INTRADAY PRICE AND VOLUME RELATIONS

IN THE STOCK AND WARRANT MARKETS

BY

LIM KOK SEE

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ABSTRAK

Kertas kajian ini meneliti struktur sebab-penyebab dalam harga dan jumlah dagangan di dalam pasaran waran dan saham di Bursa Saham Kuala Lumpur, (KLSE) Malaysia. Kami menyiasat perhubungan dalam-hari di antara harga dan jumlah dagangan bagi 25 waran dan saham mereka yang paling aktif diniagakan untuk tempoh bermula 24 September hingga 16 Disember 2003. Data di kumpulkan ke dalam selang-masa 5-minit untuk kajian ini. Ujian-ujian *unit root, cointegration, vector error correction (VEC) dan Granger causality* digunakan untuk menganalisis perhubungan *lead-lag* di antara harga dan jumlah dagangan bagi pasaran waran dan saham. Hasil kajian kami mendapati bahawa jumlah dagangan mendahului harga untuk kedua-dua pasaran saham dan waran. Waran mendahului saham bagi kedua-dua jumlah dagangan dan harga. Jumlah dagangan waran mendahului harga saham, dan jumlah dagangan saham mendahului harga waran.

ABSTRACT

This research paper examines the causal structure of price and volume in the warrant and stock markets within the Kuala Lumpur Stock Exchange (KLSE) of Malaysia. We investigate the intraday relations between price and trading volume of the top 25 most active warrants and their underlying stocks during the period from 24th September to 16th December 2003. The data were grouped into 5-minute intervals for this study. Unit root, cointegration, vector error correction (VEC) and Granger causality tests were used to analyse the lead-lag between price and volume of the warrant and stock markets. Our results show that volume leads price for both stock and warrant markets. Warrant leads stock in both volume and price. Warrant volume leads stock price, and stock volume leads warrant price.

Chapter 1

INTRODUCTION

1.1 Background

There have been many studies on stock price movements done locally and abroad over the years. These have always attracted investors' interest. Such studies are generally classified as either short or long-term focused, of which a few of them are zoomed down to within a day. This study will focus on the trend of price movements within a day, which is an extreme of short-term. Studies on stock price movements within the day are known as intraday.

Leveraged investments such as warrants, stock rights, options and futures, allows the investors to participate in the market with a smaller sum of money than their underlying securities or common stock. The value of these leverage investments are normally derived from the value of their underlying securities. Aside from this regular longer term leverage investments facility, if there exist an option versus stock lead or lag within the day (intraday) the investors would be interested to know if there is an arbitrage opportunity.

Evidence of stock option market leading stock market has appeared in various literatures by Manaster and Rendleman (1982) and Bhattacharya (1987). On the contrary, there is also a study by Stephan and Whaley (1990) that claimed that the stock market lead the stock option market.

1.2 Problem Statement

In an efficient market there should be complete simultaneity in that the stock and its warrant price changes should be synchronised. New information disseminated into the market place should reflect in the price and volume of both securities simultaneously. Since various studies have indicated possibilities of both lead or lag opportunities in the stock market against its option market, it would be interesting to note which one applies to our local Kuala Lumpur Stock Exchange (KLSE). As stock option market is not popular in Malaysia, this study will compare the stock market against its warrant instead.

In short, the problem to be investigated here is:

"Does the stock market lead or lag the warrant market in price changes and trading activity in the KLSE?"

1.3 Research Question

This research study will attempt to answer the following questions:

1. Is there a lead or lag in the stock market compared to its warrant market in terms of price change?
2. Is there a lead or lag in the stock market compared to its warrant market in terms of volume?
3. Is there a lead or lag in the price change compared to its volume for the stock market?

4. Is there a lead or lag in the price change compared to its volume for the warrant market?
5. Is there a lead or lag in the stock market price change compared to its warrant market volume?
6. Is there a lead or lag in the stock market volume compared to its warrant market price change?

1.4 Research Objective

The objective of this study is to answer the research questions listed in section 1.3 above, which is mainly to determine if there is an intraday lead or lag in the stock market compared with the warrant market in the KLSE. The lead-lag effect would be reviewed at both price change and trading activity levels. This study hopes to identify if there is a possible arbitrage in the intraday trade. Where the arbitrage is significant, it could be beneficial to capitalize from this study by sharing this information with a brokerage house.

