Three Essays on Pricing and Market Behaviour around Corporate Acts and Information Releases

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A dissertation submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

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Certificate

This is to certify that to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes.

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Signature of Candidate

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Craig D. Mellare

(January 2012)

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Synopsis

This dissertation studies pricing and market behaviour around corporate acts and information releases. The issues examined within this thesis are a fundamental part of the functioning of secondary markets and the broader integrity of the financial system. The three essays in this dissertation examine factors related to the efficiency of price adjustment on equity markets in response to new information and the influence of third party certification on initial public offering process. In particular, the speed by which the information contained in corporate earnings announcements is incorporated into equity prices; the behaviour of algorithmic traders around such announcements; and the insights that venture capitalist backing of newly listing companies has for third party investors are comprehensively examined. The outcomes of these studies provide new insights into how equity markets function and, therefore, the findings are relevant for market practitioners, policy makers and the academic community.

Chapter 1: Introduction

1.1 Purpose of the Dissertation

Ever since the early works of Fama (1965, 1970), Ball and Brown (1968) and Beaver (1968), researchers have examined the way in which security prices react to the release of corporate information, in particular periodic earnings reports. It is broadly accepted that the speed with which securities prices fully respond to the availability of new information defines the level of informational efficiency of that exchange.[1] The timely adjustment of prices to the information contained in such announcements is an essential element in ensuring that an equity security's current market value and intrinsic value are as closely aligned as possible. Significant divergence between the underlying value of the security and its traded price, caused by a delay in adjustment following the arrival of new information, leads to informational arbitrage. Should the existence of informational arbitrage become widespread this would have potentially very serious consequences for the perceived fairness of the equity market by uninformed (liquidity) traders. This could lead to the partial, or even full, withdrawal of liquidity traders from participation in that market. The consequence of such an outcome would be a dramatic decline in the provision of liquidity on the exchange. Therefore the question of whether the market is informational efficient is of significant importance to the investment community, market regulators, and the academic community.

[1] Fama (1970) defined the speed and accuracy of the market's reaction to public information such as periodic earnings reports as semi-strong market efficiency.

Considerable scholarly research has been undertaken to determine if equity markets are informationally efficient. One of the major types of information examined by previous researchers has been periodic corporate earnings announcements. Periodic earning announcements are seen as providing clues about the amount, timing and/or uncertainty of future cash flows of the firm. That information is then used by market participants to revise their previous expectations of the firm's value, and hence, adjust the current security price. Nevertheless, there remain contradictions in the existing literature about the relationship between the timing of corporate earnings announcements, information content and speed of price adjustment. Furthermore, there remains a scarcity of literature examining how the phenomenal rise of algorithmic trading has impacted the adjustment process. The first part of this dissertation will add to this knowledge base by examining these issues around the release of preliminary final earnings reports by Australian companies.[2]

The second part of the dissertation examines the role of venture capitalists in initial public offering process on the Australian Securities Exchange (ASX). The price uncertainty that typically accompanies new offerings to the market has long been an area of interest to scholars. Many theories have been advanced as possible explanations of this phenomena; asymmetric information, institutional reasons (which create an incentive for investment banks to underprice), control considerations, and behavioural approaches.[3] Of these, the argument that underpricing is a rational response by potential investors to the inherent uncertainty about the fair value of the firm in a market characterised by informational asymmetry is the most firmly

[2] The companies selected for this dissertation are all included in the S&P/ASX 200 index. This index comprises approximately 80% of the total market capitalisation of the Australian equities market.
[3] Ljungvist (2004) uses these broad categories to summarise the empirical evidence of IPO underpricing research.

established. This is essentially a problem of adverse selection by uninformed investors.

The presence of a venture capitalist on the registry at the time of public offering adds an additional dimension to this problem. Whilst this has received good coverage in the existing literature that attention has been focused largely in the US market where the venture capital industry has long been established. However, there are important structural differences in both scale and investment focus between the Australian venture capital industry and its US counterpart that raise legitimate questions about whether those findings would apply here.[4] It is the scarcity of research into the role of venture capital participation in the initial public offering process in Australia that the final essay in this dissertation will address.

1.2 Stock Returns around Corporate Earnings Announcements

The first essay in this dissertation examines the relationship between timing of the release of corporate earnings announcements, information content and security price reaction. Beginning with Ball and Brown (1968), researchers have used event studies to test the efficient markets hypothesis by measuring the speed of adjustment to various types of public information. Using an event study, the researcher infers whether the event, such as an earnings announcement, conveys new information to market participants as reflected by changes in the level or variability of security prices

[4] In 2009, Australian venture capital funds held A$2 billion under management (AVCAL, 2009) whereas in the same year US venture capital funds held US$179.4 billion under management (NVCA, 2010). Furthermore, OECD (2007) figures show that the share of venture capital dedicated to high-technology sectors in the US was 87.5% whereas in Australia it was significantly lower at 19.6% in 2005.

or trading volume over a period of time around the event.[5] Early work measured response time in monthly, or daily, intervals after the event date. This work gave rise to the post-earnings-announcement drift literature and long-window event literature, which demonstrates that abnormal returns persist for extended periods of time following earning announcements.[6]

Commencing with the work of Patell and Wolfson (1984), researchers have also been interested in exploring the intraday speed of adjustment to the information content of corporate earnings announcements. The use of intraday data has the significant advantage of allowing the researcher to more precisely determine the speed with which the information content of an announcement is impounded within the security price. Market microstructure research has shown that the intraday price adjustment process is affected by a diverse set of influences. The speed of adjustment following the release of a corporate earnings announcement on an intraday level may be affected by the inventory levels of the liquidity providers (Garman 1976; Stoll 1978; Amihud and Mendelson 1980), the degree of information asymmetry in the marketplace (Diamond and Verrecchia 1981; Glosten and Milgrom 1985; Easley and O'Hara 1987; Blume et al. 1994), the strategic trading behaviour by informed traders (Kyle 1985; Holden and Subrahmanyam 1992), and actions of discretionary liquidity traders (Chordia et al. 2001; Chae 2005).

Furthermore, a large body of research, beginning with Patell and Wolfson (1982), has examined the theory that managers strategically release information in order to effect

[5] For a more detailed discussion of the event study methodology see Watts and Zimmerman (1986), Collins and Kothari (1989) and MacKinlay (1997) .

[6] Kothari (2001) states that post-earnings-announcement drift can last for up to one year after the announcement date.

the market reaction. The suggestion is that managers will release positive news during trading but hold negative news until after trading to minimise the potentially adverse price consequences. Francis et al (1992) specifically examine differences between the market's reactions to overnight announcements and find no evidence of investors having impounded the value of the information in the opening price the next day but rather their results suggest that volumes and prices soon after the open reflect the value of the information. Greene and Watts (1996) examine the timing of announcements on the NYSE and NASDAQ and found evidence that the two markets respond differently to announcements suggesting that market mechanisms play a role in influencing the adjustment process.

Existing empirical literature on the intraday adjustment to earnings announcements provides evidence of differences in speed of price response based upon the timing of the announcement (Patell and Wolfson 1984; Lee 1992; Francis et al. 1992; Greene and Watts 1996) and the type of trading systems used by the market (Francis et al. 1992). The inconclusive nature of this evidence requires further investigation. The first essay in this dissertation examines the intraday returns around corporate final earnings announcements using data from the Australian Securities Exchange (ASX). Unlike previous studies the ASX is a market which operates an open electronic central limit order book (CLOB), with exchange initiated trading halts for market sensitive announcements made during normal trading hours. Most previous studies have eliminated trading halts from the sample (Patell and Wolfson 1984), not specified how they were treated (Woodruff and Senchack 1988; Lee 1992; Francis et al. 1992; Lee and Park 2000), or identified them but been unable to draw general conclusions due to the small sample size (Greene and Watts 1996).

Therefore, the contribution of the first study is to examine the speed of adjustment for corporate earnings announcements in a different type of market from previous studies. This expands our understanding of this fundamental equity market activity.

1.3 Algorithmic Trading around Corporate Earnings Announcements

There is considerable interest in the role that Algorithmic Trading (AT) and its subset High-Frequency Trading (HFT) now plays in operational efficiency of stock exchanges around the world. This became especially true in the wake of the 'flash crash' on 6 May 2010 when the DJIA, already down around 300 points, dropped an additional 600 pts and before recovering most of that 600 point loss within 20 minutes. The advance of technology in financial markets has meant all aspects of the trading process, from order placement through to back room processing, are now highly automated. In particular, market participants are able to utilise computer algorithms to determine the optimal price, timing, and quantity of an order, to minimise the market impact and risk or to generate a profit. This change, combined with constantly increasing computer capacity that can be acquired at ever decreasing costs, has meant that the volume of algorithmic trading has increased considerably in the previous decade. Figures from the US suggest that 73% of the volumes in US markets were the result of HFT in 2009.[7] Recent figures from TABB Group also found that HFT accounts for 77% of transactions in the UK market.[8] An Australian Securities Exchange (ASX) survey of brokers determined that the level of algorithmic

[7] "SEC runs eye over high-speed trading", *Financial Times*, July 29 2009.
[8] "High-Frequency Trading is 77% of UK Market, Tabb Group says", *Bloomberg*, 23 January 2011.

trading on the ASX was between 30-40% of total volumes traded, with HFT comprising around 10% of that figure.[9] However, Lepone and Mistry (2011) used a dataset from 2006 to 2009 to study HFT on the ASX and they found that whilst high frequency traders participated in around 35% of all dollar volume of trade in 2006 that figure had risen to around 80% towards the end of their sample period. These figures suggest that AT and HFT represent a very significant portion of the volume traded on global stock exchanges.

The limited amount of academic literature on AT, and HFT, means that there is no firm consensus on precise definitions for each of these terms. However, there are some broad definitions that seem to have found a measure of acceptance in the existing research. Hendershott and Riordon (2011:2) broadly define algorithmic trading as "the use of algorithms to automatically make trading decisions, submit orders and manage those orders". Brogaard (2010: 1) defines HFT as "a type of investment strategy whereby stocks are rapidly bought and sold by a computer algorithm and held for a very short periods, usually seconds or milliseconds". Thus, HFT is a subset of AT.

Hasbrouck and Saar (2011) identify two main types of algorithms used by algorithmic traders. The first are *agency algorithms* which were developed to minimise the market impact of large orders and thus reduce the cost of trading. Perhaps the most common of these is VWAP, which is designed to achieve, or better, the volume weighted average price of the day. The second are *proprietary algorithms*, which seek to profit from changes in data information and events. The ASX uses the terms *execution*

[9] "Algorithmic Trading and Market Access Arrangements", *ASX Review*, 8 February 2010.

algorithms and *situational algorithms* to describe agency and propriety algorithms respectively (ASX Review 2010).

The effectiveness of AT (in particular HFT) strategies is determined by the level of latency that operates within the trading environment. Hasbrouck and Saar (2011:1) define latency as "the time it takes for information to reach the trader, the time it takes for the trader's algorithms to analyse the information, and the time it takes for the generated action to reach the exchange and get implemented". Riordan and Storkenmaier (2011) use more narrow definition of latency; the time it takes for an investor to submit and receive feedback about an order. This is the element of latency that stock exchanges have recently devoted significant resources towards improving. Many exchanges around the world[10] now offer co-location facilities to market participants seeking to capture the trading opportunities available with millisecond transaction times. Co-location is the practice of locating the broker or client trading software and hardware in close proximity to the trading platform's trading engine. The goal of co-location is to minimise the transmission latency. The Australian Securities Exchange (ASX) commenced offering co-location to its equity and options trading platforms in November 2008.

A number of scholars have examined the influence of algorithmic trading and high-frequency trading on financial markets. Existing research has focused upon exploring the general trading activities of algorithmic traders (Prix et al. 2007; Brogaard 2010), the impact algorithmic traders (or high frequency traders) have had upon market

[10] For example, NYSE Euronext, NASDAQ, LSE, Deutsche Börse, TSE, SGX, TMX, and ASX all offer co-location services with many other exchanges planning on doing so in the near future.

quality (Brogaard 2010; Hendershott and Riordan 2011; Hendershott et al. 2011; Hasbrouck and Saar 2011), or the impact of technology on algorithmic trading (Hendershott and Moulton 2010; Riordan and Storkenmaier 2011). Other research has examined the impact of AT on execution costs (Engle et al 2007; Domowitz and Yegerman 2005) or the impact of AT in non-equity markets such as the foreign exchange market during 2006-2007 (Chaboud et al 2009).

Lepone and Mistry (2011) is the only research to date to examine either AT or HFT in the Australian market. They examined a dataset consisting of ASX 200 companies over the period 2006-2009. They looked at the participation of high frequency traders on the ASX and tested the view that high frequency traders are liquidity takers. They found that high frequency traders are, on average, liquidity suppliers in the market rather than liquidity takers. They also examined the market conditions that might be considered sufficiently favourable to trigger an algorithmic generated trade. Those factors were; when spreads are wider, when price volatility is lower, when total depth at the best price is lower and, when trade volumes are lower.

Whilst the existing research demonstrates that algorithmic traders (and high frequency traders) appear to play an increasingly important role in influencing measures of market quality it does not address the question of how algorithmic traders respond to information shocks such as corporate earnings announcements. No research has examined whether algorithmic traders behave in a manner consistent the theoretical predictions of informed or uninformed traders. The second essay in this dissertation examines the behaviour of algorithmic traders around the release of final corporate earnings releases on the Australian Securities Exchange (ASX) and what impact the introduction of co-location has had upon this observed behaviour. This fundamental question had not previously been addressed in scholarly literature.

