incentive to buy back warrants to reduce its risk exposure. However, it is also expected to provide liquidity by selling warrants. But selling warrants increases its risk exposure. Unless it attempts to profit from secondary market trading like a designated market maker would, it would have less incentive to sell than buy warrants. It would be more willing to sell when the risk of being exercised upon is less. When stock price decreases, the exercise risk is smaller. Therefore, we expect the stock price to fall significantly before the issuer sells warrant. And if the issuer’s warrant sell trade is triggered by stock price change, its chance of being picked-off by informed traders is not as high as the warrant buy trade. So there should be significant stock price drops after the issuer buys warrant, but there need not be significant price changes after the issuer sells
warrant.

This type of asymmetric prediction on the impact of the issuer’s warrant buy trade and sell trade on stock price is distinct for the warrant. For the option both buy trade and sell trade should have significant impacts on future stock prices. Berkman (1996) and Easley, O’Hara and Srinivas (1998) present evidence for the option market.

Easley, O’Hara and Srinivas (1998) also show that stock prices lead option volumes, which they interpret as the result of hedge related trading in options induced by stock price changes. For the warrant we expect the issuer’s sell trade to more likely be induced by stock price change than the buy trade.

We also study the effect of warrant issuer’s stock trading on warrant price. Easley, O’Hara and Srinivas’ (1998) theory suggest that if the leverage effect of options is large enough, or if the liquidity in the stock is small, then some informed traders would use options. Conversely, we may say that when the stock market is very liquid, then there should be some informed traders using stock. If the warrant issuer uses the stock market primarily for hedging the risk exposure of warrant exercise, the relationship between warrant price and issuer’s trade is determined by the nature of its hedging behavior.

In practice, delta hedge is the common method of risk management of Taiwan’s
warrant issuers. Rebalancing of stock inventory could be called for in the following situations. One, after the issuer trades on the warrant market, the inventory of the underlying stock needs to be adjusted accordingly. It would increase (decrease) the stock inventory as he sells (buys) warrant. Two, as the warrant price rises (drops), the issuer increases (decreases) the stock inventory position due to rise (fall) in the chance of warrant exercise.

In the first case, the issuer should place a limit order that has a high priority of execution. Otherwise, the order will probably not be executed soon after its submission, which has a higher chance of being picked-off by informed traders and will result in significant changes in warrant price. The second case would more likely apply when the issuer’s stock buy trade is preceded by a warrant sell trade than when the issuer’s stock sell trade is preceded by a warrant buy trade. Recall that the warrant issuer has stronger incentive to buy warrant than to sell warrant. So it is more likely that stock sell trade follows warrant buy trade than the other way around. In this case, since the stock sell trade is not triggered by changes in warrant price, significant warrant price changes preceding the issuer’s stock trade are not expected. But since it is less likely that the issuer’s stock buy trade follows its warrant sell trade, the stock buy trade is more likely a result of issuer’s response to significant rise in warrant price.
C. Issue and Trading Profits of Warrant Issuers

Whether an issuer can stay in the market as a market maker is critical to the development of the warrant market. If it is possible to earn a reasonable profit from playing the role of a market maker, then the issuer would be willing to make the market and the chance that investors would continue to invest in the warrant market would increase. There are several sources of profits: the premium collected from investors on the primary market, the profits from trading warrants on the secondary market, and the profits from trading the underlying stock on the secondary market.

When warrant is issued on the primary market, the issuer usually keeps a portion of the total issue as inventory for making market on the secondary market. The issuer collects premium for the portion sold to investors, which presumably is the primary source of the issuer’s profit. In principle, the issuer can lock in its issue profit by continuously rebalance its stock inventory based on the warrant’s delta to hedge the risk exposure of warrant exercise. But the issuer is bound to bear risk because it is difficult to hedge on a continual base.

In addition, the issuer can profit from buying low and selling high on the secondary market. In practice, it is a net buyer on the secondary market. The purchase cost of the net buy offsets the issue premium. Finally, the issuer can make money by trading
stock on the secondary market. Over the life of warrant it usually a net seller of stock. The sell price of the net sell reduces the cost of purchasing the inventory in the beginning of the issue. In the Appendix, our approach of calculating the issuer’s profit is explained.

Given the nature of the source of profit, it is sensible for the issuer to prioritize on ensuring that the issue premium will not be lost due to warrant exercise in the future. Making trading profit on the secondary market ought to be a secondary concern. To increase the probability of success of future issue, when trading on the secondary market the issuer would actually focuses more on providing liquidity than making profit. The more the issuer overprices the warrant, the more it would be willing to provide liquidity on the secondary market to make up for the excessive premium investors pay on the primary market. The degree of the issuer’s willingness to provide liquidity can be manifested by the amount of trading on the secondary market and the profit made by the issuer. The issuer would be less concerned about transaction price as it feels more obligated to provide liquidity. As a result, it’s final profit could be less.
IV. Empirical Analysis

A. Market Liquidity and the Issuer’s Trading on the Secondary Market

Figure I shows the weekly average of daily turnover ratio across warrants on the warrant and the underlying market. The turnover ratio is the ratio of the total trading volume (in shares) to the total number of shares outstanding. Except for the first and the last week when the warrant is much more actively traded, the trading activity of the underlying market is somewhat higher than that of the warrant. The turnover is on average about 1.5% daily on the warrant market and 1.55% on the stock market, which amounts to about 390% and 403% annually (about 260 trading days per year). So the warrant and the underlying stock are both very actively traded.\footnote{The annual turnover ratio of the NYSE is usually much less than this figure.}

We now examine the importance of the issuer’s trading activity to the liquidity on the warrant and the stock market. Figure II shows the weekly average of the daily trading volume of the warrant issuer as a percentage of the total trading volume in the underlying stock and the warrant, respectively. The total trading volume is the sum of the registered buy and sell volume. Thus, a figure of 50% would mean that the warrant issuer participates in all the trades. The result in the figure is the mean across all warrants.

Figure II shows that the warrant issuer participates relatively much more in the
warrant market than in the underlying market. Except for the last week in which the warrant issuer contributes about 40% to the total trading volume (participates in almost 80% of all trades), in between 10% to 15% of the total trading volume can be attributed to the warrant issuer. In contrast, the warrant issuers are responsible for only less than 1% of the total trading volume on the underlying stocks. So the warrant issuer is an important liquidity provider on the warrant market. In addition, the warrant issuer also provides liquidity to the underlying market. Although the warrant issuer contributes only 1% to the total trading volume of the underlying stock, in light of the large number of traders who trade on the underlying market the liquidity provided by the warrant issuer should not be considered insignificant.

Figure III shows the weekly average of daily buy and sell volume of the issuer as a percentage of its total warrant trading volume. The warrant issuer tends to be more active on the buy side than on the sell side in the early and late life of the warrant but comparably active on the buy and the sell side for the rest of the life of the warrant. Figure IV shows that, except toward the end of the life of warrant, in general the warrant issuer is relatively more active on the sell side than on the buy side in the trading of the underlying stock. Figures III and IV imply that the issuer behaves

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8 The warrant issuer can only submit limit orders for trading. According to Handa and Schwartz (1996) and Berkman (1996), limit order traders issue “free option” to market order traders, thereby providing liquidity to the market.

9 Chow, Hsu and Tso (2001) find that on average 50,000 traders trade on a particular stock during a 18 months period.
more like a market maker on the warrant market than on the stock market. Its trading on the underlying market aims primarily to gradually reduce its inventory amassed in the beginning of the issue of warrant.

Figure V depicts the issuer’s weekly average inventory position in the warrant and the underlying. The observations in the figure are scaled by the total number of shares issued. For the underlying stock the ratio can be considered as the actual delta of the hedged portfolio. The first observation is the initial inventory before trading on the secondary market starts. The observations in the figure are the mean across four warrants which we have access to their initial inventory. In the beginning the stock inventory of the issuer is about 56% of the warrant issued. Since all the warrants in our sample were issued at the money, the stock inventory level exceeding 50% at the beginning of the issue shows that the issuer over hedges.

As the warrant approaches maturity, the stock inventory position diminishes to almost nil. The inventory of warrant increases with time but not at a rate as fast as that of the underlying since the issuer does not buy back all the outstanding warrants. Figure V is consistent with our observation above that the issuer tries to make market on the warrant market but mainly trades on the underlying market to reduce its inventory position overtime.

