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**INTRADAY STOCK
VOLATILITY:
A NEW ZEALAND PERSPECTIVE**

A thesis presented in partial fulfilment of the requirements
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ABSTRACT

Open-to-open, close-to-close, open-to-close (trading) and close-to-open (non-trading) time periods are examined for dually and non-dually listed stocks in an attempt to explain the volatility patterns which were observed in the New Zealand Stock Exchange. The time period analysed covers the 1997 calendar year.

The intraday volatility pattern for the New Zealand Stock Exchange showed similar results to previous studies performed on large exchanges around the world. That is, when the return variances are plotted against the trading time they follow a distinct U-shaped curve, caused by high volatility at the opening and closing of the market.

Previous studies have found that the high volatility experienced at the opening of the market results from the long non-trading period prior to the opening. This was examined by analysing the open-to-open to close-to-close variance ratio for both dually and non-dually listed stocks. The explanation that the long non-trading period prior to the opening of the market is a major cause of the volatility experienced at the market opening is not supported by the results found in this study. The results obtained from this study show that the high volatility at the market opening is associated with high capitalised stocks.

A low open-to-close (trading) to close-to-open (non-trading) variance ratio was observed in the New Zealand market. Previous research has attributed this low ratio to dually listed stocks continuing to trade during the non-trading overnight period of the domestic market. The findings in this study contradict this explanation and suggest that it is low capitalised stocks that are associated with the low trading to non-trading variance ratio observed in the New Zealand Stock Exchange.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

Stock markets play a vital role in the economic and social lives of millions of people around the world, making them an integral component of every country's economy. Even though the New Zealand Stock Exchange is small by world standards, it has roles and functions to perform similar to other larger stock exchanges. Grant (1997, p. 11) describes the New Zealand Stock Exchange as having two primary functions. "First, the exchange acts as a financial intermediary in the mobilisation of capital for businesses in either the public or private sectors. Secondly, the exchange acts as a facilitator, enabling individuals and institutions to buy and sell company shares in order to influence the company's direction, as well providing an investment option to increase the buyer's personal assets."

Since the worldwide stock market crash in October 1987, many analysts have researched stock markets in order to gain an insight into stock market volatility. The majority of these studies were performed on markets in the United States. Volatility can be defined as the change in stock price, relative to some average for a period. Jones and Wilson (1989) analysed volatility in the United States over 104-years, in order to gauge whether volatility has increased over the sample period. They found that the great depression in the 1930's was the longest period of extreme volatility, with volatility during the 1980's being similar to the 1890's and the 1920's. Jones et al. (1989) concluded that there appears to be no increase in long-term or short-term stock price volatility.

Gerety and Mulherin (1991) conducted further research into long term stock market volatility by analysing the Dow Jones over a fifty-five year period. They found that of the 50 largest (absolute) hourly changes, eighteen occurred in 1987, with seventeen of these occurring in October. May 1933 to December 1939 had twenty out of the top 50 most volatile hours, with twelve of these occurring in 1933. Their study found that other than

these two periods large price changes occurred in a random fashion, and confirmed Jones et al.'s (1989) finding that volatility appears not to have increased dramatically in the long-term.

Despite evidence to the contrary, public perception is that volatility has increased in recent years, with the 1998 Asian crisis doing nothing to detract from this perception. Jones et al. (1989) points out that much of this misperception is likely to be based on the amount of price change, when it should be based on percentage change. Percentage change is more informative as a volatility measure, compared to the absolute price change because stock prices and indices inevitably increase over time. Therefore a 5-point increase in a stock or index, would be more volatile twenty years ago than a 5-point increase today.

Volatility can only be caused when several investors trade simultaneously in the same direction. Schwert (1990) outlines three explanations as to why this may occur. The first relates to the arrival of new information. That is, new information can cause traders to sell or buy shares perceived to be too high or low. If this is the major cause of volatility, then it is not necessarily bad for investors. This is because if prices decline or rise slowly, which reduces short-term volatility, investors would be either paying too much or too little for the stock. Hence short-term volatility enables investors to achieve a "fair price".

The second cause of volatility is the use of stock price behaviour as an input to trading strategies. If the common perception of investors is that stock prices will fall, once they start to drop these investors will sell expecting them to fall further.

The third cause of volatility is that many investors may revise their beliefs about stock values. The rational behind this theory is that no investor believes that he or she has all the available information about a company, hence every investor learns something by watching the trading activities of others. If stock prices fall, some investors may believe they have less information than those currently selling do, therefore they will follow suit and sell causing the price to drop even further.

These three explanations mainly contribute to short-term volatility, with long-term volatility being caused by economic factors such as a country's monetary policy. According to the New York Stock Exchange (1990, cited in Gerety and Mulherin, 1991) investors

should be more concerned with short-term volatility rather than volatility over long time periods. They justify this by suggesting intraday reversals have an impact on the perception of the investors ability to get a “fair price.” A suggested method to reduce intraday volatility is to have stocks trade for longer hours, which can be achieved by two methods. One method is to extend the trading hours of the stock exchange, while the other is to cross list securities in foreign exchanges around the world.

There are numerous reasons why a company may dual list their shares in addition to the reduction of volatility. There is the possibility to improve relations between the domestic and foreign countries; an increase in the demand, price and/or exposure of the firms’ stock; foreign markets often provide a cheap source of capital; the acceptance of a foreign country can serve as a positive signal to investors (Howe and Kelm, 1987; Forester and Karolyi, 1993; Lee, 1992). Along with the potential benefits of cross listing shares, also come potential disadvantages to the firm. The downside of cross listing shares are associated with the costs of dual listing. Additional fees can be charged by the foreign exchange; costs may result from providing new information to the foreign financial community; costs may also be incurred by having to comply with any different standards of disclosure in the foreign country (Howe and Kelm, 1987; Forester and Karolyi, 1993; Lee, 1992).

Another possible advantage of cross listed stocks relates to the volatility experienced in the domestic country. There is an ongoing debate over whether the act of dual listing securities, leads to a greater level of volatility in domestic returns following the listing in the foreign exchange. Barclay, Litzenberg and Warner (1990, cited in McConnell, Dybeuik, Hashatter and Lie, 1996) found in their study that new dual listings do not increase return variances in the domestic market. Makhija and Nachtmann (1990), Jayaraman, Narayanan, Shastri and Tandon (1993), and Howe, Madura and Tucker (1993) all oppose Barclay et al.’s (1990) findings, and report that the act of dual listing securities result in an increased variance of returns in the domestic markets. Therefore it is unclear whether cross listing reduces or increases volatility within the domestic market after the dual listing date.

Because of the advantages gained through dual listing stocks on foreign exchanges, 113 stocks listed on the New Zealand Stock Exchange during 1997 were also listed in at least

one other foreign exchange (Allison, 1998). Of these, 94 stocks were foreign companies listed in New Zealand, with only 19 New Zealand stocks dual listed elsewhere. This suggests that the New Zealand stock market is relatively easy for foreign companies to gain access to.

As short-term volatility influences the perception of investors ability to achieve a “fair price” (New York Stock Exchange, 1990, cited in Gerety and Mulherin, 1991), this study analyses intraday volatility within the New Zealand Stock Exchange. This study also investigates whether dually listed stocks in a small market have a similar impact on intraday volatility as they do in larger exchanges. Research concerning stock market volatility can fall into two categories. First, studies that document observed patterns, and second, studies that develop models to predict patterns (Foster and Viswanathan, 1993). This study is of the former kind.

1.2 Aim of the study

The aim of this study is two-fold. Firstly this research will ascertain whether the securities that constitute the 40 top New Zealand listed companies by total market capitalisation (New Zealand Stock Exchange top 40 (NZSE 40)) have intraday volatility patterns consistent with major world stock exchanges. There is reason to believe these patterns within the New Zealand market may differ from other exchanges because of New Zealand’s small exchange size relative to world standards. Previous research conducted on smaller markets is difficult to find, hence knowing if New Zealand will act similar to large exchanges can not be known in advance with any certainty.

The second aim of this study is to analyse whether the extended trading hours caused by dually listed stocks on foreign exchanges impact on volatility. Two categories of dual listed stocks will be compared to a group of stocks that trade frequently and are only listed in New Zealand. Previous research has accepted that cross listing stocks on foreign exchanges reduces intraday volatility, and volatility experienced at the opening of the market (relative to the close). However, these studies have been conducted on large exchanges, therefore it

is unclear whether New Zealand dual listed shares will behave in a similar fashion coming from a smaller market.

1.3 Justification for this study

The insufficient information obtained from research conducted on financial markets in New Zealand is justification in itself for the undertaking of this study. However, it is hoped that this study will ultimately provide benefits for investors and fellow researchers. To the author's knowledge, no research has been conducted in this field on the New Zealand Stock Exchange. Therefore this study will add to the topics analysed on the New Zealand financial market giving it a more global recognition.

Numerous studies of this nature have been performed on stock exchanges around the world. Hence this study will not only add a New Zealand prospective to this field of research, but will also add the prospective of a smaller exchange, and whether the patterns are similar to larger exchanges previously analysed.

The results produced by this study will be useful for people who invest in the New Zealand stock market, as this study will reveal volatility patterns that exist in New Zealand as well as in dually and non-dually listed stocks. This information will indicate to investors which time periods have the least amount of volatility, hence enabling them to achieve a "fair price" when trading.

1.4 Organisation of the study

This study is divided into five chapters. The next chapter details the relevant literature of stock market and dually listed stock volatility. The purpose of this section is to describe each study's aim, methodology, results and conclusions. There has been little statistical development through previous studies, hence the most informative layout of these studies is to present the articles in chronological order. Chapter three explains the data utilised in this study, along with the statistical methodology used. Chapter four presents the results and discussion based on the statistical findings. The final chapter presents the conclusions and a summary of the findings given in the results and discussion section. This section also outlines limitations of the study, and suggests additional research areas within this field.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The foundations of stock market volatility evolved from studies that were confined within the United States. This resulted in analysts believing that the observed characteristics were also confined to United States markets, and resulted from the unique operating procedures and the use of the specialist in the United States. Recent studies are now focused on large markets outside the United States that do not employ a role similar to the specialist, in order to ascertain whether the findings observed from United States markets also hold in these exchanges. While it is not possible to include all relevant studies in this review, an attempt has been made to include those that had a significant influence in this subject area, and those that are of particular relevance to this study.

Section 2.2 reviews intraday stock market volatility, with section 2.3 reviewing studies conducted on intraday volatility concerning dually listed stocks. The methodology utilised in the earlier studies continued in later research, therefore the statistical methodology did not develop over the studies. This suggests the most appropriate way to present this literature review is on a chronological article by article basis. The aim of this chapter is to provide a comprehensive background of previous studies, their sample, time period analysed, the methodology utilised and the conclusions reached.

2.2 Stock market volatility

Wood, McInish and Ord (1985) conducted one of the founding studies on stock market volatility. They examined intraday (minutes) data on the New York Stock Exchange to analyse the behaviour of returns and the characteristics of trades, with a sample consisting of an equally weighted index of common stocks. This sample is broken into two time

intervals, September 1971 through to February 1972, and the calendar year of 1982. Before the analysis, stocks were adjusted for dividends and changes in capitalisation. The return variances during each minute were calculated by the logarithmic price relatives given in equation 1.

$$R_t = \ln[(P_t + d_t)/P_{t-1}] \quad (1)$$

Where: P_t is the price of the security during the trading minute
 P_{t-1} is the price of the security in the prior minute
 D_t is any dividend declared since the last trade

The findings from the study indicated that the mean return variances followed a U-shaped curve over the trading day. The initial high volatility dropped and spanned around zero until the end of the trading day where high return variances were recorded in the last trading minute; these high ending return variances were more pronounced in 1971 to 1972 compared to 1982. When overnight¹ trades were excluded from the sample, the high volatility during the first few minutes were present, but not as high as when these trades were included in the sample. The standard deviations of returns also illustrated a similar U-shaped pattern. When overnight returns were excluded from the sample, the variances dropped at the opening compared to when overnight returns were included in the sample. The finding of the U-shaped curve is consistent with noise trading, as the high volatility rapidly declined at the opening of the market (Kyle, 1985). Kyle (1985) suggested that the decline in volatility is representative of investors trading on private information absorbed during the non-trading overnight period. These prices then converge to an unbiased representation of the security's underlying value (Kyle, 1985). From these results *Wood et al. (1985)* concluded that the mean market return and risk were the highest during the first few minutes of the opening of the market.

¹ Trades that occurred before or after the official open or close of the market.

Amihud and Mendelson (1987) conducted a similar study to that of Wood et al (1985), however instead of examining intraday data, *Amihud and Mendelson (1987)* compared the behaviour of open-to-open and close-to-close returns on the New York Stock Exchange. This study was conducted to examine how the different trading mechanisms at the beginning and end of the trading day influenced volatility. The opening transactions represent the outcome of a trading call procedure; this differs from the closing procedure, which is carried out at prices set by the exchange's market makers. The data utilised in this study were the daily opening and closing prices of the 30 stocks that constituted the Dow Jones Industrial list over the sample period February 8th 1982 to February 18th 1983. These observations were adjusted for any cash/stock dividends or stock splits. The statistical test used to analyse the dispersion of the opening and closing transactions was a modified version of the logarithmic return variance given in equation 1. The open-to-open and close-to-close returns were calculated with equation 2.

$$R_t = \log(P_t + D_t) - \log(P_{t-1}) \quad (2)$$

Where:

P_t represents the opening/closing price, adjusted for splits stock dividends in time period t

D_t represents cash dividends in time period t

Amihud and Mendelson (1987) suggested that the time period of both return series are of equal length, therefore any new information would be reflected in both return series. Hence new information could not be the major factor of volatility. They suggested that this implied any observed differences in the two return series can be contributed mainly to the attributes of the different opening and closing mechanisms utilised. *Amihud and Mendelson (1987)* found that the variance of the open-to-open returns exceeded the close-to-close returns for 29 out of the 30 stocks analysed. On average the variance of open-to-open returns were 20% greater than the close-to-close variance returns. They argued these results suggest that different trading mechanisms have an impact on the dispersion of stock returns. They justified this by concluding that the return volatility is greater in a call procedure (opening) than the closing procedure (prices set by exchange's market makers). That is,

those who transact during the opening of the market are exposed to more variation in stock prices than those who transact at the end of the trading day.

Amihud and Mendelson (1987) also analysed this sample period for market efficiency using autocorrelations by replicating Fama's 1965 research on the random walk. Fama (1965) suggested that if the market is efficient there is no way of using any historic information to price a stock in the future. The formula is presented in equation 3.

$$E[R_t | R_{t-1}] = E[R] \quad (3)$$

This implies that if previous returns have no informational content on which to base future returns, autocorrelation coefficients should equal zero. *Amihud and Mendelson (1987)* found by utilising this method, that 80% of the close-to-close returns had a positive correlation coefficient, averaging 0.0464. However 76.7% of open-to-open returns were negative averaging -0.0635 . These findings imply that close-to-close returns are more efficient as they average a value which was closer to zero than the open-to-open returns. *Amihud and Mendelson (1987)* argued that these autocorrelation coefficients support their previous findings on return variances; that is, trading mechanisms have a significant influence on stock price behaviour.

In this study *Amihud and Mendelson (1987)* analysed the opening and closing procedures of the New York Stock Exchange. They found there was more volatility at the opening of the market compared to the close, which they attributed to the different trading mechanisms utilised. However they failed to recognise the high variance at the market open may be due to the long non-trading period prior to the opening of the market. This is a realistic explanation, as the accumulation of private information overnight can not be utilised to trade on until the market opens (Kyle, 1985). This would explain why the opening period is more volatile than the market close, as no information build up occurs before the market closes, with information being quickly reflected into stock prices during the trading day. *Amihud and Mendelson's (1987)* conclusion that volatility at the market opening is

produced by the trading mechanism and not the non-trading period prior to the opening, implies that stock markets that have a non-trading lunch-break², and open each session with the same trading mechanism would have similar volatility levels at the opening of the morning and afternoon trading sessions.

Harris (1989) observed the price and variance rise at the end of the day documented in the New York Stock Exchange study by both *Wood et al. (1985)*. The finding of this anomaly prompted *Harris (1989)* to examine transaction prices at the end of the trading day. The data consisted of every common stock transaction made on the New York Stock Exchange for the sample period between December 1st 1981, through to January 31st 1983. Over this time period the date, time, price and number of shares traded for each transaction were recorded. *Harris (1989)* utilised mean price changes and F-statistics to draw his conclusions.

Harris' (1989) findings indicated that the last transaction of the day had a positive return, much larger than the preceding transactions. On 54.1% of the examined trading days, the daily mean of the last transaction price change was greater than each of the nine preceding transactions. For 31.4% of the securities in the sample, the mean of the last transaction price change was greater than the preceding nine transaction means. Given these findings, *Harris (1989)* concluded that as a result of the large price increase at the end of the trading day, stocks closing prices may not represent intrinsic stock values.

Up to this point in time, all previous studies conducted on stock market volatility were restricted within the markets of the United States. This led *Miller (1989)* to conclude that the U-shaped volatility curve discovered in United States securities markets, must be a result of something within these markets. Hence *Miller (1989)* suggested the U-shaped volatility curve could be attributed to the specialist performing their duties and moderating overnight price behaviour. The role of the specialist in the United States is to maintain price continuity by minimising price deviations between consecutive trades. This obligation requires the specialist to set opening prices near the previous day's closing price, preventing large changes between closing and opening prices. The specialist will open a

² Such as the Stock Exchange of Hong Kong.

stock price at the previous close, if demand and supply are equal. If demand and supply do not equal, the specialist will open the price near the previous close, but with a small change towards equilibrium (Miller, 1989).

Miller (1989) proposed the strongest evidence of the stabilising influence of the specialist is that the variance of stock prices between the close of trading on one day are very similar to the next days opening price. *Miller (1989)* also attributed the specialists' success to the fact that the variance of intraday returns is about four times larger than the variance of the non-trading period. The high initial price variance found in the United States study by Wood et al. (1985) are, according to *Miller (1989)*, a result of the specialist.

Miller (1989) also has an explanation of how specialists cause the price and variance rise at the end of the trading day. If specialists anticipate that a stock will open higher than the previous close, the specialist wants to close the day near the next day's opening equilibrium price. Hence the specialist will increase prices at the end of the trading day to maintain their continuity requirement.

It appears that Miller's (1989) conclusion regarding the specialist is unfounded, as no study at this point³ was conducted on a stock exchange without a specialist. Hence Miller (1989) has no other exchange to base this conclusion upon. If Miller's (1989) theory is correct, and the U-shaped volatility curve is solely a result of the specialist performing their duties, then markets without specialists⁴ would not exhibit similar intraday patterns.

Stoll and Whaley (1990) extended the 1987 study conducted by Amihud and Mendelson. Their research continued the examination of New York Stock Exchange volatility patterns, analysing the opening procedure to assess its impact on volatility. The data utilised spanned five calendar years from 1982 through to 1986. Every common stock transaction at the opening and closing of the market was recorded, with the time, price and volume, as well as the total number of shares traded during each day. Prior to analysis all transactions were adjusted for cash dividends, stock splits and stock dividends. Each stock had to meet strict

³ To the author's knowledge.

⁴ Such as the New Zealand market.

transaction standards to eliminate problems associated with nonsynchronous trading⁵. *Stoll and Whaley (1990)* utilised a modified version of the logarithmic return relative formula given in equation 1, to ascertain volatility as shown in equation 4.

	$R_t = e_t + (u_t - u_{t-1})$	(4)
Where:	$R_t = \ln P_t - \ln P_{t-1}$	
	$e_t = \ln P^*_t - \ln P^*_{t-1}$: new information	
	$u_t = \ln u_t$	
	P^*_t represents the true price of the security at time t	

Stoll and Whaley (1990) found that the average open-to-open to close-to-close variance ratio was 1.1329. This indicated that on average the open-to-open variance is approximately 12% greater than the close-to-close variance, hence the hypothesis that these two return series were equal was rejected. This percentage was much lower than the 20% observed by *Amihud and Mendelson (1987)* in their New York Stock Exchange study.

Stoll and Whaley (1990) further tested the opening mechanism with serial correlations. They found the serial correlation of open-to-open returns to be -0.0531 , and 0.0202 for the close-to-close returns. These results suggested the close-to-close return variances were more efficient than the open-to-open return variances as they averaged a value closer to zero.

Stoll and Whaley (1990) extended their study to examine the trading period versus the non-trading period. They found that the average monthly ratio was approximately 5.40, which amounts to an “average per-hour ratio of day-time to overnight variances of 16.20” (*Stoll and Whaley, 1990 p. 57*) This is higher than previous studies, which may reflect an increase in trading activities.

Amihud and Mendelson (1987) and *Stoll and Whaley (1990)* offer three main reasons as to why the opening of the New York Stock Exchange experiences high volatility. With each

⁵ Nonsynchronous trading is a condition where frequently traded stocks report prices closer to their “true” equilibrium price compared to infrequently traded stocks (*Gerety and Mulherin, 1991*).

of these suggestions, it is important to recognise they have different implications and solutions to resolve them.

- 1) The lack of price continuity. This theory implies that the long overnight non-trading period prior to the market open causes an information build up, which is then traded upon when the market opens. If this is the major cause of opening volatility, then the decision as to which opening mechanism to use is irrelevant. Also if the long non-trading period prior to the market open is the major cause of the high opening volatility, then this may suggest there are additional benefits to extending the trading hours of the exchange.
- 2) The lack of the specialist's price stabilising activities. Specialists trade from their own accounts only during the interior of the trading day to maintain price continuity. If the lack of price stabilising at the opening is the major cause of stock market volatility, then it is important the specialists trade from their own account at the market open as well as during the trading day.
- 3) The specialist's monopoly power. As specialists observe order imbalance before setting the opening price, he/she is able to manipulate the opening price in order to trade later from his/her own account to maximise profit. If the specialist's monopoly power is a major cause of the opening stock market volatility, *Stoll and Whaley (1990)* suggested that multiple competitive specialists should operate simultaneously.

Lockwood and Linn (1990) extended the analysis of stock market volatility on United States markets by examining the variance of hourly market returns to study the volatility of trading and non-trading time periods. The market index analysed was the Dow Jones Industrial Average from January 1964 through to February 1989. All stock returns were computed as the logarithmic price relatives seen in equation 1, without adjusting for dividends. Days immediately following holidays and days when the Dow Jones closed early were excluded from the sample to avoid unusual observations.

The results from *Lockwood and Linn's (1990)* tests indicated that the Dow Jones Industrial Average hourly variances follow a distinct U-shaped pattern, falling from an initial high variance at the opening, only to rise again at the close of the day. Their findings also indicated that the return variance for the open-to-close (trading) period exceeded the return

variance for the close-to-open (non-trading) period by a factor of 2.34 for the earlier years between January 1964 and April 1973, and 4.37 from May 1973 through to February 1989. The results of the open-to-open and close-to-close returns were mixed. Between the years January 1964 and January 1982, the open-to-open return series were higher than the close-to-close returns. This was reversed between the years from February 1982 through to February 1989.

Lockwood and Linn (1990) also tested for the equality of the variances by utilising the 1974 Brown-Forsythe, modified Levene statistical test (1960, cited in Lockwood and Linn 1990), given in equation 5.

$$F = \left[\sum_{j=1}^J n_j (D_{\cdot j} - D_{\cdot\cdot})^2 / \sum_{j=1}^J \sum_{i=1}^{n_j} (D_{ij} - D_{\cdot j})^2 \right] [(N - J) / (J - 1)] \quad (5)$$

Where:

$$D_{ij} = |R_{ij} - M_{\cdot j}|$$

R_{ij} is the return for the day i , intraday period j .

$M_{\cdot j}$ is the sample median return for period j computed over the n_j days included in the test.

$D_{\cdot j}$ is the mean absolute deviation (from the median) for period j .

$D_{\cdot\cdot}$ is the grand mean.

Their findings indicated that the Dow Jones Industrial Average intraday return variances were not equal at the 5% significance level, neither were the trading and non-trading periods.

McInish and Wood (1990) continued the investigation performed by Wood, McInish and Ord (1985). Wood, McInish and Ord's (1985) study analysed the mean and standard deviations for minute-by-minute return variances during the trading day in the New York Stock Exchange for six months within 1971 and 1972, and the calendar year of 1982. *McInish and Wood (1990)* extended this study to see if these observed patterns held for the calendar years 1980, 1981, 1983 and 1984.

The data utilised consisted of every trade in the New York Stock Exchange for the years 1980-1984; the prices were adjusted for dividends and changes in capitalisation. The return

series were calculated the same way as Wood, McInish and Ord (1985), given in equation 1. The trading day in the New York Stock Exchange consists of 361 trading minutes, *McInish and Wood (1990)* divided the day into three periods, minutes from 1-30, 31-356 and 357-361. These three time periods represented the opening, the interior, and the closing of the trading day. The hypothesis tested in this study was that the standard deviations of the market returns over the three intraday trading periods were equal.