1.4 Venture Capitalists and the Initial Public Offering Process

The third essay of this dissertation examines the role of venture capitalists in the initial public offering (IPO) process in Australia. Venture capital (VC) typically refers to an equity, or equity type, investment in high growth potential small and medium-sized unlisted enterprises (SME). With this type of investment the venture capitalist assumes a proportion of the business risk in return for the potential rewards associated with the rapid early stage growth. Venture capitalists provide financing, and expertise, to their portfolio firms, who by virtue of their small size and limited asset base, are typically unable to access public capital markets or bank finance. Once the company has grown sufficiently that these impediments are eliminated, or at least significantly reduced, the venture capitalist will seek to exit their investment in the firm. Often the preferred method of exit is via an IPO, since public capital markets are believed to offer higher prices than other exit methods such as trade sales (Bygrave and Timmons 1992; Ruhnka et al. 1992; Wall and Smith 1997; Black and Gilson 1998; Brouwer and Hendrix 1998; Golis 1998; Mahur 1999; Neidorf 1999). Previous research on VC-backed IPO’s has led to the development of two opposing models that attempt to explain the effects of VC participation in the IPO process; the certification/monitoring model (Megginson and Weiss 1991) and the adverse selection/grandstanding model (Amit et al. 1990; Gompers 1996). The certification/monitoring model suggests that the participation of a VC in the IPO process serves to certify the quality of the issue. This should result in lower issuing costs and lower underpricing during the IPO and higher post-IPO performance. Furthermore, as the VC withdraws their involvement in the portfolio company the higher post-IPO performance should decline to more 'normal' levels. The adverse selection/grandstanding model, on the other hand, suggests that the participation of a VC in the IPO indicates that the company is 'average', since companies that have strong prospects will be self-funded (adverse selection), or that the company is not yet 'ready' to go public since the VC has an incentive to bring the company to market prematurely (grandstanding). Thus, the second model implies the VC-backed company will exhibit higher IPO cost and higher underpricing and lower post-IPO performance compared with non-VC-backed companies. Previous research has proven to be contradictory with support found for both of these models.

Most of the existing research carried out on the effects of VC participation in the IPO process has examined evidence from the United States and Europe. Only a limited amount of research has been carried out in markets that do not have such a well established VC industry. Mamao et al. (2000) examined the underpricing of VC-backed versus non-VC-backed IPOs in Japan (the largest VC market in Asia) and found deep underpricing on the venture capital-backed companies consistent with the adverse selection model. Wang et al. (2003) examined the certification/monitoring and adverse selection/grandstanding models in the Singapore and found support for the certification model in companies with at least two years of VC support but also inferior post-IPO performance consistent with adverse selection/grandstanding. Chiang and Lo (2007) used a microstructure approach to examine the effects of VC participation in the Taiwanese market and found some evidence for supporting both the certification/monitoring model and adverse selection/grandstanding model. Wong and Wong (2008) found no support for the certification model but strong support for the adverse selection/grandstanding model in a study of the effects of VC participation in IPO's in the Hong Kong market.

The Australian venture capital industry differs from the more frequently examined markets, such as the United States, in terms of scale, investment focus and the skill sets of the venture capital managers. Whilst some venture capital existed in Australia in a very embryonic form from 1970 onwards, the industry in its current form did not begin to emerge until 1984 with the establishment of the Management Investment Companies (MIC) Program (AVCAL 2009). The US venture capital market, on the other hand, is commonly accepted to have begun with the founding of American Research and Development (ARD) by Ralph Flanders and Georges Doriot in 1946 (Bygrave and Timmons 1992). This delayed development means that the Australian VC market remains very small compared to its better established overseas forebears. For example, according to AVCAL, Australian venture capitalists held over AUD 2 billion in funds under management in 2009, compared to USD 179.4 billion under management by US venture capitalists in the same year (NVCA 2010). Australian VC firms have also exhibited differences in investment focus from their US counterparts. OECD figures report that almost 90 per cent of US venture capital investment activity occurs in the health, biotechnology, communications and information technology sectors whereas in Australia this figure is only around 20 per cent of investment activity (OECD 2007). Australian VCs also exhibit evidence of a different skill set from their US peers. Cornelius (2005) found evidence that Australian VC managers are far more likely than US VC managers to come from financial management and consulting rather than relevant industry backgrounds. Cornelius argued that this lack of relevant industry experience was a contributing factor behind the higher concentration on later stage investments in Australian relative to the US. This implies that an examination of the VC participation in an Australian context is warranted.

Limited academic research has been carried out on venture capitalist activities in the Australian market. Cumming et al (2005) examined the impact on venture capital fundraising of various value added activities and found that significantly more capital is allocated to venture capitalists that provide financial and strategic/management expertise to their portfolio companies than those venture capitalists that provide only marketing/administrative expertise. Suchard (2009) examined the participation of venture capitalists in the boards of their investment companies and found that whilst they tend to hold a lower number (percentage) of board seats than their US counterparts, their portfolio companies do exhibit a higher number (percentage) of independent directors, particularly those with relevant industry experience. These results are consistent with the view that venture capitalists add value to their portfolio companies through their involvement. This implies support for the certification model. However, da Silva Rosa et al (2003) examined IPO underpricing, and long-run performance for a period of 24 months after the IPO, of 38 venture capital-backed companies vs 295 non venture capital-backed companies in Australia. They found that the VC-backed companies exhibited higher underpricing than non-VC-backed companies although the differences were insignificant. Likewise, they found that VC-backed companies exhibited a slightly lower long-run performance than non-VC backed companies but again the differences were insignificant. Thus, the authors were unable to find support for the certification/monitoring model nor the adverse selection/grandstanding model. This still leaves open the question of whether venture capital participation is seen as having positive or negative consequences for the IPO of their portfolio companies.

The third essay contributes to the body of knowledge on the role of venture capitalist participation in initial public offerings in the following ways. Firstly, the two main theoretical models explaining the effects of venture capital participation in initial public offers are explicitly examined in an Australian context. Secondly, an analysis of the differences between a matched sample of VC-backed and non-VC-backed IPOs using measures of IPO pricing and post-IPO operating and market performance has been used. This enables more comprehensive conclusions than many previous studies have been able to achieve.

1.5 Summary

The three chapters that comprise this dissertation examine issues related to pricing and market behaviour around corporate acts and information releases. These activities represent some of the fundamental functions of an equity market and the studies in this dissertation are designed to enhance our understanding of these processes on the Australian Securities Exchange (ASX). This research has been motivated by a number of factors. These include the discordant nature of existing literature in these areas, the emphasis of existing research on markets which are substantially different in nature and characteristics from the Australian market, and the desire to focus attention on aspects of the financial sector that have important implications for economic development and public policy.

The remainder of this dissertation is organised as follows. Chapter 2 provides a detailed review of the existing theoretical and empirical literature on the relevant fields. The hypotheses examined in the three essays are developed at the end of this chapter. Chapter 3 examines the stock return behaviour around corporate earnings announcements. Chapter 4 examines the behaviour of algorithmic traders around corporate earnings announcements. Chapter 5 examines the role of venture capitalists in the initial public offering process. Each chapter contains sections that describe the data, sample, research design, empirical results and robustness tests, and the conclusions drawn. Chapter 6 concludes by discussing the implications of the findings of this dissertation for academics, practitioners and regulators.

Chapter 2: Literature Review

2.1 Introduction

Chapter 1 described the purpose and objectives of this dissertation. This chapter will review the existing scholarly literature in the fields under examination in this thesis. This will be done to demonstrate how the dissertation fits within our current understanding of these fields. The significance of the contribution of this work will be established by critically evaluating the existing literature and identifying those areas that have received insufficient attention to date.

This chapter is organised as follows; Section 2.2 examines the theoretical literature on investor behaviour around corporate information releases. This material has both normative and positivist elements to it. Section 2.3 focuses on the empirical literature examining the speed of reaction on the market and on the strategic timing of corporate information announcements. The focus of this section is whether this impacts upon the market's ability to efficiently process the information content of those announcements. Section 2.4 provides a review of the scant literature existing on the impact of algorithmic trading (and high frequency trading) in security markets. Section 2.5 contains a review of the nature of venture capital investments and the existing literature examining the role of venture capitalists in the initial public offering process. Section 2.6 develops testable hypotheses based on the review of the literature contained in the previous sections that will be examined in the ensuing chapters.

2.2 Theoretical impact of corporate information releases on market behaviour

This section examines the existing theoretical literature that seeks to explain market behaviour around corporate information releases. For the purposes of this review, this literature has been classified into two broad areas; (i) the efficient market hypothesis explanation of the market reaction to the release new information, and (ii) the various market microstructure models that seek to explain how the price discovery process functions in the marketplace. These later models help us to understand the determinants of the price reaction to corporate earnings announcements.

2.2.1 Efficient Market Hypothesis

Whilst most of the work in the field of corporate information releases tends to be empirical in nature, much of the basis our current theoretical understanding of the efficiency by which security prices impound the information content of those releases stems from the work of Fama (1965, 1970). In the *efficient markets hypothesis* (EMH), which was developed from early empirical work on random walk and 'fair game' (martingale) models[11], Fama gave us a theoretical model to explain the relationship between security prices and information in a perfect capital market. Fama stated that a market was informationally efficient if security prices 'fully reflect' all available information. The basis of this theory is that market participants will impound the value of the information by revising (upwards or downwards depending upon the content of the information) expected future dividends (cash flows), required

[11] Samuelson (1965) provided the first economic argument for efficient markets in a paper that focused on the concept of a martingale model.

rates of return and/or the expected future growth rate of dividends (cash flows). The present value of these changes will give rise to a new intrinsic value for the security and the process of trading on that value will establish a new equilibrium price.

In its original form, EMH predicts that this process of establishing a new equilibrium price should occur 'instantaneously'.[12] Fama (1970) defined the *perfect capital market* conditions in which prices would instantaneously fully reflect all available information; (i) there are no transaction costs in trading securities, (ii) all available information is available to all market participants without cost, (iii) all agree on the implications of current information for the current price and distributions of future prices of each security. Fama (1970) did point out though, that perfect capital market conditions are sufficient for market efficiency but not necessary.

Other early theoretical models did take into account the impact of an imperfect capital market, in which the conditions stated previously are not satisfied, on the EMH. For instance, the Jensen (1978) version of market efficiency hypothesis says that prices reflect the information to the point where the margin benefits of acting on the information (that is the profit to be made) exceed the marginal costs. Hence outside the conditions of a perfect capital market, efficiency is judged on the basis of whether the theory is a reasonable approximation of actual market conditions.

Following the initial work, Fama (1970) went on to further identify three levels of market efficiency based upon the type of information reflected in the security price: (i) *weak form* market efficiency in which prices reflect the information contained in

[12] Although Fama (1965:94) acknowledged right from the outset that instantaneously means "among other things, that the actual price will initially overshoot the new intrinsic value as often as it will undershoot".

historical prices[13], (ii) *semi-strong form* market efficiency in which prices reflect the value of information that is publicly available and, (iii) *strong form* market efficiency in which prices reflect the information content of all available information, including private information.[14] Fama was careful to point out that in a semi-strong form efficient market, where prices respond to public information (such as corporate earnings announcements), large price changes tend to be followed by further large price changes. However, provided the initial adjustment of prices to the information is unbiased then this does not in itself invalidate the hypothesis.

There are many contentious issues surrounding the application of EMH in empirical research. An often cited criticism of the EMH, acknowledged by Fama (1970), is that in order to test whether security prices 'fully reflect' the value of new information we must assume an equilibrium model that defines 'normal' security returns. Such models include simple methods such as the constant mean return model and the market model, together with economic models such as the Capital Asset Pricing Model (CAPM) (Sharpe 1964; Linter 1965; Black 1972), the Arbitrage Pricing Model (APT) (Ross 1976) or the consumption-based model (C-CAPM) (Rubinstein 1976; Lucas 1978; Breeden 1979). Therefore, any test of the EMH is both a test of market efficiency and the equilibrium model used to determine normal returns. This gives rise to the joint hypothesis problem in empirically testing EMH (Campbell et al. 1996; Lo and McKinlay 1999; Cuthbertson and Nitzsche 2005).

[13] Fama (1970) acknowledged that the distinction between weak and strong form tests was first suggested by Harry Roberts. Fama (1991) suggested this area has expanded to cover other variables of potential return predictability such as dividend yields, earnings to price ratios and term-structure variables.

[14] Fama acknowledged that the distinction between weak and strong form tests was first suggested by Roberts (1959). Fama (1991) suggested a change of title from semi-strong form to *event studies* and from strong form to *tests for private information*. He argued this better reflects the nature of the research in these fields.

Many of the concerns about the joint hypothesis originally arose from empirical evidence documenting the existence of financial market 'anomalies'. Financial market anomalies are cross-sectional and time series patterns in security returns that are not predicted by a central paradigm or theory. Currently identified anomalies include (but are not limited to); that returns are negatively correlated with market capitalisation (Banz 1981; Reinganum 1981; Fama and French 1992), that stocks with high earnings-to-price ratios earn positive abnormal returns relative to the CAPM (Basu 1977, 1983), that stocks on an upward (downward) trajectory over a period of 3 to 12 months have a higher than expected probability of continuing on that upward (downward) trajectory over the subsequent 3 to 12 months (Jegadeesh and Titman 1993; Carhart 1995; Lakonishok et al. 1994)[15], that Monday returns are on average lower than returns on other days[16] (Cross 1973; French 1980; Gibbons and Hess 1981), that returns are on average higher the day before a holiday (Ariel 1990), that returns are on average higher on the last day of the month (Ariel 1987), that returns in January tend to be higher than other months of the year (Keim 1983; Gultekin and Gultekin 1983; Blume and Stambaugh 1983; Reinganum 1983), and that stocks appear to exhibit seasonal intraday return patterns, with most of the average daily return coming at the beginning and end of each day (Harris 1986). Many of these anomalies were first identified in studies where the CAPM was used as the equilibrium model.