1.5 Scope of the Study

The scope of the study is limited to the data available from the KLSE. In this study warrant is used, since stock option is not popular in the Malaysian context. Warrant is similar to a call option with the exception of a longer expiry date.

There are 907 stock counters and 185 warrants in the KLSE as at 24th September, 2003 (source: The Star newspaper, 25th September 2003). This study is limited to stocks with corresponding warrants.

1.6 Significance of the Study

Warrant trading is attractive because it increases financial leverage and reduce transaction costs when compared to trading in the market for the underlying stock. The significance of this study can be group into 2 categories:-

1. Significance to the traders.

   The traders would be interested if there are profit opportunities between the stock market and the warrant market. For example, if there is a significant lead in the stock against its warrant, the trader would buy up the warrant whenever he/she notices a rise in the price of the stock because a subsequent rise in the price of the warrant will follow.

2. Significance to financial theories.

   In a perfectly functioning capital market, the warrant price and trading activity should be synchronised with that of its underlying stock. A lead or lag finding could raise new financial interest, in the sense that information does not arrive at the two markets simultaneously. This could give an indication to the efficiency level of the markets under study.

1.7 Organisation of Report

Chapter 1 defines the problem and research questions and justifies why this study in important. Chapter 2 describes the literatures reviewed and discusses on topics related to this study. Chapter 3 describes the methodology of this study that is its theoretical framework, hypotheses, research design and data collection method. Chapter 4 describes the statistical analysis and results of the study. Chapter 5 discusses the study as a whole, list its limitations and provides suggestions for future research.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

The subject of stock market and warrant lead-lag analysis can be reviewed from a number of different perspectives. This literature review provides information relating to:-

1. The definition of the Options,
2. The effect of market efficiency,
3. The intraday price relation,
4. The intraday price-volume relation,
5. The behavioural factor impacting market efficiency,
6. The decision support system factor.

2.2 Options

Options are a form of leveraged investments. They convey the rights to buy a security at a specified price for a stated period of time. Option prices are directly related to the prices of its common stock. Investing in options is risky, as there is a life span involved in its trading. Reduced transaction costs and increased financial leverage are two reasons why trading in the stock option market may be more attractive than trading in the market for the underlying stock. The various types of options in the market are:-

2.2.1 Stock Rights

These offerings allow the current stockholders to have first right to purchase new shares and thus maintaining their present ownership interest. For instance, when a company issues additional shares, the investor may receive a stock rights to buy an equivalent ownership interest of the new issue at a subscribed price (also known as exercise price). The exercise price is normally lower than the market price of the stock, otherwise, the public would not have any interest to buy.

2.2.2 Stock Warrants

A warrant is an option to buy a share at a specified price for a stated period of time at an exercise price that is generally higher than the current market price. A warrant is usually valid for several years. Warrants are not available for all securities. They do not pay dividends nor carry any voting rights. They are traded through the broker like common stocks. Warrants allow the holder to participate indirectly in price appreciation of the common stock and enjoy a capital gain. As at 24th September 2003, there were 185 warrants in the KLSE (of which 7 were under Practice Note 4 (PN4)). Of the 178 active warrants, 136 were from the Main Board and 42 from the 2nd Board of the KLSE (source: The Star newspaper on 25th September 2003).

2.2.3 Calls and Puts

When an investor purchase a call, the investor is buying the right to purchase stock at a fixed price. When the investor purchases a put, the investor is buying the right to sell

stock at a fixed price. Logically, the investor would buy a call when the investor expect the stock to rise and a put when the investor expect the stock to fall. A call has a life of one to nine months and if the stock does not rise within that period the investor would loose his/her full investment. Similarly, for a put the investor would loose his/her full investment if the stock does not fall within the stipulated period. Calls and puts are not popular in the KLSE.

2.3 Intraday Price Relation

Many studies have been done on intraday price relations between options and stocks. It is a general believe that options tend to lead stock on intraday price because options are leveraged investments which have a lower transaction cost and thus, more actively traded in the market than its underlying stock. Studies by Manaster and Rendleman (1982) and Bhattacharya (1987) showed that option market leads the stock market in terms of price changes and trading activity. However, Bhattacharya (1987) found that the lead seems insufficient to overcome the bid/ask and search costs. Kawaller et al. (1987) using minute-to-minute data on S&P 500 futures and S&P index found that futures price movements consistently lead index movements by 20 to 45 minutes while movements in the index rarely affect futures beyond 1 minute. Despite this significance, they found strong evidence that futures and spot prices move largely in unison and the lag was unlikely to be significant enough for profit. De Jong and Nijman (1997) did a similar study on the S&P 500 futures and index that confirmed Kawaller et al's (1987) findings but to a lesser degree of futures leading the cash index by at least 10 minutes. Chan (1992) analysed the lead-lag relationship among the Major Market cash index, Major

Market futures index and S&P 500 futures. His empirical results showed strong evidence that the futures leads the cash index suggesting that the futures market is the main source of market-wide information.