The results from the tests indicated the variability of the market returns per time interval were not equal. They found the variability of the intraday returns followed a crude U-shaped pattern with high variability at the beginning and end of the trading day. They also discovered that in each year of the sample period, the market return variability was highest at the open opposed to the close of the market. These findings were similar to the results obtained from Wood, McInish and Ord (1985). Hence the conclusion reached from this study was that the findings from Wood, McInish and Ord (1985), that the mean market return and risk were the highest during the first few minutes of the opening of the market, also held for the calendar years of 1980, 1981, 1983 and 1984.

McInish and Wood published two studies in 1990; the second was conducted on intraday (minutes) transaction data of stocks that traded on the Toronto Stock Exchange. This was one of the first significant studies on stock market volatility conducted on a market outside the United States. The Toronto Stock Exchange employs more than 135 Registered Traders, who perform the duties similar to those performed by the specialist. Since the Toronto Stock Exchange has Registered Traders who perform similar roles to the specialist in the New York Stock Exchange, Miller's (1989) theory regarding the specialist could not be tested from this study. The data utilised comprised of the price, time and number of shares traded on the Toronto Stock Exchange for the month of February 1987. Similar to their first study in 1990, they divided the trading day into three groups. Each group consisted of minutes representing the market opening, the interior of the day and the closing of the market⁶. Any cancelled trades, trades with less than a round lot and trades with special terms were excluded from the sample. The returns were calculated as the logarithmic price relatives seen in equation 1, without adjusting for dividends.

⁶ These groups were minutes of 1-10; 11-381; 382-391.

The results of the tests on the Toronto Stock Exchange are consistent with those previous studies conducted on the New York Stock Exchange. The plot of intraday returns followed a U-shaped curve, with the highest variance occurring at the market opening. This indicated that this pattern is not solely a result of the peculiarities that exist in the United States markets, however this study did not resolve the issue as to whether the curve resulted from the duties of the specialist.

As previously mentioned, *Amihud and Mendelson's* work in 1987 failed to recognise that the opening volatility may be a result of the long non-trading period prior to the opening of the exchange. *Amihud and Mendelson* claim to have addressed this problem in their 1991 study through the analysis of the Tokyo Stock Exchange. The Tokyo Stock Exchange has two daily trading sessions; a morning session from 9:00 AM to 11:00 AM; and an afternoon session from 1:00 PM to 3:00 PM, separated by a two-hour lunch break between 11:00 AM and 1:00 PM where no trading occurs. The Tokyo Stock Exchange employs two different trading methods, the Itayose and the Zaraba. The Itayose opens both the morning and afternoon trading sessions, with the Zaraba representing continuous trading. The morning open follows a long 18-hour non-trading overnight period, with the afternoon open following a short two-hour non-trading period (*Amihud and Mendelson, 1991*).

Amihud and Mendelson (1991) argued that by studying the opening transactions of the morning and afternoon trading sessions, they can distinguish between the trading patterns that are due to the trading mechanism, and those due to the non-trading period prior to opening. The data analysed by *Amihud and Mendelson (1991)* consisted of four daily prices, the opening and closing prices of the morning and afternoon trading sessions. The data included the 50 highest traded stocks on the Tokyo Stock Exchange, collected from daily stock reports that covered the period July 1st 1987, through to June 30th 1988. The high volatile week of October 19th-25th 1987, was excluded from the sample. All stock returns were calculated as the logarithmic price relatives seen in equation 2, without adjusting for dividends.

The results indicated that the opening morning session had the largest variance of the day, which was significantly different from the other three return series, which were found not to be significantly different from each other. The open-to-open return variances in the morning session were greater than the morning close-to-close return variances for 47 out of

the 50 stocks examined. Whereas in the afternoon session only 28 stocks exhibited a higher open-to-open return variance compared to the close-to-close return variances. From this *Amihud and Mendelson (1991)* concluded that the higher volatility found in the morning opening results from the non-trading period opposed to the trading mechanism. These results may suggest the time length of the non-trading period has an impact on the volatility at the opening of the trading day.

Another test of return behaviour utilised by *Amihud and Mendelson (1991)* was the first order autocorrelation coefficients. The morning open-to-open return correlation coefficients averaged approximately -12% , with the other three return series ranging between 0.7% to -1.26% . These results indicated that the morning open was the most inefficient out of the four examined transaction series.

The behaviour of the four transaction series were affected by the market microstructure and by the movements of the index. *Amihud and Mendelson (1991)* analysed residual returns after controlling for the market index movement using the formula given in equation 6.

$$R_{ijt} = \alpha_{ij} + \beta_{ij} R_{mijt} + \epsilon_{ijt} \quad (6)$$

Where: R_{mijt} is the return on an equally weighted portfolio of all 50 stocks under the trading mechanism i in session j on day t .

From this the variances and autocorrelations were calculated. The results indicated that the lowest average residual variance and the lowest average residual autocorrelation (absolute value) were obtained in the opening transaction of the afternoon trading session. They also found the residual return series for the opening morning session had the greatest variance and more negative autocorrelations than any of the other three series. These results are consistent with the findings obtained with the previous tests on the unconditional return series; thus the conclusions are identical.

The four residual return series indicated that the variance for the morning opening exceeded the variance for the afternoon closing in 74% of the stocks. Whereas the residual variances for the afternoon open exceeded the variances for the afternoon close in only 18% of the stocks. They also found the daily open-to-open and close-to-close returns exhibited a

residual coefficient totalling -6.22 and -2.43 respectively. These findings suggest that the morning opening session is the least efficient out of the four trading time periods, as the autocorrelation coefficients were furthest away from zero. *Amihud and Mendelson (1991, p. 1778)* concluded from their residual return study that the “periodic-clearing transactions per se do not hamper value discovery, and that the high volatility and negative autocorrelations at the morning opening reflect the long preceding period of no trading.”

Amihud and Mendelson (1991) also analysed return series⁷ over trading and non-trading periods using modified versions of the formula given in equation 2. The results from these tests indicated that the variance at the morning open was 5.4 times larger than the average two-hour lunch break, with the afternoon variance open being 4.5 times larger. These results were similar when the residual returns were examined. The return variance in the morning session was 3.8 times greater than the two-hour lunch break, with the variance in the afternoon session being 3.6 times larger.

These results are consistent with previous studies, such as *Lockwood and Linn (1990)*, where the intraday variance returns were larger during the trading day compared to non-trading periods.

The first intraday stock market volatility study to be conducted on a market outside the United States and Canada was conducted by *Chang, Fukuda, Rhee and Takano (1993)* on the Tokyo Stock Exchange. This study enabled the first test of *Miller's (1989)* suggestion regarding the specialist in the New York market, as the Tokyo Stock Exchange does not employ a role similar to the specialist. *Chang et al. (1993)* studied the behaviour of intraday index return volatility in Tokyo similar to *Amihud and Mendelson (1991)*. The price returns were obtained from minute by minute values of the Tokyo Stock Exchange Price Index during the time period August 12th 1987 through to April 26th 1991. Holidays, trading days surrounding October 1987 and trading days with irregular hours were excluded from the sample to avoid unusual observations. As noted in *Amihud and Mendelson (1991)* the

⁷ Morning open to previous afternoon close;
Morning close to morning open;
Afternoon open to morning close;
Afternoon open to afternoon close.

Tokyo Stock Exchange has two trading sessions; one in the morning and one in the afternoon, separated by a two-hour lunch break in which no trading occurs.

Chang et al. (1993) calculated all intraday returns as the natural logarithm relatives; the formula is shown in equation 1 (without adjusting for dividends). The results of these tests indicated a high morning opening variance of 0.042. During the interior of the first trading session the return variance dropped only to rise again at the close of the morning session. This produced return variances following a U-shaped volatility pattern for the morning trading session. The afternoon session experienced a less defined curve, with the opening and closing return variances being less volatile than in the morning session. Because of the non-trading lunch break, the intraday returns of the Tokyo Stock Exchange can not be characterised by a continuous smooth U-shaped curve, as exists in continuous trading markets. However the existence of the double U-shaped curve puts doubt to Miller's (1989) theory that the role of the specialist causes the curve to exist. The double U-shaped curve according to *Chang et al. (1993)* is consistent with noise trading, as the high volatility rapidly declined at the opening of the market (Kyle, 1985).

Choe and Skin (1993) examined intraday return volatility by analysing price data on the Korean Stock Exchange. They replicated Amihud and Mendelson's (1987) and Stoll and Whaley's (1990) studies on the New York Stock Exchange, on the Korea Stock Price Index. *Choe and Skin (1993)* utilised the Korean Stock Exchange as it does not employ a specialist, therefore high volatility in this exchange can not be a result of the specialist's activities. Therefore if the specialist is the cause of the majority of opening volatility, the variance ratio of open-to-open returns to close-to-close returns in the Korean Stock Exchange should be significantly smaller than previous New York Stock Exchange studies. *Choe and Skin (1993)* examined two data sets on the Korean Stock Exchange. The first set contained daily opening and closing values for the years between 1983 through to 1991. All days immediately following holidays were excluded. The second data set contained intraday⁸ trades for the 1991 calendar year. A typical trading day is divided into two sessions, morning and afternoon with a one hour and forty minute lunch break where no trading occurs. All returns were calculated as the natural logarithm, given in equation 1.

⁸ Ten minute intervals.

Prior to the analysis returns were adjusted for stock splits and dividends, but not cash dividends. They utilise the Levene statistical test (1960, cited in Choe and Skin, 1993) which was modified by Brown and Forsythe in 1974 given in equation 5, to test for the equality across the time intervals.

Choe and Skin (1993) found that the open-to-open return variances were consistently greater than close-to-close return variances. This casts doubt on any specialist-related explanation for greater open-to-open return variances. They also discovered that the non-trading period return volatility is less volatile (one fifth) than over the trading period. This finding is similar to previous studies performed in Japanese and United States markets.

Choe and Skin (1993) also found that intraday return variances during the morning session followed a U-shaped curve, however, unlike most other studies the afternoon session followed an inverted J-shaped curve. This finding led *Choe and Skin (1993)* to conclude their results suggested the opening prices were more volatile than during the interior of the trading day because of the lack of continuity during non-trading periods. However, they also suggested the length of the non-trading period is irrelevant to the magnitude of the volatility at the following open. This conclusion was supported by evidence in their study that showed the opening prices after the lunch break were as volatile as the opening prices after the long overnight non-trading period.

This finding differs from Amihud and Mendelson (1991), who analysed the Tokyo Stock Exchange and found the morning open volatility to be greater than the afternoon open volatility. This could imply one of two factors. First, the differences in the studies could be due to the different exchange mechanisms employed by each exchange. Or the differences could result from the time period analysed; Amihud and Mendelson (1991) only analysed one year, compared to nine years analysed by *Choe and Skin (1993)*. Both studies do, however, agree that Miller's (1989) theory regarding the specialist is unfounded.

Cheung, Ho, Pope and Draper (1994) continued the trend of studies being conducted outside the United States by analysing intraday return volatility patterns on the Hong Kong Stock Exchange. They used 15-minute time intervals of the most heavily traded stocks over the period from April 9th 1986, to the end of 1990. The Hong Kong market opens at 10:00 AM and closes at 3:30 PM, with a non-trading lunch break between 12:30–2:30, this gives

14 intraday (15-minute) index time periods. *Cheung et al. (1994)* also computes close-to-close, open-to-open, open-to-close (trading) and close-to-open (non-trading) return series. All intraday returns were calculated as the natural logarithm given in equation 1, excluding the adjustment for dividends. The open-to-open and close-to-close return variances were calculated by equation 2. The open-to-close (trading) and close-to-open (non-trading) return variances were calculated by equations 7 and 8. All days immediately following holidays and extreme observations were excluded from the sample.

$$R_{oc} = \log(P_{ct} / P_{ot}) \times 100\% \quad (7)$$

$$R_{co} = \log(P_{ot+1} / P_{ct}) \times 100\% \quad (8)$$

Where: R_{oc} represents the return variance of the trading period (open-to-close) on day t .
 P_{ct} represents the closing price at day t .
 R_{co} represents the return variance of the non-trading period (close-to-open) on day t .
 P_{ot} represents the opening price at day t .

The Stock Exchange of Hong Kong uses a continuous double action market, operating on an order driven system conducted by brokers (*Cheung et al., 1994*). This exchange has two trading sessions both utilising the same trading mechanism for the whole day, which differs from the Japanese and United States markets which operate two trading mechanisms during the trading day.

The results of the variance tests showed that, on average, the return variance for the open-to-close (trading) period was only slightly larger than for the close-to-open (non-trading) period. This finding is quiet different from the United States studies which found the open-to-close return variance exceeding the close-to-open by a substantial amount. The similarity between the trading and non-trading return variances in the Stock Exchange of Hong Kong are likely to be due to the continued trading of major Hong Kong stocks overnight in the London Stock Exchange (*Cheung et al., 1994*). The intraday volatility pattern for the Hong Kong Stock Exchange followed a double U-shaped curve that differs from the United States markets, which follow a single U-shaped curve. The double U-shaped curve is a

result of the two active trading sessions separated by a 2-hour non-trading lunch break. This shaped curve was also reported on the Tokyo Stock Exchange by Chang et al. (1993). Although there were two U-shaped volatility curves, the afternoon curve is substantially smaller in size than the morning curve, which was also found in the Tokyo Stock Exchange by Chang et al. (1993).

Cheung et al. (1994) follows Lockwood and Linn's (1990) procedure to test for the equality of the returns across the different time periods with the modified Levene statistical test (1960, cited in Lockwood and Linn, 1990) suggested by Brown and Forsythe in 1974⁹. Four hypotheses were examined.

- 1) The equality of the intraday periods including the noon non-trading period.
- 2) The equality of the intraday periods excluding the noon non-trading period.
- 3) The equality of the return variances between overnight and trading periods.
- 4) The equality of the return variance between the open-to-open and close-to-close periods.

The F-statistics indicated that the intraday 15-minute periods across the sample years were not equal, which was similar to Lockwood and Linn's (1990) findings conducted in the United States. Inconsistent results were found in equality of the trading and overnight non-trading time periods. At the 5% level only the years 1986 and 1989 rejected the equality hypothesis. This differs from most other studies, where the trading period normally has a significantly higher return variance than the non-trading period. This is likely to be due to the major stocks that continue to trade in London after the Hong Kong Stock Exchange is closed. *Cheung et al. (1994)* also found that open-to-open return variances were significantly larger than the close-to-close return variance for only two out of the five years. This finding is significantly different from previous studies. Amihud and Mendelson (1987), Stoll and Whaley (1990) and Amihud and Mendelson (1991) all found open-to-open return variances to exceed close-to-close return variances for the majority of their samples.

The observed double U-shaped volatility curve on the Hong Kong Stock Exchange documented by *Cheung et al. (1994)*, together with similar findings from Choe and Skin

⁹ Given in equation 5.

(1993) and Chang et al (1993) on their studies of the Korean and Tokyo stock exchanges respectively, contradict Miller's (1989) specialist theory. This is because these three studies find similar results as previous United States studies have. However these three studies were conducted on markets that do not employ a role similar to the role of the specialist in the New York market. As suggested by the three studies, the long non-trading period prior to the opening of the market is likely to lead to the high volatility at the beginning of the trading day.

2.3 Volatility for dually listed stocks

The findings of recent studies conducted on stock market volatility suggest that the extreme variance observed at the market opening could be due to the long non-trading period prior to the open. This can be tested with exchanges that close for a lunch break¹⁰, or through stocks that are dually listed on foreign exchanges. If the theory that the non-trading period prior to the market open leads to the high opening volatility, then stocks that are cross listed on foreign exchanges should exhibit less opening volatility (relative to the close) than those stocks listed on only one exchange¹¹.

In their 1991 study of the Tokyo Stock Exchange, *Amihud and Mendelson* compared five stocks that were dually listed in the United States with the remaining 45 stocks solely listed in Tokyo. Trading in the United States takes place in Japan's overnight non-trading period, thus the effective non-trading period for these cross listed stocks is considerably less than the other 45 stocks in the sample. *Amihud and Mendelson (1991)* hypothesised that if the high volatility and negative autocorrelation at the morning transaction are due to the non-trading period prior to the opening of the market, it follows that the five stocks traded in the United States should have a lower volatility at the opening of the Tokyo Stock Exchange and less negative autocorrelations. They explained this theory by suggesting the price discovery for these stocks traded in Tokyo may be facilitated by the availability of United

¹⁰ As shown in studies conducted by Chang et al. (1993) and Cheung et al. (1994).

¹¹ As dual listed stocks have a longer trading period, hence a shorter non-trading period.

States trading prices during Japan's non-trading period. All stock returns were computed as the logarithmic price relatives seen in equation 2, without adjusting for dividends.

Amihud and Mendelson (1991) found that the average ratio of open-to-open to close-to-close residual variances were 1.003 for the five dually listed stocks, as compared to 1.085 for the other 45 non-dually listed stocks. The average autocorrelation coefficients of the open-to-open residual returns were 0.002 for the dually listed stocks, and -0.088 for the non-dual listed stocks.

Significance tests indicated that the volatility of dual listed stocks was significantly different from the non-dual listed stocks at the 5% level. These statistics are consistent with their hypothesis, hence *Amihud and Mendelson (1991, p. 1778)* concluded that "U.S. trading prior to the daily opening in Tokyo seems to lead to a lower variance ratio and to a less negative autocorrelation, increasing the efficiency of the daily opening in Tokyo." This provides evidence that the high volatility at the morning open may be attributed to the lengthy non-trading period prior to the market open.

Similar to *Amihud and Mendelson (1991)*, *Cheung et al. (1994)* also analysed the behaviour of 25 Hong Kong stocks on this exchange that were cross listed on the London Stock Exchange. These 25 dually listed stocks were compared with 15 stocks that were solely listed on the Hong Kong Stock Exchange. Trading in London starts two hours after the Stock Exchange of Hong Kong closes at 3:30 PM. This means the dual listed stocks have a shorter non-trading period prior to the opening of the Hong Kong Stock Exchange, thus the open-to-open to close-to-close variance ratio for these stocks should be less than those solely traded in Hong Kong. Open-to-open and close-to-close stock returns were computed as the logarithmic price relatives seen in equation 2, without the adjustment for dividends. Open-to-close (trading) and close-to-open (non-trading) stock returns were computed as seen in equation 7 and 8, without the adjustment for dividends. The results of the variance tests indicated that the average trading to non-trading variance ratio was 1.597 for the stocks dually listed in London, and 2.427 for those stocks solely listed in Hong Kong. An F-statistic was also performed to test for the equality between the trading and the non-trading time periods; the hypothesis that both these return series were equal was rejected. The open-to-open return variances observed by *Cheung et al. (1994)* showed less volatility for the dully listed stocks (3.420) than the non-dual listed stocks (4.538). They

found the open-to-open to close-to-close variance ratio for dually listed stocks to be 1.218, which was considerably less than the ratio for non-dual listed stocks of 1.440.

Cheung et al. (1994) also analysed autocorrelation coefficients in their study. These results indicated that 24 out of the 40 stocks have a negative return at the market opening averaging -0.0266 , which is consistent with studies performed on United States markets. The open-to-open autocorrelation coefficients showed that 56% of the dual listed stocks had negative returns averaging -0.0195 , with 67% of stocks solely traded in Hong Kong experiencing a negative ratio averaging -0.0309 . *Cheung et al. (1994, p. 272)* concluded that a “smaller negative autocorrelation in open-to-open returns indicate that trading of Hong Kong stocks in London allows investors to absorb information relevant to the stocks while the Stock Exchange of Hong Kong is closed. Moreover, the extended trading hours on the London Stock Exchange enable transitory price disturbances to be dissipated over a longer period instead of clustering around the opening of Hong Kong Stock Exchange.” These results and conclusions reached by *Cheung et al. (1994)* are consistent with Amihud and Mendelson’s (1991) findings.

Chan, Fong, Kho and Stulz (1996) took the dual listing study a step further and compared intraday return volatility patterns during the United States trading day by examining European, Japanese, and American stocks listed on the New York Stock Exchange or on the American Stock Exchange. Their theory was that the arrival of public information would drop off for European stocks at the end of the United States morning, as the European business day ends for European stocks. The Japanese stocks differ, as the arrival of public information is uniformly low during the United States trading day because the business day in Japan does not overlap with the trading day in the United States. Hence, using both these classes of stocks, plus the group of American stocks, they compared volatility for stocks with different arrival patterns of public information.

The sample period chosen was over two calendar years, 1986 and 1987 with different stocks being analysed each year. *Chan et al (1996)* selected 13 European stocks in 1986 and 19 in 1987, with five Japanese stocks in both years. For each foreign firm selected, three matching American stocks were chosen to act as a control. These American stocks had similar trading activities to their matching foreign stocks in terms of the average

number of trades and similar volatility traits. All observations around the time period October 19th 1987 were omitted.

The results from the European stocks indicated that the variance fractions followed a U-shaped pattern during the United States trading day, with the opening variance fraction exhibiting the highest volatility. This pattern is similar to the comparative United States domestic stocks. The only significant differences between the European and the United States stocks were in the first and last time intervals.

The Japanese stocks exhibited a U-shaped pattern similar to the European stocks. However the volatility fraction of the Japanese stocks during the United States trading day was much smaller than the volatility of the European stocks with the exception of the opening time period, where the Japanese stocks experienced a far greater volatility fraction than the other stock categories. *Chan et al. (1996)* suggested that their results indicated that the differing opening variance fractions of the three categories of stocks occur because of the accumulation of public information after the close of the United States trading day. This information build up is largest for the Japanese stocks and smallest for the American stocks, hence the Japanese stocks experienced the highest volatility fraction at the opening, and the American stocks experienced the lowest.

Werner and Kleidon (1996) continued using dually listed stocks to examine whether stocks that are traded in multiple markets have a significant impact on intraday volatility. They utilised data from January 1st through to December 31st, 1991 for stocks listed in both the United Kingdom and in the United States. The British data was divided into two samples: 23 British stocks cross listed in America, and 23 British control stocks listed in their domestic market. Similarly, the United States data were divided into two samples; 28 British American Depository Receipts traded on the New York Stock Exchange or American Stock Exchange, and 28 United States control stocks. To be included in the sample, all cross listed stocks had to meet strict trading standards to eliminate problems associated with nonsynchronous trading. The trading day in each market was divided into 15-minute time intervals. *Werner and Kleidon (1996, p. 624)* used “least squares regression (with heteroskedasticity-consistent standard errors) to characterise intraday patterns.”

They found that the trading of British cross listed stocks generated a distinct and separate intraday volatility pattern in each trading market, resembling the U-shaped curve found in

most other studies. They also found that the cross listed stocks have significantly lower volatility during the early morning London trading compared to non-cross listed stocks. This is consistent with the theory that the shorter non-trading period prior to the market opening in London reduces volatility for stocks trading in New York.

The previous dual listed studies suggest that the non-trading period prior to the opening of the market have a significant impact on the volatility experienced at the market opening. As these studies observed, the shorter non-trading period of dually listed stocks greatly reduced their opening and overall volatility, when compared to non-dual listed stocks. This casts doubt on Choe and Skin's (1993) theory which suggested that the length of the non-trading period is irrelevant to the magnitude of the opening volatility. If Choe and Skin's (1993) theory were accepted, stocks that were dually listed and those stocks solely listed on one exchange would exhibit similar volatility traits. These dual listed studies suggest this is not the case.

Another method to analyse the effect of the non-trading period prior to the opening of the market can be achieved by examining volatility when trading hours on stock exchanges are extended. This was achieved by *Booth and Chowdhury (1996)* who utilised both dually listed stocks and the extended trading hours on the Frankfurt Stock Exchange to investigate stock return volatility.

Before January 15th 1990 the Frankfurt Stock Exchange had a floor trading period of two-hours. After January 15th 1990, the trading hours were extended to three. *Booth and Chowdhury (1996)* analysed twenty-eight stocks in the Deutscher Aktienindex over the period from 1989 to 1990. Nine of these stocks were also traded in London on the International Stock Exchange, which was open between 10:00 AM and 6:00 PM (Frankfurt time). *Booth and Chowdhury (1996)* analysed intraday prices over the sample period, as well as close-to-close, and open-to-open return variances for each of the stock categories. For each stock return, *Booth and Chowdhury (1996)* defined returns as the natural logarithm of the price relatives, given in equation 2, without adjusting for dividends. The variance tests showed the open-to-open to close-to-close ratio to be 1.204 for the non-dual listed stocks and 1.099 for the dually listed stocks when the exchange traded for only two hours. After the exchange increased its trading hours, the ratio for the non-dual listed

stocks dropped by 6.5%, but only 3.0% for the dually listed stock ratio. Hence the reduction in the non-trading time period, reduced the open-to-open to close-to-close variance ratio for both stock categories. These results indicated that the reduction in volatility was greatest for non-dual listed stocks when the Frankfurt Stock Exchange increased its trading hours. This is likely to result from the additional trading hour representing only 12.5% of the total trading time of the dually listed shares, and 50% extra for the non-dual listed shares. Therefore the change in trading hours had a larger influence on volatility for the shares with less total trading time.