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[15] DeBondt and Thaler (1985) found the opposite, that past 'loser' (stocks which have lower than average returns over the past three to five years) have higher than average returns than past 'winners' (stocks with high returns in the past three to five years). Fama and French (1996) tested this 'contrarian' strategy but found no estimates of abnormal returns that are reliably different from zero.

[16] In Australia, Korea, Japan and Singapore average returns on Tuesday are negative because of time zone differences relative to the U.S. and European markets.

However, Keim (1988) argues ‘seasonals’ in returns are anomalies in the sense that asset-pricing models do not predict them, but that they do not necessarily invalidate the EMH. For example, Lakonishok and Smidt (1988) demonstrate that Monday, holiday and end-of-the-month returns deviate from the normal average daily returns by less than the bid-ask spread of the average stock. Likewise, Roll (1983) found that the abnormal returns generated by small stocks in January are larger but not large relative to the bid-ask spreads of small stocks. Many of other concerns raised about cross-sectional and time-series patterns in stock prices have been addressed in the literature. Connolly (1989; 1991) argues that the day-of-the-week effect and weekend effects aren’t statistically significant when statistically significance is adjusted to reflect the large sample size used in previous studies.

2.2.2 Market Microstructure Models

Beyond the literature on EMH, the market microstructure literature has given us new insights into the behaviour of market prices. A central idea of the theory of market microstructure is that asset prices need not equal full-information expectations of value because the existence of frictions in the trading environment. One aspect of market microstructure is concerned with how various frictions and departures from symmetric information affect the trading process. Around the release of corporate earnings announcements the levels of information asymmetry are particularly high and, hence, microstructure theory allows us to better understand how the prices are established within the framework of functioning security markets.

Early work in this area focused on the role of the market maker in the price formation process. Madhavan (2000:8) pointed out that “by virtue of their central position and role as price setters, market makers are a logical starting point for an exploration of how prices are actually determined inside the ‘black box’ of a security market”. The starting point for this effort was an examination of the role of market maker as a provider of liquidity. Markets makers influence the price formation process through their quoted bid and ask prices; the bid-ask spread. Demsetz (1968) provided the first theoretical model examining the determinants of the bid-ask spread. Under the Demsetz framework, the average (percentage) bid-ask spread was modelled as a function of firm size, inverse of the price, volatility of past returns, trading volume. The simplifying assumption of the Demsetz model though, was that the market maker had a passive role, simply adjusting the bid-ask spread in response to changing conditions.

Smidt (1971) argued that market makers are not simply passive providers of liquidity but rather that they actively adjust the spread in order to manage their inventory levels, and hence their risk exposure. In this case the market maker, whilst primarily being a provider of liquidity, nevertheless also functions as a price-setter primarily with the objective of achieving a rapid inventory turnover. The implication of this model is that the security price may depart for expectations of value if the dealer is long or short relative to their desired (target) inventory, giving rise to transitory price movements during the day and possibly over longer periods. Garman (1976) extended this work by modelling the relation between dealer quotes and inventory levels. In Garman’s model there is a single, monopolistic market maker who sets prices, receives all orders, and clears all trades. Garman’s model demonstrated that, where quoted prices are set at the beginning of the trading period, the market maker is constrained with limited capital, and inventory follows a random walk with zero drift;

over a finite time period (T) failure is certain. This is the classic Gambler's Ruin problem. This means that market makers must actively adjust prices in relation to inventory, rather than simply adjusting spreads as in the Demsetz model. In this model, the spread arose, in part, because of the need to reduce failure probabilities.

The Garman model is limited by some of the simplifying assumptions made. Under this model, the market maker is not permitted to borrow either stock or money, ensuring that their position at any point in time is a function of the order arrival rates. Furthermore, all variables other than order arrival rates are assumed to be exogenous to the market maker.

A particular limitation of the Garman model is the fact that whilst inventory determines the market maker's viability, it is not explicitly incorporated into the market maker's decision problem due to the assumption that the market maker can only set prices at the beginning of the trading period. This restriction severely limits the applicability of the model in a trading environment in which prices continuously evolve. Amihud and Mendelson (1980) address this problem by explicitly incorporating inventory into the market maker's pricing problem. They demonstrate that the market maker's decision variable, their bid and ask prices, depend upon the level of current inventory and thus change over time as inventory levels fluctuate. The implications of this model are three fold. Firstly, as the market maker's inventory increases, he lowers both bid and ask prices, and as it decreases he raises both prices. Secondly, he has a preferred inventory level that he is seeking to maintain.[17] Thirdly, as with Garman (1976), the optimal bid and ask prices exhibit a positive spread. An

[17] Bradfield (1979) demonstrated that a specialist would adjust spreads to reach a preferred inventory position at the end of the day.

important assumption in this model is that inventory is bounded above and below by exogenous parameters, which removes the capital constraints of the Garman model, and means the bid-ask spread arises from the market makers efforts to maximise profits rather than simply reduce failure probabilities.

Stoll (1978) departs from the analysis of Garman (1976) and Amihud and Mendelson (1980) by considering the market maker to be simply a market participant who is willing to alter his portfolio away from desired holdings to accommodate the trading desires of other dealers.[18] As such, the market marker is assumed to be risk averse and therefore must be compensated for bearing this risk.[19] This compensation comes in the form of the bid-ask spread, which itself consists of three components; order processing costs (Tinic 1972), inventory holding costs (Stoll 1978; Ho and Stoll 1981), and an adverse selection component (Stoll 1976; Copeland and Galai 1983; Glosten and Milgrom 1985). The weakness of the Stoll (1978) model is that, like Garman (1976), it remains a one period model, whereby the market maker is assumed to have liquidated their holding at the end of the time period, and thus does not allow for random order flow. Ho and Stoll (1981) seek to address this issue by extending the model of Stoll (1978) to a multi-period framework in which both order flow and portfolio returns are stochastic. O'Hara and Oldfield (1986) developed a discrete time period model in which a trading day contained *n* trading intervals and the dealer maximises his utility over an infinite number of trading days. Under this model the dealer's utility is measured at the end of each day rather than at the terminal period and because the dealer operates within an infinite time period there is no presumed

[18] Ho and Stoll (1980) extended this considering the effect of dealer competition. They arguing that increased competition between dealers (including market makers) would then lead to narrower spreads.
[19] Garman (1976) and Amihud and Mendelson (1980) assume the market marker to be a risk neutral monopolist whose prices are a reflection of their relative market power.

date in which the dealer's inventory is liquidated. However, these models are limited to explaining how an individual dealer would operate under conditions of return and transaction uncertainty.

A further extension by Ho and Stoll (1983) models the problem of determining the equilibrium market bid-ask spread in a competitive dealer market. They are able to demonstrate that, under both homogeneous and heterogeneous opinions about the true price of the stock, there is a tendency for the observed market spread to be the reservation spread of any dealer. Ho and Stoll (1983) also explicitly recognise that although these models are framed in terms of a dealer market, they remain equally applicable to an auction market. This is because the decision of an investor to place a limit order or to trade immediately against an existing limit order is exactly analogous to the decision of a dealer to post his price and wait or to trade immediately with another dealer.

The inventory models discussed above suggest that transaction costs determine the size of the bid-ask spread. A second set of models, starting with the ideas of Muth (1961), Radner (1968, 1972) and Bagehot (1971), instead focus on the central role of information, rather than transaction costs, in the price discovery process. These models are based upon distinction between informed and uniformed traders in the market place. Uninformed traders typically have access to only public information whilst informed traders have access to public and some private information. This has important implications for price formation since trading with a potentially better informed market participant can lead to an adverse selection problem. This problem is particularly acute for the market maker since their position in the middle of trades means they will lose to informed traders. Thus they must make up those losses in trading with uninformed traders and the means they use to do that is the bid-ask spread.[20] Thus the information-based models seek to explain price behaviour in an environment of such information asymmetry.

Radner (1968, 1972) undertook some of the earliest work on the first type of information-based model, often referred to as the rational expectations equilibrium (REE) model. Under this model there is one risky asset and a riskless asset, for which a budget constraint is defined along with initial wealth. The quantity of risk is uncertain as is the payoff on the risky asset. All traders are identical initially and understand the distribution of returns based on prices. Some traders choose to be informed and each informed trader receives the same information. All traders are risk averse and have identical constant absolute risk aversion utility functions. Informed traders form demand for the risky asset by maximising their utility given the current price and signal. Uninformed (liquidity) traders observe the price but not the signal observed by the informed traders. The model then assumes that after repeated observation, uniformed traders will learn the relation between the observed price and the return on the risky asset and will form expectations rationally. They will then take that information into account in their own trading behaviour. The interaction of demand by informed traders and supply by uninformed traders on a rational basis gives rise to a price that will clear the market. And thus the price is fully revealed and prices have become a vehicle for transmitting information. This is the essential component of Fama’s efficient market hypothesis.

[20] Copeland and Galai (1983) considered a simple model of this relationship. The weakness of their model was that it did not identify how information arises or why liquidity traders would trade.

Grossman (1976) and Grossman and Stiglitz (1980) challenged this approach on the basis that the search for information is costly. When the price system is a perfect aggregator of information it removes the incentive to collect private information. They argued that if information is costly, there must be 'noise' in the price system so that traders have an incentive to gather information.[21] Grossman (1976) argued that if there is no noise and information gathering is a costly activity, then a perfect competitive market will break down because no equilibrium exists where information collectors earn a return on their information, and no equilibrium exists where no one collects the information. This has become known as the Grossman-Stiglitz paradox.

Various attempts have been made to overcome the implications of the Grossman-Stiglitz paradox. Allen (1981), Hellwig (1980) and Diamond and Verrecchia (1981) argue that prices are only partially revealing, and therefore they are always incentives to gather costly information. This is achieved by making the information dispersed rather than uniform across all traders as in the Grossman and Stiglitz (1980) model. Thus, in small economies, when the information is dispersed the individual demand of the informed trader cannot reveal all information and in large economies the trading activities of informed traders cannot affect prices if their size is small relative to the size of the market. Diamond and Verrecchia (1981) also point that if information is dispersed, then information aggregated across all traders is more valuable than the information of a single trader. This implies that private information is always more valuable and aggregated information is more informative than information belonging to a single trader. In their model, Diamond and Verrechia characterise noise as aggregate supply uncertainty.

[21] 'Noise' generally refers to supply shocks. Grossman (1976:574) suggested an example of noise "is the uncertain total return of the risky asset."

Brown and Jennings (1989) extend the Diamond and Verrecchia model to two periods and show that past as well and current prices are used by traders to resolve the underlying aggregate supply uncertainty. In each of these models the information structure employed was one in which information is dispersed and symmetric across traders. Blume et al. (1994) extend the work of Brown and Jennings. However, they assume an information structure that is also dispersed but asymmetric across traders. They also assumed that the supply of the risky asset is fixed, and uncertainty is present only in the value of the information signals given to traders. Blume et al. (1994) demonstrated that prices are fully revealing for informed traders but only partially revealing to the uninformed traders. Hence, uninformed traders must look to other sources of information, such as trading volume, in order to estimate the noisy component of prices.

Whilst the rational expectations equilibrium models assume that all traders except for noise traders are risk-averse and non-strategic, another set of models is based on the assumption that a trader with private information would have an incentive to act strategically in order to maximise their profits. These models are collectively referred to as strategic trader models. Kyle (1985) was one of the first scholars to examine the behaviour of market markers when facing insiders and liquidity traders. Kyle models the strategic interaction between a single insider, with a monopoly on information, who choose to trade in order to maximise the trading profit and a market maker who take the insiders trading strategy into account when updating their beliefs about the future value of the asset when setting the equilibrium price. Thus, price is set after the orders are placed in a batch auction market. The market maker will use an upward sloping price schedule as a protection device against adverse selection. Under this model, after many rounds of trading, prices will converge to their full information (rational expectations) value. Order flow is informative with prices responding to trading activity. In this model the market maker is simply acting as an order processor, setting the clearing price.

One obvious weakness of the Kyle model is the assumption of a single trader with monopolistic private information. Holden and Subrahmanyam (1992) address this issue by extending the Kyle model to incorporate competition among multiple risk-averse informed traders with long-lived private information. Holden and Subrahmanyam demonstrate that competition among informed traders is associated with high trading volumes and rapid revelation of private information. Back (1992) extended the Kyle model to incorporate trading in a continuous-time market, which provided insights into more general properties of the Kyle equilibrium.