Stephan and Whaley (1990) investigated on the intraday relations between price changes and trading volume of options and stocks on the Chicago Board Options Exchange. Against earlier studies, they found that price changes in the stock market lead the option market by as much as 15 minutes. Similarly, Chiang and Fong (2001) found that in the Hong Kong market the cash index returns lead more than lag the option trade returns. A likely reason given was that the options are thinly traded, so the prices are usually stale. They imply that emerging derivatives markets' relative informational efficiency seems to depend on the market maturity. Turkington and Walsh (2000) found that stock price leads option price by 15 to 30 minutes in the Australian markets.

Chan et al. (1993) confirmed Stephan and Whaley's (1990) results. However, they explained that their results were spurious lead induced by infrequent trading of options. They concluded that the relatively larger option tick causes option prices to appear to lag stock prices. The stock lead disappears when the average of the bid/ask prices is used instead of transaction prices.

Sheikh and Ronn (1994) and Chan et al. (1993) found neither stocks nor options lead each other, claiming that their findings are consistent with simultaneous or randomised informed trading in both stock and options market. Their study was based on the New

York Stock Exchange (NYSE) and Chicago Board Options Exchange (CBOE). Lim (1996) and Bakshi et al. (2000) found no lead-lag between options and stocks for Nikkei 255 and S&P 500 markets respectively.

2.4 Intraday Price-Volume Relation

There are 2 theoretical explanations for price-volume relations of stocks:-

1. Sequential Information Arrival Hypothesis (SIAH)

   SIAH assumes that traders receive new information in a sequential, random fashion. It is because traders do not receive their information at the same time that causes their reaction timings to vary. Once all traders have reacted to the information a final equilibrium is reached. This hypothesis suggests that lead-lag values of price change may have the ability to predict current trading volume and vice versa.

2. Mixture of Distribution Hypothesis (MDH)

   This hypothesis implies that price-volume relation is critically dependent upon the rate of information flow into the market. It assumes that all traders receive the new price signals simultaneously, thus, the shift to a new equilibrium is immediate and there will be no intermediate partial equilibrium.

The sequential information arrival model tested by Copeland (1976) and Jennings et al. (1981) suggest a positive causal relation between stock prices and trading volume in either direction. Karpoff (1987) concludes from his reviews of previous researches that volume is positively related to the magnitude of the price change. Using Granger causality tests Hiemstra and Jones (1994) found evidence of significant bidirectional

nonlinear causality between returns and volume of stock. They gave 4 explanations for a causal stock price-volume relation:-

1. Due to the sequential information flow, lagged trading volume could have predictive power for current absolute stock returns and lagged absolute stock returns could have predictive power for current trading volume.
2. Tax and non-tax related motives for trading. Tax related motives are associated with the optimal timing of capital gains and losses realised during the calendar year. Non-tax related motives include window dressing, portfolio rebalancing, and contrarian strategies.
3. According to the mixture of distribution model, the greater the degree of disagreement among traders, the larger the level of trading volume. Epps and Epps (1976) suggested a positive causal relation running from trading volume to absolute stock returns.
4. According to noise trader models, aggregate stock returns are positively autocorrelated in the short run, but negatively autocorrelated in the long run. Volume causing stock returns can be explained that trading strategies pursued by noise traders cause stock prices to move. Whereas, stock returns causing volume can be explained with the positive feedback trading strategies of noise traders for which the decision to trade is conditioned on past stock price movements.

Manaster and Rendleman (1982) and Bhattacharya (1987) found that the option market leads the stock market in trading activity. Easley et al. (1998) found empirically that negative and positive option volumes contain information about future stock prices. The

reason being changes in stock prices induces hedge related trading in options. Their result is strongly consistent with option markets being a venue for information-based trading. Consistent with the findings of Stephane and Whaley (1990), they provided evidence that stock price changes seem to lead option volumes. Using Granger causality, Easley et al. (1998) found that option volumes lagged stock price changes by between 20 and 30 minutes.