Figures II through V suggests something interesting that is worthy of more
examination. The phenomenon revealed in the figures should be a result of the combination of risk management and market making activities. To provide liquidity on the warrant market the issuer buys and sells warrant on the secondary market. If the issuer manages the risk exposure of its warrant inventory by adjusting the stock inventory, it would sell stock as it buys warrant and vice versa. We call this type of risk management behavior the inventory-driven approach. The inventory-driven approach would result in negative correlation between warrant inventory and stock inventory. Clearly Figures II through V do not suggest a clear negative correlation between warrant inventory and stock inventory.

We calculate for the daily observations the correlation between the net buy (shares bought minus shares sold) on the warrant and stock market. The result is the pooled correlation of all observations of all the warrants in our sample. Figure VI shows that the weekly average daily correlation is negative in the beginning and toward the end of the life of the warrant but less so in the middle of the life of the warrant. We can infer from comparing Figure VI to Figure III that the issuer tends to follow the inventory-driven approach of risk management when its trading on warrant is imbalanced. However, when its trading is more balanced, it does not seem to follow the inventory-driven approach.

The issuer can also manage its warrant risk exposure by adjusting its stock
inventory in response to stock price change and leaving the amount of warrant outstanding intact. We call this approach price-driven approach. In this case, the correlation between warrant inventory and stock inventory should be low but there should be positive correlation between stock price change and the net buy of stock.

And if the issuer mixes the inventory-driven approach with the price-driven approach, then the correlation could be irregular over time. Sometimes the correlation could even be positive because, for example, it is possible that after the issuer buys warrant the stock price rise sharply, then instead of selling stock to hedge the warrant buy the issuer buys stock. Figure VI shows that the weekly average correlation between daily stock price change and daily net buy of stock is mostly positive when the issuer’s trading is quite balanced. So the issuer’s trading behavior is affected by the price-driven approach. Figure VI also suggests that when its trading is quite balanced, the issuer follows either the price-driven approach or the mixed approach for the correlation between warrant net buy and stock net buy is either low or irregular.

The correlation between warrant net buy and stock net buy declines with measurement horizon. The daily, weekly and monthly correlation are -0.17, -0.16 and -0.26, respectively (all significant at 1% significance level). The quarterly correlation is -0.52 (significant at 1% significance level). So in the short-term the
issuer does not hedge strictly by the inventory-driven approach. However, in the longer term its hedging behavior is more like inventory-driven approach.

Actually, in addition to the inventory- and price-driven approaches of hedging the issuer sometimes takes view in its decision to hedge. If after a warrant trade it expects stock price to move in its favor, then it could delay the hedge trade until later. As a result, the short-term correlation is not negative as expected.

Whether the issuer hedges conservatively or speculatively can be made clear by studying the length of time elapsed between trades. If the issuer hedges conservatively, both inventory- and price-driven approaches imply that the time between trades ought to be pretty short. The longer the time gap between trades, the higher is the price risk of hedge. In this case, it is more likely that the issuer speculates on the direction of price move.

We study time elapsed between two issuer’s trades for eight different scenarios: two warrant trades in the opposite direction, two warrant trades on the same side of transaction, two stock trades in the opposite direction, two stock trades on the same side of transaction, a warrant trade followed by a reverse stock trade, a warrant trade followed by a stock trade on the same side, a stock trade followed by a reverse warrant trade, and a warrant trade followed by a stock trade on the same side.

The above classification is applied to intraday observations, not across trading
The average time between two trades is the mean of all the observations across warrants. Table III shows that on average on 2.7% (1.9%) of the trading days (about 270 days per warrant) there is only one warrant (stock) trade during the day. Table IV shows that on about 30% of all the trading days the issuer trades neither on the warrant market nor on the stock market. On about 32% of the trading days the issuer trades on both the warrant and the stock market. On about 27% of the trading days the issuer trades only on the warrant market, while on about 11% of the trading days on the stock market. Thus, the above eight scenarios apply to about 70% of the trading days. The issuer trades on the warrant market on about 59% of the trading days, while on the stock market on about 43% of the trading days. So the issuer is not present on the warrant market all the time.

Table V shows that most frequently the issuer has two consecutive warrant trades on the same side spanning on average 469 seconds (7.8 minutes) between them. The second most frequent scenario is the one in which the issuer has two consecutive stock trades on the same side that on average span 273 seconds (4.6 minutes) between them. Sometimes (about one fourth as frequently as the case in which the issuer have two same-side warrant trades) the issuer would have two back-to-back warrant transactions on the opposite side of the trade that on average span 677 seconds (11.3 minutes) between them. However, the issuer almost never has two consecutive stock
trades on the opposite side of the transaction. Therefore, the issuer does not seem to trade like a scalper on the warrant market, and it never scalps on the stock market.

The case in which the issuer has a warrant trade preceded or followed by a stock trade on the opposite side of the transaction is less frequent than the case in which the issuer has two consecutive warrant trades on the opposite side of the transaction. The time span between two trades in this case is about 440 seconds (7.3 minutes).

Since the time span is quite long, this kind of trade is not likely to be dominated by the behavior of a position trader. Although it is still a likely result of hedging behavior, the issuer does not seem to hedge conservatively. It allows its warrant position to be exposed to risk for a period of time before the risk is covered later.

In sum, the issuer does not aim to profit from scalping or arbitraging very much. As it makes market, in the short-run it takes view when hedging its risk exposure. Actually, it frequently has consecutive same-side trades. Thus, whether it is inventory- or price-driven approach, the issuer only tries to balance its warrant and stock position over a longer period of time. This implies that the issuer would like to time the market somewhat even to the extent of increasing its inventory risk.

B. Issue Premium and Issuer’s Profits and Trading Activity

Recall that earlier we found that the issuer participates heavily in the secondary
market trading of the warrant market. If the issuer considers providing liquidity an
important obligation, it should hedge more carefully than what our data show. After
all, the overpricing of warrant on the primary market would allow the issuer to lock in
the profit as long as hedging on the secondary market is done conservatively. What
makes the issuer willing to provide liquidity and at the same time take unnecessary
risk? Timing the market exposes the issuer to the risk of losing money from the
secondary market trading. We believe that the initial overpricing on the primary
market has bearing on the secondary market trading of the issuer.

The issuer would trade more actively on the secondary market if the warrant is
overpriced more initially. There are two plausible reasons for this conjecture.
Firstly, the issuer repeatedly issue new warrants. Overpricing could instill
unfavorable image into investors’ mind so as to hamper the success of future issue.
Trading actively on the secondary market, sometimes even in an unfavorable situation,
would relieve investors’ grudge. Secondly, since the warrant is overpriced initially,
the issuer has room to speculate somewhat in order to make trading profits. We now
examine the secondary market trading profit/activity of the issuer and the extent to
which the option is overpriced.

Table VI shows the issuer’s total profit at the end of warrant life. As explained
in the appendix, the total profit can be broken down into five components: the issue
revenue from primary market, the trading profit from secondary market warrant trading, the change in the value of warrant inventory, the trading profit from secondary market stock trading, and the change in the value of stock inventory. The trading profit and inventory value change are calculated weekly.

The first four warrants in the table are the ones that we have access to the initial inventory. For the remaining eight stocks we assume that the initial inventory is at the level dictated by that is required for hedge. Since all the warrants are issued at the money, we assume that the initial inventory is set for delta that is equal to 0.5. Although the assumption underestimates the actual initial inventory, because the issuer tends over-hedge only somewhat initially, we believe the assumption is innocuous.

But the calculation for warrants is not affected by the lack of data on the initial inventory. One can see from the Appendix that the calculation of profits for warrants can be done by assuming that the initial inventory is zero. The result is invariant to the level of initial inventory. Table VI shows that the issue revenue is the major source of total profit, which suggests that the issuer makes profit mainly from the initial premium. The mean and median warrant trading profit is negative in 8 out of 12 firms. The situation for the trading profit on the stock market is similar. Although many firms experience loss of value in inventory, the combined total profit
is positive for every firm.