Glosten and Milgrom (1985) also examined price behaviour under information asymmetry although they took a different approach from Kyle (1985). Whereas the Kyle model uses a batch auction market structure the Glosten and Milgrom model makes use of a quote driven market structure. Under this model the market maker posts bid and ask quotes that are subsequently executed against by their customers. The market marker trades with two types of agents; risk-neutral informed (insider) and uninformed (liquidity) traders. The insiders receive a perfectly informative signal about the security's value prior to trading. Each trader arrives in the market place sequentially (that is one agent at a time) and may choose to buy or sell. Each trader may trade only once and the size of the order is equal to one unit. Thus, if an informed trader wishes to trade further (to make maximum use of their information) they are obliged to return to the pool of traders and wait once more. Markets makers face an adverse selection problem in that they will lose to informed traders. In response the market maker quotes higher prices for buyer-initiated transactions (ask) and lower for seller initiated transactions (bid). Over many trading rounds the market maker is able to observe the orders placed and use that information to update their beliefs about the future value of the asset. This process will be completed when all the value of the private information is incorporated into prices. Under this model only the market makers learn the value of the information content, uninformed traders do not learn information from observing prices. Therefore the probabilities of informed and uniformed traders faced by the market maker remain the same over time.

Easley and O'Hara (1987) expanded on the Glosten and Milgrom model by incorporating the possibility of variation in trade sizes. They argued that the size of the transaction will affect the bid and ask prices by revealing the type of agent who has submitted the order. They assume that an informed trader has a greater incentive to submit larger orders than an uninformed trader. They also incorporate the possibility that there is no information and therefore trading activity provides a signal not only about the quality of information but also about the existence of information. Under this model, the informed trader faces a trade-off between initiating large trades to maximise the profitability of the information content knowing that if they do they will send a stronger signal of information to the market maker. This model gave rise to two possible equilibria. The first is the *separating equilibrium* where informed traders can be identified by their large trades and therefore small trades are undertaken by uniformed investors. In this outcome the spread for small trades does not include an adverse selection component since the market maker does not face that problem. The second possible outcome is the *pooling equilibrium*. Here the informed trader strategically submits both large and small orders to improve the prices for the large trades. This leads to a positive correlation between trade size and the size of the spread.

In an environment of asymmetric information, inferences about investor beliefs and the market's ability to assimilate information can be inferred through changes in trading volume (Kim and Verrecchia 1991a, 1991b, 1994 1997, Atiase and Bamber 1994, Blume, et al. 1994, Bamber et al. 1997). Beaver (1968) was one of the first researchers to identify the potential for trading volume information to yield unique insights regarding the nature of earnings announcements and trader behaviour.[22] Beaver argued that trading volume reflects a lack of consensus regarding the appropriate price for a firm's shares and that trading volumes capture changes in the expectations of individual investors whereas price reactions reflect changes in the expectations of the entire market. This has important implications, in that an announcement might be potentially neutral in the sense of not changing the expectations of the market as a whole (resulting in no significant price reaction) and yet greatly alter the expectations of individuals (leading to increased trading). In such a case, trading volume might yield valuable insights that returns measured might not.

Kim and Verrecchia (1991a) show that the volume reaction to the announcement is proportional to: (i) the absolute price change at the time of the announcement and (ii) the differential precision of preannouncement private information across traders. They

[22] Bachelier (1900) is generally acknowledged to have first raised this relationship.

argue that even though the announcement is commonly interpreted (that is each trader identically perceives the correct mean and precision of the signal and its realisation), the differential precision of private pre-disclosure information generates different belief revision among traders, which in turn generates trading. Traders with less precise private pre-disclosure information weight the announcement more heavily than those who had more precise pre-disclosure information. This differential belief revision causes some traders expectations to cross, which motivates them to change the original allocation of shares to trade. Kim and Verrecchia (1991b) add a variable for the cost of information that is increasing in its precision. They find that a decrease in the cost of private information causes an increase in the differential prior precision across all investors because investors with more precise information are motivated to increase the precision of their private information more than investors with less precise information.

Kyle (1985) argued that when liquidity trading is exogenous and inelastic to price, trading volume increases in information asymmetry due to informed traders attempting to exploit their information advantage. If however, the liquidity traders have discretion over the timing of their trading activities, trading volume can decrease in information asymmetry (Admati and Pfleiderer 1988, Foster and Viswanathan 1990). Chae (2005) argued that when discretionary liquidity traders (DLT) receive exogenous trade demands prior to announcements, they will postpone trading until the announcement is made and information asymmetry is resolved.

The type of announcement will significantly impact upon trader behaviour. If the type of announcement is scheduled, such as corporate earnings announcements (Chordia et al. 2001), then trading volumes will decrease prior to the announcement because DLT will delay trading in order to avoid adverse selection costs due to information asymmetry. Thus in the pre-release period, high trading demand by informed traders would not be met with the provision of supply by DLT. Once the information asymmetry is resolved then trading volumes should increase. If the announcement is unscheduled, such as corporate restructuring announcements, bond ratings changes or official interest rate changes, then DLT might not be able to change the timing of their trading behaviour in order to avoid the adverse effects of information asymmetry. In this case, trading volumes are likely to be elevated in the pre-release period as informed traders utilise the value of any private information they might have relative to uninformed traders. After the unscheduled announcement, uninformed traders will then trade in response to the information content of the announcement. This is likely to result in elevated trading volumes in both the pre-announcement and post-announcement period (Chae 2005, Fabiano 2008).

2.2.3 Summary

The models discussed in this section provide a framework for understanding how markets respond to the information contained in corporate information releases. The EMH implies prescribes a rapid and orderly response to a new equilibrium price reflective of the intrinsic value of the security. Market microstructure models suggest that the efficiency of price response around such releases will be influenced by the degree of competition between liquidity providers, dealer inventory levels, the degree of information asymmetry in the marketplace, and the amount of discretion that liquidity traders have over the timing of their trading activity. A summary of the theoretical literature discussed in this section can be found in Table 2.1.

Table 2.1
Major Theoretical Literature on the Relationship between Information and Market Behaviour

This table provides a summary of the main existing theoretical literature examining information and the price formation process. These theoretical models are classified according to their type; Efficient Market Hypothesis (EMH) or Market Microstructure (MM).

	Classification	**Expected Impact of Corporate Earnings Release on Market Behaviour**
Fama (1965, 1970)	EMH	The process of establishing a new equilibrium price reflecting the intrinsic value should occur instantaneous (or rapidly in an unbiased manner).
Jenson (1978)	EMH	Prices will adjust to reflect the information to the point where the marginal benefits of acting on the information exceed the marginal costs.
Radner (1968, 1972)	MM – Rational Expectations Equilibrium (REE)	After repeated observation uninformed (liquidity) traders learn the relation between price and return and form rational expectations. The market clearing price reflects the value of the information release.
Amihud and Mendelson (1980)	MM -Inventory Model	Extension of Garman (1976) to explicitly incorporate inventory in the pricing problem. Market makers actively adjust spreads in order to rebalance inventory levels towards a desired amount when faced with order flow imbalances.
Stoll (1978)	MM -Inventory Model	Market maker is willing to alter their portfolio away from desired levels to but must be compensated through the bid-ask spread. Large order imbalances increase the size of the spread.
Diamond and Verrecchia (1981)	MM -Information Model	Information is dispersed rather than uniform. Prices reflected aggregate information with temporary imbalances caused by noise traders.
Blume Easley and O’Hara (1994)	MM -Information Model	Information is dispersed and asymmetric across traders. Prices are fully revealing for informed traders but only partially revealing to uninformed traders.
Holden and Subrahmanyam (1992)	MM –Strategic Trader Model	Extension of Kyle (1985). Multiple risk-averse informed traders. High trading volumes and rapid revelation of information.
Glosten and Milgrom (1985)	MM –Information Model	Market maker widens spreads when faced with informed traders. Prices reflect information through the market maker observing order flow and updating their beliefs. Uniformed investors do not learn information from observing prices.
Easley and O’Hara (1987)	MM –Information Model	Extension of Glosten and Milgrom (1985). Large trades synonymous with informed traders. Larger trades result in wider spreads due to high adverse selection costs.
Chae (2005)	MM- Volume Model	Discretionary liquidity traders postpone trading until the announcement has been made and information asymmetry resolved.

2.3 Empirical evidence on stock returns around corporate earnings announcements

The existing empirical literature on stock returns around corporate information releases can be categorised into two main areas; (i) studies which examine the speed of response in the market to the information contained in earnings announcements, and (ii) studies which examine the role that strategic timing of the release of announcements by managers might have in influencing the markets response. Each of these areas will be examined in this section of the dissertation.

2.3.1 Speed of response studies

The pattern of stock returns around corporate earnings announcements has been of interest to researchers for a long time. The initial motivation for the early research in this area was to determine whether corporate earnings announcements were actually useful to market participants. Valuation theory posits a relationship between corporate earnings and a stock valuation.[13] Market efficiency theory states that security prices will rapidly impound the value of *new information* in the security price. So the question that early researchers examined was; ‘do corporate earnings releases contain new information?’

Ball and Brown (1968) and Beavor (1968) were amongst the first scholars to empirically investigate the relationship between corporate earnings and security prices. Ball and Brown (1968) assumed that investors used the previous year’s

[13] Early work by Miller and Modigliani (1966) argued that corporate earnings multiplied by the appropriate earnings multiplier for that risk class is an important determinant in determining stock valuation.

reported earnings as a benchmark for the level of earnings they expected the company to report in the current year. Using reported preliminary earnings figures for 261 NYSE-listed companies over the period 1957-1965 they then classified the earnings in their study on basis of the relationship to the 'expected' (prior year reported earnings). Using an OLS regression model they determined the component of the announcement that constituted unexpected information based upon the difference between the change in the observation company's income and the change in the broader market income. If the residual of this model was positive this was deemed to be 'good' news and negative then that was deemed to be 'bad' news. They proceeded to calculate the holding period returns for monthly intervals commencing twelve months prior to the earnings announcement date. They found that the majority of information contained within annual earnings reports was anticipated by the market in the twelve months prior to the release date. However, where the announcement contained new information they demonstrated (i) that the sign of the cumulative price residual (summed over a 12 month period including the announcement month) was highly associated with the sign of the earnings residual and (ii) that there was a persistent upward drift in the cumulative mean price residuals for the positive earnings group and a persistent downward drift in the cumulative mean price residuals for the negative earnings group. This drift started eleven months prior to the announcement and continued for approximately a month afterwards. The finding that investors tend to under-react to corporate earnings announcements has given rise to extensive literature on post-earnings announcement drift that seeks to explain the Ball and Brown findings.[14]

[14] See for example, Jones and Litzenberger (1970); Joy et al. (1977); Rendleman et al. (1982); Foster et al. (1984); Kormendi and Lipe (1987); Bernard and Thomas (1989, 1990); Ball and Bartov (1996); Barberis et al. (1998); Daniel et al. (1998); Bartov et al. (2000); Kim and Kim (2003); Nicolas and

Beavor et al. (1979) undertook a logical extension of the Ball and Brown study by examining whether the magnitude of the unexpected component of the earnings announcement (rather than just the sign of the unexpected component of the earnings announcement) was related to the magnitude of the stock price response. Beavor et al. used annual earnings figures from 276 NYSE-listed companies from 1960-1975 to construct two forecast EPS models based on previous earnings results. They then examined the relationship between the size of the forecast error (as measured as the difference between the reported earnings and the forecast earnings based upon their two models) and the unsystematic monthly stock returns (calculated using the market model). The authors partitioned the securities into twenty five portfolios based on the size of the forecast error. Using both parametric and non-parametric rank tests they found that the magnitude of the forecast error was related to the magnitude of the stock price response.[15]

Beavor (1968) likewise sought to investigate the information content of corporate earnings announcements. Beavor examined log stock returns over the S&P price index (market model returns) and various measures of volume for weekly intervals around the announcements to determine whether annual earnings announcements convey information. Rather than attempt to predict investors expectations about the information content of the earnings announcement, and hence whether the unexpected component was 'good' or 'bad' news, Beavor calculated a ratio of the squared residual of the market model during the event window standardised by the squared

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Wahlen (2004); Ke and Ramalingegowda (2005); Francis et al. (2007); Hirshleifer et al. (2008); Zhang (2008); Zheng (2009).

[15] Joy et al. (1977) had previously reported similar results.

residual of the market model during the control period.[16] Beavor argued that return tests provided useful information about changes in the expectations of the whole market whereas volume measures reflected changes in the expectations of individual investors. The sample used consisted of 143 NYSE-listed companies reporting during the period 1961-1965. This gave a sample of 506 annual earnings reports. Return analysis found that earnings reports contain information, with above normal price activity in the week of the announcement. Volume analysis confirmed these findings with evidence of elevated volumes (both raw and residual values) in the week of the announcement. To eliminate dividend changes as a possible factor in the results Beavor confirmed that there was no clustering of dividend announcements in weeks -1 to +1 of the sample.[17]

These studies, together with Fama et al. (1969), established the event study methodology as the benchmark technique for investigating the market reaction to informative events. These early studies provided valuable confirmation of the relationship between corporate earnings announcements and security returns. However, they were limited in their ability to examine the speed of the market response to the information content of the earnings announcements. Commencing with work of Patell and Wolfson (1984), researchers have been able to draw on a far richer source of data to examine the speed of response to corporate earnings announcements. Brown et al. (1992) argue that, where the capital market reacts to information in less than one trading day, intraday data will better reflect the path and speed of adjustment. Intraday stock price data has enabled scholars to examine much

[16] The control period consisted of data from the sample excluding the 17 weeks surrounding each announcement.

[17] Aharony and Swary (1980) found that dividend announcements contain useful information beyond that contained in quarterly earnings announcements and thus contemporaneous dividend clustering would limit the explanatory power of the results.

shorter measurement intervals than the daily, weekly or monthly returns used by earlier researchers.[18] This enables more a more precise examination of capital market efficiency than longer measurement intervals allowed.[19] Furthermore, Berkman and Truong (2009) identify a possible misspecification problem that arises in event studies that use daily or longer measurement intervals when announcements are made after the close of normal trading.