Dufour and Engle (2000), Engle (2000) and Chordia and Swaminathan (2000) found that trading volume is a significant determinant of the lead-lag patterns observed in stock returns. However, it was unclear that investors could profitably trade on these patterns. Dufour and Engle (2000) found that as the time duration between transactions decreases, the price impact of trades, the speed of price adjustment to trade related information and the positive autocorrelation of signed trades all increases. This means that short time durations interpreted as high activity are related to both larger quote revisions and stronger positive autocorrelations of trades. Their explanation to this is that when trading size is large and/or trading frequency is high, the liquidity providers revise upward their beliefs that an information event has occurred. Hence, some of the traders may decide to postpone their trading and/or demand larger spreads, and they adjust prices more rapidly in response to trades.

Turkington and Walsh (2000) found that volume leads price in both the stock and option markets in Australia. They conclude that volume leads price by about 15 minutes in the

stock market and by about 45 minutes in the option market. According to them, this suggests traders reacting to private information rather than public information.

Results from Anthony (1988) and Darrat et al. (2003) supported the sequential information arrival theory where trading volume and return volatility were found to follow a clear lead-lag pattern. Anthony (1988) found that trading activity in call options lead that of its underlying shares. Turkington and Walsh (2000) found that trading volume of the options market lead that of the stock market by at least 15 minutes.

2.5 Market Efficiency

According to Fama (1970), information on stocks can be classified into the following three categories:-

1. Weak Form

   This means that all information contained in the historical process is shown in the stock price, i.e. there is no opportunity to make abnormal returns by studying historical price patterns.

2. Semi-Strong Form

   The current information about the company and its incidental events has all been accounted for in the stock price i.e. stock prices efficiently adjust to information publicly available.

3. Strong Form

   This states that privileged information, which may be exclusive to the investor, would be incorporated into the stock price.

Relating this to our subject of study, the weak form of market efficiency is the one that we are basing this study on, that is, how the intraday historical price and volume information available in one market affects another market.

2.5.1 Options Efficiency

Previous tests of the Black-Scholes (BS) model have shown that the formula is highly successful in explaining the observed market prices of options Black and Scholes (1972), Galai (1977), and Chiras and Manaster (1978). According to the BS model, the value of an option can be determined through the equation:-

$$\boldsymbol{w = x\,N(d_1) - c\,e^{-rt^*}\,N(d_2)} \qquad (1)$$

where

w = the price of an option for a single share of stock

x = the current price of the stock

c = the current striking price of the option

r = the short term rate of interest

t^* = the duration of the option

$$d_1 = \frac{\ln(x/c) + (r + \tfrac{1}{2}\sigma^2)\,t^*}{\sigma\sqrt{t^*}}$$

$$d_2 = d_1 - \sigma\sqrt{t^*}$$

$N(d)$ = the value of the cumulative normal density function

σ^2 = the variance rate of the return on the stock

This means that the underlying stock price can be determined from the option price and the values of all input parameters to the BS model except the stock price. A major limitation of the BS model is the assumption that the underlying stock does not pay any dividends over the life span of the option.

Hong (2004) using BS model on KLSE warrant market, found that its model price was significantly different from the market price and that both the model and market prices deviated in a systematic pattern. He concluded that the BS model systematically overpriced in-the-money and near- or at-the-money warrants, and longer than 5 years maturity warrants.

2.5.2 The Problem of Nonsimultaneity of Stock and Option Quotations

According to Bookstaber (1981), if the stock price is used to determine the correct option price following the BS model, the option may appear to be mispriced because the stock price that was used in the formula (the stock price quoted as the closing price), is not the stock price that existed in the market when the last option price was quoted. The two nonsimultaneity problems considered were:-

1. The nonsimultaneity between the stock price at closing and the stock price at the time of the last option quote.
2. When two options are combined in a hedging strategy, at the time of the last price quote for the one option used in the hedge, the other option may have a price that differs enough from its price at the time of its last quote.

He concluded that the probability of mispricing and profit opportunities from option strategies due to nonsimultaneity are not achievable in practice. His methods suggested that there may be value in time series analysis when daily quotations are used such as the extent of error induced from the nonsimultaneity of the data due to day-to-day variation within the time of the last closing quotation.