The correlation between the extent of overpricing and total profit (total profit as a percentage of issue premium) is –0.81 (-0.69), significant at the 5% significance level. The correlation between the extent of overpricing and total buy and sell in terms of number of shares scaled by the total number of shares outstanding (in terms of number of trades) is 0.10 (-0.21). So higher overpricing results in less profit but not less issuer’s trading activity.

C. Issuer’s Trading and Asset Prices

We adopt the following sampling strategy in order to have a sample that would allow us to clearly examine the relationship between issuer’s trading and asset prices. We start with searching for all the warrant trades of the issuer during the trading day. Once an issuer’s warrant trade is identified, we take all the warrant and stock trades that occur within six minutes before and after the identified issuer’s warrant trade, which constitutes a sample in our analysis. We then classify our samples into different scenarios according to the following rule. We separate the sample in which the identified warrant trade is a buy from the sample in which the trade is a sell. We then calculate five consecutive continuous rates of return in the underlying stock
before and after the issuer trades on the warrants market.\textsuperscript{10}

The samples are further classified into four categories. The first one is the sample in which stock trades of the issuer can be found before the identified warrant trade but no stock trades of the issuer can be found after the identified trade. The second one is the sample in which stock trades of the issuer can be found both before and after the identified warrant trade. The third one is the sample in which stock trades of the issuer cannot be found before the identified warrant trade but stock trades of the issuer can be found after the identified trade. The fourth one is the sample in which no stock trades of the issuer can be found either before or after the identified warrant trade.

Each category is subdivided into 16 sub-categories. The first one is the sub-category that only the issuer’s warrant trades can be found before and after the identified warrant trade. The second one is the sub-category that only the issuer’s warrant trades can be found before the identified warrant trade but no warrant trades at all are found after the identified trade. The third one is the sub-category that only the issuer’s warrant trades can be found before the identified warrant trade and only the warrant trades of other traders after the identified trade can be found. The fourth one is the sub-category that consists of only the issuer’s warrant trades before the

\textsuperscript{10} Note that only stocks that are very liquid can be the underlying stocks. As a result, our analysis shows that there are only very few cases in which we cannot find five consecutive price changes within
identified warrant trade and warrant trades of both the issuer and other traders after
the identified trade. The remaining sub-categories are grouped employing the same
logic.

We record the number of observations of each sub-category. The number of
observations of each sub-category could also shed light on the trading behavior of the
issuer. For example, if the issuer usually does not have stock trade before and after
the identified warrant trade and there are issuer’s other warrant trades before and after
the identified trade, then the trading behavior could be more like a scalper.

The continuous rate of return is calculated for stock trades. The first continuous
rate of return after the issuer’s warrant trade is that between the first stock trade after
the issuer’s warrant trade and the stock trade before the issuer’s warrant trade. The
second continuous rate of return after the issuers warrant trade is that between the
second stock trade and the first stock trade after the issuer’s warrant trade. The other
rates of returns are calculated similarly.

The first continuous rate of return before the issuer’s trade is that between the
second stock trade before the issuer’s warrant trade and the first stock trade before the
issuer’s warrant trade. The second continuous rate of return before the issuer’s
warrant trade is that between the third stock trade before the issuer’s warrant trade and

the six minutes window.
the second stock trade before the issuer’s warrant trade. The remaining rates of return before the identified warrant trade are calculated similarly.

We employ the same methodology to study the stock trade of the issuer and calculate the rates of return of warrant trades before and after the identified issuer’s stock trade.

Figures VIIA-VIID summarize the number of occurrences of each sample category for the case where the identified issuer’s trade is a warrant buy, a warrant sell, a stock buy, and a stock sell, respectively. Overall we identify more warrant trades than stock trades. In addition, consistent with our observation in Figures III and IV, there are more buy transactions than sell ones for warrants but more sell than buy transactions for stocks.

Figures VIIA and VIIB show that about 80% of the time the issuer does not trade the underlying stock during the period six minutes before and after it buys or sells warrant. And if the issuer does not trade on the underlying market during the period six minutes before and after it trades warrant, about 75% of the time the issuer would trade warrant before or after the identified warrant trade. Corroborating with our earlier finding, since the issuer normally does not trade on the underlying market after it has a warrant trade, its behavior is not like a market maker who adjusts the underlying inventory soon after a warrant trade. However, it is possible that its
warrant trade is induced by change in the price of the underlying stock.

In the case where the identified warrant trade is a buy, then either the issuer buys warrant after significant price change in the underlying stock, or its outstanding limit order is picked off by other warrant traders, or the issuer trades warrant to take advantage of its private information. For the first scenario there should be significant increase in the price of the underlying stock before the identified warrant buy, for the issuer adjusts the risk exposure by decreasing the number of its outstanding warrants. For the second scenario the price change before the identified warrant buy could also be significantly negative, for other warrant traders sell warrants when stock price significantly drops to arbitrage on the overvalued warrants. But in both scenarios the information content of the identified warrant trade may not be strong because the issuer and warrant traders react to the underlying market situation. However, if there is not significant price change before the identified warrant trade, then it is possible that either the issuer or other warrant traders trade warrant price based on their private information. As a result, there should be significant price change after the identified trade. If the issuer’s limit order is picked off by other information traders, then there should be significant price decline after the warrant trade. If the warrant trade is initiated by the warrant trader, then there should be significant price increase after the warrant trade. But this case is less
likely because the warrant trader cannot place the most aggressive limit orders.

Since Figure VII shows that the issuer generally does not trade stock before or after the identified warrant trade, in order to investigate the relationship between the issuer’s warrant trade and the price change of the underlying stock, we focus on this case. Focusing on this case also precludes the possibility of the issuer’s stock trade having any influence on the stock price. Table VII (No Stock Trade row) shows that before the identified warrant buy, there is no evidence of significant price change, but there is significant negative price changes after the warrant buy. Thus, our finding suggests that the warrant buy is a result of the issuer’s limit order having been picked off by other warrant traders and that the issuer’s decision to buy warrant is not triggered by the events on the underlying market.

But the case we focus on includes the situation where there are other warrant trades before or after the identified warrant trade. Thus, the stock price change could be affected by those warrant trades rather than the identified warrant trades. But Table VII (No Stock or Warrant Trade row) shows that stock price still declines significantly in the case where there are no other warrant trades before or after the identified warrant trade. Therefore, our finding suggests that the issuer’s warrant buy tends to be picked off by informed traders, rather than being triggered by stock price changes.
The call market on the TSEC could result in a trade that involves multiple traders. If the issuer’s trade tends to be picked off by informed traders, then trades that have the issuer as the only party on the buy side should exhibit significant price decline following the identified warrant buy more so than otherwise. The row in Table VII indicated by “Equal 50%” shows the result for the case where the issuer’s trade constitutes 50% of the total trading volume (the other 50% is made by the sellers). In this case there is significant price decrease after the issuer’s warrant buy. But when there are no other stock or warrant trade before or after the identified trade, there is significant price decrease following the issuer’s warrant buy only in the case where the issuer is the only buyer. This finding suggests that the issuer’s trade tends to be more easily picked off by informed traders than other trader’s trade and supports our hypothesis that the issuer’s strong incentive to buy warrant exposes itself to the risk of losing to informed traders.

In the case where the identified trade is an issuer’s warrant sell, our reasoning is similar to that for the identified warrant buy. We also focus on the case in which the issuer does not trade on the underlying market before and after it has a warrant sell. Although this behavior is not like a market maker who adjusts the underlying inventory immediately before or after a warrant trade, it is possible that the warrant sell is induced by change in the price of the underlying stock. If this is the case, then
there should be significant decrease in the price of the underlying stock before the
identified warrant sell, for the issuer adjusts the risk exposure by increasing the
number of its outstanding warrants. But when there is significant negative stock
price change before the identified warrant sell, the issuer’s warrant sell trade could
have been a result of its order being picked off by other warrant traders that buy
warrants to arbitrage on the undervalued warrants. In this case, significant stock
price increase should ensue as the arbitragers complete the arbitrage by buying the
underlying stock. However, in both scenarios the information content of the
identified warrant trade is not strong because the issuer and warrant traders react to
the underlying market situation. However, if there is not significant price change
before the identified warrant trade, then it is possible that either the issuer and other
warrant traders trade the warrant price based on their private information. As a
result, there should be significant price change after the identified trade. If the
issuer’s limit sell order is picked off by other information traders, then there should be
significant price increase after the warrant trade. If the warrant sell is initiated by the
issuer, then there should be significant price decrease after the warrant trade. But
this case is less likely because the warrant trader cannot place the most aggressive
limit orders.