Patell and Wolfson (1984) examined the speed of adjustment of stock prices following earnings and dividend announcements. The authors used a sample of 571 earnings and dividend disclosures released by 96 firms during the period 1976-1977.[20] The choice of firms was based upon the availability of data. Sixteen announcements were eliminated from the sample when an examination of the stock price data indicated that they triggered a trading halt.[21] The authors examined the market behaviour following the announcements using three measures; mean returns, return variance and serial correlation in consecutive price changes. For the return measure, the researchers used a trading strategy of taking a long/short position in the security based upon the sign of the forecast error (this was calculated as the difference between the reported earnings figure and the *Value Line Investment Survey* forecast)

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[18] For example, Potter (1992) used quarterly data, Ball and Brown (1968) used monthly data, Beavor (1968), Shores (1990) and Sivakumar and Waymire (1993) used weekly data, whilst Kiger (1972) and Morse (1981) used daily data. Lev (1989) provides a detailed summary of early event studies on price reactions to earnings announcements.

[19] Although Easton et al. (1992) provide empirical evidence that a longer aggregation period leads to higher correlation between earnings and returns.

[20] 93 firms were NYSE-listed companies, 2 were AMEX-listed and 1 switched from the OTC market to AMEX during the sample period.

[21] The authors argued this was necessary because the trading-halt announcements 'exert a disproportionately large effect in many of the tests both because of the intensity of the trading activity following the halt and because this activity is postponed to a point when typical announcement effects have disappeared." Patell and Wolfson (1984:229). Patell and Wolfson (1982) stated that ordinary earnings and dividend announcements rarely involve trading halts in the US.

for various holding periods around the earnings announcement.[22] Each stock was assigned an equal weight in computing test statistics. A control sample was constructed by matching five of the firm's non-announcement days to each disclosure date (at random) and replicating the trading strategy. The authors do not clearly state how announcements made outside of trading hours are treated but it *appears* as through announcements prior to the commencement of trading are treated as having an announcement time of 10am (the start of trading) and announcements made after the close of trading at treated as though they were made at 10am the following day for the calculation of holding period returns. The study found highly significant positive returns in the first 30 minutes after the release of the information. A 30 minute holding period commencing 5 minutes after the release of the information also exhibited positive returns although they were much smaller than the one commencing at the time of the announcement. The authors also found significant positive returns in the overnight period (close to open) *after* the announcement, as well as the first 30 minutes of trading on the *day after* the announcement date. There was little evidence of significant returns neither for holding periods prior to the release of the information, nor for any other holding periods after the announcement.

These results were important in that they implied a delayed reaction by market participants to the information content of the earnings (and dividend) announcements. Patell and Wolfson (984:235) suggested as a possible explanation for the results that the "evening following the announcement provides an opportunity for the news to be disseminated to investors who are unable to execute intraday trading strategies and

[22] Thus the stocks were bought if the earnings exceeded the forecast and sold if the earnings fell short of the forecast.

their actions may affect the overnight price change and opening trades of the next day".

Jennings and Starks (1985) extended the work of Patell and Wolfson (1984) to examine the speed of stock price adjustment to the size of the earnings surprise. The findings of Joy et al. (1977) and Beavor et al. (1979) showed that magnitudes, as well as the signs, of earnings forecast errors were associated with the differences in abnormal returns following information events.[23] Jennings and Stark argued that Patell and Wolfson’s findings were limited by the fact that it was not possible to conclude whether the adjustment stock price adjustments observed on average were due to the little or no new information (requiring minimal price adjustments) or if the market process permits rapid adjustments regardless of how informative the new information was. Furthermore, they argued that it was not possible to determine if the differential in observed adjustment times in the Patell and Wolfson study was simply random differences or the result of differences in the information content of the announcements. Jennings and Starks employed a measure of revisions of analyst’s forecasts as a proxy for investor beliefs to classify the information content of the earnings announcements. Using the financial analysts’ forecasts in the *Standard and Poor’s Earnings Forecaster* or the *Value Line Investment Service Reports* the authors split their sample into two groups: (i) those which led to less than average belief revision (low information content) and (ii) those which led to above average revision

[23] Numerous studies have shown that analyst recommendations reveal information to the market. Lloyd Davies and Canes (1978), Bjerring et al. (1983), Beneish (1991), Brown and Kim (1991), Stickel (1995), Womack (1996), Kim et al. (1997), Asquith et al. (2005) and Green (2006) all found positive abnormal returns following the release of analyst recommendations. Juergens (1999) demonstrated that abnormal returns were greater when the recommendation were released in conjunction with other public news. Busse and Green (2002) found prices respond to the information contained in analysts’ TV segments within seconds of the initial mention, with positive reports fully incorporated within one minute.

of investor beliefs (high information content). Then using price data for two sample periods (15 June 1981 to 21 August 1981 and 4 October 1982 to 31 December 1982) for 214 and 204 NYSE-listed firms with either options or inclusion in the S&P 500 respectively, the authors examined the stochastic process (price continuances and reversals) around earnings/dividend announcements. They found that most adjustments take place between price sequences -1 and +4 although they also found significant results in sequences +8 through to +16 for the high information content group but was inconsistent for the low information content group. As a secondary test they used the variance of price changes (in either 5% tails of the non-announcement period) for hourly intervals around the event time. For the high information content group the increase in variance began 1-2 hours before the announcement and extended for 7-8 hours after the announcement. For the low information content group it began 2 hours after the announcement and extended until 6-8 hours after the announcement. Although this study demonstrated a link between information content and speed of adjustment it did not use stock returns.[24]

Woodruff and Senchack (1988) also examined the speed and path of adjustment in stocks to the degree of earnings surprise in their quarterly announcement. Their main contributions to this literature was that they control for the degree of information content by dividing their sample into five groups[25], and they included trading volume, transaction frequency and transaction size in their analysis. As with Patell and Wolfson (1984) and Jennings and Starks (1985), the authors used *Value Line Investment Survey* as their proxy for investor's expected earnings. Their sample

[24] Jennings and Starks (1986) expands upon this research by looking at the effect of option trading on the underlying stock prices. They find that firms without listed option require substantially more time to adjust to earnings announcements than firms with traded options.
[25] The five groupings used were; most favourable, less favourable, neutral, less unfavourable, and most unfavourable.

comprised 325 NYSE-listed stocks from 15 January to 15 April 1980. As with previous literature the authors defined day 0 (the event day) as the following calendar day for any announcements made after the close of trading. The authors then measured the speed until the price fully adjusts to the information by using the closing price on day +1 as a proxy for the fully adjusted price.[26] They measured the percentage of the return between the last trade prior to the release of the information and the fully adjusted price that had been achieved at intervals of one-half-hour, one hour, two-hours and three-hours. They found that stocks with the largest positive earnings surprise had 61% adjustment within one hour and 91% adjustment after three hours. Stocks with the largest negative earnings surprise reached 69% of their full adjustment after 3 hours. Using transaction price, those with the largest positive earnings surprise reached 83% adjustment by the tenth trade after the release time whilst those with the largest negative surprise had reached 73% adjustment by the same trade interval. The volume and transaction frequency tests showed increased activity the first half-hour but that it had dissipated after three hours. These results were consistent with previous research which suggested the speed of adjustment for 'bad' news is slower than that for 'good' news. The authors suggest the uptick rule on the NYSE, which makes shorting the stocks more difficult, might have been responsible for this result.

Lee (1992) examined the intraday directional volume (buy/sell trade imbalance) and returns patterns around the release of different types of earnings announcements. He argued that the duration and adjustment path of buy/sell imbalance provides new insights how quickly market participants (rather than just prices) adapt to the new

[26] The authors based this proxy on "the conclusions of earlier work and our own results" Woodruff and Senchack (1988:482).

equilibrium price. Announcements sourced from the *Dow Jones News Service (DJNS)* for 302 NYSE-listed firms between 4 January 1988 and 30 December 1988 (253 trading days) were used to create the study sample. Only announcements made during normal trading were used in the study on the grounds that the focus of the study was the intraday dissemination process. As with Patell and Wolfson (1984) and Jennings and Starks (1985), Lee used the *Value Line Investment Survey* as a proxy for expected earnings, although he also uses the change in price (measured as the mid-point of the spread) after the announcement as a second proxy. This enabled the classification of 'good' and 'bad' news consistent with previous research. Returns and trade imbalance were then measured in half hour intervals surrounding the earnings release. The 30 minute interval that contains the announcement was labelled 'interval 0'. This meant the time after the announcement varied *within* each interval zero.

Consistent with Patell and Wolfson (1984), Lee found both 'good' and 'bad' news resulted in significant positive abnormal returns in 30 minute interval containing the announcement but no other intervals exhibit any significant abnormal returns. They also found that order imbalance for large trades (a proxy for informed trading) largely mirrors the pattern of return behaviour but small trades exhibit order imbalance for much longer intervals (and in the case of 'bad' news starts to exhibit significant activity at least 3 hours *after* the information release).[27]

Lee and Park (2000) extend the previous research by using intraday returns to examine the speed of adjustment and explanatory power of interim and fourth quarter earnings announcements. Using quarterly announcements drawn from January 1989

[27] For large trades/'bad' news the order imbalance (selling) extended 90 minutes after the information release.

to December 1990 the authors constructed a sample of 1,359-1,393 NYSE and AMEX-listed firms.[28] Announcements were drawn from the *PR Newswire* and *Business Newswire databases*. As with Lee (1992), the sample was restricted to those announcements that were released during normal trading hours (9:30 to 16:00 EST). Also consistent with previous research, analysts' forecasts were used as a proxy for market expectations, although this study used EPS forecasts drawn from the I/B/E/S database to classify announcements as 'good' or 'bad' news. Returns were calculated using the mid-point of the spread for 30 minute intervals around the announcement time, starting 90 minutes before the announcement and ending 6 hours after the announcement. As with Lee (1992) the 30 minute interval that contained the announcement was labelled 'interval 0'. The study found that the market adjusted to new equilibrium price levels within 2 hours after the fourth quarter announcements, whereas it took at least one trading day to do so for the interim quarter announcements.

Furthermore, constructing an equally weighted portfolio that took a long position in securities that reported 'good' news and a short position in securities that reported 'bad' news, the authors were able to demonstrate a two stage reaction to the information content of those announcements. This consisted of an initial reaction in the period commencing 1 to 1½ hours before the announcement and dissipating between 1 and 1½ hours after the announcement, followed by a second stage reaction commencing approximately 3½ hours after the announcement and dissipating approximately 5½ hours after the announcement. This response is broadly consistent

[28] The sample contained 1,393 firms for 1989 and 1,359 firms for 1990. The authors note the firms had a larger than average market capitalisation.

with the findings of Patell and Wolfson (1984) who also found a delayed reaction to the information contained in earnings announcements.

Francis et al. (1992) extend previous research by examining the price and volume reactions to trading and non-trading hours' announcements made by the same firm in adjacent years. They argue that the market response to trading and non-trading hours' announcements might differ for a number of reasons. Firstly, differences in the sign and magnitude of unexpected earnings released during, versus outside, of normal trading hours might affect the speed of adjustment process.[29] Secondly, investors have more time to analyse the information content contained in overnight announcements prior to trading on it relative to daytime announcements. This might reduce the adverse impact of information asymmetry for overnight announcements. Thirdly, differences between the market mechanism used to determine the opening price and the price discovery process that operates during normal trading might influence the speed of adjustment.[30] Finally, the accumulation of orders that remain in the system from prior to the announcement (uninformed orders) mixing with newly placed orders (informed orders) might preclude the opening price from fully reflecting the value of the information contained in the announcement.[31]

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[29] For example, the release of 'bad' news by managers outside of normal trading hours in order to minimise its potentially adverse price impact. This is explored in more detail in the next section of this chapter.

[30] For example, the opening priced might be determined using a call-market procedure (NYSE) or an informal price discovery procedure (NASDAQ). Likewise the price formation process is a function of an order-driven, quote-driven or a hybrid system.

[31] The authors acknowledge that all pre-announcement (post-announcement) orders placed are not necessarily uninformed (informed) orders.

The authors used a sample of annual earnings releases for 558 NYSE-listed firms reporting between 1982 and 1986.[32] The full sample was divided into two subsamples; (i) a "daytime' subsample that released their earnings report during normal trading hours (9:30am - 4:00pm EST), and (ii) an 'overnight' subsample that released their earnings report outside of these hours.[33] As with previous research, the *Value Line Investment Survey* consensus analysts' forecasts were used as a proxy for the expected earnings result. Abnormal returns were calculated as the raw return minus the median return computed over the control period (days -14, -3; +3, +14). They found no evidence that investors impounded the information contained in overnight announcements at the open of the following day's trading but rather that this information is impounded in within the first half hour of normal trading that day. As the result they concluded that the opening price was not that informative.

Furthermore there was also evidence that the reaction to daytime announcements began in the trading period in which they occur and extended into the overnight period following the announcement (consistent with Patell and Wolfson 1984). There was no evidence that these results were sensitive to either the size of the earnings surprise, or whether the news was good or bad news. Francis et al. (1992:181) suggested two possible explanations for their findings; "(1) characteristics of an active market are necessary to impound new information in stock prices; and (2) traders' actions preclude full revelation of the supply and demand for shares of the stock at the open".

[32] Sample companies were restricted to those that released their annual earnings report within a two-week window each year.
[33] The full sample contained 150 companies that reported prior to the market open, 129 companies that reported after the market closed and 279 that reported during normal trading hours.