2.6 Behavioural Factors

Behaviourists believe that profits can be realised from market inefficiency, which comes from stock prices' irrational reactions to information and investors' herd behaviour. Daniel et al. (1998) and Hong and Stein (1997) develop models that are based on behavioural bias. Their models are based on the cognitive bias which leads investors to either underreact to information or adopt positive feedback strategies that result in delayed overreaction to information. In the studies conducted by Grinblatt et al. (1995) and Lakonishok et al. (1994), they found that the herd mentality (or "momentum investor") explains the higher returns observed.

These behavioural factors can help to explain the lead-lag variations in the intra-day stock market versus warrant market analysis. As one market reacts to these factors, there may be a delay or over reactions on another market. This could result in a lead-lag between the stock and warrant markets in terms of price and/or volume for this study.

2.7 Decision Support System

With the advances of hardware and software technology, it is possible to develop sophisticated decision support systems. Leigh et al. (2002) exemplifies the potential that lies in the novel application and combination of methods. They consider more electic (or "romantic") options in their technical analysis based on the approach of "bull flag" price and volume pattern heuristic which is a change from the classical approach. The availability of decision support system can further extend the lead-lag analysis of this study.

2.8 Review Summary

The high leverage available in options markets encourages informed traders to transact options rather than stocks. From the above literatures reviewed, it can be summarised that:-

1. The evidence on intraday stock and option markets lead-lag relationship is not conclusive (see section 2.3 and 2.4). Since the lead-lag relationship is not conclusive, it is a research potential to understand it from KLSE perspective.
2. Behavioural factors can contributes toward market inefficiency such as stock prices' irrational reactions to information and investors' herd behaviour (see section 2.6).
3. Market efficiency models are available to help in determining and explaining the stock and option price changes (see section 2.5). The models are required to understand the pricing of the stock option against its underlying stock.

4. With the technological advances of the 21st century, complexity or computational heavy algorithms should hardly be a limitation in our decision support systems (see section 2.7).

As far as the literatures reviewed through this study, there was no evidence of similar studies conducted using KLSE data. Hence, it would be interesting to observe and understand the intraday interrelationships of the stock and option (or warrant) markets in Malaysia.

Chapter 3

METHODOLOGY

3.1 Introduction

The methodology used for this study adopts the approach used by Stephan and Whaley (1990). Their study was based on CBOE and Fitch data, but this study will be based on the local KLSE data. This study also replaces the stock options used in their study with warrants since stock options are not popular in Malaysia.

3.2 Theoretical Framework

A warrant on a common stock is a leveraged long position in the stock, where the degree of leverage is continuously re-balanced as the stock price changes and as the warrant approaches expiration. It is through this redundancy that relative warrant pricing models can be developed for example the BS model.

The price of a warrant (W) may be expressed as a function of the underlying stock price (S) as follows:

$$W = f(S) \tag{2}$$

The value of the stock may also be written as a function of the warrant price by inversing its function:

$$S = f^{-1}(W) \tag{3}$$

If a warrant price changes from W^{t-1} to W^t over a small interval of time and if the equilibrium relation between the stock price and the warrant price remains intact, the stock price change over the same interval of time should be:

$$f^{-1}(W_t) - f^{-1}(W_{t-1}) = \hat{S}_t - \hat{S}_{t-1} \equiv \hat{s}_t \tag{4}$$

It is the relation between the implied stock price change $\hat{s}_t$ in (4) and the actual stock price change $S_t - S_{t-1} \equiv s_t$ that is the primary focus of this study. In a perfectly functioning stock and warrant markets, the price change relation should be perfectly simultaneous:

$$\hat{s}_t = s_t \tag{5}$$

The theoretical price change relation (5) is the primary focus of this study. With perfectly frictionless and continuous markets, the implied warrant price variation should be equal to the stock price change. In practice price changes in the two markets will vary for the following reasons:-

- The markets are not frictionless (i.e. inefficient markets),
- Price changes from the two markets are not simultaneous, and
- If there are economic profits for traders to transact in one market vis-à-vis the other, a lead-lag relation will arise.