This study confirms previous research that documented dually listed stocks exhibiting a lower open-to-open return variance (relative to the close-to-close return variance) than non-dual listed stocks.

2.4 Summary

This chapter reviewed the literature concerning stock market volatility. The first studies conducted were concentrated on United States markets, therefore the researchers suggested the volatility patterns observed in their studies were a result of the unique peculiarities that exist in United States markets. Eventually studies were performed on exchanges outside the United States with similar volatility patterns being observed. As these results were similar to the studies performed in the United States, the theory that these volatility patterns were unique to the United States was no longer valid. This led researchers to explore other reasons as to why the volatility patterns existed. A popular theory that developed in the literature was that the long non-trading period prior to the market opening leads to the high volatility observed in all markets at the opening. This theory was supported by studies conducted on dually listed stocks, which exhibited a lower open-to-open (relative to the close-to-close) return variance compared to non-dual listed stocks. Hence, these studies concluded that a stock's total trading time has an impact on volatility patterns.

CHAPTER THREE

DATA AND METHODOLOGY

3.1 Data

The data utilised in this study is the price data for every trade that occurred for the most frequently traded stocks on the New Zealand Stock Exchange for the entire 1997 calendar year. The data was provided by the New Zealand Stock Exchange. To examine the intraday New Zealand Stock Exchange volatility patterns, individual stocks were chosen to represent the market. This procedure differs from previous research conducted on intraday stock market volatility, as previous studies have utilised a major index to represent the market. Entire country exchanges (such as the entire New Zealand Stock Exchange) have not been previously examined because nonsynchronous trading effects can influence country's stock exchange indices. The appropriate New Zealand index would have been the NZSE 40, however this index was not utilised because of the dominating influence of Telecom. Telecom alone contributed approximately 30% of the NZSE 40's total capitalisation in 1997, and a considerable level of the trading volume each day. Hence the NZSE 40 is heavily biased towards Telecom's volatility patterns. Because of this, the best representative of the New Zealand market is an un-weighted cross-securities average of the most frequently traded stocks.

The data was scrutinised for any transactions that would distort the results. Two common errors were identified that needed to be corrected before the analysis could begin. The first was incorrect pricing of securities, an example of such a mistake was Telecom trading for \$87.20, when the transaction should have gone through at \$8.72. These mistakes were likely to result from brokers incorrectly entering the stock's price. These trades were cancelled and reversed the next trading day, which led to more trades being removed from the sample. These data errors were detected and removed through a process of visually scanning the data. During the analysis any outstanding figures were further examined and removed if classified as an error.

The other common data error related to unusual observations. Presumably these transactions were not data errors, as they were too similar to the previous selling price, but deviated enough to produce unusual observations. They were likely to be a result of investors wanting a quick sale for liquidity purposes, which were extremely difficult to detect. An attempt was made to identify such transactions, and any transaction that was substantially different from the majority of transactions¹ was deemed to be an outlier and removed from the sample.

The payment of dividends also has the potential to distort result. Although this is not a data error, the issue of dividends influences stock prices. Hence on the days that companies issued dividends, all transactions for that company were excluded from the sample.

Days in which the New Zealand Stock Exchange closed early were also excluded from the sample, as these days have the potential to distort the results.

Stocks representing the market

Stocks within the NZSE 40 were chosen to represent the New Zealand market because they trade frequently and cover a wide range of business activities. This index also constituted approximately 75% of trades for the entire New Zealand Stock Exchange during 1997. However as earlier stated, a weighted index was not utilised in New Zealand because of Telecom's dominating influence. Hence an un-weighted cross-securities average of stocks within the NZSE 40 were utilised to represent the New Zealand market. This is the best representation of the New Zealand Stock Exchange, as returns are calculated on a transaction basis and are not weighted like an index. The stocks extracted² to represent the market had to trade within the NZSE 40 for the majority of the 1997 calendar year. Thirty-nine stocks were examined to represent the New Zealand market, which provided approximately 400,000 observations.

¹ Identified through the use of plots.

² Given in appendix A.

Trading Hours

As this study examines dually listed stocks, it is important to outline the different trading hours of the three exchanges utilised in this study. Each international stock exchange has different opening and closing times as a result of both world time zones and different exchange policies. The different time zones allow stocks that are dually listed to experience a longer total trading time than those stocks solely listed in their domestic market. The New Zealand and the Hong Kong stock exchanges illustrate the different policies that exist in different exchanges. The New Zealand exchange opens at 9:30 AM and trades continuously until 3:30 PM. The Hong Kong Stock Exchange opens at 10:00 AM and closes at 3:30 PM, with a two-hour non-trading lunch break starting at 12:30 PM.

The trading hours of the three stock exchanges³ utilised in this study are presented below, with an adjustment made to convert the opening and closing times into the New Zealand time zone.

New Zealand Stock Exchange:

Opens:	9:30 AM
Closes:	3:30 PM

Australia is 2 hours behind New Zealand:

Opens:	10:00 AM	(12:00 PM	New Zealand time)
Closes:	4:00 PM	(6:00 PM	New Zealand time)

New York is 17 hours behind New Zealand:

Opens:	9:30 AM	(2:30 AM	New Zealand time)
Closes:	4:00 PM	(9:00 AM	New Zealand time)

³ New Zealand, Australia, and New York.

Stocks solely listed in New Zealand

Stocks that are solely listed in New Zealand have a total trading time of six hours, with a long eighteen-hour non-trading period. Therefore the non-trading period is three times the length of the trading period for stocks that are solely listed in New Zealand.

Stocks dually listed in New Zealand and Australia.

Stocks that are traded in both New Zealand and Australia have a two and a half-hour longer trading period than the stocks that solely trade in New Zealand. These stocks have a trading period that starts when the New Zealand Stock Exchange opens (9:30 AM New Zealand time), and finishes when the Australian Stock Exchange closes (6:00 PM New Zealand time). Hence the trading period for these stocks is eight and a half-hours, with a fifteen and a half-hour non-trading period. This means stocks that trade in New Zealand and Australia have a non-trading period that is almost double their trading period.

Stocks cross listed in New Zealand, Australia and New York.

Stocks that are cross listed in New Zealand, Australia and New York have the longest trading period out of the three stock categories being analysed. These stocks open when the New Zealand Stock Exchange opens, trade for eight and a half-hours until the close of the Australian market. They then have a non-trading period for eight and a half-hours until the open of the New York market where they trade for a further six and half-hours. These stocks then have a short half an hour non-trading period between the New York Stock Exchange close and the opening of the New Zealand Stock Exchange for the next trading day. This means the stocks that are traded in all three exchanges have a trading period of fifteen hours, and a nine-hour non-trading period.

The comparative trading and non-trading time periods for each category of stock are illustrated in Table 1.

Table 1**Hours Stocks Trade on Respective Exchanges⁴**

The Table presents the number of hours a stock has for the trading and non-trading time periods depending on the different exchanges they list on. The first trading session represents the opening of the New Zealand market, through to either the close of the New Zealand or Australian markets, depending on which exchanges a stock is listed on. The second trading session represents the open to the close of the New York Stock Exchange.

Stock exchanges respective stocks trade on

	NZSE 40	NZSE 40 & ASX	NZSE 40, ASX & NYSE
First trading session	6	8 ½	8 ½
First non-trading session	18	15 ½	8 ½
Second trading session			6 ½
Second non-trading session			½
Total Trading Hours	24	24	24

Trading Mechanisms

Many stock exchanges around the world employ different procedures in order to establish securities prices when the market opens and closes. There is an ongoing debate over which mechanism produces the most accurate⁵ results; this debate so far has not produced a clear definitive answer. Each respective exchange opening mechanism influences the volatility. Hence those stocks that trade in New Zealand and Australia may experience unusual volatility levels in the New Zealand market at 12:00 PM when the Australian exchange opens.

New Zealand

The New Zealand Stock Exchange adopted the Australian based and developed screen trading system known as SEATS⁶ on Monday 24th June 1990. The computer system needed slight modifications to it in order to be compatible with New Zealand conditions. The main modification resulted from the New Zealand Stock Exchange and the Australian Stock Exchange having different settlement methods. The system deals with transactions on a time based priority list. If two brokers lodged a buy order at the same price, the broker who

⁴ No provisions have been made for daylight savings at either end.

⁵ Closest to the intrinsic value; that is, reduces volatility.

⁶ Stock Exchange Automated Trading System.

lodged the order first would secure the transaction as long as the seller accepted (Grant, 1997).

In August 1992 another electronic computer system was introduced to aid SEATS, this system is known as FASTER⁷. FASTER enables the electronic transfer of share ownership based on transaction data entered by the brokers (Grant, 1997). The purpose of this system was to link various associated computer systems that automatically record and settle share transactions. Prior to the market open, orders are taken but not traded on. At the opening, the system generates trades that either overlap or match, utilising a weighted average price. The price of each trade is the weighted average of the bid and offer prices being matched for each individual trade. This is illustrated in equation 9

$$\frac{(\text{quantity bid} \times \text{bid price}) + (\text{quantity ask} \times \text{ask price})}{(\text{quantity bid} + \text{quantity ask})} \quad (9)$$

Once the opening prices are established, continuous trading occurs throughout the trading day up until the market closes at a random time between 3:27 PM and 3:30 PM. There is no formal algorithm used at the close of the New Zealand trading day.

Australia⁸

The Australian Stock Exchange employs a computerised trading system called SEATS to conduct transactions during the trading day. This system also establishes the prices of new securities or securities prices when there has been a trading halt in continuous trading⁹. The procedure used by SEATS for the opening of the market is similar to the New Zealand algorithm, it is the weighted average price of the last buy order and the last sell order

⁷ Fully Automated Screen Trading and Electronic Registration.

⁸ All information in this section was obtained from the Australian Stock Exchange via email correspondence. INFO.asx.com.au.

⁹ Such as the start of the trading day.

matched before the priority buy price is below the priority sell price. This is illustrated in equation 10.

$$\frac{(\text{buy quantity} \times \text{buy price}) + (\text{sell quantity} \times \text{sell price})}{(\text{buy quantity} + \text{sell quantity})} \quad (10)$$

During the interior of the trading day continuous trading occurs, until the closing stages of the day when SEATS may purge certain orders. Order purging ensures the capacity of the trading system does not overload with orders that may never trade. Orders can be purged based on their price or expiry date.

At the end of the trading day orders may be purged because they are considered too far away from the “current market value¹⁰”, meaning they will probably not trade. That is, at the end of each trading day¹¹ SEATS compares the price of all equities, rights issues and warrants to their current market price. If there is only one order for the trading day, the price is not validated and the order is not purged.

The other way an order can be purged is through the expiry date of the order. Orders can be entered with or without expiry dates, however SEATS has a default expiry time limit that is applied to all orders that have been entered without an expiry date. This time limit for active securities is three weeks, and for inactive securities is nine weeks. All orders that have been entered with an expiry date are to remain in the system for a maximum of nine weeks, after this time period they are deleted from the market.

New York

The New York Stock Exchange has been placed under more scrutiny than any other market around the world. The New York Stock Exchange employs specialists who act for the exchange and transact orders when they arrive. The role of the specialist is to maintain

¹⁰ The best price at the top of the order queue at the closing of the trading day.

¹¹ Approximately 7.00 PM (Australian time).

price continuity, which is achieved by having minimum price changes between consecutive trades.

The opening of the New York Stock Exchange closely resembles the characteristics of a call auction market. The opening prices on the New York Stock Exchange are established by the following procedure. All market orders are accumulated overnight (during the non-trading period), with any limit orders to buy at or above the opening price, and any limit orders to sell at or below the opening price, are executed at a single price; the market price. The specialist is the “auctioneer” who gathers the orders and determines the opening prices with the aid of the OARS¹² (Stoll and Whaley 1990). The specialist can participate in the opening transactions to offset any order imbalances by trading from their own accounts as a dealer.

The closing mechanism utilised by the New York Stock Exchange resembles a dealership market, where orders are carried out continuously by market-makers who quote bid and ask prices at which they are willing to buy or sell¹³ (Amihud and Mendelson, 1987). Each stock has one specialist¹⁴ who acts as the market maker and is obligated to offer continuous quotes. This gives each specialist a monopoly power over every stock they perform transactions for.

Summary of trading mechanisms

The New Zealand and Australian stock exchanges operate virtually the same mechanism at the opening of the exchange to discover the opening price of securities. This resulted from the New Zealand Stock Exchange adapting the Australian based procedure to be compatible with New Zealand’s market conditions. Both the New Zealand and Australian markets utilise continuous trading during the trading day up until the market closes. Unlike New York, there is no set method utilised to set a closing price for each stock. The opening mechanism employed by both the New Zealand and Australian markets, differ significantly from the opening procedure utilised to open the New York Stock Exchange. The major difference between the New York exchange and the two previous exchanges, is the

¹² Opening Automated Reporting System.

¹³ This is also how trades during the interior of the trading day are executed.

¹⁴ Each specialist operates as the market-maker for several stocks.

existence of the specialist. The specialist sets the opening price, and has the power to trade from his/her own account to offset imbalances. Even though each specialist is closely monitored, there is still the possibility for a specialist to open the price above or below the stocks 'intrinsic' value to make profits for themselves.

The 1997 Calendar Year¹⁵

The 1997 calendar year was chosen as the sample period because it was recent and not unusually volatile for exchanges in New Zealand and abroad. This section gives a summary of the 1997 calendar year for the New Zealand Stock Exchange and other influential markets around the world. The New Zealand Stock Exchange finished the 1997 calendar year slightly weaker than at the close of the previous year. The New Zealand Stock Exchange Capital Index was down 3.25% to 805.24, with all other indices, with the exception of the NZSE 10 Index, declining over the year. Despite a large number of new listings, market capitalisation was down by 3.92% at the end of the 1997 calendar year. However the value of shares traded increased by 11.28% to \$16,378 million from the previous year, which value set the all time record. The amount of shares traded was also a record with nearly 7,000 million shares changing hands, this was an increase of 4.59% from the 1996 calendar year.

The major world markets, with the exception of the NIKKEI Index, all recorded gains for the 1997 calendar year. The FT100 Index recorded the largest gain of 24.62% for the year, with the Dow Jones finishing 22.76% up from the previous year. The Australian All Ordinaries also increased by 7.59%.

¹⁵ This information has been extracted from the New Zealand Stock Exchange Internet Home Page (1998).

3.2 Methodology

Each of the 400,000 individual trades were utilised in this analysis. For each transaction, return variances were calculated between successive trades of the same stock. The return variances calculated included six intraday periods of 1-hour time intervals during the trading day, as well as trading (open-to-close), non-trading (close-to-open), open-to-open, and close-to-close time periods. Stock returns were calculated with equation 11, with variances being calculated from these stock returns. The market was represented by the cross-securities average of each stocks price return.

Stock return were calculated with logarithmic price relatives.

$$R_{ts} = \log(P_{ts}/P_{st-1}) \times 100\% \quad (11)$$

Where:

R_{st} represents the return for stock s at transaction t .

P_{st} is the traded price for stock s at transaction t .

This method of measuring intraday return variances is standard among the literature analysing stock market volatility. The only difference from this study and previous research, is previous studies have utilised movements in an index as the data. Because this study did not utilise an index, every trade for every stock in the sample had to be analysed. The stock returns were then divided into six hourly periods, with the variances calculated to indicate the New Zealand Stock Exchange price return variance per hour.

The trading (open-to-close) and non-trading (close-to-open) stock returns were calculated with equations 12 and 13 respectively for each stock. The market was represented by the cross-securities average of each stock's price return variance.

$$R_{stoc} = \log(P_{cst}/P_{ost}) \times 100\% \quad (12)$$

$$R_{stco} = \log(P_{ost+1}/P_{cst}) \times 100\% \quad (13)$$

Where:

R_{stoc} represents the return for stock s for the trading period t .

P_{ost} represents the opening price for stock s on day t .

R_{stco} represents the return for stock s for the non-trading period t .

P_{cst} represents the closing price for stock s on day t .

The open-to-open and close-to-close stock returns were calculated with equations 14 and 15 respectively for each stock. The market was represented by the cross-securities average of each stock's price return variance.

$$R_{ots} = \log(P_{ots}/P_{ost-1}) \times 100\% \quad (14)$$

$$R_{cts} = \log(P_{cts}/P_{cst-1}) \times 100\% \quad (15)$$

Where:

R_{ots} is the open-to-open price return for stock s on day t .

P_{ost} represents the opening price of stock s on day t .

R_{cts} is the close-to-close price return for stock s on day t .

P_{cst} represents the closing price of stock s on day t .

Dual listed stock methodology

The stocks utilised to represent the New Zealand market were further divided into dual listed groups, based on the world exchanges each stock lists on. Three categories of stocks were required to fulfil the analysis, these were stocks solely listed in New Zealand; stocks dually listed in New Zealand and Australia; and stocks cross listed in New Zealand, Australia and New York. Although certain stocks listed in New Zealand are traded on the London Stock Exchange and the NASDAQ¹⁶, there were insufficient quantities of them to achieve large enough sample groups.

¹⁶ Such as Brierley Investments and Goodman Fielder in London, and Sky Network and Tranz Rail Holdings on the NASDAQ.

The criteria required to be included in the dual listed stock analysis sample, included being either solely listed on the New Zealand exchange; dually listed in New Zealand and Australia; or cross listed in New Zealand, Australia and New York. Each stock had to trade frequently within each of their listed exchanges for the entire 1997 calendar year. If any stock listed on any exchange during 1997 they were excluded from the sample. Appendix B presents a full account of the exchanges traded on for the NZSE 40 stocks, and their listing dates. This appendix also gives the stocks that constitute each category of the three stock groups, and reasons why the remaining stocks were eliminated.

By dividing the stocks into these three categories, it was possible to analyse the groupings with respect to their total trading time. Those stocks solely listed in New Zealand experience less trading time than those dually listed in New Zealand and Australia, with the stocks cross listed in New Zealand, Australia and New York experiencing the greatest length of total trading time. This is evident from Table 1.

The dual listed stock analysis follows a similar pattern as the stocks representing the market, utilising equations 11 through to 15, to examine the volatility behaviour of the three stock categories. Each transaction is utilised to calculate the price relatives for each individual stock. Each stock was then divided into their dual listed category, with the return variances calculated and averaged to give each group a price return variance for each respective time period.

Autocorrelations

The two dually listed stock categories, and the group of stocks solely listed in New Zealand was further examined through the utilisation of first order autocorrelation coefficients. The first order autocorrelation coefficient can be expressed with equation 16.

$$y_t = \beta_0 + \beta_1 x_t + e_t \quad (16)$$

where:

$$e_t = p e_{t-1} + u_t$$

p represents the first order autocorrelation coefficient.

(Dielman, p. 458 1991)

The closer p is to ± 1 , the stronger the correlation between the price variances. In the unusual circumstance where $p=0$, the return variances are totally uncorrelated (Harraway, 1995). First order autocorrelation coefficients can indicate two aspects of efficiency.

The first aspect is based on the sign of the coefficient, which is determined by two factors, the adjustment process or noise. The contribution of the noise factor to the first order autocorrelation is always negative, a negative autocorrelation suggests an over-reaction by investors. The adjustment process is given as a positive coefficient, which represents partial price adjustment (Amihud and Mendelson 1987).

The other form of efficiency is based on the random walk hypothesis. The random walk hypothesis suggests that previous price changes can not be used as a basis for an accurate estimate of future price changes. Numerous theorists have proved the random walk hypothesis accurate¹⁷. Fama (1965) suggested that one could use first order autocorrelation coefficients to measure efficiency through the random walk hypothesis. That is, if past returns have no informational content for future price movements, the price return first order autocorrelation coefficients should equal zero.

Capitalisation categories

A volatility analysis was also performed on groupings of stocks based on capitalisation levels. The stocks utilised in the previous dual listed analysis were classified into one of five groups depending on their company's capitalisation. The six stocks that had the highest average capitalisation levels during the 1997 calendar year were placed into the first group, and so on. The two Australian based companies¹⁸ in the dual listed stock analysis were excluded from this sample, as their New Zealand capitalisation is not representative of the company's capitalisation. This meant each capitalisation group consisted of six stocks, except the final group which consisted of only five stocks. The rationale behind investigating volatility patterns of capitalisation groupings is because the New Zealand market is characterised by a few large dominating stocks, such as Telecom, with the majority of stocks being relatively small by world standards. The stocks utilised in this study have

¹⁷ For a review of random walk tests see Young, Lawoko and Inglis (1995, p.3 cited in Fung, 1996, p.10).

¹⁸ National Mutual Holdings and Infratile Australia.

substantially different capitalisation levels. By analysing groups of stocks based on their capitalisation levels, it may be possible to ascertain if the size of a company influences its volatility pattern. Appendix C provides an account of the five capitalisation groupings, and each group's average capitalisation level for the 1997 calendar year.

A similar methodological approach was utilised for the capitalisation groupings as was used in the dual listed stock analysis, with the results produced by equations 11 through to 16 being examined. Each transaction was utilised to calculate price relatives for each individual stock. Each stock was then divided into their capitalisation categories, with the return variances calculated and averaged to give each group a price return variance for each respective time period.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Stock market volatility

The stocks representing the New Zealand Stock Exchange have shown intraday volatility results that are in line with previous research, as presented in Table 2. Table 2 is divided into quarters, with the first quarter representing the first three months of the 1997 calendar year; the right column represents the overall results for the entire period. When the trades that occurred before the official opening of the exchange were included in the sample, the market return variance for the first hour, which was calculated utilising equation 11, was found to be extremely high (0.096). This variance dropped substantially to 0.069 when only those trades that occurred after the market officially opened at 9:30 AM were included in the sample. From this initial high volatility experienced during the first hour, the return variance fell sharply to 0.0551 during the next hour of trading ending at 11:30 AM. From this point the return volatility remained reasonably steady for the duration of the day, until the final trading hour. The variance increased sharply during the final hour of trading to 0.075 including trades that occurred after the close of the market, and 0.072 when only those trades that occurred before the official close of the market at 3:30 PM were included. These results are consistent with the rational trading noise hypothesis proposed by Kyle (1985), which was later extended by Admati and Pfleiderer (1988, cited in Chan and Chan, 1993). In Kyle's (1985) model, private information of informed traders is reflected into securities prices at the opening of the market. As trading continues, prices converge to the underlying unbiased estimate of securities value. Admati and Pfleiderer's (1988, cited in Chang et al., 1993) model suggested that high volatility experienced at the market opening and closing is consistent with the "clustering of discretionary liquid traders and informed traders. This indicates that the liquidity demand of discretionary liquid traders is realised either after the market closes or late in the trading day" (Chang et al., 1993, p.77).

The lowest return variance in this study of 0.0500 was observed during the hour 12:30 PM to 1:30 PM, covering the majority of lunch breaks. Similar results were found by Lockwood and Linn (1990), who reported a return variance of 0.0612 during the 12:00 PM to 1:00 PM time interval in their New York study. Also, Cheung et al. (1994) in their Hong Kong study reported their lowest variance (0.025) occurring just before 12:00 PM, with this low level of volatility continuing during lunch.

The return variances for the fourth quarter of the year are an anomaly which is evident in Table 2. The fourth quarter consists of the last three months of the 1997 calendar year; during these three months, a substantially higher level of volatility was observed in all time periods compared to the other three-quarters. Investors ongoing scepticism to October because of the world wide stock market crash on October 19th 1987 is the likely explanation for this anomaly. This explanation is plausible as an analysis on the fourth quarter was undertaken excluding the month of October, which found the return variances to be similar to the first three-quarters of the year.

Table 2

Stock Market Volatility Including/Excluding Overnight Trades

Return variances were calculated for 39 of the most frequently traded stocks (chosen to represent the New Zealand market) in the New Zealand Stock Exchange during the 1997 calendar year. This year is divided into quarters, with the first quarter representing the first three months of the year. The right column shows the overall return variances for the Exchange during 1997. The trading day is separated into six hours, highlighting the intraday effect of the Exchange. The bottom four rows of the Table present the return variances for the Exchange over the time periods open-to-open, close-to-close, open-to-close and close-to-open.