Greene and Watts (1996) extend this research one step further by examining the market response to quarterly earnings announcements made during trading and non-trading hours on the NYSE and NASDAQ. Following the reasoning of Francis et al. (1992), the authors posited that differences between the trading mechanisms (specialist versus dealer market, call auction versus continuous trading) and opening mechanisms used by the two exchanges might lead to differences in the path of adjustment of prices following the release of earnings announcements.[34] The authors tested this by constructing a sample of quarterly earnings announcements for 100 NYSE-listed firms and 100 NASDAQ-listed firms over the period 1990-1994.[35] Consistent with previous studies the expected earnings per share was proxied using the consensus analyst forecasts from the I/B/E/S database. The authors identified 5 out of 1307 NYSE-listed company announcements that resulted in trading halts. These were discussed in a footnote separately.[36] Using the same technique as Patell and Wolfson (1984), the authors measure cumulative abnormal returns (CARs) in transaction time[37] and clock-time[38] based on a strategy of trading on the sign of the analyst forecast error.

[34] Four hypotheses were tested: (i) no difference in the price discovery process following trading and nontrading hours announcements on the NYSE, (ii) no difference in the price discovery process following trading and nontrading hours announcements on the NASDAQ, (iii) no difference in the price discovery process following non-trading hours news announcements on the NYSE and NASDAQ, and (iv) no difference in the price discovery process following trading hours news announcements on the NYSE and NASDAQ.

[35] The sample firms were randomly selected from all NYSE and NASDAQ firms whose stocks were traded at least 30 times per day, on average, over the sample period. This was done to ensure the firms were visible enough to be followed by financial analysts and to ensure that their earnings announcements were broadcast over financial newswires and retained on the Dow Jones News/Retrieval text database.

[36] The authors found evidence of significant transaction period returns for a number of periods after the announcement but the small sample size limited the inferences that could be drawn.

[37] Event period transaction abnormal returns are calculated by adjusting each observed raw transaction return for a firm-, quarter-, and time-of-the-day-specific average transaction return.

[38] Event period clock-time abnormal returns are calculated by measuring the difference between each observed 15 minute return and a firm-, quarter-, and time-of-the-day-specific average return

For the NYSE subsample the authors found the significant CARs for the first transaction after the release for the ‘trading hours’ group and the first three transactions after the release for the ‘non-trading hours’ group. They also found that regardless of the release time, 80% of the CAR is generated by the seventh post-announcement trade. For the NASDAQ subsample they found the significant CARs for the first transaction after the release for the ‘trading hours’ group and the first four transactions after the release for the ‘non-trading hours’ group. However, for both groups most of the CAR was generated during the first post-announcement trade (72% and 88% of the CAR for the trading hours’ and non-trading hours’ partition respectively).

With respect to clock–time returns, the authors measured CAR’s using 15 minute intervals commencing 1½ hours before then announcement and proceeding until 1½ hours after the announcement.[39] For the NYSE subsample they found the significant results for first two intervals following the announcement (the 15 minutes containing the announcement and the following 15 minutes) for the ‘trading hours’ group and the first pre-announcement interval (15 minutes before the close), the announcement interval (close to open) and first two post announcement intervals (the first 30 minutes of trading the next day) around the release for the ‘non-trading hours’ group. Unlike Patell and Wolfson (1984) and Francis et al. (1992) they found no significant results in the overnight period after, nor subsequent trading day, following the release of the earnings result for announcements made during trading hours. For the NASDAQ subsample they found significant results for the first post announcement interval (15 minutes containing the announcement) for the trading hours’ group and the overnight

[39] Period 0 contains the announcement.

interval (close to open) for the non-trading hours' group. Thus the authors conclude there are differences between the speed with which these two markets adjust prices following the release of earnings information, especially for non-trading hours releases. However, both markets still impound the information relatively quickly.

2.3.2 Strategic timing studies

The timing of the release of earnings announcements has also been demonstrated to play an important role in how the market responds to the information contained. This branch of research emerged from the belief that manager's may attempt to strategically time information releases to minimise any adverse affects that might arise out of lower than anticipated earnings results.[40] Patell and Wolfson (1982) were the first scholars to empirically test the hypothesis that 'good' news is more likely to be released when security markets are open while 'bad' news appears more frequently after the close of trading. The authors used a sample consisting of 1000 earnings and dividend announcements released by 96 US firms between 1976 and 1979.[41] Sample firms were selected on the basis of data availability.[42] The announcements were classified as 'good' or 'bad' news based on two techniques; (i) the earnings change from the previous period (an increase constituted 'good' news whilst a decrease constituted 'bad' news) and (ii) sign of the change in the price following the announcement release (price increase constituted 'good' news whilst a 'decrease'

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[40] Genotte and Trueman (1996) provide a theoretical proof that if announcements have a positive impact on firm value, managers should prefer to make them separately during trading hours as this will maximise the stock price benefit. Likewise, if the announcements have a negative impact upon firm value, the managers should prefer to make them together after trading hours as this will reduce the negative stock price impact.

[41] 93 firms in the sample were NYSE-listed, 2 firms were AMEX-listed and 1 firm went from over-the-counter to AMEX-listing during the sample period.

[42] Data was sourced from the CBOE.

constituted ‘bad’ news). The authors found evidence that ‘bad’ news announcements are more likely to be released after the market is closed whilst ‘good’ news is more likely to be released during trading. They argued that it is possible that managers are doing this to create a natural non-trading period for the dissemination and evaluation of news releases, especially since trading halts were not commonly employed

Damodaran (1989) also considered the strategic timing of information releases by examining whether earnings and dividends released on Fridays are more likely to contain reports of declines and are more likely to be associated with negative abnormal returns than those on other weekdays.[43] A primarily motivation for this research was examine whether such timing could explain the previously identified ‘weekend effect’ market anomaly.[44] The study sample comprised 18,929 earnings announcements and 11,544 dividend announcements for NYSE-listed firms over the period January 1981 to December 1985. Earnings surprise was defined as the proportional change in quarterly earnings per share relative to the corresponding quarter in previous years. Using the market model daily abnormal returns and cumulative abnormal returns were calculated for an event window for day -3 to day +3. Damodaran found evidence of negative abnormal returns on the day following the announcement for reports on every day of the week, which he argued was consistent with two complementary explanations; (i) earnings reports containing bad news are released after the close of trading and markets do not have the opportunity to respond to them until the following day and/or (ii) there is some evidence that markets do not

[43] Penman (1987) had previously identified that bad news was more likely to reach the market on Mondays and Fridays than on other days of the week during his sample period of October 1971 to December 1982. Whilst he did not seek to explain these results he did suggest that the reported practice of firm’s releasing bad news over the weekend could explain the Monday result.

[44] For a more detailed discussion of the weekend effect refer to Cross (1973), French (1980), and Gibbons and Hess (1981).

adjust instantaneously to earnings surprises (as exhibited by the findings of previous research). The study also found evidence that announcements made on Friday tend to contain more bad news than announcements made on other days of the week and that Friday announcements elicit negative abnormal returns not only on that day but also on the following day (which was usually a Monday). There was also evidence on a size effect; with smaller firms have a larger negative abnormal return on the following day than larger firms. Damodaran interpreted these results as possible evidence that the market adjusts to the information content of small firm announcements more slowly than it does for large firm announcements.

Bagnoli et al. (2005) expand upon the previous strategic timing research by investigating whether the rise of 24/7 media coverage and other technological advances have impacted on the propensity of managers to release bad news announcements after the close of trading and on Fridays. The authors cited four possible motivations for releasing earnings announcements outside of trading hours; (i) to minimise the negative price impact of bad news, (ii) to reduce the coverage of bad news on newswire services that only operate during business hours, (iii) because investors are less attentive to news broadcasts outside of business hours or as the weekend approaches, and (iv) to deliberately delay the release of the information from the intended release time to give investors time to absorb the fact it will be bad news.[45] Using a sample of 49,238 quarterly earnings announcements made by 4,183 firms on US equity markets between 2000 and 2003, the authors they use the sign of

[45] Other factors that might create differential incentives to disclose good and bad news at different times have also been examined in the literature. These include; the incentive to release bad news early to reduce litigation risk (Kasznik and Lev 1985, Skinner 1994, 1997, Baginski et al. 2002), the timing of good news and bad news to influence capital raising (Frankel et al. 1995, Lang and Lundholm 2002), and the timing of good news bad news to influence executive options (Yermack 1997, Aboody and Kasznik 2000).

the earnings surprise (based on the difference between the reported EPS and analysts forecasts taken from the Reuters Forecast Pro database[46]) to classify the announcements as 'good' and 'bad' news. They found that if managers consistently announce outside of trading hours, there was no difference in the news they release before trading commences or after the market closes. If however the manager releases information both during and outside of trading hours, they found weak evidence that the manager would release worse news when the markets were closed. They also found that evidence that price response to Friday announcements was more muted than for mid-week bad news announcements suggesting that investors anticipated at least a portion of the news. The authors concluded that increasing news coverage and technology advances did not significantly impact of previously reported strategic timing behaviour.

DellaVigna and Pollet (2009) also test the theory that managers will strategically time bad news announcements for Friday because limited investor attention on that day will minimise the adverse price consequences. By constructing a theoretical model of endogenous choice, the authors demonstrate how investors respond to the announcement signal when either a high fraction or a low fraction of investors are distracted by other events/information. To test the model, the authors used a sample of 143,583 quarterly earnings announcements taken from the COMPUSTAT and I/B/E/S databases for the period January 1994 to June 2006.[47] Only 5.7 per cent of announcements in the sample period were on Fridays. Earnings surprise was defined as the difference between the earnings announcement and the consensus analyst

[46] The authors assert that the analysts' and brokerage houses that contribute to this database overlap to a large degree with those of First Call and I/B/E/S. They argue this means their results are comparable with previous research.
[47] Issues with accurately being able to identify announcement dates resulted in 85,068 announcements made prior to 1994 being discarded from the sample.

forecast. They then constructed CARs for various holding periods around the announcement date. They used the market model to estimate each firm's beta for over a control period beginning 300 days prior to- and ending 46 days prior to- the earnings release date. They then used the market model again to estimate CARs over various holding periods around the announcement date. The study measured the immediate response (using an interval from the close before the announcement to the close after) and a delayed response (for the period commencing two days after the announcement continuing through to seventy five days after the announcement).[48] They found that Friday announcements were associated with a 15.8% lower immediate response and a 70% higher delayed response. For non-Friday announcements they determined that 40% to 45% of the market response to information content is delayed whereas for Friday announcements this figure was much higher (between 54% and 62%). The authors were also able to demonstrate that a portfolio that was long on Friday drift and short on the other weekdays was able to generate a significant monthly abnormal return of 3.84%. This result was robust to matching extreme surprises and less extreme surprises. Finally the study also used an abnormal volume measure to demonstrate that volume was lower on the announcement day for Friday announcements (by 8%) even after controlling for announcement quality, control variables and firm-specific variation. These results supported the theory of strategic timing by managers.

Doyle and Magilke (2009) investigate why earnings announcements released after the market closed and or/on Friday's tended to be worse than those released at other times. They investigate this by testing the strategic timing using only firms that have

[48] The authors were unable to separate announcements made outside of trading hours from those made during trading hours.

switched their announcement time rather than including those that consistently report at the same time.[49] By this technique the authors sort to capture those firms that appeared to exhibit opportunistic timing of their results. The authors argued that this created a more powerful test of strategic timing than previous pooled research. The study used a sample of 51,352 earnings announcements collected from the *Wall Street Journal Online* for the period 2000 to 2005. Only announcements made outside of trading hours were included in the sample.[50] Earnings surprise was defined as the difference between mean analyst forecasts and the actual earnings per share taken from the I/B/E/S database. This was used to calculate a measure of the percentage of observations that meet or exceeded the mean analyst forecasts. The study found a very small number of announcements were made on Fridays (81.9 per cent lower than the average number reporting on other weekdays), with very few reporting after the market closed (94.1 per cent lower than the average for other weekdays).

The results indicated little evidence that firms switching from announcing before the market opens to after the market closes (or the reverse) announced worse news (better news). Likewise, there was little evidence that firms switching announcements from Monday through Thursday to Friday announced worse news. They also found little evidence that media attention (as proxied by firm size and number of analysts) or institutional ownership had any influence on the choice of announcement time. Furthermore, there was little evidence that switching times lowered the earnings response coefficient (suggesting that firms were not able to fool the market). Thus the

[49] Bagnoli et al. (2002) previously found that if managers consistently announce results outside of trading hours, there was no difference in the news they release before trading commences or after the market closes.
[50] The authors reported that 4.3 per cent of announcements in the full sample were made during trading hours. This was much lower than that reported by previous research, especially Bagnoli et al. (2005) who sample a similar timeframe.

authors rejected strategic timing as the reason for firm announcement timing. Instead they concluded that corporate headquarter location (time zones)[51], industry clustering, and firm complexity were the main factors influencing the choice of reporting after the close of trading.