Panel B of Table VII (No Stock Trade row) shows that there is significant price
decline before the identified warrant sell but insignificant price change after the
warrant sell. Thus, our finding suggests that the warrant sell is a result of the
issuer’s reaction to the price decline on the underlying market and the trade does not
have information content. To exclude the impact of warrant trades other than the
identified trade on the underlying, we further limit our sample to the case in which
there is no other warrant trades before and after the identified trade. The result as
indicated by the No Stock or Warrant Trade row is similar, although the two
consecutive returns before the identified trade become insignificant.

If the issuer tends to be triggered by stock price decline to sell warrant, then the
phenomenon should be stronger when the issuer is the only one on the sell side of the
trade. Panel B of Table VII shows that stock price declines significantly before the
identified trade when the issuer is the only seller (the Equal 50% row) but not so when
there are also other warrant sellers in the trade (the Less Than 50% row). This
finding reinforces our conclusion that the issuer’s warrant sell is triggered by stock
price decline.

Thus, in the case of the issuer’s warrant sell, the issuer trades like a market
maker that follows the price-driven approach to hedge its warrant risk exposure.
However, the issuer’s warrant buy trade does not seem to react to stock price change
and has significant impact on the price of the underlying asset. Although we do not
have an unequivocal explanation for why the issuer’s behavior is not symmetric with respect to the direction of warrant trade, our result is consistent with our hypothesis—the issuer is more willing to buy back warrants to lock in the issue profit (which makes it susceptible to information trading) and the issuer is more willing to sell warrants when the risk exposure reduces (as stock price declines). So our finding is consistent with the issuer’s incentive to reduce (buy warrant) rather than increase (sell warrant) risk exposure overtime. The issuer would be more willing to sell warrant after stock price decrease. But it will buy warrant even if there is no stock price increase. In addition to the incentive of locking in the issue profit, since the issuer is the only party on the short side, it feels obligated to buy back warrants even when it does not think that the timing is adequately appropriate.

We now examine the relationship between the issuer’s stock trade and warrant price. Figures VIIC and VIID show that about 60% of the time it does not trade warrant during the period six minutes before and after the issuer buys or sells the underlying. And if the issuer trades the underlying during the period six minutes before and after it trades the underlying, it mainly happens when the issuer does not trade on the warrant market. In this case about 85% of the time the issuer would trade stock before or after it has another stock trade. This finding suggests that within a relatively short period of time the issuer’s decision to trade the underlying is
not closely linked to its warrant trade and that if it trades the underlying, the trade is not an isolated incident.

At the first glance, Panels C and D of Table VIIA shows that before the identified buy stock trade of the issuer the warrant price rises significantly, then falls significantly after the identified trade, and that warrant price rises significantly after the issuer’s stock sell. However, after excluding the effect of other stock trades around the identified stock trade on warrant prices, there is no evidence of significant warrant price change before and after the identified stock trade. So our finding suggests that the issuer’s stock trade does not react to warrant price change and does not have significant impact on warrant price.

V. Conclusion
This paper studies the trading behavior of derivative warrant issuer on the Taiwan Stock Exchange and its relationship to stock price. We find that the issuer is the major liquidity provider on the warrant market. It contributes about 20% of the total trading volume to the warrant market. About 40% of the warrant trading volume can transpire because of its participation. It also participates in the trade of 4% of the underlying market. Thus, the issuer of warrant also helps increase the liquidity of the underlying.

The issuer does not trade like a scalpers or a position trader. It makes market. Unlike the designated market makers on the options market, although overall its inventory of the underlying stock decreases as the inventory of warrant increases, it does not quickly adjust their underlying inventory as it trades warrant. There could be several reasons for the issuer not to hedge conservatively. Warrant is not like option having a series of many similar contracts that differ only by exercise price and maturity date and having puts as well as calls traded simultaneously. As a result, it is difficult to hedge the gamma risk of issuing warrant. Since continuous hedge based on delta is impractical, taking a view (speculating) on the direction of price movement is a way of hedging gamma risk.

In addition, the issue premium is the main source of the issuer’ s profit. Since in practice the issuer sets a higher premium than the volatility of the underlying stock
warrants, high premium allows the issuer to trade more aggressively (speculate more) on the secondary market.

We find that the issuer’s profit is significantly negatively related to the degree of overpricing of warrant. And the degree of overpricing does not seem to hamper the liquidity of the secondary market. Thus, our finding provides a new insight on the regulation of a market maker’s (underwriter’s) issue premium. Since higher degree of overpricing does not result in higher profit or less secondary market liquidity, there is no need to regulate issue premium. Actually, the issuer’s warrant buy seems to be picked off often by informed traders. Higher degree of overpricing induces the issuer to buy back warrant premium, which helps the warrant and underlying market to be efficient because private information is revealed through the issuer’s trade. In this regard, higher premium leads to more efficient secondary market.

Finally, the nature of derivative warrant market makes the issuer the only trader on the short side, which gives the issuer more incentive to buy back warrant than to sell warrant. This is the reason why the issuer’s warrant buy is more susceptible to be picked off by informed traders, but the issuer’s warrant sell is not. The issuer has higher incentive to sell warrant after stock price drops significantly (the chance of exercise is smaller).
Appendix

We calculate the profit from trading the underlying stocks and warrants separately.

Our method for the stock is as follows. Let $S_0$ be the amount of inventory of the underlying stock (in number of shares) at the open of the first trading day of the warrant. Let $PS_0$ be the last price of the underlying stock before the first trading day of the warrant. Let $S_t$ be the amount of inventory of the underlying stock at time $t$. Let $PS_t$ be the price of the underlying stock at time $t$. Let $SB_t$ ($SS_t$) be the number of shares bought (sold) by the issuer at time $t$. Let $PSB_t$ ($PSS_t$) be the buy (sell) price of the underlying stock at time $t$. There are two ways to calculate the profits from trading the underlying stock. The first is what we called the inventory approach.

Suppose the value of the inventory at time $t+3$ is $V_{t+3}$, then:

$$V_{t+3} = S_{t+3} PS_{t+3} = (S_0 + SB_{t+1} - SS_{t+2}) PS_{t+3}$$

(1)

The cost of inventory change between time 0 and $t+3$ is:

$$C_{t+3} = SB_{t+1} PSB_{t+1} - SS_{t+2} PSS_{t+2}$$

(2)

The total gain/lose taking into account the cost of inventory change is:

$$TG_{t+3} = V_{t+3} - C_{t+3} - V_0 =$$

$$= (S_0 + SB_{t+1} - SS_{t+2}) PS_{t+3} - (SB_{t+1} PSB_{t+1} - SS_{t+2} PSS_{t+2}) - S_0 PS_0$$

$$= [S_0 PS_{t+3} - S_0 PS_0] + [(SB_{t+1} - SS_{t+2}) PS_{t+3} - (SB_{t+1} PSB_{t+1} - SS_{t+2} PSS_{t+2})]$$

(3)
The first bracketed part of equation (3) is the “change in the value of initial inventory.” The second bracketed part is the “trading profit,” assuming that the trading imbalance during the period is reversed at the ending price. In the paper we calculate weekly profits, assuming that in the end of a week the trading imbalance is reversed at the last close price of the week. Another way to calculate the total gain/loss is what we call the trading approach. The gain/loss of the ending inventory from price change is:

\[ G_{t+3} = S_{t+3} (P_{t+3} - P_0) \]  

(4)

The gain/loss from trading is:

\[ TR_{t+3} = SS_{t+2} PSS_{t+2} - SB_{t+1} PSB_{t+1} - (S_0 - S_{t+3}) P_0 \]  

(5)

The total gain/lose taking into account the inventory price change and trading is:

\[ TG_{t+3} = G_{t+3} + TR_{t+3} = S_{t+3} (P_{t+3} - P_0) + SS_{t+2} PSS_{t+2} - SB_{t+1} PSB_{t+1} - (S_0 - S_{t+3}) \]

\[ = S_{t+3} P_{t+3} + SS_{t+2} PSS_{t+2} - SB_{t+1} PSB_{t+1} - S_0 P_0 \]  