Time Period	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
9:30 – 10:30	0.072 (0.064)	0.074 (0.053)	0.079 (0.048)	0.164 (0.112)	0.096 (0.069)
10:30 – 11:30	0.0498	0.0409	0.0463	0.0828	0.0551
11:30 – 12:30	0.0564	0.0498	0.0409	0.0757	0.0552
12:30 – 1:30	0.0483	0.0441	0.0382	0.0707	0.0500
1:30 – 2:30	0.0466	0.0514	0.0438	0.0742	0.0537
2:30 – 3:30	0.069 (0.066)	0.067 (0.065)	0.066 (0.062)	0.102 (0.096)	0.075 (0.072)
Open-to-Open	1.48	2.09	1.81	5.66	2.76
Close-to-Close	1.47	1.69	1.90	6.32	2.84
Open-to-Close	1.03	1.15	1.29	2.99	1.62
Close-to-Open	0.79	0.56	0.63	2.96	1.22

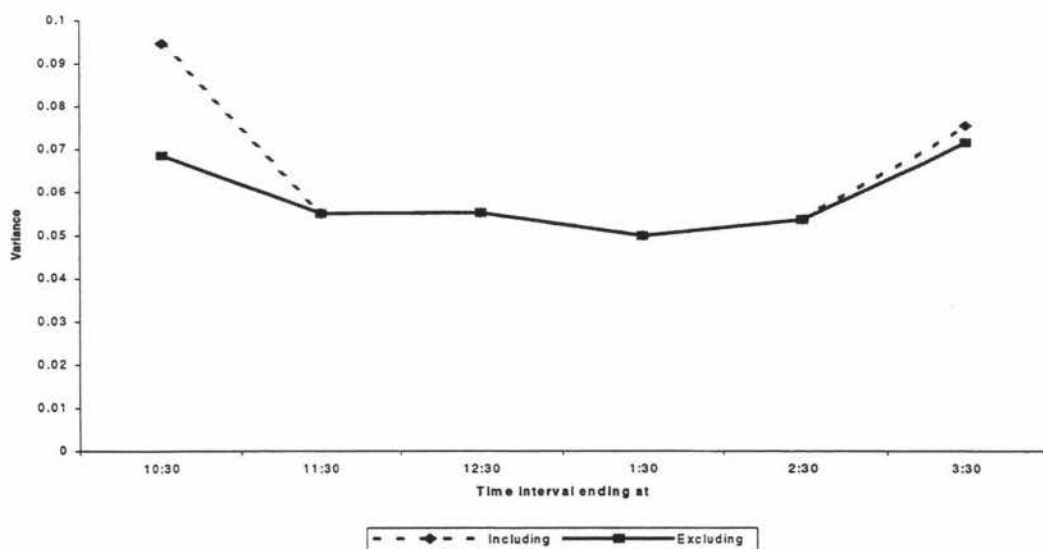
Variances in parenthesis exclude trades that occurred outside of the normal trading day.

The intraday volatility pattern for the New Zealand market, when plotted against the time of the day, follows a distinct U-shaped curve, which is illustrated in Figure 1. This curved shape is not surprising and is consistent with other studies performed on continuous trading markets around the world. Similar curves were observed in the Toronto stock market by McInish and Wood (1990), and in the New York Stock Exchange by Lockwood and Linn (1990). Miller (1989) proposed a theory that suggested the activities of the specialist in the New York Stock Exchange caused the intraday variance curve to be U-shaped. However the results in this study¹ do not support Miller's (1989) theory, as the New Zealand Stock Exchange has no role similar to that of the specialist and still exhibits a U-shaped volatility curve.

Figure 1

Intraday Stock Market Volatility

The intraday volatility for the 39 stocks chosen to represent the New Zealand market is plotted against the trading day. The time intervals are given in hours, with the first and last trading hours including/excluding trades that occurred outside the regular trading day.



¹ And others, such as Amihud and Mendelson (1991), and Cheung et al. (1994).

Equations 14 and 15 calculated the open-to-open (2.76) and close-to-close (2.84) return variances, which are given in Table 2. The stock return variances result in an open-to-open to close-to-close variance ratio of 0.972. Following the procedure proposed by Amihud and Mendelson (1987), the difference in these two return variances can only reflect differences in the behaviour of the opening and closing procedures. They justify this by suggesting that both return series represent a duration of 24-hours, but are measured over different time intervals. Therefore any new information would be reflected in both return series, hence the arrival of new information cannot be the reason for any variation. A ratio of one would represent the equality of the opening and closing transaction procedures. The New Zealand market has no formal closing procedure, and closes with continuous trading. Although the New Zealand open-to-open return variance was observed to be less than the close-to-close return variance, it does not imply that the opening algorithm utilised by the New Zealand Stock Exchange creates less volatility than continuous trading, as stock price variances increase at the close of the market. Harris (1989) examined this closing price anomaly in the New York Stock Exchange, and suggested that closing prices may not represent “true” stock values because of the increased volatility experienced at the close of the market. Because volatility rises at the close of the market, the last trading hour cannot be representative of continuous trading. However, an open-to-open to close-to-close return variance ratio less than one is highly unusual, as other studies have reported substantially larger ratios. These documented ratios range between 1.13 discovered in a New York study (Stoll and Whaley, 1990), through to 1.40 discovered in a Hong Kong study (Cheung et al., 1994). To the authors knowledge the ratio discovered in this study on the New Zealand stock market is the lowest open-to-open to close-to-close ratio reported. The reason for this low ratio is investigated in section 4.4.

Table 2 also provides figures for the New Zealand Stock Exchange trading (open-to-close, 1.62) and non-trading (close-to-open, 1.22) return variances, which were calculated with equations 12 and 13. The stock return variances represent a trading to non-trading variance ratio of 1.328, which was again substantially smaller than previous studies have documented. The majority of other studies have reported this ratio ranging between 5.4 (Stoll and Whaley, 1990) and 3.1 (Lockwood and Linn, 1990), which were both observed in United States markets. The only other result similar to the present finding is in a study

conducted by Cheung et al. (1994) on the Hong Kong Stock Exchange, which reported a trading to non-trading variance ratio of 1.10. Cheung et al (1994) offered an explanation as to why this ratio was substantially smaller than other reported ratios; major Hong Kong stocks continue to trade in London after the close of the Hong Kong market, causing the non-trading variance to increase relative to the trading variance. This explanation would appear to provide the New Zealand market with an explanation for the low trading to non-trading variance ratio, as major New Zealand securities continue to trade in foreign markets when the New Zealand exchange is closed. Using stock capitalisation's as an example, at the beginning of 1997 52.69%² (of market capitalisation) of shares on the New Zealand Stock Exchange continued to trade in foreign exchanges³ during the New Zealand overnight non-trading period.

Table 3 shows the return variance per hour as a fraction of the variance's daily total. As can be seen from the Table when trades were included that occurred before the market was officially opened, the first hour contributes nearly a quarter of the daily volatility. This dropped to nearly a fifth when only trades that occurred after 9:30 AM were included. Apart from the final trading hour, the remaining fractions of the day were reasonably stable ranging between 0.130 and 0.156. During the final trading hour the intraday fraction increased to 0.196 when all trades were included, and 0.202 when only trades that occurred before the close of the market were included. It is obvious from this Table that a large proportion of the variance is observed during the first and last trading hours.

Table 3

Intraday Variance as a Fraction of the Intraday Total

The intraday return variances for the 39 stocks chosen to represent the New Zealand market are calculated as a fraction of the intraday total. These fractions are calculated when trades were included and excluded in the sample that occurred outside the official trading day.

	With overnight trades	Without overnight trades
9:30 – 10:30	0.249	0.193
10:30 – 11:30	0.143	0.156
11:30 – 12:30	0.143	0.156
12:30 – 1:30	0.130	0.141
1:30 – 2:30	0.139	0.152
2:30 – 3:30	0.196	0.202

² This percent excludes Tranz Rail Holdings which listed on the NASDAQ on the 13th June 1997.

³ Not including stocks listed in only New Zealand and Australia.

Because of the high proportion of volatility experienced during the first hour of trading, Table 4 examines the return volatility for this time period by dividing the hour into 15-minute time intervals. The right column of Table 4 indicates that the majority of volatility experienced during the first trading hour is concentrated within the first 15-minute time interval. A variance of 0.112 was recorded when trades were included that occurred prior to the market open. This compared to only 0.056 when the sample excluded trades that occurred prior to the market open. The remaining three time periods exhibited relatively similar volatility levels ranging from 0.043 to 0.048. This suggests that the majority of volatility observed during the first trading hour on the New Zealand Stock Exchange is a result of the trading activities prior to the market opening. The finding that the high return volatility results from the trading activities within the first 15-minute time interval and rapidly declines after this, reinforces the suggestion that market opening volatility is caused by discretionary liquidity traders and informed traders (Admati and Pfleiderer, 1988 cited in Chan and Chan, 1993).

Table 4

Stock Market Volatility for the First Trading Hour

The first hour of trading is divided into 15-minute time intervals where the return variances are calculated for the 39 stocks chosen to represent the New Zealand market. The 1997 year is divided into quarters, with the right column showing the overall return variance for the year.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
9:30 – 9:45	0.072 (0.051)	0.088 (0.047)	0.096 (0.039)	0.189 (0.091)	0.112 (0.056)
9:45 – 10:00	0.048	0.033	0.032	0.069	0.046
10:00 – 10:15	0.031	0.025	0.028	0.086	0.043
10:15 – 10:30	0.049	0.030	0.027	0.086	0.048

Variances in parenthesis exclude trades that occurred outside of the normal trading day.

The last hour of trading was also divided into 15-minute time intervals because of the large proportion of volatility observed within this time period. Table 5 shows that the three time intervals before the final 15-minute period, all experienced return variances of 0.038. However the return variance rose to 0.075 during the final 15-minutes before the close of the market when all trades were included. When only those trades that occurred before the official close of the market were included, the return variance was 0.066. This indicates a large portion of the volatility observed in the final hour occurs in the final 15-minutes of the

trading day, irrespective of whether trades that occurred after 3:30 PM were included in the sample. A possible explanation for the late increase in volatility at the end of the trading day is brokers “clearing out the books”. This implies that at the end of the trading day brokers buy and sell shares to increase their turnover volume which may not be at the best price for the investor.

Table 5

Stock Market Volatility for the Last Trading Hour

The last hour of trading is divided into 15-minute time intervals where the return variances are calculated for the 39 stocks chosen to represent the New Zealand market. The 1997 year is divided into quarters, with the right column showing the overall return variance for the year.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
2:30 – 2:45	0.029	0.027	0.031	0.069	0.038
2:45 – 3:00	0.035	0.033	0.041	0.042	0.038
3:00 – 3:15	0.042	0.034	0.033	0.043	0.038
3:15 – 3:30	0.064 (0.060)	0.068 (0.062)	0.064 (0.055)	0.104 (0.090)	0.075 (0.066)

Variances in parenthesis exclude trades that occurred outside of the normal trading day.

The observation that the first and last 15-minutes of the trading day explain the majority of volatility within each hour is not surprising. Studies such as Cheung et al. (1994) who utilised 15-minute time periods as intervals within the trading day reported similar results.

4.1.1 Summary

Although this study utilised an un-weighted cross-securities average of stocks to portray the intraday volatility effect of the New Zealand Stock Exchange, the results are strikingly similar to previous studies that used an index. The explanation behind using an un-weighted cross-securities average of stocks, was to eliminate the dominating influence that Telecom has on the index; Telecom alone contributed approximately 30% of the capitalisation of the NZSE 40 during 1997. The results of the intraday volatility tests show a distinct U-shaped curve when plotted against the trading time of the day. The majority of the volatility observed in the first and last hour time intervals were actually experienced

during the first and last 15-minutes of each time period, respectively. The high variance reported during the first trading hour is likely to result from investors trading on private information. That is, informed traders reflect information into securities prices at the beginning of the trading day. This creates high volatility which declines as trading continues and stock prices converge to their underlying unbiased value (Kyle, 1985). The results on the New Zealand Stock Exchange revealed two anomalies, the first concerning the open-to-open to close-to-close return variance ratio. Unlike other exchanges the New Zealand market has an open-to-open to close-to-close variance ratio of less than one. Cheung et al. (1994) suggested a low open-to-open to close-to-close variance ratio results from the extended trading hours of dually listed stocks. They argued that extended trading hours enables transitory price disturbances to be dissipated over a longer time period, instead of clustering around the market open. This anomaly is investigated in section 4.4. The other anomaly is the low trading to non-trading variance ratio. This ratio is similar to one other study conducted by Cheung et al. (1994) which examined volatility on the Hong Kong Stock Exchange. They argued their observed low ratio was a result of major Hong Kong stocks continuing to trade in London after the close of the Hong Kong Stock Exchange, hence increasing the volatility during the overnight non-trading period. This explanation fits the New Zealand market, whose major stocks continue to trade in foreign markets once the New Zealand exchange is closed. Hence for these stocks the New Zealand overnight non-trading period continues to act as their trading period. This anomaly is examined in section 4.5.

4.2 Intraday descriptive statistics for dually listed stocks

There is a lack of research which analyses volatility patterns during the trading day for dually listed stocks. To the author's knowledge, no previous research has analysed intraday volatility patterns for dual listed stocks in a similar fashion to this study. Therefore the results in this section are presented with no reference to previous studies. The intraday volatility patterns for the two categories of dually listed stocks and the category of stocks solely listed in New Zealand are analysed and compared with previous research in section 4.3.

4.2.1 Intraday volatility for stocks solely listed in New Zealand

Intraday volatility for those stocks solely listed in New Zealand are summarised in Table 6, with the right column showing the overall variance for each time interval over the sample period. Similar to the overall New Zealand stock market previously examined, initial high volatility was observed during the first trading hour, exhibiting an average variance of 0.128 when trades that occurred before 9:30 AM were included in the sample. When those trades that occurred before the official opening were excluded from the sample, the return variance declined to 0.118. This initial high return variance dropped during the second trading hour to 0.112, where it remained reasonably steady for the remainder of the trading day, except for the final hour. The return variance increased substantially in the last hour to 0.154 when all trades were included, and 0.150 when trades that occurred after the close of the market were excluded. Similar to the overall New Zealand market previously examined, the lowest variance of 0.087 was recorded during the time interval 12:30 PM to 1:30 PM.

The high volatility at the beginning and end of the trading day gives the intraday volatility pattern for stocks solely listed in New Zealand a distinct U-shaped curve. Figure 2 illustrates this curve, and shows return variances when trades that occurred outside the official trading hours were included and excluded in the sample. This Figure shows the largest volatility was experienced during the last hour of trading regardless of whether trades that occurred outside the normal trading day were included in the sample.

Table 6

Intraday Volatility for Stocks Solely Listed in New Zealand

Return variances were calculated for 20 of the most frequently traded stocks that are solely listed in New Zealand during the 1997 calendar year. The 1997 year is divided into quarters, with the first quarter representing the first three months of the year. The right column shows the overall return variances for the stocks solely traded in New Zealand during the 1997 year. The trading day is separated into six hours, highlighting the intraday effect of these stocks.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
9:30 – 10:30	0.012 (0.011)	0.103 (0.090)	0.096 (0.088)	0.206 (0.183)	0.128 (0.118)
10:30 – 11:30	0.098	0.089	0.101	0.160	0.112
11:30 – 12:30	0.131	0.098	0.075	0.114	0.104
12:30 – 1:30	0.079	0.084	0.072	0.116	0.087
1:30 – 2:30	0.108	0.097	0.096	0.133	0.100
2:30 – 3:30	0.153 (0.151)	0.139 (0.136)	0.132 (0.128)	0.198 (0.192)	0.154 (0.150)
Total	0.581 (5.78)	0.610 (0.594)	0.545 (0.533)	0.927 (0.898)	0.685 (0.671)

Variances in parenthesis exclude trades that occurred outside of the normal trading day.

Figure 2**Intraday Volatility for Stocks Solely Traded in New Zealand**

The intraday volatility for the 20 stocks solely traded in New Zealand is plotted against the trading day. The time intervals are given in hours, with the first and last trading hours including/excluding trades that occurred outside the regular trading day.

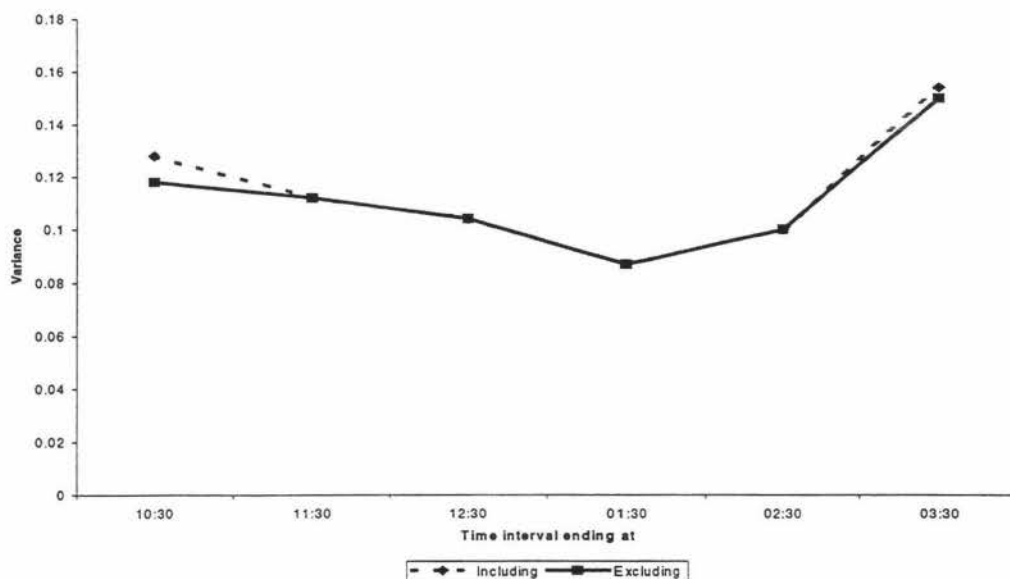


Figure 2 shows the first and last trading hours account for a significant portion of the intraday volatility, hence it would be beneficial to examine these time periods in more detail. Table 7 illustrates the return variances for the first hour of trading in 15-minute time intervals. Similar to the overall market, the first 15-minute time period experienced the largest variance of 0.105 when all trades were included, and 0.091 when only trades that occurred during the trading day were included in the sample. The volatility in the remaining time periods declined steadily with the last 15-minute time period ending at 10:30 AM experiencing a variance of 0.056.

Table 7**Volatility for Stocks Solely Listed in New Zealand for the First Trading Hour**

The first hour of trading is divided into 15-minute time intervals where the return variances are calculated for 20 frequently traded stocks solely listed in New Zealand. The 1997 calendar year is divided into quarters, with the right column showing the overall return variances for the year.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
9:30 – 9:45	0.093 (0.084)	0.090 (0.080)	0.065 (0.062)	0.187 (0.150)	0.105 (0.091)
9:45-10:00	0.100	0.047	0.038	0.107	0.072
10:00 – 10:15	0.046	0.048	0.056	0.121	0.067
10:15 – 10:30	0.053	0.034	0.017	0.122	0.056

Variations in parenthesis exclude trades that occurred outside of the normal trading day.

Table 8 shows the return variances for the last hour of trading divided into 15-minute time intervals. As expected the last 15-minute time interval recorded the highest level of volatility, with 0.150 and 0.143, when all trades were included in the sample and when only trades that occurred before the close of the market were included in the sample respectively. The other three time periods examined showed a steady declining volatility level before the upturn in the final 15-minute time interval. As previously mentioned, the late increase in volatility could result from brokers “clearing out the book”. This implies that brokers buy or sell stocks at the end of the trading day to increase their sales volume at prices which may not be the best price for the investor.

Table 8**Volatility for Stocks Solely Listed in New Zealand for the Last Trading Hour**

The last hour of trading is divided into 15-minute time intervals where the return variances are calculated for 20 frequently traded stocks solely listed in New Zealand. The 1997 calendar year is divided into quarters, with the right column showing the overall return variances for the year.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
2:30 – 2:45	0.042	0.058	0.065	0.179	0.085
2:45 – 3:00	0.095	0.066	0.084	0.044	0.073
3:00 – 3:15	0.078	0.062	0.047	0.0704	0.063
3:15 – 3:30	0.143 (0.140)	0.144 (0.138)	0.117 (0.109)	0.205 (0.195)	0.150 (0.143)

Variations in parenthesis exclude trades that occurred outside of the normal trading day.

4.2.2 Intraday volatility for stocks dually listed in New Zealand and Australia

The right column of Table 9 presents the intraday variance returns for the 1997 calendar year for those stocks dually listed in New Zealand and Australia. As can be seen from the Table, the initial high volatility (0.075 including trades that occurred before the open of the market, and 0.054 excluding these trades) observed during the first hour of trading declined during the second trading hour to a variance of 0.043. The return variances remained reasonably steady for the duration of the trading day, with a slight increase during the final hour of trading to 0.054 and 0.051⁴. The lowest level of volatility observed was during the second trading hour with a variance of 0.043.

Table 9

Intraday Volatility for Stocks Dually Listed in New Zealand and Australia

Return variances were calculated for 6 frequently traded stocks that were listed in New Zealand and Australia during the 1997 calendar year. The 1997 year is divided into quarters, with the first quarter representing the first three months of the year. The right column shows the overall return variances for the stocks dually listed in New Zealand and Australia during the 1997 year. The trading day is separated into six hours, highlighting the intraday effect of these stocks.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
9:30 – 10:30	0.046 (0.034)	0.063 (0.043)	0.060 (0.038)	0.124 (0.100)	0.075 (0.054)
10:30 – 11:30	0.034	0.024	0.033	0.082	0.043
11:30 – 12:30	0.033	0.041	0.044	0.077	0.049
12:30 – 1:30	0.034	0.027	0.032	0.087	0.045
1:30 – 2:30	0.030	0.037	0.034	0.090	0.047
2:30 – 3:30	0.040 (0.039)	0.039 (0.036)	0.055 (0.051)	0.081 (0.080)	0.054 (0.051)
Total	0.217 (0.204)	0.231 (0.208)	0.258 (0.232)	0.541 (0.516)	0.313 (0.289)

Variances in parenthesis exclude trades that occurred outside of the normal trading day.

The intraday volatility pattern exhibited by those stocks dually listed in New Zealand and Australia was found to follow an inverted J-shaped curve. Figure 3 illustrates this curve, and shows return variances when trades that occurred outside the official trading hours were included and excluded in the sample. Unlike those stocks that solely traded in New Zealand, the end of the trading day did not experience a substantial rise in volatility. This

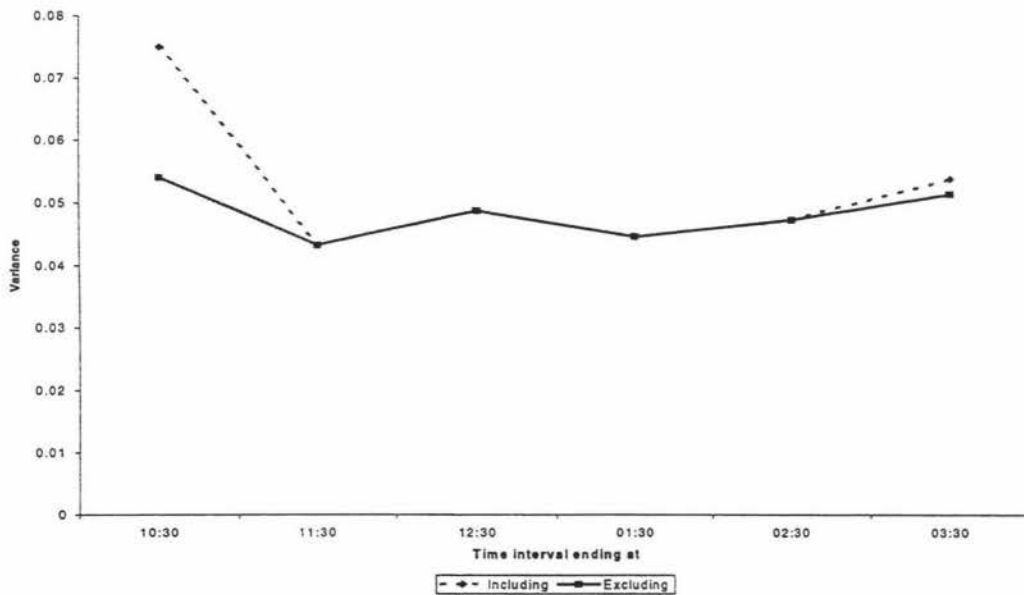
⁴ When trades that occurred after the close of the market were included in the sample, and when these trades were excluded from the sample respectively.

finding was expected, as many brokers trade internationally enabling them to continue to trade these stocks in Australia for two and a half-hours after the close of the New Zealand market. Therefore the end of the New Zealand trading day is not the end of the trading day for these stocks. It is probable that these stocks experience an increase in volatility at the end of the Australian trading day.