Kothari et al. (2009) used voluntary management earnings forecasts (rather than mandatory periodic earnings announcements) to examine whether managers are more likely to delay disclosure of unfavourable information relative favourable information and, if this is the case, why? The sample used in the study consisted of 4,016 public management forecasts of quarterly earnings per share between 1995 and 2002 from the *First Call* database. Forecasts were classified as good or bad news based on the sign of the difference between the management forecast EPS and the most recent consensus analyst forecast EPS.[52] After calculating the market adjusted cumulative abnormal return in a five day event window around the announcement date they found that the reaction to pessimistic management forecasts exceeds that for optimistic forecasts (4.7 per cent CAR for good news and -8.3% CAR for bad news). These results held even after controlling for magnitude of the announcement. The authors then examined the cumulative stock return commencing 60 days prior to the announcement and found that around 63% of the news is pre-released or leaked prior to good news events. However, for bad news events this figure was much lower at 49%. This indicates that good news is leaked to the market whereas bad news is withheld until it becomes inevitable. The authors also found that managerial

[51] This contrasts with Patell and Wolfson (1982) who did not find a significant difference between the reporting patterns of firms located on the East versus West Coast of the United States.
[52] The sample contained 965 good news management earning s forecasts and 3,051 bad news management forecasts.

incentives to withhold bad news dominate disclosure behaviour and, on average, led managers to withhold bad news and leak good news.

Truong (2010) builds upon previous research by examining whether after-hours earnings announcements are associated with reduced stock price reaction and hence encourage strategic timing of information releases. They used a sample of 48,536 quarterly earnings announcements by 2,672 firms from the 2004 Russell 3000 index listed on the NYSE and NASDAQ. The earnings announcements collected from the *Wall Street Journal Online* for the period commencing with the fourth quarter 1998 and ending at the fourth quarter 2007. As with Doyle and Magilke (2009), the sample excluded earnings announcements made during trading hours.[53] Only firms with at least one before market opens (BMO) and after market closes (AMC) announcements are included in the sample in order to focus on possible strategic timing.[54] Analysts forecasts used as a proxy for expected returns are sourced from the I/B/E/S database. Two period abnormal returns were calculated: (i) close on the day prior to the release to open on the day of the announcement, and (ii) open on the day of the announcement to close on the day of the announcement.[55] Abnormal returns were measured as the actual interval return minus the return on the size-decile the stock belongs to.

The study found that most of the market reaction to earnings released outside of trading hours is realised at the opening the following day. Also firm specific

[53] Trading hours announcements accounted for only 9 out of 2887 firms and 457 out of 53,947 announcements. 49% of the sample announcements were released after the market closed whilst 51% of the sample announcements were released before the market commenced trading.
[54] This is consistent with the sampling technique of Doyle and Magilke (2009).
[55] For a BMO announcement the 'announcement day' is the trading day on which the announcement was released. For AMC announcements the 'announcement day' is the trading day following the date on which the announcement was released.

regressions found little evidence that the response varies regardless of whether the announcement was made before trading commenced or after the market closed. To further investigate possible strategic timing the author examined only ‘straddle’ announcements. Straddle announcements were defined as cases in which an AMC (BMO) announcement was preceded by two BMO (AMC) announcements and followed by two BMO (AMC) announcements. Such cases should be indicative of opportunistic reporting by managers. The study found that is such cases there was no relationship between the announcement time and the measured abnormal return. Also three day event window abnormal returns and CARs centred on the announcement day found no significant under-/over-reaction and no evidence of pre-announcement leakage. Overall, the research found little support for the notion of strategic timing by managers.

2.3.3 Summary

The existing empirical evidence on the intraday speed of adjustment to the information contained in corporate earnings announcements is mixed. Previous research has indicated that the price adjustment can take as little as 30 minutes or as long as several hours, appears to be dependent upon the trading mechanisms used by the market, is contingent upon the degree of earnings surprise, and could be affected by the timing of the announcement (although this remains disputed in the previous literature). The scholarly research examined in this chapter on speed of response and strategic timing of corporate earnings announcements is summarised in Tables 2.2 and 2.3 respectively.

The existing evidence on releases outside of trading hours suggests that the opportunity for investors to reflect upon the information prior to the commencement of trading can affect the efficiency of price response. This raises the question of whether trading halts also provide this benefit and how release timing might interact with the existence of trading halts. This has not been explored in the existing literature, which concentrates on US markets where trading halts are rarely implemented for corporate earnings announcements during trading hours.

Table 2.2
Empirical Literature on Intraday Speed of Response around Corporate Earnings Announcements

This table provides details of the market, sample size and period, proxy for expected return, timing of announcements included in sample, whether trading halts were included in the sample, return measurement interval used and the findings on return behaviour for the existing empirical literature.

	Market	Sample Size/Period	Expected Return Proxy/s	Announcement Timing	Trading Halts	Interval	Main Findings
Patell and Wolfson (1984)	NYSE/AMEX /OTC	96 firms 1976-1977	Analysts forecasts	No restrictions	Deleted	30 min	Abnormal returns in first 30 minutes, overnight period and first 30 minutes of the next day.
Woodruff and Senchack (1988)	NYSE	325 firms 1980	Analysts forecasts	No restrictions	Not specified	Various	Stocks reached equilibrium price within three hours. 'Bad' news reactions were slower.
Lee (1992)	NYSE	302 firms 1988	Analysts forecasts Price change	Restricted to trading hours	Not specified	30 min	Abnormal returns in first 30 minutes. No other intervals significant.
Francis et al. (1992)	NYSE	558 firms 1982-1986	Analysts forecasts	Used to partition sample	Not specified	30 min	Differences in speed of adjustment for trading and non trading hours. 'Daytime' announcement returns extended into overnight period. 'Overnight' announcement returns extended beyond the opening.
Greene and Watts (1996)	NYSE/ NASDAQ	200 firms 1990-1994	Analysts forecasts	Used to partition sample	Discussed separately	15 min	Differences in speed of adjustment between the two markets. NYSE abnormal returns extend beyond the first interval. NASDAQ limited to first measurement interval.
Lee and Park (2000)	NYSE/AMEX	1359-1393 firms 1989-1990	Analysts forecasts	Restricted to trading hours	Not specified	30 min	Abnormal returns for first 2 hours for quarterly announcements. Interim took even longer.

Table 2.3

Empirical Literature on Strategic Timing of Corporate Dividend and Earnings Announcements

This table provides details of the market, announcement sample size and period, method used to classify announcements as good/bad news (News Classification), and the findings on strategic timing for the existing empirical literature.

	Market	**Sample Size/Period**	**News Classification**	**Main Findings**
Patell and Wolfson (1982)	NYSE/AMEX /OTC	1,000 announcements 1976-1979	Change from previous Sign of price change	Evidence that ‘bad’ news more likely to be released after close whilst ‘good’ news more likely to be released during trading.
Damodaran (1989)	NYSE	30,473 announcements 1981-1985	Change from previous	Abnormal returns on day after announcements. Friday announcements more likely to be bad news with larger abnormal returns that extend to Monday.
Bagnoli et al. (2005)	US equity markets†	49,238 announcements 2000-2003	Analyst forecast error	If the manager varies announcement times between trading and non-trading hours, there was weak evidence they would release bad news after the close.
DellaVigna and Pollet (2009)	US equity markets†	143,583 announcements 1994-2006	Analyst forecast error	Friday announcements were associated with a lower immediate response and higher delayed response than other days.
Doyle and Magilke (2009)	US equity markets†	51,352 announcements 2000-2005	Analyst forecast error	Little evidence that switching between before the market opens and after the market closed, or to Friday, was correlated with the information content.
Kothari et al. (2009)	US equity markets†	4,016 announcements 1995-2002	Analyst forecast error	The negative reaction to bad news was significantly larger than the positive reaction to good news. Suggests good news is leaked and bad news withheld.
Truong (2010)	NYSE/ NASDAQ	48,536 announcements 1998-2007	Analyst forecast error	For ‘Straddle’ announcements, no evidence of relationship between timing and abnormal returns. No evidence of under-/over-reaction or information leakage.

† Actual equity market/s are not explicitly identified

2.4 The impact of algorithmic trading in security markets

As both AT and HFT are relatively new in academic literature, there is no firm consensus on precise definitions for each of these terms. However, there are some broad definitions that seem to have found a measure of acceptance in the literature. Hendershott and Riordon (2011:2) broadly define algorithmic trading as “the use of algorithms to automatically make trading decisions, submit orders and manage those orders”. Brogaard (2010:1) defines HFT as “a type of investment strategy whereby stocks are rapidly bought and sold by a computer algorithm and held for a very short periods, usually seconds or milliseconds”[56]. Thus, HFT is a subset of AT. Karagozoglu (2011) argues that both HFT and AT are made possible by (and hence are themselves subsets of) Direct Market Access (DMA) improvements.

Hasbrouck and Saar (2011) identify two main types of algorithms used by algorithmic traders. The first are *agency algorithms* which were developed to minimise the market impact of large orders and thus reduce the cost of trading. Perhaps the most common of these is VWAP, which is designed to achieve, or better, the volume weighted average price of the day. The second are *proprietary algorithms*, which seek to profit from changes in data information and events. These have developed more recently. Generally then it could be argued that agency algorithms tend to be used by investors (especially superannuation/pension funds, mutual funds and other institutional investors) for market impact minimisation, arbitrage, asset allocation and other traditional trading strategies, whereas proprietary algorithms are more likely to be

[56] Kearns et al. (2010) define high frequency traders as those traders who hold positions between 10 milliseconds and 10 seconds.

used by high frequency traders (especially proprietary desks, hedge funds and institutional investors) seeking to exploit trading opportunities that may open up for only seconds or even milliseconds.[57]

Prix et al. (2007) undertook one of the earliest attempts to detect algorithmic trading with a study that examined the lifetimes of cancelled orders on the Xetra trading system used on the Deutsche Böerse (DB). They noted that as at April 2007 round-trip speeds were 10 milliseconds on the Xetra system. They focused their study on 'no-fill-deletion' orders, which are orders that are inserted and subsequently cancelled. The sample used consisted of all order book changes for the 30 DAX stocks on Xetra for two periods; 8-15 December 2004 and 5-12 January 2005. The first period was used to get the defining criteria that were then subsequently applied to the second sample period. They found that no-fill-deletion orders embody 65% of all order insertions during the sample periods. The authors analysed all no-fill-deletion orders with lifetimes equal to multiples of 60 seconds and detect sequences of orders which they term constant-initial-cushion (CIC) orders. These are orders which consist of both bids and asks, where the bids and asks have the same order size and a constant cushion at insertion.[58] Further analysis found that the distance at insertion between the bid (ask) limit and the best bid (ask) limit was about 0.2% of the median price for most 30 DAX stocks. They concluded that these observed trading patterns might be interpreted as fishing for profitable roundtrips.

[57] The Australian Securities Exchange (ASX Review 2010) uses the terms *execution algorithms* and *situational algorithms* to refer to agency and proprietary algorithms respectively.
[58] The cushion at insertion was defined as (best bid limit – bid limit) for the bid side and (ask limit – best ask limit) for the ask side.

Hendershott and Riordan (2011) examine algorithmic trading and its role in the price discovery process. They use data from the Automated Trading Program (ATP) from the Xetra trading system used by the Deutsche Böerse. This program provides rebates on the exchange fees for participants who are registered with the program. In order to qualify for the ATP an electronic system must determine the price, quantity, and submission time for orders. Before being admitted potential participants must submit a high-level overview of the electronic trading strategies they plan to employ and once admitted this is periodically reviewed for compliance. Because the rebates can be quite substantial, the authors are confident that algorithmic traders have a strong incentive to join the program, and as such, the dataset provides a comprehensive insight into their trading activities.[59] Data used in the study comprises all orders submitted for the 30 DAX stocks between 1 January and 18 January 2008 (13 trading days). To examine the impact upon market quality the authors measure quoted half-spreads, effective spreads and depth (depth at the inside quote and depth at 3 times the quoted half-spread).

They found that 51% of price discovery comes from AT quotes, 39% from human traders and 10% occurs contemporaneously in AT and human quotes. They also found that algorithmic traders are more likely to initiate trades when liquidity is high in terms of narrow spreads and higher depth. They demonstrated that AT liquidity demanding trades are not related to volatility but are negatively related to volume in the 15 minutes prior to order placement. The study also found that ATrs contribute to price discovery by having more efficient quotes and by demanding liquidity so as to move prices towards the efficient price. Furthermore, the authors found that, after

[59] Gsell and Gomber (2009) were the first to use the ATP to explicitly identify algorithmic trading on the Deutsche Böerse. They provided a very basic analysis of the activities of ATrs.

decomposing the variance of the efficient price into its trade-correlated and non-trade correlated components, AT liquidity demanding trades help impound 40% more information than human trades. The authors concluded that this suggested ATrs have more private information than human traders.

Brogaard (2010) undertook a study examining the impact of HFT on US equity markets using a unique dataset that allowed him to identify HFT firms. Brogaard examined HFT trading behaviour using a sample of 120 NYSE- and NASDAQ–listed firms between various periods from 2008 and 2010.[60] Although NYSE-listed firms are included in the sample, the study only observed trading on the NASDAQ, which accounts for 20-30% of US equity trading activity. The NASDAQ dataset also allowed him to distinguish 26 firms that were primarily engaged in high frequency trading. This identification was based upon "...known information regarding the different firms' trading styles and also on the firms' website descriptions" (Brogaard 2010:7).[61] Brogaard found that HFTrs trade primarily in large value stocks, tend to follow a price reversal strategy driven by order imbalances, were involved in 68.5% of all dollar-volume activity, and supply liquidity in 48.7% of all trades. HFTrs provided the inside quotes 65.3% of the calendar time for all stocks and 80.5% to 85.7% of the calendar time for large stocks but provided only one-fourth as much book depth as non-HFTrs. During periods of high volatility, HFTrs were demonstrated to increase their trading demand and transfer from liquidity supplying to liquidity demanding trading. During extreme 15 minute price movements HFTrs

[60] 50% of the sample firms were listed on NYSE and 50% were listed on the NASDAQ.
[61] Brogaard (2010:7) noted that "potential HFT firms are excluded if they fall into one of the following categories: brokerage firms that provide direct market access and other powerful trading tools to their customers; proprietary trading firms that are a desk of a larger, integrated firm, like a Wall Street bank; independent firms that are engaged in HFT activities, but route their trades through a Market Participant ID (MPID) of a non-HFT firm; small firms that engage in HFT activities."

increase their supply of liquidity and decrease the amount they demand. In particular, around corporate earnings announcements he found that HFTrs take less liquidity than during normal periods and increase the liquidity they supply. He also found that HFTrs tend to have more private information than other market participants[62], avoid trading with informed traders and do not seem to engage in non-HFTr anticipatory trading. Overall, Brogaard suggested his findings demonstrated that HFTrs were not detrimental to other market participants and their activities tend to improve market quality.