(6)

Equations (3) and (6) are clearly identical. In fact, equation (4) is written under the assumption that \( S_{t+3} \) is smaller than \( S_0 \). One can verify that when \( S_{t+3} \) is greater than \( S_0 \), equation (4) ought to be written as the following:

\[ G_{t+3} = S_0 (P_{t+3} - P_0) \]  

(7)

Equation (5) would be rewritten as the following:
\[ \text{TR}_{t+3} = S_{t+2} \text{PSS}_{t+2} - S_{t+1} \text{PSB}_{t+1} - (S_0 - S_{t+3}) \text{PS}_{t+3} \]  

(8)

But TG\(_{t+3}\) would still be the same as equation (6).

\[ \text{TG}_{t+3} = G_{t+3} + \text{TR}_{t+3} = S_0 (\text{PS}_{t+3} - \text{PS}_0) + S_{t+2} \text{PSS}_{t+2} - S_{t+1} \text{PSB}_{t+1} - (S_0 - S_{t+3}) \]

\[ \text{PS}_{t+3} = S_{t+3} \text{PS}_{t+3} + S_{t+2} \text{PSS}_{t+2} - S_{t+1} \text{PSB}_{t+1} - S_0 \text{PS}_0 \]  

(9)

For ease of programming, we take the inventory approach to calculate the gain/loss from trading the underlying stocks.

The profit from trading the warrant needs to be calculated with some adjustment to the method for the stock. Let W\(_0\) be the amount of inventory of the warrant (in number of shares) at the open of the first trading day of the warrant and W be the amount of the total issue of the warrant. Then (W-W\(_0\)) is the amount that is subscribed by investors before the secondary market trading of the warrant starts.

Let PW\(_0\) be the issue price of the warrant. Let W\(_t\) be the amount of inventory of the underlying stock at time t. Let PW\(_t\) be the price of the warrant at time t. Let WB\(_t\) (WS\(_t\)) be the number of warrant bought (sold) by the issuer at time t. Let PWB\(_t\) (PWS\(_t\)) be the buy (sell) price of warrant at time t. There are also two ways to calculate the profits from trading warrant. The first is what we called the inventory approach. Suppose the value of the inventory at time t+3 is WV\(_{t+3}\), then:

\[ \text{WV}_{t+3} = W_{t+3} \text{PW}_{t+3} = (W_0 + \text{WB}_{t+1} - \text{WS}_{t+2}) \text{PW}_{t+3} \]
The cost of inventory change between time 0 and $t+3$ is:

$$WC_{t+3} = WB_{t+1} PWB_{t+1} - WS_{t+2} PWS_{t+2}$$

The total gain/lose taking into account the cost of inventory change is:

$$WTG_{t+3} = WV_{t+3} - WC_{t+3} - WV_0 =$$

$$(W_0 + WB_{t+1} - WS_{t+2}) PW_{t+3} - (WB_{t+1} PWB_{t+1} - WS_{t+2} PWS_{t+2}) - W_0 PW_0$$

$$= [W_0 PW_{t+3} - W_0 PW_0] + [(WB_{t+1} - WS_{t+2}) PW_{t+3} - (WB_{t+1} PWB_{t+1} - WS_{t+2} PWS_{t+2})] \text{(12)}$$

The first bracketed part of equation (3) is the “change in the value of initial inventory.” The second bracketed part is the “trading profit,” assuming that the trading imbalance during the period is reversed at the ending price. In the paper we calculate weekly profits, assuming that in the end of a week the trading imbalance is reversed at the last close price of the week. However, unlike the underlying stock, the value of the beginning inventory is the opportunity cost of holding the inventory because it would have been the income of the issuer had the warrants been purchased by investors before the start of secondary market trading. In addition, the actual opportunity cost to the issuer is determined if the warrant expires in the money or not.
As a result, the last price used for calculating the last weekly trading profit and the change in the value of inventory for the duration of the warrant depends on if the ending inventory is lower than the beginning inventory. If the ending inventory is not lower than the beginning inventory, then the last price is 0. Otherwise, the last price is the intrinsic value of warrant if it matures in the money or 0 if it matures out of money. Thus the total profit from issuing the warrant if

\[ WG_{t+3} = PW_0 W - WTG_{t+3} \]

Just like the case of the underlying stock we can calculate the total gain/loss using the trading approach. Since the logic is identical to that of the stock, we will not repeat the calculation of the trading approach. The combined profits from trading the warrant and the underlying stock is thus the following:

\[ WSTG_{t+3} = WG_{t+3} + TG_{t+3} \]

(13)

References


1835-1861.


Table I
Sample Descriptive Statistics

The sample period begins from September of 1997 to July of 1999. There are fifteen plain vanilla warrants and four warrants for which the underlying asset is a portfolio of stocks (portfolio warrants) that are listed and mature during the sample period. In order to focus on the trading behavior of the issuer of warrant, we excluded the four portfolio warrants. Besides, three vanilla warrants issued by the same securities firm having overlapping life are also excluded. As a result, there are twelve warrants and their underlying stocks in our data. The theoretical price of the warrant is calculated using the Black-Scholes formula for a call option. “% of overpricing” of the warrant is calculated by dividing the difference between the issue premium (i.e., issue price) and the theoretical price by the theoretical price. “% of underlying shares” is calculated by dividing the number of issue shares of the warrant by the outstanding shares of the underlying stock.

<table>
<thead>
<tr>
<th>Warrant Number</th>
<th>Stock Number</th>
<th>Exercise Price</th>
<th>Issue Price</th>
<th>Theoretical Price</th>
<th>% of Overpricing</th>
<th>Stock Price at the Issue Date</th>
<th>Issue Date</th>
<th>Listing Date</th>
<th>Maturity Date</th>
<th>No. of Issue (in 1,000 Shares)</th>
<th>% of Underlying Shares</th>
</tr>
</thead>
<tbody>
<tr>
<td>0501</td>
<td>2327</td>
<td>133.5</td>
<td>36.100</td>
<td>26.69</td>
<td>35.25</td>
<td>133.5</td>
<td>1997/8/20</td>
<td>1997/9/4</td>
<td>1998/9/3</td>
<td>22,000</td>
<td>3.47%</td>
</tr>
<tr>
<td>0502</td>
<td>1602</td>
<td>42.0</td>
<td>11.340</td>
<td>7.67</td>
<td>47.87</td>
<td>42.0</td>
<td>1997/8/21</td>
<td>1997/9/4</td>
<td>1998/9/3</td>
<td>22,000</td>
<td>1.42%</td>
</tr>
<tr>
<td>0504</td>
<td>2817</td>
<td>69.0</td>
<td>16.420</td>
<td>10.47</td>
<td>56.77</td>
<td>69.0</td>
<td>1997/12/9</td>
<td>1997/12/19</td>
<td>1998/12/18</td>
<td>20,000</td>
<td>2.41%</td>
</tr>
<tr>
<td>0505</td>
<td>2327</td>
<td>77.0</td>
<td>22.720</td>
<td>18.91</td>
<td>20.17</td>
<td>77.0</td>
<td>1997/12/16</td>
<td>1998/1/5</td>
<td>1999/1/4</td>
<td>20,000</td>
<td>2.98%</td>
</tr>
<tr>
<td>0506</td>
<td>2323</td>
<td>78.5</td>
<td>21.600</td>
<td>20.14</td>
<td>7.24</td>
<td>78.5</td>
<td>1997/12/23</td>
<td>1998/1/8</td>
<td>1999/1/7</td>
<td>20,000</td>
<td>4.58%</td>
</tr>
<tr>
<td>0507</td>
<td>1301</td>
<td>68.5</td>
<td>16.440</td>
<td>11.48</td>
<td>43.26</td>
<td>68.5</td>
<td>1998/1/16</td>
<td>1998/2/7</td>
<td>1999/2/6</td>
<td>20,000</td>
<td>0.81%</td>
</tr>
<tr>
<td>0508</td>
<td>1303</td>
<td>59.5</td>
<td>14.875</td>
<td>10.12</td>
<td>46.92</td>
<td>59.5</td>
<td>1998/1/21</td>
<td>1998/2/12</td>
<td>1999/2/11</td>
<td>20,000</td>
<td>0.64%</td>
</tr>
<tr>
<td>0510</td>
<td>2324</td>
<td>134.5</td>
<td>36.420</td>
<td>35.75</td>
<td>1.88</td>
<td>134.5</td>
<td>1998/2/11</td>
<td>1998/2/26</td>
<td>1999/2/25</td>
<td>20,000</td>
<td>3.44%</td>
</tr>
<tr>
<td>0511</td>
<td>2804</td>
<td>109.0</td>
<td>29.430</td>
<td>21.90</td>
<td>34.36</td>
<td>109.0</td>
<td>1998/2/17</td>
<td>1998/3/5</td>
<td>1999/3/4</td>
<td>20,000</td>
<td>0.77%</td>
</tr>
<tr>
<td>0512</td>
<td>1504</td>
<td>45.1</td>
<td>10.820</td>
<td>7.72</td>
<td>40.23</td>
<td>45.1</td>
<td>1998/3/4</td>
<td>1998/3/16</td>
<td>1999/3/15</td>
<td>20,000</td>
<td>1.81%</td>
</tr>
<tr>
<td>0513</td>
<td>2303</td>
<td>91.0</td>
<td>25.810</td>
<td>24.38</td>
<td>5.87</td>
<td>91.0</td>
<td>1998/3/4</td>
<td>1998/3/19</td>
<td>1999/3/18</td>
<td>20,000</td>
<td>0.48%</td>
</tr>
<tr>
<td>0516</td>
<td>2323</td>
<td>70.5</td>
<td>14.875</td>
<td>17.26</td>
<td>-13.80</td>
<td>70.5</td>
<td>1998/7/7</td>
<td>1998/7/23</td>
<td>1999/7/22</td>
<td>20,000</td>
<td>3.20%</td>
</tr>
</tbody>
</table>
Table II
The Trading Behavior of Scalper, Position Trader, Designated Market Maker, and Warrant Issuer