Figure 3

Intraday Volatility for Stocks Traded in New Zealand and Australia

The intraday volatility pattern for 6 frequently traded stocks dually listed in New Zealand and Australia is plotted against the trading day. The time intervals are given in hours, with the first and last hours including/excluding trades that occurred outside the regular trading day.



As a large proportion of the variance was observed in the first hour of trading, Table 10 examines this period in 15-minute time intervals. The right column shows the largest return variance was observed during the first hour of trading with 0.080 including all trades, and 0.046 excluding trades that occurred prior to the open of the market. This suggests that the high volatility experienced during the first hour for this stock category is mainly a result of

the trades that occurred prior to the market opening at 9:30 AM. From this initial high volatility the return variance levels decline with the final period exhibiting a variance of 0.017. This finding is similar to the results obtained in the analysis of the overall New Zealand stock market and those stocks solely listed in New Zealand.

Table 10

Volatility for Stocks Dually Listed in New Zealand and Australia for the First Trading Hour

The first hour of trading is divided into 15-minute time intervals, where the return variances are calculated for 6 frequently traded stocks dually listed in New Zealand and Australia. The 1997 calendar year is divided into quarters with the right column showing the overall return variance for the year.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
9:30 – 9:45	0.055 (0.030)	0.084 (0.045)	0.069 (0.034)	0.107 (0.069)	0.080 (0.046)
9:45-10:00	0.020	0.023	0.022	0.088	0.040
10:00 – 10:15	0.013	0.020	0.018	0.075	0.032
10:15 – 10:30	0.009	0.013	0.017	0.027	0.017

Variances in parenthesis exclude trades that occurred outside of the normal trading day.

4.2.3 Intraday volatility for New Zealand stocks cross listed in Australia and New York

Table 11 shows the return variances for the New Zealand stocks that were cross listed in both Australia and New York. The variance recorded during the first trading hour was 0.090 including trades that occurred before the market open were included. When these trades were excluded from the sample, the return variance nearly halved to 0.048. The initial high volatility experienced during the first hour declined rapidly to 0.025 for the next trading hour which spanned 10:30 AM to 11:30 AM. From this point the return volatility levelled off, with a slight increase during the final trading hour ending at 3:30 PM. The lowest variance occurred was during the hour of 11:30 AM to 12:30 PM, with a return variance of 0.020.

Table 11**Intraday Volatility for Stocks Cross Listed in New Zealand, Australia and New York**

Return variances are calculated for the 5 stocks that were cross listed in New Zealand, Australia and New York during the 1997 calendar year. The 1997 year is divided into quarters, with the first quarter representing the first three months of the year. The right column shows the overall return variances for the stocks cross listed in New Zealand, Australia and New York during the 1997 year. The trading day is separated into six hours, highlighting the intraday effect of these stocks.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
9:30 – 10:30	0.061 (0.052)	0.056 (0.029)	0.069 (0.031)	0.169 (0.084)	0.090 (0.048)
10:30 – 11:30	0.017	0.020	0.021	0.039	0.025
11:30 – 12:30	0.018	0.021	0.015	0.027	0.020
12:30 – 1:30	0.032	0.019	0.015	0.032	0.024
1:30 – 2:30	0.015	0.019	0.017	0.036	0.022
2:30 – 3:30	0.020 (0.019)	0.022 (0.021)	0.022 (0.021)	0.050 (0.042)	0.029 (0.026)
Total	0.163 (0.153)	0.157 (0.129)	0.159 (0.120)	0.353 (0.260)	0.210 (0.165)

Variances in parenthesis exclude trades that occurred outside of the normal trading day.

The intraday volatility pattern for New Zealand stocks cross listed in Australia and New York resembles an inverted J-shaped curve. This curve is illustrated in Figure 4, and shows the return variances when trades that occurred outside the official trading day were included and excluded from the sample. Similar to the stocks that are dually listed in New Zealand and Australia, this stock category does not experience a significant increase in volatility at the end of the New Zealand trading day. As stated earlier, a possible reason for this is that these stocks continue to trade in Australia for two and a half-hours after the close of the New Zealand market, giving international New Zealand brokers further opportunities to trade these stocks. Therefore these stocks are likely to experience an upturn in volatility at the end of the Australian trading day.

Table 12 shows the first hour of the New Zealand trading day for those New Zealand stocks cross listed in Australia and New York. This period is examined, as it accounts for a significant portion of the volatility experienced by this stock category. The Table suggests that the majority of the variance experienced during in the first hour of trading occurred during the first 15-minute time period, when trades that occurred before the market open were included. This period had a variance of 0.130, which then quickly declined to 0.031 in the next 15-minute time period where it remained reasonably steady for the remaining two time intervals. When trades that occurred before the market open were excluded from the

sample, the first 15-minute time period did not experience the largest level of volatility; in fact the final 15-minute time period ending at 10:30 AM exhibited the largest variance of 0.050. These results again indicate that the high variance observed during the first trading hour is a result of investors trading prior to the opening of the market.

Figure 4

Intraday Volatility for Stocks Cross Listed in New Zealand, Australia and New York

The intraday volatility for the 5 stocks cross listed in New Zealand, Australia and New York during 1997 is plotted against the trading time of the day. The time intervals are given in hours, with the first and last hours including/excluding trades that occurred outside the regular trading day.

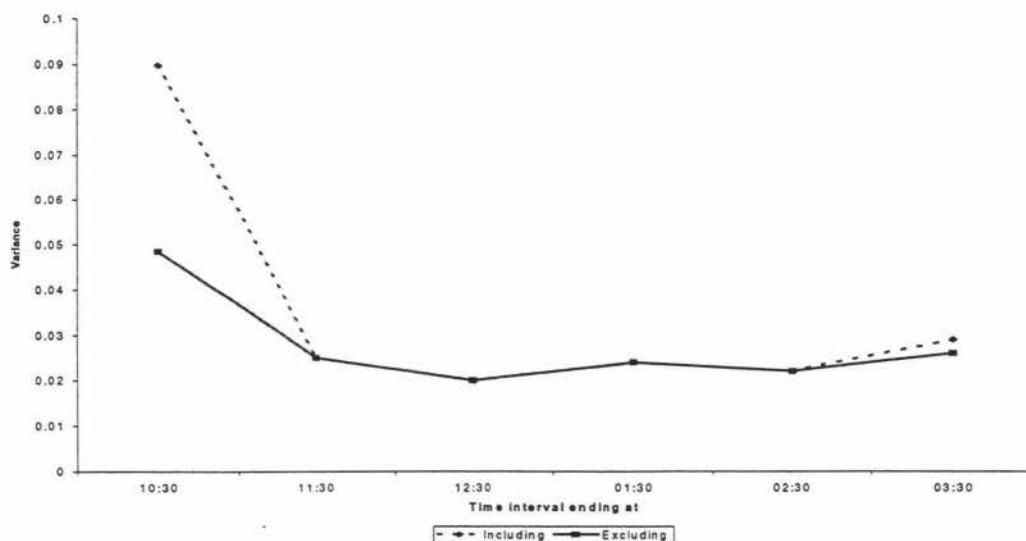


Table 12

Volatility for Stocks Cross Listed in New Zealand, Australia and New York for the First Trading Hour

The first hour of trading is divided into 15-minute time intervals, where the return variances are calculated for the 5 stocks traded in New Zealand, Australia and New York during 1997. The 1997 calendar year is divided into quarters, with the right column showing the overall return variances for the year.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Overall
9:30 – 9:45	0.070 (0.048)	0.085 (0.028)	0.103 (0.028)	0.258 (0.078)	0.130 (0.044)
9:45-10:00	0.033	0.025	0.022	0.045	0.031
10:00 – 10:15	0.022	0.013	0.016	0.067	0.030
10:15 – 10:30	0.064	0.014	0.034	0.087	0.050

Variations in parenthesis exclude trades that occurred outside the normal trading day.

4.3 Dual listed stock analysis

The similarities between the three categories of stocks, which are the two groups of dually listed stocks, and the group of stocks solely listed in New Zealand are examined here. Table 13 shows the intraday return variance for the 1997 calendar year for each of the three stock categories. It is obvious from the Table that the dually listed stocks exhibited a lower level of volatility during the first trading hour than those stocks solely listed in New Zealand. This may suggest the additional trading time of dually listing shares in foreign markets reduces the amount of volatility experienced within the first trading hour. When trades that occurred before the market opened were included in the sample, the volatility experienced by those stocks listed in New Zealand, Australia and New York (0.090) was actually greater than those stocks listed in New Zealand and Australia (0.075). This may indicate that the length of the additional trading time caused by cross listing shares in foreign markets does not have an impact on the volatility within the first trading hour, as proposed by Choe and Skin (1993). However a more plausible explanation for this anomaly is that two firms within those stocks dually listed in New Zealand and Australia are based in Australia. This means that these two stocks do not begin their business day for half an hour after the New Zealand exchange has opened⁵. Hence there is little public information for these two stocks released until the beginning of the Australian business day, which is 10:00 AM New Zealand time; this would reduce the volatility experienced by this stock category during the first trading hour. These two Australian based firms appear to influence the intraday volatility of this group of stocks. The stocks dually listed in New Zealand and Australia experienced a slight rise in their return variance in the hour 11:30 AM to 12:30 PM, shown in Table 13. This slight increase in volatility is likely to have resulted from the two Australian based companies beginning their trading day in their domestic market.

When the trades that occurred before the official opening of the trading day were excluded from the sample, the return variances for the three categories of stocks showed expected results. The opening return variances, shown in Table 13, are lower for those stocks that are traded in all three exchanges; stocks solely listed in New Zealand exhibited an opening

⁵ Australia is two hours behind New Zealand, hence when the New Zealand Stock Exchange opens at 9:30 AM it is 7:30 AM in Australia, with half an hour until the Australian business day begins at 8:00 AM.

variance of 0.118; stocks dually listed in New Zealand and Australia experienced a variance of 0.054; stocks cross listed in New Zealand, Australia and New York exhibited a variance of 0.048. This may suggest additional trading time caused by dually listed stocks, reduces the volatility experienced during the opening trading hour.

The intraday variance totals shown at the bottom of Table 13 suggest that longer trading hours may reduce total intraday volatility. Those stocks solely listed in New Zealand exhibited the greatest level of total volatility (0.685 and 0.671), with the New Zealand stocks cross listed in Australia and New York exhibiting the lowest intraday volatility total (0.210 and 0.165). This provides further support for the theory that longer trading hours reduces volatility.

Table 13

Comparative Return Variances for the Three Stock Categories

This Table shows the intraday return variances for the stocks solely listed in New Zealand, and the two dually listed stock categories. The last row highlights the total intraday return volatility experienced over the 1997 calendar year by each stock category.

	Listed in NZ	Listed in NZ, ASX	Listed in NZ, ASX, NY
9:30 – 10:30	0.128 (0.118)	0.075 (0.054)	0.090 (0.048)
10:30 – 11:30	0.112	0.043	0.025
11:30 – 12:30	0.104	0.049	0.020
12:30 – 1:30	0.087	0.045	0.024
1:30 – 2:30	0.100	0.047	0.022
2:30 – 3:30	0.154 (0.150)	0.054 (0.051)	0.029 (0.026)
Total	0.685 (0.671)	0.313 (0.289)	0.210 (0.165)

Variances in parenthesis exclude trades that occurred outside the regular trading hours.

Table 14 shows the intraday variance as a fraction of the daily variance for the three categories of stocks when all trades were included in the sample. This is illustrated in Figure 5. The Figure clearly depicts the lowest fraction for the first trading hour being exhibited by those stocks solely listed in New Zealand with a variance fraction of 0.1869. The Figure also shows that those stocks that traded in all three markets exhibited the highest fraction (0.4285) in the first trading hour, which accounted for nearly half of the total intraday volatility for this stock category. This finding is similar to the results obtained by Chan et al. (1996), who analysed Japanese and European stocks dually listed in America. They found that during the first trading hour, those stocks that had the longest

total trading time (Japanese stocks dual listed in America) exhibited the highest volatility fraction. They explained this finding by suggesting the majority of public information concerning Japanese stocks is generated during the Japanese trading day (American non-trading period), this public information is then traded upon during the opening of the American trading day. However in this study, all those stocks that traded in New York are New Zealand based companies, hence public information released about these stocks is mainly concentrated within the New Zealand trading day. Therefore the high opening volatility fraction observed from those stocks listed in all three exchanges, cannot be a result of a build up of public information obtained during the home market trading day as suggested by Chan et al. (1996). The variance fractions do, however, support the theory that private information is the cause of the volatility at the market opening. The private information hypothesis states that "stock return volatility is caused by private information revealed through the trading activities of informed traders" (Chan et al., 1993, p. 192). Hence New Zealand investors are able to watch the trading activities of New York investors, on those New Zealand stocks that trade in New York during the New Zealand overnight non-trading period. This creates a build up of private information for New Zealand investors, hence increasing the volatility fraction at the opening of the New Zealand Stock Exchange for those New Zealand stocks cross listed in New York. Whereas investors have no additional private information to trade upon for those stocks solely listed in New Zealand, hence lowering the volatility fraction during the first trading hour for this stock category.

As shown in Figure 5, apart from the first trading hour of the day, those stocks listed in all three exchanges have a consistently lower variance fraction in every time period compared to the other two stock categories. Those stocks that were solely listed in New Zealand experienced a more even volatility fraction distribution over the trading day than those dually listed stocks, with a volatility fraction spread of 0.0978. Those stocks dually listed in New Zealand and Australia experienced a fraction spread of 0.1022, with a spread of 0.3333 being exhibited by those stocks cross listed in all three exchanges. These intraday volatility fractions are similar to the results found by Chan et al. (1996), who suggested they were caused by public information flows. As previously mentioned, the opening hour variance fractions in this study are more likely to result from investors trading on private

information opposed to public information. The intraday variance as a fraction of the intraday total without the impact of trades that occurred outside the official trading hours were also examined. The results are not presented, as they were very similar to when all trades were included in the sample.

Table 14

Intraday Variance as a Fraction of the Intraday Total – including trades that occurred outside the official trading hours

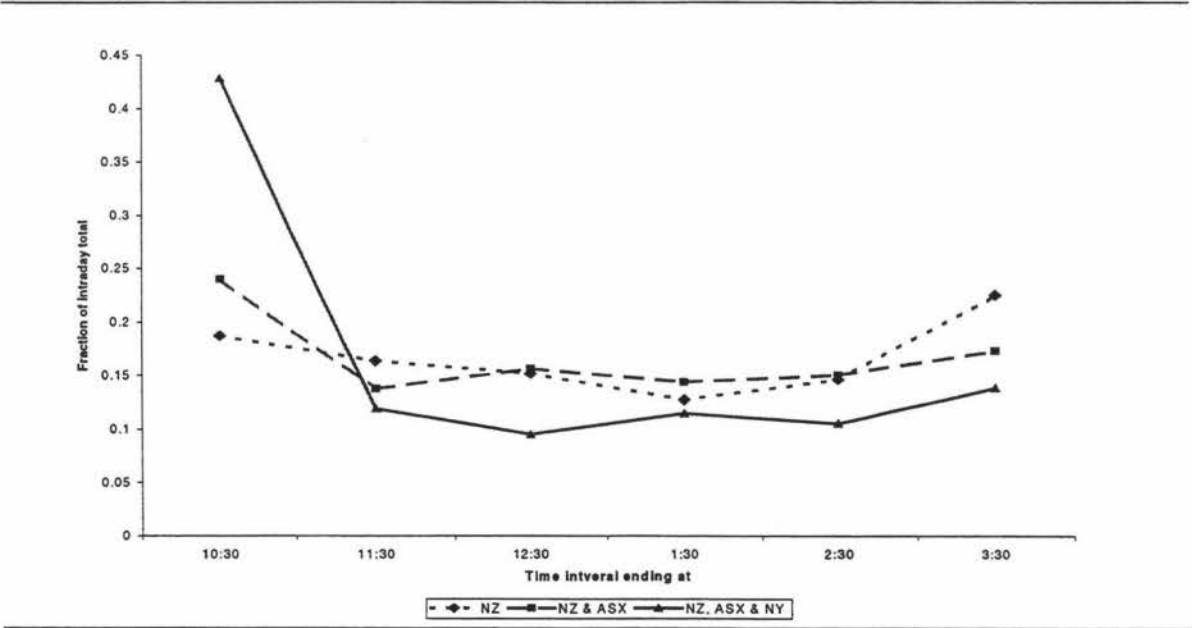
The intraday return variances as a fraction of the intraday total are presented for the stocks solely listed in New Zealand, and the two categories of dually listed stocks. These fractions are calculated when all trades that occurred outside the regular trading day were included in the sample.

	Listed in NZ	Listed in NZ, ASX	Listed in NZ, ASX, NY
9:30 – 10:30	0.1869	0.2396	0.4285
10:30 – 11:30	0.1635	0.1374	0.1190
11:30 – 12:30	0.1518	0.1565	0.0952
12:30 – 1:30	0.1270	0.1437	0.1143
1:30 – 2:30	0.1460	0.1502	0.1048
2:30 – 3:30	0.2248	0.1725	0.1380

Figure 5

Intraday Variance as a Fraction of the Intraday Total

This Figure illustrates the intraday fractions of the intraday total for the stocks solely listed in New Zealand, and the two dually listed stock categories, including trades that occurred outside official trading hours.



4.3.1 Summary

The stocks solely listed in New Zealand experienced the highest level of volatility in every time period, as well as the intraday variance total. Those stocks listed on all three exchanges exhibited the lowest level of volatility in all time periods except the first hour when all trades were included in the sample. These stocks also experienced the lowest intraday variance total. This suggests that increasing a stocks trading hours by cross listing them in foreign exchanges, may reduce their intraday volatility. The intraday variance fractions showed that the high volatility during the first trading hour is likely to result from investors trading on private information. Private information is revealed through the trading activities of informed traders. Private information is therefore obtainable for those stocks cross listed in all three exchanges during the New Zealand overnight non-trading period, through the trading activities on the New York Stock Exchange. This creates information build up prior to the opening of the New Zealand Stock Exchange for those stocks cross listed on all three exchanges. Trading on built up private information causes a high variance fraction at the opening of the market for those stocks listed in New Zealand, Australia and New York. There is no build up of private information for those stocks that are solely listed in New Zealand during the New Zealand overnight non-trading period. Hence these stocks do not experience a high variance fraction at the opening of the New Zealand Stock Exchange.

4.4 Opening and closing price return variances

The anomaly of the low open-to-open to close-to-close variance ratio observed in the New Zealand Stock Exchange is examined in this section. Cheung et al. (1994) suggested a theory as to why a low ratio may occur; extended trading hours of dually listed stocks enables transitory price disturbances around the market open to be dissipated over a longer time period, instead of clustering around the opening of the market. This creates a low open-to-open variance, which creates a low open-to-open to close-to-close variance ratio. Hence this section examines the open-to-open and close-to-close return variances for the

two categories of dually listed stocks and those stocks solely listed in New Zealand. If dual listed stocks reduce the volatility at the market opening, hence reducing the open-to-open to close-to-close variance ratio; one would expect those New Zealand stocks cross listed in Australia and New York to exhibit a lower volatility at the opening (relative to the close) than non-dual listed stocks.

This hypothesis was examined by analysing the open-to-open and close-to-close return variances for both the group of stocks solely listed in New Zealand and the two categories of dually listed stocks. Table 15 presents the results obtained from the return variance equations 14 and 15. This Table clearly highlights that the more exchanges a stock was traded on, the greater the open-to-open and close-to-close return variances became. This is illustrated with those stocks listed in all three exchanges experiencing the largest open-to-open (3.306) and close-to-close (2.759) variance returns, which compared to 2.189 and 2.421 for those stocks solely listed in New Zealand respectively. The large return volatility experienced by those stocks that traded in all three exchanges lead to the open-to-open to close-to-close return variance ratio (shown in the right column of Table 15) being substantially higher than those stocks that solely traded in New Zealand. That is, those stocks solely listed in New Zealand experienced an open-to-open to close-to-close ratio of 0.901, with the stocks that traded in New Zealand and Australia experiencing a ratio of 0.954. Comparatively the New Zealand stocks cross listed in Australia and New York observed a ratio of 1.200. These ratios indicate that those stocks that traded in all three exchanges experienced a greater volatility level at the market open (relative to the market close) compared to the other two stock categories. These results are inconsistent with previous studies performed on larger markets around the world, which report that dually listed stocks exhibit a lower open-to-open to close-to-close variance ratio than non-dual listed stocks. Amihud and Mendelson (1991) observed the open-to-open to close-to-close variance ratio for Tokyo dual listed stocks to be 1.003, and a ratio of 1.085 for non-dual listed stocks. Booth and Chowdhury (1996) found similar results in the Frankfurt Stock Exchange; dually listed stocks exhibited a ratio of 1.066 and non-dual listed stocks observed a ratio of 1.099⁶. Cheung et al. (1994) observed slightly higher ratios in their

⁶ These ratios were observed after the Frankfurt Stock Exchange increased their trading hours to three per day. Prior to this change the ratios were 1.126 and 1.204 for dual and non-dual stocks respectively.

Hong Kong study, but still reported dually listed stocks exhibiting a lower variance ratio than non-dual listed stocks. The dual listed stocks exhibited an open-to-open to close-to-close variance ratio of 1.218, with non-dual listed stocks exhibiting a ratio of 1.440. These studies suggest that additional trading time caused by dually listed stocks, decreases the volatility experienced at the market opening relative to the close of the market. The results in this study contradict this finding and indicate that dually listed stocks have a higher level of volatility at the opening of the market relative to the close, when compared to those stocks solely listed in New Zealand. The ratios in Table 15 indicate that stocks with little or no additional trading time outside the New Zealand trading day may be associated with the low open-to-open to close-to-close variance ratio observed in the New Zealand market. The difference in results from this study and previous research is likely to result from the significant size difference in the exchanges examined. All previous research has been conducted on large exchanges, whereas this study was performed on a very small exchange by world standards. Therefore the results are not directly comparable.

A second anomaly observed in this study is found in the magnitude of the variance ratios. Previous studies all reported ratios greater than one irrespective of whether the stocks were dually listed. That is, these studies observed all stock categories experiencing greater price volatility for the open-to-open return variances compared to the close-to-close return variances. This study contradicts their findings, and reports that those stocks with little or no additional trading time experienced greater price volatility in their close-to-close returns compared to their open-to-open returns. As shown in Table 15, the stocks solely listed in New Zealand and those dually listed in New Zealand and Australia reported open-to-open to close-to-close variance ratios of less than one. As previous studies have been conducted on large exchanges, the likely explanation for this anomaly also results from the small size of the New Zealand Stock Exchange by world standards.

An F-test was also performed to test the hypothesis of whether the open-to-open returns were statistically equal to the close-to-close returns. The results are presented at the bottom of Table 15. These results show that at the 5% significance level, three stocks solely listed in New Zealand and two stocks cross listed in all three exchanges rejected the hypothesis.

Those stocks dually listed in New Zealand and Australia all accepted the hypothesis. At the 1% significance level, all stocks but Enerco Gas (solely listed in New Zealand) accepted the hypothesis. These significance tests show mixed results, therefore neither support or detract from the suggestion that those stocks with little or no additional trading time are associated with the low open-to-open to close-to-close variance ratio observed in the New Zealand market.

Table 15**Open-To-Open and Close-To-Close Return Variances for Dually Listed Stocks**

The average open-to-open and close-to-close return variances are calculated for those stocks solely listed in New Zealand, and for the two categories of dually listed stocks. The right column shows the open-to-open to close-to-close variance ratios. Significant tests of whether the open-to-open return variances statistically equal the close-to-close return variances are given at the bottom of the Table.

	Open-to-Open Var (Ro)	Close-to-Close Var (Rc)	Var (Ro) / Var (Rc)
a) 20 stocks solely listed in NZ			
Mean	2.189	2.421	0.901
Standard Deviation	0.817	0.854	0.230
Number of ratios < 1			15
b) 6 stocks listed in both NZ and ASX			
Mean	2.570	2.637	0.954
Standard Deviation	1.426	1.272	0.111
Number of ratios < 1			4
c) 5 stocks listed in NZ, ASX and NY			
Mean	3.306	2.759	1.200
Standard Deviation	0.704	0.437	0.314
Number of ratios < 1			1

F-test for testing $H_0: \text{Var (Ro)} = \text{Var (Rc)}$

Number of cases that rejected the hypothesis:

	5% significance	1% significance
Listed solely in NZ:	3 (15%)	1 (5%)
Listed in both NZ and ASX:	0 (0%)	0 (0%)
Listed in NZ, ASX and NY:	2 (40%)	0 (0%)

Equation 16 was utilised to examine the first order autocorrelation coefficients as a further test of market behaviour for the three stock categories. The results are presented in Table 16. For the 31 stocks in this sample, the average open-to-open first order autocorrelation coefficient was 0.0293. This coefficient is not supported by other studies performed on larger exchanges around the world. Previous research has reported negative open-to-open first order autocorrelation coefficients. Amihud and Mendelson (1987) observed an open-to-open first order autocorrelation coefficient of -0.0635 in their Tokyo study, while Cheung et al. (1994) reported the coefficient to be -0.0266 in their Hong Kong study. As suggested by Amihud and Mendelson (1987), a positive open-to-open first order autocorrelation coefficient as found in this study, suggests that trading at the market opening is not dominated by “noise” trading (Black, 1986), instead the variance in stock prices can be attributed to the adjustment process.