Following the above empirical model, the implied price change to investigate would be:

$$\hat{s}^0_t = \alpha + \sum_{k=-K}^{K} \beta_k s^0_{t-k} + \epsilon_t \tag{6}$$

where s^0_t *and* $\hat{s}^0_t$ are the observed actual and implied stock price changes, respectively, ϵ_t is the random disturbance, and K is the (arbitrary) number of leading and lagged

regressors. Market frictions will contribute to the error variance in (6). Leading and lagged effects will be reflected through nonzero, non-simultaneous coefficients.

3.3 Statement of Hypothesis

From the list of research questions in section 1.3 above, the following statements of hypothesis can be drawn.

- There are more studies that showed options/futures market leads its underlying stock/cash market (e.g. Manaster and Rendleman (1982), Bhattacharya (1987), and Kawaller et al. (1987), De Jong and Nijman (1997) and Chan (1992)) than the stock/cash market leading the options/futures market (see section 2.3). With this information, we would similarly state our first alternate hypothesis as shown below which would also answer the research question of whether there is a lead or lag between the stock market and the warrant market:

  H_{1a}: "The warrant market leads the stock market in terms of price change"

- Anthony (1988) and Turkington and Walsh (2000) found that volume of option market leads that of its underlying stock (see section 2.4). Hence, this encourage us to state our alternate hypothesis as shown below:

  H_{2a}: "The warrant market leads the stock market in terms of volume"

- Copeland (1976) and Jennings et al. (1981) found a positive causal relation between stock prices and trading volume in either direction. Dufour and Engle (2000), Engle (2000), Chordia and Swaminathan (2000) and Turkington and Walsh (2000) found that trading volume is a significant determinant of the lead-lag patterns observed in prices (see section 2.3). In order to investigate this in our stock and warrant market and at the same time answer our research question on lead-lag between price change and volume for the stock and warrant market, the following alternate hypotheses are created:

  H_{3a}: "Volume leads price change for the stock market"

  H_{4a}: "Volume leads price change for the warrant market"

- Stephane and Whaley (1990) and Easley et al. (1998) found that stock price changes lead option volumes (see section 2.4). The alternate hypothesis below is created to investigate this finding together with our research question on lead-lag between stock market price change and warrant volume.

  H_{5a}: "Stock market price change leads warrant market volume"

- Turkington and Walsh (2000) found that stock trading activity leads option price in five of the seven stocks. The alternate hypothesis below is created to investigate this finding together with our research question on lead-lag between warrant market price change and stock market volume.

  H_{6a}: "Stock market volume leads warrant market price change"

3.4 Research Design

In this study, warrant is used in place of stock option, since stock option is not popular in the Malaysian context. Warrant is similar to a call option with the exception of a longer expiry date.

From the various studies on intraday options-stock price and/or volume relations done over the years (e.g. Manaster and Rendleman (1982), Bhattacharya (1987), Stephane and Whaley (1990), etc.), it is found that they either use raw prices or price changes for their data analysis. In foreign markets the question of market synchronisation often arise due to the different start and close timing of their markets (e.g CBOE and NYSE). Since both the stock and warrant markets are traded within KLSE in Malaysia the question of synchronisation does not exist.

As at 24th September 2003, there were 185 warrants. It is not practical to analyse all warrants for 2 reasons:

1. Not all warrants are actively traded. Since we are going to summarise the activities into 5 minute intervals, it would be wise to select warrant counters with sufficient transactions covering that period over the day.
2. The time available for this thesis would not permit us to analyse all warrant counters.

Hence, we need to select sufficient warrant counters (preferably > 20) to conduct our study. In the selection process of warrant counters, it is assumed that it's underlying share

counters would be just as active and not pose a problem for insufficient transactions that would deviate our study.

3.5 Methodology

3.5.1 Population

The population of this study comprises of all warrants and its respective stock counters listed in the Main Board, Second Board and Mesdaq of the KLSE. As at 24th September 2003, there are 185 warrants (of which 7 were classified as PN4) and 907 stock counters (of which 75 were classified as PN4) within the KLSE (source: The Star newspaper on 25-Sept-04). The warrants mentioned are of those issued by their respective underlying stocks.

3.5.2 Sample

For the purpose of this study a sample of warrants were selected out of the 185 based on the following criteria:-

- Warrants not under PN4.
- The warrants should have sufficient transactions to cover 5 minute intervals throughout the day, which total about 72 5-minute intervals over a 6 hour trading day (i.e. 6 X 60 / 5).
- The warrants should not expire during the observation period of September to December 2003.
- Price and volume data are available during the observation period.