<table>
<thead>
<tr>
<th>Features</th>
<th>Scalper</th>
<th>Position Tader</th>
<th>Designated Market Makers</th>
<th>Warrant Issuer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of Trade</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>High/Low</td>
</tr>
<tr>
<td>Evenness of Trade</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Size of Trade</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High/Low</td>
</tr>
<tr>
<td>Simultaneous Trading on the Derivative and the Underlying Market</td>
<td>Low</td>
<td>High</td>
<td>High/Low</td>
<td>High/Low</td>
</tr>
</tbody>
</table>
Table III
Summary Statistics of Percentage of Trading Days on Which the Issuer Only Has One Trade in Warrant or Stock across 12 Warrants

For each warrant, the percentage of trading days on which the issuer only has one trade in warrant (or stock) is calculated by dividing the number of days which issuer only trade once on the warrant (or stock) market by the total number of trading days. Then, the mean, median, standard deviation, minimum, and maximum of the percentage across 12 warrants are calculated.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warrant Market</td>
<td>2.7</td>
<td>2.8</td>
<td>1.2</td>
<td>0.7</td>
<td>4.8</td>
</tr>
<tr>
<td>Stock Market</td>
<td>1.9</td>
<td>1.5</td>
<td>1.7</td>
<td>0.4</td>
<td>5.8</td>
</tr>
</tbody>
</table>
Table IV
Summary Statistics of Percentage of Trading Days on Which the Issuer Trades on the Warrant and/or Stock Market across 12 Warrants

For each warrant, if the issuer trades on both warrant and stock market during the same day, that day is categorized as a sample observation of “trade on both markets”. If the issuer trades on warrant market but not on stock market during the same day, that day is categorized as a sample observation of “only trade warrant market”. If the issuer trades on stock market but not on warrant market during the same day, that day is categorized as a sample observation of “only trade stock market”. If the issuer doesn’t trade on warrant and stock markets during the same day, that day is categorized as a sample observation of “trade on neither market”. For each warrant, the percentage of trading days of each category is calculated. Then, the mean, median, standard deviation, minimum, and maximum of the percentage across 12 warrants are calculated.

<table>
<thead>
<tr>
<th>Category</th>
<th>Mean</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade on Both Markets</td>
<td>32.2</td>
<td>26.0</td>
<td>20.7</td>
<td>7.4</td>
<td>77.8</td>
</tr>
<tr>
<td>Only Trade Warrant Market</td>
<td>27.0</td>
<td>23.6</td>
<td>13.5</td>
<td>10.4</td>
<td>52.8</td>
</tr>
<tr>
<td>Only Trade on Stock Market</td>
<td>11.1</td>
<td>9.9</td>
<td>8.7</td>
<td>1.4</td>
<td>24.8</td>
</tr>
<tr>
<td>Trade on Neither Market</td>
<td>29.7</td>
<td>27.4</td>
<td>19.1</td>
<td>7.2</td>
<td>64.1</td>
</tr>
</tbody>
</table>
Table V

Time Elapsed between Two Issuer's Trades

“Two warrants in different direction” means that two consecutive warrant trades are done in different direction. “Two warrants in the same direction” means that two consecutive warrant trades are done in the same direction. “Two stocks in different direction” means that two consecutive stock trades are done in different direction. “Two stocks in the same direction” means that two consecutive stock trades are done in the same direction. “One warrant before one stock in different direction” means that one warrant trade is done before one stock trade in different direction. “One warrant before one stock in the same direction” means that one warrant trade is done before one stock trade in the same direction. “One stock before one warrant in different direction” means that one stock trade is done before one warrant trade in different direction. “One stock before one warrant in the same direction” means that one stock trade is done before one warrant trade in the same direction.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>No. of Warrants</th>
<th>No. of Observation</th>
<th>Observations per Warrant</th>
<th>Time between Trades (Seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Warrants in Different Direction</td>
<td>10</td>
<td>3853</td>
<td>385.3</td>
<td>9.6</td>
</tr>
<tr>
<td>Two Warrants in the Same Direction</td>
<td>12</td>
<td>18096</td>
<td>1508.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Two Stocks in Different Direction</td>
<td>11</td>
<td>74</td>
<td>6.7</td>
<td>5.4</td>
</tr>
<tr>
<td>Two Stocks in the Same Direction</td>
<td>12</td>
<td>9510</td>
<td>792.5</td>
<td>2.5</td>
</tr>
<tr>
<td>One Warrant before One Stock in Different Direction</td>
<td>12</td>
<td>2317</td>
<td>193.1</td>
<td>0.1</td>
</tr>
<tr>
<td>One Warrant before One Stock in the Same Direction</td>
<td>12</td>
<td>1141</td>
<td>95.1</td>
<td>0.2</td>
</tr>
<tr>
<td>One Stock before One Warrant in Different Direction</td>
<td>12</td>
<td>2331</td>
<td>194.3</td>
<td>0.1</td>
</tr>
<tr>
<td>One Stock before One Warrant in the Same Direction</td>
<td>12</td>
<td>1173</td>
<td>97.8</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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### Table VI

**Summary Statistics of Issuer’s Profits in 1,000 NT Dollars**

The first four warrants in the table are the ones that we have access to the initial inventory. For the remaining eight stocks we assume that the initial inventory is at the level dictated by that is required for hedge. Since all the warrants are issued at the money, we assume that the initial inventory of stock is set for delta that is equal to 0.5. In addition, we assume that the initial inventory of warrant for each of the remaining eight warrant is zero. Trading profit and inventory value change are calculated weekly. Mean and median of weekly figures are calculated. Issue revenue is calculated by multiplying the issue shares of warrant and the issue price. Total profit is calculated by summing the trading profit, inventory value change, and the issue revenue.