Table 16

Open-To-Open and Close-To-Close First Order Autocorrelation Coefficients for Dually Listed Stocks

The open-to-open and close-to-close first order autocorrelation coefficients are calculated for the stocks solely listed in New Zealand and for the two dual listed stock categories. Also presented are the coefficients for the 31 stocks within the dual listed sample.

	Auto (Ro)	Auto (Rc)
a) 31 stocks in dual listed sample		
Mean	0.0293	0.0186
Number of autocorrelations < 0	20	14
b) 20 stocks solely listed in NZ		
Mean	0.0391	-0.0032
Number of autocorrelations < 0	14	7
c) 6 stocks listed in both NZ and ASX		
Mean	-0.0224	-0.0040
Number of autocorrelations < 0	3	3
d) 5 stocks listed in NZ, ASX and NY		
Mean	0.0527	0.1331
Number of autocorrelations < 0	3	4

Ro and Rc represent open-to-open and close-to-close returns, respectively. Auto (.) represent the autocorrelations of the returns.

Another use of the first order autocorrelation is testing for market efficiency. The form of market efficiency tested implies that stock prices reflect all available information at any point in time. Fama (1965) suggested that if markets are efficient, there is no way to use past price changes to predict future price changes. Market efficiency can be applied to both the opening and closing return series, which is achieved by examining whether the opening/closing prices contain all the available information of the opening/closing price that preceded it. This form of market efficiency implies the autocorrelation coefficients given in Table 16 should be zero (Amihud and Mendelson, 1987). The greater the dispersion the autocorrelation coefficients are from zero, indicates that less efficiency is present. The autocorrelation results presented in Table 16 show that those stocks solely listed in New Zealand (open-to-open of 0.0391 and close-to-close of -0.0032) and those stocks dually listed in New Zealand and Australia (open-to-open of -0.0224 and close-to-close of -0.0040) were more efficient at both the opening and closing of the market when compared to those stocks listed on all three exchanges (open-to-open of 0.0527 and close-to-close of 0.1331). This is due to those stocks that trade in New Zealand, Australia and New York having autocorrelation coefficients further away from zero than the other two stock categories. If the additional trading time caused by dually listed stocks allows investors to absorb relevant information while the New Zealand market is closed⁷, one would expect the stocks that trade in all three exchanges to exhibit an opening coefficient closer to zero than those stocks solely listed in New Zealand. The results in this study do not support this theory, and contradict previous research performed on larger exchanges around the world. Cheung et al. (1994) found the opening first order autocorrelation coefficient of Hong Kong dually listed stocks to be -0.0195 and non-dual listed stocks to be -0.0309 . Amihud and Mendelson (1991) found that dually listed Tokyo stocks had an opening first order autocorrelation coefficient of 0.002 and -0.088 for the non-dual listed stocks. Amihud and Mendelson (1991) concluded from their findings that the high volatility experienced at the market opening may be attributed to the lengthy non-trading period prior to the market open. Hence dually listed stocks aid price efficiency at the opening of the market. However this conclusion cannot be reached for the New Zealand

⁷ As suggested by Amihud and Mendelson (1991), and later supported by Cheung et al. (1994).

market, as this study found that those stocks dually listed in all three exchanges appear to decrease the efficiency at the market opening. Hence this autocorrelation analysis reconfirms previous findings that the extended trading hours caused by dually listed stocks on foreign exchanges does not result in the low open-to-open to close-to-close variance ratio observed in the New Zealand market. Instead, those stocks that have little or no additional trading time outside the New Zealand trading day are more efficient at both the opening and closing of the market, and appear to be associated with to the low variance ratio.

The explanation that stocks with little or no additional trading time outside the New Zealand trading day are related to the low open-to-open to close-to-close variance ratio observed in the New Zealand market does not seem viable, as it contradicts all previous research. Another more plausible explanation for this anomaly is based on the small size of the New Zealand market, that is, smaller sized firms⁸ cause the low ratio. This theory suggests that lower capitalised stocks have lower liquidity levels compared to higher capitalised stocks, hence they trade less which reduces volatility. Previous studies have been conducted on large markets where the capitalisation levels of all firms in the research were likely to have been relatively similar, hence firm size would not influence volatility. This was not possible in this study as stocks within the NZSE 40 have a large range of stock capitalisations. The explanation that smaller sized firms are associated with the low open-to-open to close-to-close variance ratio observed in the New Zealand market seems to be applicable, as the stocks solely listed in New Zealand had generally lower capitalisation levels than the stocks that are dually listed. Hence the low open-to-open to close-to-close variance ratio observed in the New Zealand market is not likely to result from the lack of additional trading time of non-dual listed stocks, instead it is more probable the anomaly is associated with lower capitalised stocks. This hypothesis is examined in Table 17, with the return variances being presented for five groups of stocks based on their firm's capitalisation levels. The six highest capitalised firms combine to represent group one, with the fifth group representing the lowest capitalised stocks in the sample. The stocks listed in

⁸ Smaller sized firms refer to firms with low capitalisation levels.

each capitalisation group are presented in appendix C, along with the average capitalisation of each group.

Table 17**Open-To-Open and Close-To-Close Return Variances for Capitalisation Groupings**

The average open-to-open and close-to-close return variances are calculated for five stock groups based on their capitalisation levels. Group one consists of the six highest capitalised stocks in the sample. The right column shows the open-to-open to close-to-close variance ratios. Significant tests of whether the open-to-open return variances statistically equal the close-to-close return variances are given at the bottom of the Table.

	Open-to-Open Var (Ro)	Close-to-Close Var (Rc)	Var (Ro) / Var (Rc)
a) Group one			
Mean	3.172	2.818	1.124
Standard Deviation	0.916	0.654	0.205
Number of ratios < 1			0
b) Group two			
Mean	1.860	1.989	0.964
Standard Deviation	0.914	0.859	0.154
Number of ratios < 1			2
c) Group three			
Mean	2.009	2.177	0.912
Standard Deviation	0.580	0.476	0.091
Number of ratios < 1			1
d) Group four			
Mean	2.194	2.417	0.910
Standard Deviation	0.482	0.339	0.177
Number of ratios < 1			0
e) Group five			
Mean	2.699	3.099	0.887
Standard Deviation	0.681	0.974	0.085
Number of ratios < 1			1
<hr/>			
F-test for testing $H_0: \text{Var (Rc)} = \text{Var (Ro)}$			
Number of cases that rejected the hypothesis:	5% significance	1% significance	
Group one:	2 (33%)	0 (0%)	
Group two:	1 (17%)	0 (0%)	
Group three:	0 (0%)	1 (17%)	
Group four:	2 (33%)	0 (0%)	
Group five:	0 (0%)	0 (0%)	

As shown in Table 17, there is no sequential pattern for the open-to-open or close-to-close variance returns⁹, however these returns are more informative when compared in a ratio. The variance ratios shown in the right column of Table 17 clearly highlight a declining sequence as the capitalisation's of each grouping descend. Group one has a return variance ratio of 1.124, which indicates the open-to-open returns were more volatile than the close-to-close returns. The variance ratios declined to less than one, after the first capitalisation group. This indicates the last four capitalisation groupings experienced a higher close-to-close return variance compared to their open-to-open return variances, with the fifth group exhibiting the lowest return variance ratio of 0.887. These results suggest that the hypothesis tested may be accepted, and that lower capitalised stocks may be associated with the low open-to-open to close-to-close variance ratio observed in the New Zealand market.

An F-test was also performed to test whether the open-to-open returns were statistically equal to the close-to-close returns, the results are given at the bottom of Table 17. At the 1% significance level, all stocks but Enerco Gas (in the third capitalisation group) accepted this hypothesis. Mixed results were found at the 5% significance level, with only a total of five stocks rejecting the hypothesis. Two of these stocks were from the first group, one was from the second group, and the remaining two were from group four. These mixed results do not add any weighting to accepting the hypothesis that lower capitalised stocks are associated with the low open-to-open to close-to-close variance ratio observed in the New Zealand Stock Exchange. However, because these results are mixed they do not detract from the findings in the previous ratio analysis that supported this hypothesis.

Similar to the dual listed analysis performed earlier, equation 16 calculated the first order autocorrelation coefficients for the five capitalisation groups to further test market behaviour. The results are presented in Table 18. The first order autocorrelation coefficients for the open-to-open return variances highlight an interesting pattern. That is, the last two groupings have negative coefficients, with the first three groupings returning positive coefficients. As noted by Amihud and Mendelson (1987), this indicates an overreaction

⁹ Calculated with equations 14 and 15.

effect to stock prices is likely at the market open for lower capitalised stocks, but unlikely for higher capitalised stocks.

Table 18

Open-To-Open and Close-To-Close First Order Autocorrelation Coefficients for Capitalisation Groupings

The average open-to-open and close-to-close first order autocorrelation coefficients are calculated for five stock groups based on their capitalisation levels. Group one consists of the six highest capitalised stocks in the sample.

	Auto (Ro)	Auto (Rc)
a) Group one		
Mean	0.0718	0.1549
Number of autocorrelations < 0	1	0
b) Group two		
Mean	0.0276	-0.0212
Number of autocorrelations < 0	2	5
c) Group three		
Mean	0.0271	0.0264
Number of autocorrelations < 0	1	3
d) Group four		
Mean	-0.0124	-0.0190
Number of autocorrelations < 0	3	4
e) Group five		
Mean	-0.0168	0.0132
Number of autocorrelations < 0	2	3

Ro and Rc represent open-to-open and close-to-close returns, respectively. Auto (.) represent the autocorrelations of the returns.

As mentioned in the dual listed analysis, the autocorrelation coefficients given in Table 18 for the open-to-open and close-to-close returns should be zero, with a greater dispersion away from zero representing less efficiency. If the low open-to-open to close-to-close variance ratio observed in the New Zealand market is a result of smaller capitalised stocks, then the group of stocks with the lowest average capitalisation should experience an

opening autocorrelation coefficient closer to zero than groups of stocks with a higher average capitalisation. The results from the open-to-open first order autocorrelation tests support this hypothesis, as group one, with the highest average capitalisation exhibited an opening coefficient of 0.0718. The lowest average capitalised group (group five) exhibited a coefficient of -0.0168 . The close-to-close coefficients followed a similar pattern as the open-to-open coefficients. The group with the highest average capitalisation experienced the highest autocorrelation coefficient (0.1549), and the lowest average capitalised group experienced the lowest coefficient of 0.0132. The decline in coefficients is not in a strict descending order¹⁰, however, an obvious pattern emerged from the coefficients that supports the earlier suggestion that lower capitalised stocks are related to the low open-to-open to close-to-close variance ratio observed in the New Zealand market. Hence, smaller capitalised stocks appear to be more efficient for the open-to-open and close-to-close return series compared to higher capitalised stocks. This is likely to result from low capitalised stocks having lower liquidity levels compared to high capitalised stocks, which reduces their trading volume and therefore reduces their volatility.

4.4.1 Summary

The open-to-open and close-to-close results analysed in this section suggest that the New Zealand market differs from previously examined exchanges. These previous studies have reported open-to-open returns to be lower for dually listed stocks (relative to their close-to-close returns) compared to non-dual listed stocks. This results in a lower open-to-open to close-to-close variance ratio. This study contradicts these findings as New Zealand's dually listed stocks experienced a higher open-to-open to close-to-close return variance ratio, than non-dual listed stocks. The coefficients of the first order autocorrelation also contradict previous studies, and suggest that dually listed stocks are less efficient at the opening and closing of the New Zealand market when compared to those stocks solely listed in New Zealand. As this suggestion does not seem viable, a similar analysis was conducted on

¹⁰ The fifth group experienced a coefficient slightly further away from zero than the fourth group in the open-to-open autocorrelations. In the close-to-close autocorrelations, the third group exhibited a coefficient slightly further away from zero than the second group did.

stock groupings depending on each firm's capitalisation. It was evident from the results obtained through the capitalisation variance analysis that the stocks whose firms exhibited the lowest average capitalisation, also exhibited the lowest open-to-open to close-to-close return variance ratio. Hence the low open-to-open to close-to-close variance ratio observed in the New Zealand market is likely to be associated with those stocks whose firms have low capitalisations. This finding was supported by the first order autocorrelation coefficients, which showed that the open-to-open and close-to-close returns were more efficient for the lower average capitalised groups. A possible explanation as to why these findings differ from previous research is based on the size of the New Zealand Stock Exchange. New Zealand has a very small stock exchange by world standards, with all previous studies being conducted on large exchanges. The results and conclusions from these previous studies cannot therefore be directly compared to the results obtained from this study, as no other study has been published¹¹ on an exchange that is of comparative size to New Zealand. Another possible explanation as to why this study observed different results from previous research could result from the trading mechanisms utilised by different exchanges. Trading mechanisms differ between stock exchanges; hence these unusual findings in the New Zealand market could result from the algorithm utilised by the New Zealand Stock Exchange. Another possible explanation for the anomaly could result from the time period analysed. This study only covered one calendar year, therefore these results may be specific to this year and not characteristic of normal New Zealand trading activities. This last explanation is however, unlikely to be a reason for this anomaly observed in the New Zealand Stock Exchange, as there is no reason why the 1997 calendar year should deviate from normal trading activities.

¹¹ To the author's knowledge.

4.5 Volatility during trading and non-trading periods

The anomaly of the low open-to-close (trading) to close-to-open (non-trading) return variance ratio observed in the New Zealand Stock Exchange, is examined in this section by analysing the trading and non-trading time intervals of the two categories of dually listed stocks, and those stocks solely listed in New Zealand. The hypothesis being examined in this section is that the extra trading time caused by dually listed stocks increases the volatility during the New Zealand non-trading period relative to the trading period. This explanation is the common reason found in previous studies for a low trading to non-trading variance ratio that have been conducted on large markets. If this hypothesis were to be accepted in the New Zealand market, then those New Zealand stocks cross listed in Australia and New York should exhibit the highest non-trading return variance (relative to their trading variance), hence lowering the trading to non-trading variance ratio. This is expected as these stocks continue to trade in New York during the New Zealand overnight non-trading period; hence the non-trading period should act similar to the trading period for this category of stock.

Utilising equations 12 and 13, the trading and non-trading return variances for the two categories of dual listed stocks and the category of stocks solely listed in New Zealand were calculated, with the results presented in Table 19. Shown in the left column of the Table are the open-to-close (trading) return variances. These results indicate that the longer total trading time a stock had, the greater their trading return variance became. Those stocks solely listed in New Zealand experienced a trading variance of 1.521, with those stocks cross listed in all three exchanges experiencing a trading variance of 2.666. That is, non-dually listed stocks were less volatile than dual listed stocks during the trading day. Previous research contradicts the findings in this study and report that dually listed stocks experience lower trading return variance than non-dually listed stocks. Cheung et al. (1994) found that Hong Kong dually listed stocks exhibited a trading variance of 2.596, with non-dual listed stocks experiencing a trading variance of 4.345. A possible explanation as to why the results observed in this New Zealand study differs from Cheung et al's. (1994) Hong Kong study is based on the size of the respective exchanges. The Hong Kong market by world standards is large and contains numerous equal sized large companies which are

both dually and non-dually listed. The stocks utilised in Cheung et al's. (1994) study are likely to be large equal sized firms, hence are likely to have relatively equal trading volumes. Comparatively the New Zealand market is small by world standards and contains few large stocks. Therefore the stocks utilised in this study were not all large equal sized firms, and did not have similar trading volumes¹² (refer to appendix D). It has been shown that high levels of price return volatility coincide with high levels of trading volume¹³. Appendix D shows that the dually listed New Zealand stocks have a higher trading volume in the New Zealand market compared to those non-dual listed stocks. Hence as New Zealand dually listed stocks experience higher levels of trading volume, it is not surprising to see this category of stock experiencing a comparatively higher open-to-close return variance.

The middle column of Table 19 presents the results for the close-to-open (non-trading) return variances. This time period covers the close of the New Zealand trading day, through to the open of the next trading day, therefore covering the entire trading period of the New York Stock Exchange. As expected, the return variances shown in Table 19 are the highest for those stocks that trade in New Zealand and cross list in Australia and New York, with a variance of 1.003. What was unexpected however, was the return variance for those stocks solely listed in New Zealand (0.956) being similar to the variance recorded by the stocks listed in all three exchanges. This may indicate that the trading activities of New York investors during the New Zealand overnight non-trading period, do not substantially alter New Zealand investor's views on stock prices for those stocks that trade in all three markets.

The right column of Table 19 presents the average trading to non-trading variance ratios for the three stock categories. It is evident from the Table that those New Zealand stocks cross listed in Australia and New York experienced an average trading to non-trading variance ratio of 2.783, which was substantially larger than the remaining two stock categories. Comparatively this ratio was 1.811 for those stocks solely listed in New Zealand and 2.661

¹² Trading volume in this study refers to the turnover value of trades, such as utilised in Ho, Cheung and Cheung (1993).

¹³ For a review of studies on the price-volume relationship see Karpoff (1987).

for those stocks dually listed in New Zealand and Australia. This finding indicates that those New Zealand stocks cross listed in Australia and New York observed the lowest non-trading return variance relative to their trading variance, and those stocks solely listed in New Zealand experienced the highest non-trading variance, relative to their trading variance. This contradicts other studies performed on larger stock exchanges. Cheung et al. (1994) observed that Hong Kong stocks not dually listed exhibited a trading to non-trading ratio of 2.427, and 1.597 for those Hong Kong stocks dually listed in London. Booth and Chowdhury (1996) found that the non-dually listed Frankfurt stocks had a trading to non-trading variance ratio of 3.738, and 2.467 for those Frankfurt stocks dually listed in London. Both of these studies report that dually listed shares exhibited a lower trading to non-trading variance ratio than non-dual listed stocks. Cheung et al. (1994) concluded from this finding on the Hong Kong market, that the high non-trading return variance¹⁴ observed by the dually listed stocks was the reason behind the high volatility during the Hong Kong overnight non-trading period, hence causing the market trading to non-trading variance ratio to decline. This conclusion is inconsistent with the findings in this study, as these results suggest the stocks that do not experience additional trading time outside the New Zealand market appear to be associated with the low trading to non-trading variance ratio which was observed in the New Zealand market.

An F-test was also performed to examine whether the trading return variances statistically equaled the non-trading return variances, the results are presented at the bottom of Table 19. This hypothesis was rejected for all the stocks in the sample except Miburn New Zealand (at the 5% significance level), which was solely listed in New Zealand. At the 1% significance level the hypothesis was rejected for all those stocks that trade in all three exchanges. However, it was only rejected for 83% and 70% of those stocks dually listed in New Zealand and Australia, and those stocks that solely trade in New Zealand respectively. These F-tests are not surprising as those stocks traded in all three exchanges observed the largest trading to non-trading variance ratio, with those stocks solely listed in New Zealand experiencing the lowest trading to non-trading variance ratio. Hence these findings are consistent with the previous variance analysis, and reconfirm the suggestion that the low

¹⁴ Relative to the trading return variance.

trading to non-trading variance ratio observed on the New Zealand market may result from stocks that are not dually listed.

Table 19

Open-To-Close and Close-To-Open Return Variances for Dually Listed Stocks

The average open-to-close and close-to-open return variances are calculated for those stocks solely traded in New Zealand, and for the two categories of dually listed stocks. The right column shows the open-to-close to close-to-open variance ratios. Significant tests of whether the open-to-close return variances statistically equal the close-to-open return variances are presented at the bottom of the Table.

	Open-to-Close Var (Roc)	Close-to-Open Var (Rco)	Var (Roc) / Var (Rco)
a) 20 stocks solely listed in NZ			
Mean	1.521	0.956	1.811
Standard Deviation	0.725	0.382	0.923
Number of ratios < 1			4
b) 6 stocks listed in both NZ and ASX			
Mean	2.026	0.932	2.661
Standard Deviation	0.970	0.649	1.562
Number of ratios < 1			0
c) 5 stocks listed in NZ, ASX and NY			
Mean	2.666	1.003	2.783
Standard Deviation	0.442	0.266	0.709
Number of ratios < 1			0
F-test for testing $H_0: \text{Var (Roc)} = \text{Var (Rco)}$			
Number of cases that reject the hypothesis			
	5% significance:	1% significance	
Listed solely in NZ:	19 (95%)	14 (70%)	
Listed in both NZ and ASX:	6 (100%)	5 (83%)	
Listed in NZ, ASX and NY:	5 (100%)	5 (100%)	

The explanation that non-dually listed stocks are associated with the low trading to non-trading variance ratio in the New Zealand market does not seem viable, as it contradicts previous research. A more plausible hypothesis is that smaller sized firms (firms with low capitalisations) are responsible for the low ratio; this explanation is examined here. This theory is analysed by examining the open-to-close (trading) and close-to-open (non-trading) return variances for five groups of New Zealand stocks based on their capitalisation levels. These groups are given in appendix C. If this theory is accepted, then the group of stocks with the lowest average capitalisation should observe the lowest trading to non-trading

return variance ratio. Utilising equations 12 and 13, the return variances were calculated for the capitalisation groupings displayed in Table 20, with the highest average capitalisation group entitled “group one”, and the lowest average capitalisation group entitled “group five”. The left column of Table 20 shows the average trading (open-to-close) return variances for the five capitalisation groupings. No defining pattern emerged from these variances, apart from the first group experiencing a substantially higher volatility level (2.527) than the remaining four groups. A possible explanation for this anomaly is that lower capitalised stocks have lower liquidity levels compared to higher capitalised stocks. This reduces their trading volume, which lowers their volatility and trading to non-trading variance ratio. If this explanation is accepted, the trading return variances in Table 20 should descend as the capitalisation groups decline. However the variance returns do not show a strict descending order, therefore this hypothesis cannot be accepted with certainty.

The non-trading return variances in the middle column of Table 20 do not illustrate any identifiable patterns. However, a noteworthy observation in these return variances is the low non-trading return variance experienced by the first group of 0.848, and the high non-trading variance experienced by the fifth group of 1.134. These return variances indicate that lower capitalised stocks exhibited higher volatility during the New Zealand non-trading period compared to higher capitalised stocks. This may suggest that investors revise their views towards low capitalised stock prices more than they do for high capitalised stocks during the New Zealand overnight non-trading period. This would increase the volatility experienced during the non-trading period for low capitalised stocks, hence reducing the trading to non-trading variance ratio. If this explanation were to be accepted, the non-trading return variances should descend orderly. This is not shown to be the case, therefore this explanation can not be accepted with certainty.

The low non-trading return variance coupled with the high trading return variance observed by the first capitalisation group, created a high trading to non-trading variance ratio of 3.264. This is shown in the right column of Table 20. This compares with a substantially smaller trading to non-trading variance ratio for the fifth capitalisation group¹⁵ of 1.592.

¹⁵ The group with the lowest average capitalisation.

These variances suggest that low capitalised stocks are associated with the low trading to non-trading return variance observed in the New Zealand Stock Exchange. However, as can be seen in Table 20, the return variance ratios do not descend in the strict order that one would expect if the hypothesis were to be accepted. However, there is a definite decline from the first group of stocks to the remaining groups, therefore this theory cannot be rejected.

Table 20
Open-To-Close and Close-To-Open Return Variances for Capitalisation Groupings

The average open-to-close and close-to-open return variances are calculated for five groups of stocks based on their capitalisations. Group one has the six highest capitalised stocks in the sample. The right column shows the open-to-close to close-to-open variance ratios. Significant tests of whether the open-to-close return variances statistically equal the close-to-open return variances are presented at the bottom of the Table.

	Open-to-Close Var (Roc)	Close-to-Open Var (Rco)	Var (Roc) / Var (Rco)
a) Group one			
Mean	2.527	0.848	3.264
Standard Deviation	0.466	0.811	1.238
Number of ratios < 1			0
b) Group two			
Mean	1.347	1.093	1.436
Standard Deviation	1.039	0.552	0.971
Number of ratios < 1			2
c) Group three			
Mean	1.472	0.934	1.847
Standard Deviation	0.656	0.579	1.157
Number of ratios < 1			1
d) Group four			
Mean	1.834	0.905	2.208
Standard Deviation	0.475	0.342	0.807
Number of ratios < 1			0
e) Group five			
Mean	1.803	1.134	1.592
Standard Deviation	0.808	0.166	0.648
Number of ratios < 1			1

F-test for testing $H_0: \text{Var (Roc)} = \text{Var (Rco)}$

Number of cases that rejected the hypothesis:

	5% significance	1% significance
Group one:	6 (100%)	6 (100%)
Group two:	6 (100%)	4 (67%)
Group three:	6 (100%)	5 (83%)
Group four:	6 (100%)	5 (83%)
Group five:	4 (80%)	2 (40%)

An F-test was also performed on the five stock capitalisation groupings to test whether their trading period was statistically equal to their non-trading period. The results are given at the bottom of Table 20. At the 1% significance level, all the stocks that contributed to group one rejected the hypothesis. Over two-thirds of the next three capitalisation groupings rejected the same hypothesis, with only 40% of the fifth group rejecting the hypothesis. These significance tests suggest that high capitalised stocks have statistically different trading and non-trading return variances, with over half of the lowest average capitalised stock group having statistically equal trading and non-trading return variances. Hence these significance tests give further weighting to accepting the hypothesis that lower capitalised stocks are associated with the low trading to non-trading return variance ratio observed on the New Zealand market.

4.5.1 Summary

The results of the dual listed stock analysis indicated that the extended trading hours of the dually listed New Zealand stocks, was not the reason why the New Zealand market observed a low trading to non-trading variance ratio, as was seen in previous research. This theory was dismissed because those stocks solely listed in New Zealand displayed the lowest trading to non-trading variance ratio, with the dually listed stocks exhibiting the highest ratio. This finding contradicts previous research performed on larger exchanges. A possible explanation to explain the low trading to non-trading variance ratio observed in the New Zealand market, is that low capitalised stocks are less volatile during the trading day because they have lower liquidity levels compared to high capitalised stocks. This would reduce volatility during the trading day and lower the trading to non-trading variance ratio for low capitalised stocks. Another possible explanation to explain the low trading to non-trading variance ratio is that New Zealand investors revise their views towards stock prices for low capitalised stocks more than they do for high capitalised stocks during the New Zealand overnight non-trading period. This would increase the non-trading volatility and decrease the trading to non-trading variance ratio for low capitalised stocks. Both of these explanations were only partly supported by the findings, and could not be accepted with certainty.

4.6 Trading and non-trading intervals following high volatile periods in the Dow Jones.

It appears that during the New Zealand overnight non-trading period, New Zealand investors revise their views on stock prices. This creates high volatility during the New Zealand overnight non-trading time period, which was shown to be more pronounced for lower capitalised stocks. Therefore it would be interesting to examine the degree of volatility for specific categories of New Zealand stocks, after high levels of volatility occur in a large exchange during the New Zealand non-trading period. This section analyses the New Zealand trading and non-trading time periods after the Dow Jones Industrial Index experienced volatility of 2% or more. Trading on the Dow Jones occurs when the New Zealand Stock Exchange is closed. Hence the open-to-close price returns are taken the day after the volatile trading day in the United States. The New Zealand non-trading price returns represent prices from the close of the New Zealand Stock Exchange through to the open the next trading day. Therefore this time period includes the high volatile trading day in the United States.

Equation 12 calculated the trading (open-to-close) return variances shown in Table 21 for the two dually listed stock categories and the stocks solely listed in New Zealand. The “negative” title in Table 21 represents the average return variances in New Zealand when the Dow Jones decreased by 2% or more. The title of “positive” refers to the average return variances for New Zealand trading when the Dow Jones increased by 2% or more. The Table shows that the trading return variances follow a similar pattern (except they are more volatile) to the entire 1997 calendar year for the three stock categories shown in Table 19. That is, the stocks solely listed in New Zealand experienced the lowest trading volatility, with the stocks listed in all three exchanges experiencing the highest level of trading volatility. The Table also shows that those New Zealand stocks cross listed in Australia and New York experienced the greatest level of trading volatility regardless of whether the Dow Jones experienced a large fall or rise in the index. This group of stocks exhibited return variances of 35.826 when the Dow Jones decreased, and 12.101 when the Dow Jones increased. The other two stock categories exhibited substantially lower return variances, those stocks dually listed in New Zealand and Australia experienced volatility levels of

19.683 and 7.251 after the Dow Jones fell and rose respectively. Those stocks that solely traded in New Zealand experienced a comparatively lower volatility level of 4.534 and 3.015 respectively. Although these trading return variances are vastly different from each other, they do illustrate a similar phenomenon. That is, all three categories of stock exhibited a higher level of trading volatility when the Dow Jones experienced a large fall compared to a similar sized rise. This is illustrated by those New Zealand stocks cross listed in Australia and New York, who experienced a variance approximately three times larger after a fall in the Dow Jones compared to a similar sized rise. This indicates a form of risk aversion from New Zealand investors during the trading day. That is, New Zealand investors are more likely to trade heavily and create volatility when the Dow Jones has fallen¹⁶, opposed to when the Dow Jones rose. As expected, investors were most risk averse towards stocks that traded in all three exchanges. This is because these stocks trade in New York where the high volatility originated.

Through equation 13, return variances were calculated for the non-trading (close-to-open) period of the New Zealand Stock Exchange, after the Dow Jones experienced high volatility. These results are presented in the right column of Table 21. The non-trading return variances follow a similar pattern as shown in Table 19 for the entire 1997 calendar year, with the variances increasing as the total trading time increased for each category of stock. As expected, these return variances were substantially larger than the variances shown in Table 19 for the entire 1997 calendar year. Out of the three categories of stocks, those stocks solely listed in New Zealand experienced the lowest level of volatility when the Dow Jones fell (4.082) and rose (3.045). Comparatively those New Zealand stocks cross listed in Australia and New York experienced the largest non-trading return volatility of 33.521 and 28.587 respectively. Similar to the previous open-to-close (trading) variances, all three stock categories exhibited a larger volatility level in the New Zealand overnight non-trading period when the Dow Jones experienced a large decline opposed to a large rise. This suggests that investors on the New Zealand Stock Exchange are risk averse during the non-trading time period.

¹⁶ To protect themselves from potential losses.

Table 22 shows F-statistics for the trading and non-trading time periods for the two categories of dually listed stocks, and the group of stocks solely listed in New Zealand. This test was designed to analyse whether any statistical differences existed in the return variances when the Dow Jones increased compared to when the Dow Jones decreased for the trading and non-trading time periods. The results suggest that volatility experienced by all three stock categories were significantly different at the 5% level. Hence volatility in all three stock categories differs when the Dow Jones increased compared to when the Dow Jones decreased at the 5% level, for both the trading and non-trading time periods.

Table 21

Open-To-Close and Close-To-Open Return Variances For Dual Listed Stocks Following High Volatility in the Dow Jones

Open-to-close and close-to-open return variances are calculated for the two groups of dually listed stocks, and the group of stocks solely listed in New Zealand after the Dow Jones experienced high volatility. High volatility in the Dow Jones refers to when the index falls or rises by 2% or more.

	Open-to-Close Var (Roc)		Close-to-Open Var (Rco)	
a) 20 stocks solely listed in NZ				
Negative	4.534		4.082	
Positive		3.015		3.045
b) 6 stocks listed in both NZ and ASX				
Negative	19.683		17.554	
Positive		7.251		15.857
c) 5 stocks listed in NZ, ASX and NY				
Negative	35.826		33.521	
Positive		12.101		28.587

Table 22**F-Statistic on Return Variances when the Dow Jones Rose Compared to when the Dow Jones Fell**

The equality of return variances when the Dow Jones rises and falls for the trading (open-to-close) and non-trading (close-to-open) time periods is analysed for the stocks solely listed in New Zealand, and the two dually listed stock categories.

	O-C	C-O
Solely listed in NZ	18.159 ***	13.718 ***
Dual listed in NZ and ASX	11.531 ***	4.269 **
Dual listed in NZ, ASX and NY	17.964 ***	5.742 **

** Statistically different at the 5% significant level.

*** Statistically different at the 1% significant level.

O-C, F-statistic for testing the equality of New Zealand trading return variances after the Dow Jones increased compared to when it decreased.

C-O F-statistic for testing the equality of New Zealand non-trading return variances when the Dow Jones increased compared to when it decreased.

Earlier sections within this study suggested that low capitalised stocks might be associated with the low trading to non-trading variance ratio observed in the New Zealand market. Therefore it would be interesting to examine the return variances of the five capitalisation stock categories, listed in appendix C, to analyse their behaviour when the Dow Jones experienced high volatility. This is shown in Table 23. It is obvious from the Table that the average trading (open-to-close) variances decreased as each group's capitalisation declined, regardless of whether the Dow Jones fell or rose. The trading return variances showed that the group with the highest average capitalisation experienced a return variance of 28.234 and 11.440 when the Dow Jones declined and increased respectively. From this high volatility, the variances descend until the group with the lowest capitalisation recorded variances of 2.713 when the Dow Jones declined and 1.922 when the Dow Jones increased. As shown in Table 23, all five capitalisation groupings experienced higher volatility when the Dow Jones fell compared to when it rose. This was expected, as it is a form of risk aversion which was also shown to exist in the dually listed stock analysis earlier in this section.

Table 23**Open-To-Close and Close-To-Open Return Variances for Capitalisation Groupings Following High Volatility in the Dow Jones**

Open-to-close and close-to-open return variances are calculated for five groups of stocks based on their capitalisation levels after the Dow Jones experienced high volatility. High volatility in the Dow Jones refers to when the index falls or rises by 2% or more. Group one consists of the six highest capitalised stocks, with the fifth group consisting of the lowest capitalised stocks in the sample.

	Open-to-Close Var (Roc)		Close-to-Open Var (Rco)	
a) Group one				
Negative	28.234		26.150	
Positive		11.440		25.176
b) Group two				
Negative	17.613		14.951	
Positive		8.428		11.702
c) Group three				
Negative	4.679		3.932	
Positive		2.056		3.038
d) Group four				
Negative	4.320		3.931	
Positive		1.984		3.904
e) Group five				
Negative	2.713		3.535	
Positive		1.922		2.479

The right column of Table 23 presents the non-trading (close-to-open) return variances when the Dow Jones experienced high volatility. These return variances follow a similar pattern as the trading variances. That is, the return variances are higher for those higher capitalised stocks, group one has return variances of 26.150 when the Dow Jones experienced a decline, and 25.176 when the Dow Jones increased. These variances descend until the fifth group, which observed return variances of 3.535 and 2.479 when the Dow Jones declined and increased respectively. Another similarity with the non-trading and trading variances, relates to investors risk attitude. All of the return variances were lower when the Dow Jones increased compared to when the Dow Jones fell. Hence New Zealand investors tend to re-value stock prices during New Zealand's overnight non-trading period

more, after a large decline in the Dow Jones compared to a similar sized increase, therefore showing risk aversion.

4.6.1 Summary

The New Zealand trading (open-to-close) and non-trading (close-to-open) return variances observed after the Dow Jones experienced substantial volatility, showed similar patterns as the entire trading year. The return variances for both the trading and non-trading periods indicated that investors in the New Zealand market exhibit risk aversion, as the variances were higher after the Dow Jones experienced a large decline compared to a large rise. This was the most evident for those stocks that traded on all three exchanges. This was expected, as these stocks continue to trade in New York during the high volatile period in the Dow Jones, hence are directly affected by their trading activities. Tables 21 and 23 showed that the stocks dually listed in all three markets, and the stocks that had the highest average capitalisation level, experienced the highest volatility regardless of whether the Dow Jones declined or increased. This was expected as the higher capitalised stocks are mainly cross listed in New York, hence they continue to trade in New York during the high volatile period of the Dow Jones.

4.7 Opening and closing intervals following high volatile periods in the Dow Jones

This section extends the analysis of return variances which followed high volatility in the Dow Jones. The open-to-open and close-to-close return variances for the two categories of dually listed stocks, those stocks solely listed in New Zealand, and the five capitalisation categories are examined following high volatility in the Dow Jones Industrial Index. The open-to-open time series starts at the opening of the New Zealand Stock Exchange and ends at the opening of the New Zealand Stock Exchange the next trading day; the close-to-close time period starting at the close of the New Zealand Stock Exchange and ends at the close of the New Zealand Stock Exchange the next trading day. Hence the high volatile trading day in the United States is included in the middle of both time series analysed in this section.

The left column of Table 24 shows the open-to-open return variances for the two dually listed stock groups, and the group of stocks solely listed in New Zealand after the Dow Jones experienced high volatility. Those values that represent the variances when the Dow Jones fell by 2% or more are given under the title “negative”, where the Dow Jones increased by 2% or more the variances are entitled “positive”. As evident from the Table when the Dow Jones fell, those stocks dually listed in New Zealand and Australia exhibited the highest open-to-open return variance of 11.164. This was mainly due to National Mutual Holdings experiencing high volatility of 45.542 for the open-to-open time period. When National Mutual Holdings were removed from the sample, the open-to-open return variance experienced by this stock group was 5.118. The other two stock categories experienced similar open-to-open volatility levels when the Dow Jones fell. Those stocks solely listed in New Zealand experienced a variance of 2.721, and those New Zealand stocks cross listed in Australia and New York exhibited a variance of 2.173. These return variances do not show any patterns that relate to the trading hours of the different categories of stocks. Alternatively a clear pattern was evident in the open-to-open return variances for the three stock categories when the Dow Jones experienced a substantial rise. The return variances for the open-to-open time period increased the longer the total trading time each category of stock had. Those stocks listed in all three exchanges had a high

variance of 26.689, with those stocks dually listed in New Zealand and Australia experiencing a variance of 19.465. These volatility levels are large compared to those stocks solely traded in New Zealand who exhibited an open-to-open variance of 3.045. These return variances follow a similar pattern as the entire New Zealand trading year, which was shown in Table 15. As is evident from both Tables 15 and 24, the volatility level increased along with the total trading time of each stock category. Although the pattern was similar the variances were not; as expected the variances in this section are substantially higher than the variances for the entire 1997 year shown in Table 15. As shown in Table 24, the open-to-open return variances were more volatile when the Dow Jones increased compared to when it decreased. This difference was the most defined for those New Zealand stocks cross listed in Australia and New York. This stock category experienced a volatility level approximately 12 times larger when the Dow Jones increased compared to when the Dow Jones declined. This pattern of price behaviour shows an attitude of risk taking at the opening of the market. Hence when the Dow Jones experienced a substantial increase, New Zealand investors were more reactive than when the Dow Jones declined. Investors are likely to react this way in an attempt to lock in potential profits at the opening of the New Zealand Stock Exchange.

The close-to-close return variances presented in Table 24 show similar patterns to the regular New Zealand trading year which were shown in Table 15. As is evident in Table 24, the return variances are greater the more total trading time each category of stock had, regardless of whether the Dow Jones experienced a decline or a rise in the index. The stocks that solely traded in New Zealand exhibited a close-to-close variance of 5.187 and 2.548 when the Dow Jones fell and rose respectively. Those stocks dually listed in New Zealand and Australia had variances of 5.818 and 2.638. While the New Zealand stocks cross listed in Australia and New York exhibited close-to-close variances of 7.015 when the Dow Jones declined, and 3.494 when the Dow Jones rose. A noteworthy aspect drawn from these variances, is that when the Dow Jones declined the volatility for the close-to-close variances were greater for every category of stock compared to when the Dow Jones experienced a similar sized increase. These variances unlike the open-to-open return variances suggest that investors on the New Zealand Stock Exchange are risk averse for the

close-to-close time period, hence they are more likely to trade and create volatility when the Dow Jones falls compared to when it rises.

An F-statistic was performed to analyse whether any statistical differences existed in the return variances when the Dow Jones increased compared to when the Dow Jones decreased for the open-to-open and close-to-close time periods. The results are presented in Table 25. The Table clearly shows that significant differences exist in the close-to-close return variances at the 1% level. The open-to-open F-statistics offer different findings that suggest the return variances were similar, with the exception of the New Zealand stocks cross listed in Australia and New York which experienced significant differences at the 1% level.

Table 24

Open-To-Open and Close-To-Close Return Variances for Dually Listed Stocks Following High Volatility in the Dow Jones

Open-to-open and close-to-close return variances are calculated for those stocks solely listed in New Zealand, and the two dually listed stock categories after the Dow Jones experienced high volatility. High volatility in the Dow Jones refers to when the index falls or rises by 2% or more.

	Open-to-Open Var (Ro)	Close-to-Close Var (Rc)
a) 20 stocks solely listed in NZ		
Negative	2.721	5.187
Positive	3.045	2.548
b) 6 stocks listed in both NZ and ASX		
Negative	11.164	5.818
Positive	19.465	2.638
c) 5 stocks listed in NZ, ASX and NY		
Negative	2.173	7.015
Positive	26.689	3.494

Table 25**F-Statistic on Return Variances when the Dow Jones Rose Compared to when the Dow Jones Fell**

The equality of return variances when the Dow Jones rises and falls for the open-to-open and close-to-close periods is analysed for the stocks solely listed in New Zealand, and the two dually listed stock categories.

	O-O	C-C
Solely listed in NZ	0.146	60.008 ***
Dual listed in NZ and ASX	2.852	34.607 ***
Dual listed in NZ, ASX and NY	30.218 ***	39.949 ***

** Statistically different at the 5% significant level.

*** Statistically different at the 1% significant level.

O-O, F-statistic for testing the equality of New Zealand open-to-open return variances when the Dow Jones increased compared to when it decreased.

C-C, F-statistic for testing the equality of New Zealand close-to-close return variances when the Dow Jones increased compared to when it decreased.

Table 26 shows the open-to-open and close-to-close trading return variances for the five capitalisation categories. The open-to-open return variances follow a distinct descending pattern, with those stocks that had a higher capitalisation level experiencing the greatest volatility regardless of whether the Dow Jones experienced a decline or a rise in the index. The highest average capitalised group (group one) experienced open-to-open return variances of 4.498 when the Dow Jones declined and 24.968 when the Dow Jones rose. The extremely high return variance exhibited by this capitalisation group when the Dow Jones increased is due to high variances from Carter Holt Harvey, Telecom and Fletcher Challenge Paper. The variances descend with the decline in the group's capitalisation levels until the fifth group with the lowest average capitalisation recorded an open-to-open return variance of 0.884 and 2.409 when the Dow Jones declined and increased respectively. Consistent with the dual listed analysis performed earlier in this section, the variance returns when the Dow Jones increased were greater than when the Dow Jones declined, which suggests a risk taking behaviour by New Zealand investors during this time period. This was more pronounced for higher capitalised stocks.

The average close-to-close price return variances presented in the right column of Table 26 show similar results as the open-to-open return variances. That is, the return variances

exhibited a declining variance as each group's capitalisation declined. The group with the highest average capitalisation experienced return variances of 6.133 and 3.859 when the Dow Jones declined and increased respectively. These variances declined until the fifth group that had the lowest average capitalisation, which exhibited close-to-close return variances of 1.260 when the Dow Jones declined and 1.647 when the Dow Jones increased. Unlike the open-to-open return variances, the close-to-close return variances show a higher level of volatility when the Dow Jones has declined compared to when it increased for all capitalisation groups except the fifth. This indicates that New Zealand investors are generally risk averse for the close-to-close time period, except when trading on low capitalised stocks where New Zealand investors appear to demonstrate a risk taking attitude.

Table 26

Open-To-Open and Close-To-Close Return Variances for Capitalisation Groupings Following High Volatility in the Dow Jones

Open-to-open and close-to-close return variances are calculated for five stock groups based on their capitalisation levels after the Dow Jones experienced high volatility. High volatility in the Dow Jones refers to when the index falls or rises by 2% or more. Group one consists of the six highest capitalised stocks, with the fifth group consisting of the lowest capitalised stocks in the sample.

	Open-to-Open Var (Ro)		Close-to-Close Var (Rc)	
a) Group one				
Negative	4.498		6.133	
Positive		24.968		3.859
b) Group two				
Negative	1.702		4.813	
Positive		6.404		3.498
c) Group three				
Negative	1.088		4.317	
Positive		4.290		2.034
d) Group four				
Negative	1.066		3.891	
Positive		2.867		2.222
e) Group five				
Negative	0.884		1.260	
Positive		2.409		1.647

4.7.1 Summary

The open-to-open and close-to-close return variances observed after the Dow Jones experienced substantial volatility were generally similar to the volatility patterns shown for the entire 1997 calendar year. The return variances did however show an unexpected result, that New Zealand investors are risk takers for the open-to-open time period. This is likely to result from investors trying to capture potential price rises which were experienced in the Dow Jones. This was the most pronounced for the stocks cross listed in New Zealand, Australia and New York, and for the group of stocks which exhibited the highest average capitalisation. The close-to-close return variances showed expected results. These variances illustrated that New Zealand investors are generally risk averse for this time period, with the return variances being higher after the Dow Jones declined compared to when it increased.

CHAPTER FIVE

CONCLUSIONS

5.1 Conclusions

The objective of this study has been to examine the volatility patterns of the New Zealand Stock Exchange and dually listed stocks during the trading day. Earlier research has shown that the price return variances of stock exchanges to be U-shaped when plotted against the trading day. This indicates that volatility is the highest at the beginning and end of the trading day, and reasonably stable for the interior of the trading day. This study has shown that the New Zealand market exhibits a similar intraday U-shaped volatility curve as other markets. Researchers have put this shaped curve down to numerous aspects including the different trading mechanisms utilised, and the use of the specialist in the United States. The strongest theory to be developed in the literature is that the long non-trading period prior to the market open leads to the high volatility at the opening of the market.

The non-trading period prior to the market opening was examined by analysing the open-to-open to close-to-close return variance ratios for dually and non-dually listed stocks. Dually listed stocks have additional trading time in foreign markets, hence reducing their non-trading period prior to the opening of the New Zealand market. Previous research has found that dually listed stocks experienced a lower opening variance (relative to the closing variance) when compared to non-dual listed stocks. That is, dually listed stocks exhibited a lower open-to-open to close-to-close return variance ratio than non-dual listed stocks. The explanation presented in previous studies for this finding, is that the additional trading hours of dually listed stocks enable price disturbances to be dissipated over a longer time period instead of clustering around the market opening (Cheung et al., 1994). If this explanation were to be accepted in the New Zealand market, then those New Zealand stocks cross listed in Australia and New York should exhibit less volatility at the opening of the market (relative to the close) than those stocks solely listed in New Zealand. However, the findings in this study do not support this explanation, and contradict previous studies. This study found that New Zealand dually listed stocks experienced a higher

opening return variance (relative to the close) than non-dual listed stocks. This finding may suggest that the additional trading time of dually listed stocks creates volatility at the market opening. There are three possible explanations as to why these results differ from previous studies. First, it could result from the size of the New Zealand Stock Exchange. All previous research has been conducted on large world exchanges, and as the New Zealand market is comparatively small the results could differ. Another possible cause for this anomaly is due to the opening trading mechanism utilised by the New Zealand Stock Exchange. Many exchanges around the world utilise different mechanisms to obtain securities prices at the market open; the algorithm employed in the New Zealand market may cause the low ratio. An unlikely but possible cause of the anomaly could result from the time period analysed. This study only covered one calendar year (1997), therefore it is unclear if these results represent normal New Zealand trading activities.

The explanation that the additional trading time of dually listed stocks creates volatility at the market opening does not seem viable, therefore further tests on the open-to-open and close-to-close return variances were conducted on groups of stocks based on their capitalisation levels. These results indicated that lower capitalised stocks experienced the least amount of volatility at the market opening relative to the market close. Further tests of market behaviour were conducted on the capitalisation groupings with first order autocorrelation coefficients. These results reconfirmed earlier suggestions, and indicated that lower capitalised stocks were more efficient at both the opening and closing of the market. These results suggest that high capitalised stocks appear to be associated with the high volatility observed at the opening of the New Zealand market. A possible explanation for this finding is that high capitalised stocks have higher liquidity levels compared to low capitalised stocks, hence they trade more which creates volatility. Previous research has been conducted on large world exchanges where it would have been possible to have equal sized firms in the sample, both dually and non-dually listed. Therefore size could not be a cause of the difference in volatility between dually and non-dually listed stocks. It was not possible to have a sample of equal sized companies in this study as the NZSE 40 consists of stocks that have a substantial range in capitalisation levels. Therefore size is a factor which could influence volatility in this study.