<table>
<thead>
<tr>
<th>Warrant No.</th>
<th>Warrant Trading Profit</th>
<th>Stock Inventory Value Change</th>
<th>Warrant+Stock Total Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Mean</td>
</tr>
<tr>
<td>0504</td>
<td>42.6</td>
<td>0.0</td>
<td>70.4</td>
</tr>
<tr>
<td></td>
<td>-28160.3</td>
<td>-28160.3</td>
<td>-133265.6</td>
</tr>
<tr>
<td></td>
<td>428400.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0507</td>
<td>-3.4</td>
<td>0.7</td>
<td>-120.7</td>
</tr>
<tr>
<td></td>
<td>-27043.8</td>
<td>-27043.8</td>
<td>-133137.2</td>
</tr>
<tr>
<td></td>
<td>328800.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>0511</td>
<td>-240.5</td>
<td>11.4</td>
<td>161.0</td>
</tr>
<tr>
<td></td>
<td>-29430.0</td>
<td>-29430.0</td>
<td>-244420.9</td>
</tr>
<tr>
<td></td>
<td>588600.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warrant No.</td>
<td>Warrant</td>
<td>Stock</td>
<td>Warrant+Stock</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>-------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Mean</td>
</tr>
<tr>
<td>0512</td>
<td>Trading Profit</td>
<td>12.8</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Inventory Value Change</td>
<td>-17647.4</td>
<td>-17647.4</td>
</tr>
<tr>
<td></td>
<td>Issue Revenue</td>
<td>216400.0</td>
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</tr>
<tr>
<td></td>
<td>Total Profit</td>
<td>199227.3</td>
<td></td>
</tr>
<tr>
<td>0501</td>
<td>Trading Profit</td>
<td>-10.7</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Inventory Value Change</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Issue Revenue</td>
<td>794200.0</td>
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</tr>
<tr>
<td></td>
<td>Total Profit</td>
<td>793814.1</td>
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</tr>
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<td>0502</td>
<td>Trading Profit</td>
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</tr>
<tr>
<td></td>
<td>Inventory Value Change</td>
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</tr>
<tr>
<td></td>
<td>Issue Revenue</td>
<td>249480.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Profit</td>
<td>249157.4</td>
<td></td>
</tr>
<tr>
<td>0505</td>
<td>Trading Profit</td>
<td>-43.7</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Inventory Value Change</td>
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<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Issue Revenue</td>
<td>454400.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Profit</td>
<td>452870.9</td>
<td></td>
</tr>
<tr>
<td>0506</td>
<td>Trading Profit</td>
<td>-41.3</td>
<td>31.0</td>
</tr>
<tr>
<td></td>
<td>Inventory Value Change</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Issue Revenue</td>
<td>432000.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Profit</td>
<td>429101.0</td>
<td></td>
</tr>
<tr>
<td>Warrant No.</td>
<td>Trading Profit</td>
<td>Inventory Value Change</td>
<td>Issue Revenue</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------</td>
<td>------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>0508</td>
<td>-517.8</td>
<td>0.0</td>
<td>297500.0</td>
</tr>
<tr>
<td></td>
<td>-13.7</td>
<td>-117614.5</td>
<td>96451.4</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>-110000.0</td>
<td>91500.0</td>
</tr>
<tr>
<td></td>
<td>-488.7</td>
<td>-121702.6</td>
<td>96451.4</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
<td>-125000.0</td>
<td>91500.0</td>
</tr>
</tbody>
</table>
Table VII

The Mean Cumulative Rate of Returns of the Stock Trades (or Warrant Trades) before and after the Identified Warrant Trade (or Identified Stock Trade)

In order to examine the relationship between issuer’s trading and asset prices, we calculate the cumulative rate of return of the stock (or warrant) trades within six minutes before and after the identified issuer’s warrant (or stock) trade. –R5~R1 is the cumulative five consecutive continuous rates of return in the underlying stock before the identified warrant trade. –R4~R1 is the cumulative four consecutive continuous rates of return in the underlying stock before the identified warrant trade. –R3~R1 is the cumulative three consecutive continuous rates of return in the underlying stock before the identified warrant trade. –R2~R1 is the cumulative two consecutive continuous rates of return in the underlying stock before the identified warrant trade. –R1 is the continuous rates of return between the first stock trade and the second stock trade before the identified warrant trade. R1 is the continuous rates of return between the first stock trade after the identified warrant trade and the stock trade before the identified warrant trade. R1~R2 is the continuous rate of return between the second stock trade and the first stock trade after the identified warrant trade. R1~R3 is the continuous rate of return between the third stock trade and the first stock trade after the identified warrant trade. R1~R4 is the continuous rate of return between the fourth stock trade and the first stock trade after the identified warrant trade. R1~R5 is the continuous rate of return between the fifth stock trade and the first stock trade after the identified warrant trade. R1~R6 is the continuous rate of return between the sixth stock trade and the first stock trade after the identified warrant trade.

Similar methodology is employed to calculate the rates of return of warrant trades before and after the identified issuer’s stock trade. “Equal 50%” (“Less Than 50%”) means that the issuer’s trade constitutes 50% (less than 50%) of the total trading volume.

Panel A: When the Identified Warrant Trade Is a Buy Trade

<table>
<thead>
<tr>
<th>Stock Trade</th>
<th>N</th>
<th>-R5~R1</th>
<th>-R4~R1</th>
<th>-R3~R1</th>
<th>-R2~R1</th>
<th>-R1</th>
<th>R1</th>
<th>R1~R2</th>
<th>R1~R3</th>
<th>R1~R4</th>
<th>R1~R5</th>
<th>R1~R6</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Stock Trade</td>
<td>11750</td>
<td>0.0085</td>
<td>0.040</td>
<td>0.040</td>
<td>-0.0061</td>
<td>0.0064</td>
<td>-0.0067</td>
<td>-0.0161</td>
<td>-0.0185</td>
<td>-0.0195</td>
<td>-0.0261</td>
<td>-0.0276</td>
</tr>
<tr>
<td>Equal 50%</td>
<td>9761</td>
<td>0.0086</td>
<td>0.0044</td>
<td>0.0044</td>
<td>-0.0051</td>
<td>0.0053</td>
<td>-0.0073</td>
<td>-0.0143</td>
<td>-0.0171</td>
<td>-0.0187</td>
<td>-0.0258</td>
<td>-0.0250</td>
</tr>
<tr>
<td>Less Than 50%</td>
<td>1989</td>
<td>0.0081</td>
<td>0.0018</td>
<td>0.0018</td>
<td>-0.0107</td>
<td>0.0123</td>
<td>-0.0042</td>
<td>-0.0247</td>
<td>-0.0253</td>
<td>-0.0235</td>
<td>-0.0275</td>
<td>-0.0400</td>
</tr>
<tr>
<td>No Stock or Warrant</td>
<td>2450</td>
<td>0.0085</td>
<td>0.0117</td>
<td>0.0117</td>
<td>-0.0035</td>
<td>0.0047</td>
<td>-0.0019</td>
<td>-0.0202</td>
<td>-0.0156</td>
<td>-0.0197</td>
<td>-0.0313</td>
<td>-0.0310</td>
</tr>
<tr>
<td>Trade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equal 50%</td>
<td>1966</td>
<td>0.0086</td>
<td>0.0121</td>
<td>0.0121</td>
<td>-0.0002</td>
<td>0.0066</td>
<td>-0.0046</td>
<td>-0.0257</td>
<td>-0.0159</td>
<td>-0.0218</td>
<td>-0.0359</td>
<td>-0.0333</td>
</tr>
<tr>
<td>Less Than 50%</td>
<td>484</td>
<td>0.0084</td>
<td>0.0098</td>
<td>0.0098</td>
<td>-0.0171</td>
<td>0.0030</td>
<td>0.0090</td>
<td>0.0019</td>
<td>-0.0144</td>
<td>-0.0111</td>
<td>-0.0128</td>
<td>-0.0216</td>
</tr>
</tbody>
</table>

Price Change

* Significant at the 10% level.
** Significant at the 5% level.
### Table VII (Continued)