Volatility over trading (open-to-close) and non-trading (close-to-open) time periods were also examined in this study. The trading to non-trading variance ratio observed in the New Zealand Stock Exchange was very low compared to other markets. An explanation for a low trading to non-trading variance ratio presented in previous research is that dually listed stocks continue to trade during the domestic overnight non-trading period, therefore increasing the non-trading period and lowering the ratio (Cheung et al., 1994). The findings in this study do not support this suggestion, as the dually listed stocks exhibited a lower non-trading return variance relative to their trading return variance, when compared to non-dual listed stocks. This means the New Zealand stocks cross listed in Australia and New York exhibited the highest trading to non-trading variance ratio, which contradicts previous research. Because of this unusual finding in the New Zealand market, stock groupings based on their capitalisations were examined. The findings from these tests indicated that low capitalised stocks exhibited a higher non-trading variance relative to the trading variance, when compared to high capitalised stocks. This suggests that low capitalised stocks may be associated with the low trading to non-trading variance ratio observed in the New Zealand Stock Exchange. There are two possible explanations developed in this study to explain this anomaly. The first is that low capitalised firms have lower liquidity levels compared to high capitalised firms. This would reduce their trading volumes and volatility during the trading day, hence decreasing the trading to non-trading variance ratio. The other explanation is that investors on the New Zealand market revise their views on stock prices for low capitalised stocks, more than large capitalised stocks during the New Zealand overnight non-trading period. This would create more volatility during the non-trading period for low capitalised stocks, hence reducing the trading to non-trading variance ratio. Both of these explanations were however, only partially supported by the results.

As it appears that New Zealand investors revise their views on stock prices during the overnight period¹, this study analysed return variances for the categories of stocks when the Dow Jones experienced high volatility of at least 2%. The results from these tests indicated that for the trading, non-trading and close-to-close time periods, New Zealand investors generally showed risk aversion. That is, New Zealand investors were more likely to trade

¹ This was especially evident for low capitalised firms.

and cause higher levels of volatility in the New Zealand market for these time periods when the Dow Jones declined as opposed to rising. This shows that investors are attempting to protect themselves from potential losses. This was the most pronounced in the stocks listed in all three exchanges, and in the highest average capitalised group. The open-to-open return variances showed unexpected results, which indicated that New Zealand investors were risk takers for this time period. Hence investors on the New Zealand market traded and caused more volatility when the Dow Jones increased compared to when it decreased. This indicates that New Zealand investors attempted to secure potential profits that may result from the high index rise in the United States. This was again the most pronounced in the stocks listed in all three exchanges, and in the highest average capitalised group. The volatility was found to be the highest in those stocks that had the highest average capitalisation levels, and those stocks that were dually listed in all three exchanges for all time periods, regardless of whether the Dow Jones declined or rose. This result was expected as those New Zealand stocks dually listed in Australia and New York trade during the high volatility in the Dow Jones, and hence are directly affected.

5.2 Limitations and future research areas

This study utilised an un-weighted cross-securities average of stock returns to represent the market. Previous research has used an actively traded index to represent the exchange in their country; this was not utilised in this study as the only index which could have been used (NZSE 40) is dominated by Telecom. Approximately 30% of the NZSE 40's capitalisation was contributed from Telecom. Therefore the volatility patterns of this index are biased towards Telecom's volatility patterns. Hence an un-weighted cross-securities average was the only method to achieve an unbiased representation of the New Zealand Stock Exchange. This is a limitation of this study, as it is not directly comparable to previous research that utilised an index.

The sample size of the dually listed stocks also creates limitations within this study. There were only five stocks cross listed in New Zealand, Australia and New York, and six frequently traded stocks dually listed in New Zealand and Australia. These low sample sizes enable them to be influenced by one or two of the more volatile stocks. Unfortunately

when studying the New Zealand Stock Exchange, sample numbers are frequently low, due to the small size of the New Zealand market by world standards.

Another limitation within this study is that the individual stocks within each of the two dually listed groupings, and the group of stocks solely listed in New Zealand were not of comparable size. This limitation results from the small size of the New Zealand Stock Exchange. Previous studies have been conducted on large world exchanges, hence they have numerous large stocks to select from being both dually and non-dually listed. The stocks selected in these studies would have been of comparable size and trading volumes, unlike this study conducted on a much smaller exchange. This is a limitation, as size and trading volume are factors which can influence volatility as shown in the capitalisation analysis of this study.

The final limitation of this study results from only examining one calendar year. Because of the high volume of data (approximately 400,000 observations) this study only analysed one trading year. This creates a limitation, as the findings in this study may only be representative of the 1997 calendar year, and not of regular trading activities of investors in New Zealand.

There are numerous future areas of research concerning volatility and/or dually listed stocks, which would be advantageous for both theoretical and practical reasons.

The analysis could be extended to cover other years, to ascertain whether the volatility patterns and ratios discovered in the New Zealand 1997 calendar year also hold for other years.

Interesting studies could be conducted if intraday data could be obtained from the foreign exchanges that the dually listed stocks trade on. This was unable to be achieved in this study because of the funds required to obtain the data. A number of areas can be examined if access to foreign intraday data is collected, for example market integration. Werner and Kleidon (1996) performed a study on market integration for stocks dually listed in the United Kingdom and United States. A similar study performed on New Zealand and Australian cross listed stocks before and after "Closer Economic Relations" was implemented could also yield interesting results. Another possible area of research

conducted with foreign intraday data is to examine whether those New Zealand stocks dual listed in Australia experience a rise in volatility at the end of the Australian trading day. These stocks did not exhibit a significant rise in price return volatility at the end of the New Zealand trading day. This is likely to result from international New Zealand brokers being able to continue to trade these stocks on the Australian Stock Exchange for two and a half hours after the close of the New Zealand market. A third possible area of research conducted on foreign intraday data would be to empirically analyse the efficiency of the different trading mechanisms employed at the market opening of different exchanges. This would aid stock markets to ascertain which trading mechanism produces the least amount of volatility.

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APPENDIX A

STOCKS REPRESENTING THE NEW ZEALAND STOCK EXCHANGE

Appendix A presents the stocks that were chosen to represent the New Zealand Stock Exchange for the sample period of this study. To be included in the sample, each stock had to trade in the NZSE 40 for all, or the majority of the 1997 calendar year. NZSE 40 stocks were chosen as they trade frequently which eliminates any problems associated with nonsynchronous trading.

The chosen stocks represented 94.30% and 87.69% of the total capitalisation of the NZSE 40 and the New Zealand Stock Exchange respectively, at the beginning of the 1997 calendar year. At the end of the 1997 calendar year, they represented 93.76% and 87.83% of the total capitalisation of the NZSE 40 and the New Zealand Stock Exchange respectively.

The stocks representing the New Zealand Stock Exchange

Air New Zealand Group A	AIRVA	Air New Zealand Group B	AIRVB
Brierley Investments	BRY	Carter Holt Harvey	CAH
CDL Hotels	CDL	Corporate Investments	CIL
DB Group	DBG	Enerco Gas New Zealand	ENC
Fisher and Paykel	FAP	Fernz Corporation	FER
Fletcher Challenge Buildings	FLCTB	Fletcher Challenge Energy	FLCTE
Fletcher Challenge Forests	FLCTF	Fletcher Challenge Paper	FLCTP
Goodman Fielder	GMF	Guinness Peat Group	GPG
Independent Newspapers	INL	Infratile Australia	IFT
Kiwi Property Trust	KIP	Lion Nathan	LNN
Milburn New Zealand	MBN	National Gas Corporation	NCH
National Mutual Holdings	NMH	New Zealand Refining	NZR

Ports of Auckland	POA	Progressive Enterprises	PRO
Power New Zealand	PWR	Sanford	SAN
Sky City	SKC	St. Lukes	STL
Steel & Tube Holdings	STU	Telecom	TEL
TransAlta New Zealand	TLT	Trustpower	TPW
Tranz Rail Holdings	TRH	Trans Tasman Properties	TTP
Wilson & Horton	WHO	The Warehouse	WHS
Wrightsons	WRI		

APPENDIX B

LISTING DATES

The stocks that constituted the NZSE 40 at the 31st of December 1997 are given in Table 27, along with each exchange they are listed on plus the date they listed on each exchange. The database for recording the listing dates on the New Zealand Stock Exchange was established in 1986, hence the exact date that stocks listed prior to 1986 was unable to be determined. Therefore these stocks have a listing date of "prior to 1986".

Table 27

Markets where NZSE 40 Stocks are Listed and their Listing Dates

The top 40 stocks within New Zealand (by market capitalisation) at the end of 1997 are presented in the table, along with each exchange they listed on and their listing dates.

Stocks	NZSE	ASX	NYSE	NASDAQ	LSE
Air NZ A	24-Oct-89	29-Sep-97			
Air NZ B	09-Dec-91	29-Sep-97			
AMP NZ Office	18-Dec-97				
Baycorp Holdings	30-Jun-86				
Brierley Investments	Prior to 1986	14-Nov-85			Prior to 1986
Carter Holt Harvey	Prior to 1986	14-Nov-85			
CDL Hotels	13-Aug-85				
Corporate Investments	Prior to 1986				
DB Group	Prior to 1986				
Enerco NZ	06-May-92				
Fernz Corp.	Prior to 1986	10-Nov-88			
F&P Industries	Prior to 1986				
FCL Buildings	14-Mar-96	14-Mar-96	14-Mar-96		
FCL Energy	14-Mar-96	14-Mar-96	14-Mar-96		
FCL Forests	14-Mar-96	13-Dec-93	13-Dec-93		

Table 27 continued

Stocks	NZSE	ASX	NYSE	NASDAQ	LSE
FCL Paper	14-Mar-96	14-Mar-96	14-Mar-96		
Goodman Fielder	27-Mar-86	01-Mar-74	27-May-88		April-1987
Guinness Peat	28-Jul-91	18-Aug-93			Prior to 1986
Independent News.	Prior to 1986				
Infratile Australia	30-Sep-94	16-Dec-96			
Kiwi Inc. Prop.	03-Dec-93	12-Jun-98			
Lion Nathan	Prior to 1986	03-Oct-91			
Milburn NZ	30-May88				
National Mutual	08-Oct-96	08-Oct-96			
Natural Gas	22-Oct-92				
Nuplex Industries	Prior to 1986				
NZ Refining	Prior to 1986				
Ports of Auckland	19-Oct-93				
Power NZ	05-Dec-94				
Progressive Enterprises	14-Apr-92				
Restaurant Brands	June-97				
Sanford Ltd.	Prior to 1986				
Sky City	04-Sep-95				
Sky Network	10-Dec-97			09-Dec-97	
St. Lukes	14-Dec-93	14-Dec-93			
Steel & Tube	Prior to 1986				
Telecom NZ	18-Jul-91	22-Aug-91	17-Jul-91		
The Warehouse	14-Nov-94				
Trans Tasman Prop.	Prior to 1986				
TransAlta NZ	30-Sep-96				

Table 27 continued

Stocks	NZSE	ASX	NYSE	NASDAQ	LSE
Trustpower	18-Apr-94				
Tranz Rail	14-Jun-96			13-Jun-97	
Wilson & Horton	Prior to 1986				
Wrightson	01-Jul-94				

Notes to Table 27.

NZSE 40 listing dates obtained through e-mail correspondence with Allison Michele. Michele@nzse.co.nz
 Australian listing dates were obtained from the Australian Stock Exchange Internet Home Page.

<http://www.asx.com.au>.

New York listing dates were obtained from the New York Stock Exchange Internet Home Page.

<http://www.nyse.com>.

National Association of Securities Dealers listing dates were obtained from the NASDAQ Internet Home Page. <http://www.nasd.com>.

Listing information for CDL Hotels were obtained through e-mail correspondence with Joanda Law.

Sales.marketing@cdlhms.co.nz. CDL Hotels parent company is a Singapore based company with CDL Hotels also being listed in Singapore, hence CDL Hotels can not be used in the dual listed groupings.

Listing dates for Goodman Fielder Wattie were obtained through e-mail correspondence with Carmen Velasco. Carman.Velasco@goodmanfielder.com.au.

The listing dates for Brierley Investments and Guinness Peat on the London Stock Exchange were unable to be ascertained, therefore they are recorded in the Table as having a listing date of "Prior to 1986."

From the information provided in Table 27, certain stocks were eliminated from the dual listing sample. Stocks were excluded if they traded on any stock exchange other than the New Zealand, Australian and New York exchanges, or they listed on any exchange after the 1st of January 1997. Some stocks had more than one reason for being excluded from the sample¹; therefore they appear in multiple lists below.

Stocks eliminated for trading in London.

- Brierley Investments. BRY
- Goodman Fielder. GMF
- Guinness Peat Group. GPG

¹ For example, listing in New Zealand after the 1st of January 1997, and being dual listed in London.

Stocks eliminated for trading on the NASDAQ.

- Sky Network. SKC
- Tranz Rail Holdings. TRH

Other Exclusions.

- CDL Hotels – CDL Hotels was listed in Singapore. CDL
- Baycorp – not listed in the NZSE 40 for the entire 1997 calendar year. BCH
- Nuplex - not listed in the NZSE 40 for the entire 1997 calendar year. NPX

Stocks eliminated for listing on any exchange after January 1st 1997.

- Air New Zealand Ordinary A. AIRVA
- Air New Zealand Ordinary B. AIRVB
- AMP NZ Office Trust. APT
- Kiwi Income Property Trust. KIP
- Restaurant Brands. RBD
- Sky Network. SKY
- Tranz Rail Holdings. TRH

After these stocks were removed from the sample, the remaining stocks were placed into their dual listing categorises.

Stocks listed solely in the New Zealand.

- Corporate Investments. CIL
- DB Group. DBG
- Enerco Gas New Zealand. ENC
- Fisher & Paykel Industries. FAP
- Independent Newspapers. INL
- Milburn New Zealand. MBN
- National Gas Corporation Holdings. NCH
- New Zealand Refining. NZR

• Ports of Auckland.	POA
• Progressive Enterprises.	PRO
• Power New Zealand.	PWR
• Sanford.	SAN
• Sky City.	SKC
• Steel & Tube Holdings.	STU
• TransAlta New Zealand.	TLT
• Trustpower.	TPW
• Trans Tasman Properties.	TTP
• Wilson & Horton.	WHO
• The Warehouse.	WHS
• Wrightson.	WRI

Stocks dually listed in New Zealand and Australia.

• Carter Holt Harvey.	CAH
• Fernz Corporation.	FER
• Infratile Australia.	IFT
• Lion Nathan.	LNN
• National Mutual Holdings.	NMH
• St. Lukes.	STL

Stocks cross listed in New Zealand, Australia and New York.

• Fletcher Challenge Building.	FLCTB
• Fletcher Challenge Energy.	FLCTE
• Fletcher Challenge Forests.	FLCTF
• Fletcher Challenge Paper.	FLCTP
• Telecom.	TEL

APPENDIX C

CAPITALISATION CATEGORIES

The stocks utilised in the dual listed stock analysis (presented in appendix B) were reallocated into capitalisation groupings. The two Australian companies National Mutual Holdings and Infratile Australia were excluded from the groupings, as their New Zealand capitalisation was not representative of their overall capitalisation. This meant the last group which exhibited the lowest average capitalisation, consisted of only five companies. The average capitalisation of each stock was calculated by aggregating each stock's capitalisation at the beginning and end of the 1997 calendar year, this total was then averaged. Convertible shares as well as ordinary shares were taken into consideration for this calculation. These stocks were then arranged into groups based on their average capitalisation levels. Group one contains the six stocks which exhibited the highest average capitalisation's, whereas the fifth group contains the five lowest capitalised stocks in the sample.

The capitalisation groupings are presented along with each group's average capitalisation (000's) for the 1997 calendar year.

Group 1 - \$4,471,476

- 1) Telecom
- 2) Carter Holt Harvey
- 3) Natural Gas Holdings
- 4) Lion Nathan
- 5) Fletcher Energy
- 6) Fletcher Paper

Group 2 - \$1,153,644

- 1) Fletcher Forestry
- 2) Fletcher Buildings
- 3) Power New Zealand
- 4) Wilton & Horton
- 5) Independent News
- 6) Ports of Auckland

Group 3 - \$620,043

- 1) Fernz Corporation
- 2) Sky City
- 3) Fisher & Paykel
- 4) New Zealand Refining
- 5) St. Lukes
- 6) The Warehouse

Group 4 - \$406,452

- 1) Enerco Gas
- 2) TransAlta
- 3) Transtasman Prop.
- 4) Prog. Enterprises
- 5) Corporate Investment
- 6) DB Group

Group 5 - \$275,523

- 1) Milburn New Zealand
- 2) Sanford
- 3) Trustpower
- 4) Steal & Tube
- 5) Wrightsons

APPENDIX D

TRADING VALUE

The two dual listed stock categories, the group of stocks solely listed in New Zealand, and the five capitalisation groupings are given in this appendix along with each groups average trading value¹ for the 1997 calendar year. Trading value refers to the amount of money that was traded for each stock during the 1997 calendar year (Ho et al., 1993). As is evident in the dual listed categories, the highest average trading values occurred from those stocks cross listed in New Zealand, Australia and New York. The capitalisation groupings illustrated that the higher a group's capitalisation was, the higher their trading value was.

Dual Listing Groups

- Stocks solely listed in New Zealand - \$ 74,865,582
- Stocks dual listed in New Zealand and Australia - \$ 422,065,299
- Stocks listed in New Zealand, Australia and New York - \$1,418,814,543

Capitalisation Groupings

- Group 1 (highest average capitalisation) - \$1,321,894,416
- Group 2 - \$ 253,875,104
- Group 3 - \$ 152,987,961
- Group 4 - \$ 67,254,075
- Group 5 (lowest average capitalisation) - \$ 53,850,673

¹ The average trading value of each individual stock in the sample was obtained from the New Zealand Stock Exchange Fact Book (1998).

APPENDIX E

STOCK EXCHANGE LISTING REQUIREMENTS

Introduction

Every stock exchange has different listing rules and procedures that it requires both local and overseas based entities to adhere to in order to become listed on their exchange. These listing requirements vary between each exchange depending on how regulated the country's stock market is. The purpose of this section is to provide a summarised version of the conditions required for foreign firms to become listed on the New Zealand, Australian and New York stock exchanges.

New Zealand

The New Zealand economy¹ is one of the most open and deregulated markets in the world, which is partly due to the physical isolation and size of New Zealand as a country. If the economy and stock exchanges were highly regulated, very few companies would list in New Zealand, as the size of the New Zealand Stock Exchange is very small by world standards. The following requirements must be met for overseas-based companies in order to gain access to the New Zealand Stock Exchange².

5.1.6 **Overseas Listed Issuers:** An Overseas Listed Issuer shall:

- (a) Be deemed to satisfy and comply with all the Rules so long as it remains listed on its Home Exchange, and is not suspended by its Home Exchange, provided that the Exchange may, at any time, by notice to any Overseas Listed Issuer, declare that any of the Rules shall thereafter apply to that Issuer.

¹ Including the New Zealand Stock Exchange.

² This information has been extracted from the New Zealand Stock Exchange Listing Rules (1994), section 5.1.6.

- (b) analogous provision, and whether or not that Issuer is then complying with any such provision;
 - (c) If application has been made to the Exchange for a Class or Classes of its Securities quoted on its Home Exchange to be Quoted on the Exchange, be deemed to satisfy and comply with all of the Rules for so long those Securities remain quoted on its Home Exchange; and
 - (d) Give to the Exchange the same information and notices it is required to give to its Home Exchange, at the same time as it is required to give such information and notice to its Home Exchange.
1. The intention of above rules, is that a company or other entity which is listed on a recognised overseas stock exchange, and is accepted by the Exchange for listing on the Exchange as well, is not required to comply with the Rules, so long as that company or other entity complies with the rules of the overseas stock exchange. The Exchange may however in its discretion at any time require that company or entity to comply with any provisions of the Rules.
 2. As a general rule, the Exchange will cancel the listing of an Overseas Listed Issuer if the listing of that Issuer is cancelled on its Home Exchange, and will suspend Quotation of a class of securities if Quotation is suspended on the Home Exchange.

Australia³

A foreign company may apply for listing on the Australian Stock Exchange as an exempt foreign entity. Before a company can trade on the Australian Stock Exchange they must first be admitted to the official list, and then their securities must be granted official quotation.

Requirements for admission to the official list.

The following conditions must be met by a foreign entity before the Australian Stock Exchange will grant admission.

1. The entity must be foreign and have an overseas home exchange or market that is a member of the International Federation of Stock Exchanges.
2. The entity must be subject to the listing rules of its home overseas exchange (this condition will not be waived by the Australian Stock Exchange).
3. The Australian Stock Exchange must be satisfied the foreign entity complies with the overseas home exchange.
4. The entity must give the Australian Stock Exchange a copy of their latest annual report and any subsequent interim reports, and must give the Australian Stock Exchange additional reports when they fall due.
5. The entity must establish in Australia, either an Australian securities register, or a register of depository receipts, or other suitable facilities for the transfer of registration.
6. The entity must apply for and be accepted for quotation of the securities that are in the class for which it seeks quotation. However, if the overseas home exchange is

³ Information for the listing requirements on the Australian Stock Exchange was extracted from the Australian Stock Exchange Internet Home Page. <http://www.asx.com.au>.

the New Zealand Stock Exchange, the entity must apply and be accepted for quotation of all the securities that are in the class.

7. The foreign entity must satisfy either the profit or net tangible asset tests. This condition is excluded if the entity's home exchange is New Zealand.
8. The entity must have at least 1,000 shareholders, each having a parcel of securities that are in the class for which it seeks quotation with a value of at least \$500. This condition is excluded if the entity's home exchange is New Zealand.
9. If the foreign entity is a company, it must be registered as a foreign company under the Corporations Law.

The profit test for an exempt foreign entity.

For an exempt foreign entity to meet the profit test, the following conditions must be satisfied.

1. The entity must be a going concern.
2. The entities operating profit before income tax for each of the last three full financial years must be at least \$10 million, and derived from the entity's normal activities.
3. The financial reports and statements of the foreign entity must have been prepared and audited to the Australian Stock Exchange standards.

The net tangible assets test.

1. To meet the net tangible asset test, the foreign entity must have at least \$50 million of net tangible assets at the time of admission.

Applying for admission to the official list.

This is a simple process that requires the entity to complete a portion of a form. The report covers three areas

1. Application for admission to the official list;
2. Information about the entity;
3. Agreement.

New York⁴

The majority of overseas-based entities that list on the New York Stock Exchange do so under American Depositary Receipts. An American Depositary Receipt is a receipt issued by a United States depository bank⁵, which represents shares in a foreign entity held by the bank. American Depositary Receipts are quoted in United States dollars and trade like any other security on the same exchange.

Non-United States corporations may elect to qualify for listing by either the alternative listing standards for non-United States corporations, or through the New York Stock Exchange domestic listing criteria.

Alternative listing standards.

The alternative listing standards primary function is to enable major non-United States corporations to list their shares on the New York Stock Exchange. Hence this method is utilised by most non-United States corporations in order to list on the New York Stock Exchange. The principal criterion of this procedure is based on worldwide, rather than United States distribution of shares. The following conditions must be satisfied before the non-United States corporation can list.

1. There must be 5,000 worldwide shareholders, each holding at least 100 shares each.

⁴ Information for the listing requirements on the New York Stock Exchange was obtained from the New York Stock Exchange Internet Home Page. <http://www.nyse.com>.

⁵ A depository bank is a United States bank that organises all the stock transfers and agency services in connection with the depository receipt.

2. The corporation must have at least 2.5 million worldwide public shares.
3. The market value of the public shares must be at least \$100 million.
4. The aggregate for the last three years of net tangible assets⁶ must be at least \$100 million, with the minimum of any one of these three years being \$25 million.

Domestic listing standards.

The domestic listing standards is solely concerned with the corporation's earnings and distribution of shares within the United States. Therefore although this is an option available for non-United States corporations to use to list on the New York Stock Exchange, it is seldom utilised over the alternative listing standards.

Summary

New Zealand has a very small economy and stock exchange by world standards. The New Zealand Stock Exchange has extremely relaxed conditions that foreign entities are required to meet before they can gain entry into the New Zealand market, all that is basically required is the entity is a member of the International Federation of Stock Exchanges. The New York Stock Exchange is the largest exchange in the world, operating within one of the world's largest economies. The requirements for foreign entities to list on the New York Stock Exchange are extremely ridged, and require the company to fulfil numerous conditions that only large organisations could adhere to. The size of the Australian Stock Exchange and economy is somewhere between New Zealand's and New York's. The requirements for foreign entities to list on the Australian Stock Exchange are far more complex than the New Zealand market, requiring profit or asset tests. The Australian Stock Exchange does make it easier for New Zealand base companies to list on their exchange by waiving some of their requirements. However these conditions are still far less than what New York is demanding.

⁶ Before income tax.

There appears to be a strong relationship between the size of each exchange or economy, and the number of conditions required for foreign entities to list on each exchange. The smaller an exchange/economy is the less conditions are required for foreign entities to list, such as in the New Zealand. A country that has a small economy also has a small stock exchange, as there are only a limited number of local companies that can become listed. Therefore a small exchange will attempt to attract overseas-based companies by having very few listing requirements. A country with a large economy already has numerous local entities wanting to list on their exchange⁷. Therefore they do not require foreign entities to expand their local stock market. Hence a country with a large economy makes the listing criteria for foreign entities extremely complex to encourage only the large well-established overseas-based corporations.

⁷ Such as in New York.