#### Panel B: When the Identified Warrant Trade Is a Sell Trade

<table>
<thead>
<tr>
<th>Stock Trade</th>
<th>N</th>
<th>-R5~-R1</th>
<th>-R4~-R1</th>
<th>-R3~-R1</th>
<th>-R2~-R1</th>
<th>-R1</th>
<th>R1</th>
<th>R1-R2</th>
<th>R1-R3</th>
<th>R1-R4</th>
<th>R1-R5</th>
<th>R1-R6</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Stock Trade</td>
<td>9202</td>
<td>-0.0312**</td>
<td>-0.0274**</td>
<td>-0.0274**</td>
<td>-0.0203**</td>
<td>-0.0050</td>
<td>0.0061*</td>
<td>0.0045</td>
<td>0.0038</td>
<td>0.0049</td>
<td>0.0067</td>
<td>0.0051</td>
</tr>
<tr>
<td>Equal 50%</td>
<td>7780</td>
<td>-0.0376**</td>
<td>-0.0323**</td>
<td>-0.0323**</td>
<td>-0.0218**</td>
<td>-0.0051</td>
<td>0.0044</td>
<td>0.0057</td>
<td>0.0046</td>
<td>0.0059</td>
<td>0.0073</td>
<td>0.0073</td>
</tr>
<tr>
<td>Less Than 50%</td>
<td>1422</td>
<td>0.0043</td>
<td>-0.0004</td>
<td>-0.0004</td>
<td>-0.0123</td>
<td>-0.0042</td>
<td>0.0154*</td>
<td>-0.0022</td>
<td>-0.0005</td>
<td>-0.0006</td>
<td>0.0038</td>
<td>-0.0066</td>
</tr>
</tbody>
</table>

#### Panel C: When the Identified Stock Trade Is a Buy Trade

<table>
<thead>
<tr>
<th>Warrant Trade</th>
<th>N</th>
<th>-R5~R1</th>
<th>-R4~R1</th>
<th>-R3~R1</th>
<th>-R2~R1</th>
<th>-R1</th>
<th>R1</th>
<th>R1-R2</th>
<th>R1-R3</th>
<th>R1-R4</th>
<th>R1-R5</th>
<th>R1-R6</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Warrant Trade</td>
<td>1197</td>
<td>0.2290**</td>
<td>0.2056**</td>
<td>0.2056**</td>
<td>0.1799**</td>
<td>0.1157**</td>
<td>-0.1497**</td>
<td>-0.1537**</td>
<td>-0.1430*</td>
<td>-0.1540*</td>
<td>-0.1665**</td>
<td>-0.1676**</td>
</tr>
<tr>
<td>Equal 50%</td>
<td>220</td>
<td>0.1892**</td>
<td>0.1751**</td>
<td>0.1751**</td>
<td>0.1619*</td>
<td>0.0961</td>
<td>-0.4886</td>
<td>-0.4816</td>
<td>-0.5033</td>
<td>-0.4929</td>
<td>-0.4828</td>
<td>-0.4875</td>
</tr>
<tr>
<td>Less Than 50%</td>
<td>977</td>
<td>0.2379**</td>
<td>0.2124**</td>
<td>0.2124**</td>
<td>0.1840**</td>
<td>0.1201**</td>
<td>-0.0734</td>
<td>-0.0798</td>
<td>-0.0619</td>
<td>-0.0777</td>
<td>-0.0953</td>
<td>-0.0955</td>
</tr>
<tr>
<td>No Warrant or Stock</td>
<td>225</td>
<td>0.1073</td>
<td>0.1052</td>
<td>0.1052</td>
<td>0.1190</td>
<td>0.0688</td>
<td>-0.4657</td>
<td>-0.5169</td>
<td>-0.4206</td>
<td>-0.4172</td>
<td>-0.3882</td>
<td>-0.3941</td>
</tr>
<tr>
<td>Trade</td>
<td>9</td>
<td>0.2014</td>
<td>0.0723</td>
<td>0.0723</td>
<td>0.1339</td>
<td>-0.1291</td>
<td>-7.9239</td>
<td>-7.9473</td>
<td>-7.7708</td>
<td>-7.7708</td>
<td>-7.7708</td>
<td>-7.7708</td>
</tr>
<tr>
<td>Equal 50%</td>
<td>216</td>
<td>0.1034</td>
<td>0.1065</td>
<td>0.1065</td>
<td>0.1184</td>
<td>0.0771</td>
<td>-0.1549</td>
<td>-0.2073</td>
<td>-0.1144</td>
<td>-0.1108</td>
<td>-0.0806</td>
<td>-0.0867</td>
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</table>
Panel D: When the Identified Stock Trade Is a Sell Trade

<table>
<thead>
<tr>
<th>Warrant Trade</th>
<th>N</th>
<th>-R5−R1</th>
<th>-R4−R1</th>
<th>-R3−R1</th>
<th>-R2−R1</th>
<th>-R1</th>
<th>R1</th>
<th>R1−R2</th>
<th>R1−R3</th>
<th>R1−R4</th>
<th>R1−R5</th>
<th>R1−R6</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Warrant Trade</td>
<td>2606</td>
<td>0.0683</td>
<td>0.0700</td>
<td>0.0700</td>
<td>0.0628</td>
<td>0.1444</td>
<td>**</td>
<td>0.0958</td>
<td>0.1540</td>
<td>**</td>
<td>0.1759</td>
<td>**</td>
</tr>
<tr>
<td>Equal 50%</td>
<td>766</td>
<td>-0.0756</td>
<td>-0.0752</td>
<td>-0.0752</td>
<td>-0.0389</td>
<td>-0.0102</td>
<td>0.1564</td>
<td>0.0840</td>
<td>0.1197</td>
<td>0.1637</td>
<td>0.1701</td>
<td>0.1701</td>
</tr>
<tr>
<td>Less Than 50%</td>
<td>1840</td>
<td>0.1282</td>
<td>0.1305</td>
<td>0.1305</td>
<td>0.1051</td>
<td>0.2088</td>
<td>**</td>
<td>0.0706</td>
<td>0.1832</td>
<td>**</td>
<td>0.1993</td>
<td>**</td>
</tr>
<tr>
<td>No Warrant or Stock</td>
<td>330</td>
<td>-0.1255</td>
<td>-0.1238</td>
<td>-0.1238</td>
<td>-0.0788</td>
<td>-0.0106</td>
<td>0.1295</td>
<td>0.1048</td>
<td>0.0264</td>
<td>0.0059</td>
<td>0.0362</td>
<td>0.0368</td>
</tr>
<tr>
<td>Trade Equal 50%</td>
<td>9</td>
<td>-0.1007</td>
<td>-0.1007</td>
<td>-0.1007</td>
<td>-0.1007</td>
<td>-0.1533</td>
<td>-0.4469</td>
<td>*</td>
<td>0.0129</td>
<td>0.0129</td>
<td>0.0129</td>
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</tr>
<tr>
<td>Less Than 50%</td>
<td>321</td>
<td>-0.1261</td>
<td>-0.1244</td>
<td>-0.1244</td>
<td>-0.0781</td>
<td>-0.0066</td>
<td>0.1457</td>
<td>0.1073</td>
<td>0.0267</td>
<td>0.0057</td>
<td>0.0368</td>
<td>0.0375</td>
</tr>
</tbody>
</table>

Notes: 1. **: 5% significant level  
2. *: 10% significant level
Figure I

The Weekly of Average of Daily Turnover Ratio on the Warrant and the Stock Market across Warrants

The turnover ratio is calculated as the ratio of trading volume (in shares) to the total number of shares outstanding.
Figure II
The weekly Average of the Daily Trading Volume of the Issuer as a Percentage of the Total Trading Volume on the Warrant and the Underlying Market
Figure III
The Weekly Average of Daily Buy and Sell Volume of the Issuers on the Warrant Market as a Percentage of the Total Trading Volume
Figure IV
The Weekly Average of Daily Buy and Sell Volume of the Issuers on the Underlying Market as a Percentage of the Total Trading Volume
Figure V
The Average Weekly Inventory Position of Four Warrants Scaled by the Number of Shares Issued
Figure VI

The Weekly Average Correlation between Daily Net Buy on the Warrant and the Underlying Market and the Correlation between Stock Return and the Net Buy on the Stock Market
Figure VIIA

The Mean Number of Observations across Warrants of Each Sample Category for the Case in Which the Identified Trade is a Warrant Buy
Figure VIIB

The Mean Number of Observations across Warrants of Each Sample Category for the Case in Which the Identified Trade is a Warrant Sell
Figure VIIC
The Mean Number of Observations across Warrants of Each Sample Category for the Case in Which the Identified Trade is a Stock Buy

[Bar chart image]
Figure VIID

The Mean Number of Observations across Warrants of Each Sample Category for the Case in Which the Identified Trade is a Stock Sell