Hendershott et al. (2011) examined the impact of algorithmic trading upon market quality in the US. In particular they use the introduction of the NYSE autoquote system to establish causality between AT and liquidity. The authors use a sample of 943 NYSE-listed stocks from 2001 to 2005.[63] The authors proxy the amount of algorithmic trading (which cannot be directly observed on the NYSE) using rate of message traffic.[64] They justify this proxy on the grounds that it is commonly used by market participants, including consultants such as AITE Group and TABB group, as well and exchanges and other market venues. Liquidity is measured using the standard microstructure variables of quoted half-spreads, effective half-spreads, 5 minute and 30 minute realised spreads and 5 and 30 minute price impacts. The authors found evidence that realised spreads decline, as do adverse selection losses, over the sample period of 2001 to 2005, whilst the rate of message traffic has increased over the same period. This implies a generally positive impact from the rise of AT. They are also able to demonstrate a casual relationship between the

[62] Consistent with Hendershott and Riordan (2011)

[63] The liquidity tests in the paper use 1082 NYSE-listed stocks over the period 2 December 2002 to 31 July 2003 (this period commences 2 months prior to the introduction of autoquote and ends 2 months after the completion of the implementation of the autoquote system).

[64] Specifically the measure is the number of messages per $100 of trading volume.

introduction of autoquote and message traffic; autoquote increases message traffic by an average of 2 messages per minute. Overall they demonstrate that, for large stocks in particular, AT lowers adverse selection and decreased the amount of price discovery that is correlated with trading. They found that AT lowers the cost of trading and increases the informativeness of quotes.

Fabozzi et al. (2011) examined the existing literature on HFT and the impact of HFT on financial markets. The authors outline the reasons for the increase in HFT identified in previous literature. The reasons identified were; (i) the change to decimalisation in the US in 2001, (ii) the cost of trading has declined over time, (iii) the increase in derivatives products and ETF's has lead to an increase in overall trading volume, and (iv) faster transaction speeds enabled by new technology has facilitated more HFT. They also identified the main HFT trading strategies; (i) trading on news by exploiting the time advantage in placing orders before the market reacts to news, (ii) price arbitrage which is based on revealing and exploiting small price discrepancies between different markets or between different assets that should theoretically have the same price, and (iii) short-term forecasts based on the econometric properties of data (including 'front running'). Drawing on interviews with prominent scholars in the field and previously published research, the authors identified a number of impacts of HFT on security markets. Those effects were; (i) increased correlation between securities (which has potential consequences for the ability to diversify investments), (ii) increased information efficiency (as measured in terms of parameters such as bid-ask spreads), (iii) reduced volatility but possibly volatility spikes, (iv) reduction of bid-ask spreads, and (v) increased (short-term) liquidity.

The effectiveness of AT (in particular HFT) strategies is determined by the level of latency that operates within the trading environment. Hasbrouck and Saar (2011:1) define latency as "the time it takes for information to reach the trader, the time it takes for the trader's algorithms to analyse the information, and the time it takes for the generated action to reach the exchange and get implemented". Riordan and Storkenmaier (2011) use more narrow definition of latency; the time it takes for an investor to submit and receive feedback about an order. This is the element of latency that stock exchanges have recently devoted significant resources in terms of new technology towards improving. This can have many benefits. If automation and speed can reduce transaction costs, that would enable more efficient allocation of securities among heterogeneous investors, improve risk sharing and can raise asset prices (Paster and Stambaugh 2003, Acharya and Pederson 2005). Automation and speed may also enhance price discovery, or how efficiently new information is incorporated into prices (Barclay et al. 2003, Chordia et al. 2008, Boehmer and Kelley 2009). Many exchanges around the world[65] now offer co-location facilities to market participants seeking to capture the trading opportunities available with millisecond transaction times. Co-location is the practice of locating the broker or client trading software and hardware in close proximity to the trading platform's trading engine.[66] The goal of co-location is to minimise the transmission latency.

Hasbrouck and Saar (2011) examine the influence of low-latency traders on the market environment. The millisecond environment shows evidence of two types of

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[65] For example, NYSE Euronext, NASDAQ, LSE, Deutsche Börse, TSE, SGX, TMX, and ASX all offer co-location services with many other exchanges planning on doing so in the near future.
[66] The SEC refers to co-location as "a service offered by trading centres that operate their own data centres and by third parties that host the matching engines of trading centres". (SEC, 2010: 3610)

activities: traders who seem to operate according to a schedule (agency algorithms) and those that respond to events (proprietary HFTrs). The study sample consisted of 345 (2007) and 394 (2008) NASDAQ-listed stocks.[67] The research found that the millisecond environment consists of activity by some traders who are able to respond to market events (such as changes in the limit order book) within 2-3 milliseconds.[68] The authors construct a measure of low-latency trading behaviour by identifying 'strategic runs'; "...which are linked submissions, cancellations and executions that are likely to be parts of a dynamic strategy" (Hasbrouck and Saar 2011:16). This was done by using the reference numbers that are attached to each initial order and are linked with its subsequent cancellation or execution. The runs are created by then linking each cancelled order with a subsequent limit order submission or execution in the same direction, of the same size and placed within one second of the previously cancelled order.

The authors found that roughly 60 per cent of cancellations in the 2007 sample and 55 per cent in the 2008 sample can be linked in this way. Using measures of liquidity and short-term volatility observed during 10-minute intervals throughout the trading day the authors assess the influence of this low-latency trading behaviour. They find higher low-latency trading activity implies lower posted and effective spreads (consistent with Hendershott et al. 2011, and Riordan and Storkenmaier 2011), greater depth and lower short-term volatility. This was consistent across all stocks (whereas Hendershott et al. 2011 found this was only the case lower for large stocks).

[67] This consisted 23 trading days in 2007 and 21 trading days in 2008.
[68] The authors note that Kosinski (2010) found human response time was in the order of 200 milliseconds. Thus they conclude 2-3 millisecond response time must be algorithmic traders.

Hendershott and Moulton (2010) examined the introduction at the end of 2006 of the NYSE Hybrid market, which increased automation and reduced execution time for market orders from 10 seconds to less than 1 second. The study used a sample of 400 NYSE-listed stocks matched against a sample of 400 NASDAQ-listed stocks for the period June 2006 to May 2007 (roughly four months either side of the introduction of Hybrid).[69] The study found that automation led to a reduction in floor trading (which the authors speculate could lead to a breakdown in cooperation among floor traders which in turn may result in higher adverse selection costs for transactions between floor traders). The results demonstrated increases in effective and quoted spreads on NYSE as well as an increase in the differences between the spreads of the NYSE and NASDAQ group following the introduction of Hybrid. This resulted in an increase in the cost of immediacy of about 10 per cent. They found the adverse selection component of the spread increased over both a 40 day and 8 month event window following the introduction of Hybrid which was consistent with liquidity demanders becoming more informed. They also demonstrated that pricing efficiency improves with a reduction in pricing error after the introduction of Hybrid, especially for small stocks.

Riordan and Storkenmaier (2011) also undertook a study examining the impact that improving automation (reducing latency) had upon two dimensions of market quality; liquidity and price discovery. As with Prix et al. (2007) and Hendershott and Riordan (2011), the authors examined the Deutsche Böerse Xetra system. The upgrade to Xetra 8.0 provided a natural test of reduced latency without any changes in the market model, mechanism, or other meaningful microstructure changes (this contrasts with

[69] Matching is done using a matching error technique based on market capitalisation and closing price. Prices below $1 and above $500 were excluded from the sample.

the Hendershott and Moulton (2010) study of the introduction of Hybrid which introduced broader market changes other than just a reduction in transaction spreads). Xetra 8.0 reduced trading system latency from an average of 50 milliseconds to an average of 10 milliseconds. The study sample consisted of 98 stocks that made up the Deutsche Böerse HDAX index for the period 22 February 2007 to 19 June 2007.[70] The authors found that quoted and effective spreads fell after Xetra 8.0 was introduced. Depth also fell and turnover increased. The effective spread was then decomposed into its two components; liquidity suppliers' revenue (realised spread) and adverse selection costs (price impact).

The reduction in latency was found to have caused a substantial increase in realised spreads that was counteracted by a much larger decline in the adverse selection component of the spread. These results were consistent with the findings of Hendershott et al. (2011), suggesting an apparent lack of competition between liquidity suppliers following increased system automation. Decomposing the information of quotes into trade-correlated and uncorrelated portions (Hasbrouck 1991) the authors found the percentage of price discovery increases dramatically from roughly 42% to nearly 80% post upgrade. Consistent with Brogaard (2010), the study found that liquidity suppliers are better able to avoid informed trades, stating that "it appears as if, post upgrade, liquidity suppliers are able to impound more information into quotes before liquidity demanders can exploit this information." (Riordan and Storkenmaier 2011:18).

[70] The HDAX is a combination of three main Deutsche Böerse indices: DAX, TecDAX and MDAX.

Whilst most research has focused on the role of AT and HFT in equity markets there has also been a limited amount of research into other markets. Karagozoglu (2011) provides empirical evidence of the positive impact of AT and HFT on liquidity in US futures markets using data from five CME Group futures contracts (crude oil, Euro FX, Eurodollar, E-Mini S&P 500, and 10 Year US Treasury note) over the period 2008 to 2010. The study uses the Hendershott et al. (2011) method to measure liquidity (although it does not use the same proxy for AT). They find that increases in AT lead to lower spreads and higher market depth. Chaboud et al. (2009) investigate the effects of AT in the spot foreign exchange markets over the period 2006 to 2007 and find that AT activity and volatility are not correlated, and that order flow generated by AT does not affect the return variance. This suggests that humans contribute more to the price discovery process than do algorithms in currency markets.

2.4.1 Summary

The relatively recent rise of algorithmic trading, and in particular HFT, means there is very limited amount of academic literature available on its impact in financial markets. Only Hendershott and Riordan (2011) have explicitly examined the behaviour of Algorithmic Traders (ATrs) response to information.[71] What research is available has generally examined two aspects of this phenomenon; firstly, what has been the impact of algorithmic trading (and HFT) upon measures of security market quality and, secondly, what impact has advances in new technologies (in particular trading systems) had upon the behaviour of algorithmic traders (especially high

[71] Brogaard (2010) explicitly examines the behaviour of high frequency traders (HFTrs) around corporate earnings announcements.

frequency traders). This is a significant gap in the research that this dissertation will seek to address.

Table 2-4
Major Empirical Literature on the Impact of Algorithmic Trading on Equity Markets

This table provides a summary of the main existing empirical literature examining algorithmic trading on equity markets. The table provides details of the market (and trading system used where relevant), study sample size and period, type of computer trading examined [Algorithmic Trading (AT), High Frequency Trading (HFT) or Not Specified (NS)], method of identifying computer trading, focus of the research, and the major findings of the study.

	Market (Trading System)	**Sample Size/Period**	**Type**	**Method**	**Focus**	**Main Findings**
Prix et al. (2007)	Deutsche Böerse (Xetra)	30 stocks 2004-2005	NS	No-fill-deletion orders	Trading patterns	Evidence of fishing for profitable round trips.
Brogaard (2010)	NYSE/NASDAQ	120 stocks 2008-2010	HFT	26 HFT firms	Trading activities and market quality	HFT increases liquidity supply around information releases. HFTr better informed. HFT improve market quality.
Hendershott and Moulton (2010)	NYSE (Hybrid)/ NASDAQ	800 stocks 2006-2007	NS	Trading technology	Market quality	Hybrid increased spreads, increased immediacy costs, and increased pricing efficiency.
Hendershott and Riordan (2011)	Deutsche Böerse (Xetra)	30 stocks 2008	AT	ATP registered traders	Market quality	AT provides liquidity and the efficiency of price discovery. ATr better informed.
Hendershott at el. (2011)	NYSE (Autoquote)	943 stocks 2011-2005	AT	Message traffic proxy	Market quality	AT lowers adverse selection costs, improves price discovery, lowers cost of trading, and improves informativeness of quotes.
Hasbrouck and Saar (2011)	NASDAQ	345-394 stocks 2007-2008	HFT	Strategic runs	Market quality	HFT decreases spreads, increases depth and reduces volatility.
Riordan and Storkenmaier (2011)	Deutsche Böerse (Xetra)	98 stocks 2007	NS	Trading technology	Market quality	Xetra 8.0 reduced spreads, decreased depth and increased turnover.

2.5 Venture capitalists and the IPO process

It is generally accepted in the literature that venture capitalists (VCs) play a role in capital markets that is distinct from other capital providers.[72] This section will examine the unique characteristics of the venture capital investment process and how those characteristics impact upon the initial public offering (IPO) process. This will be accomplished in two parts. The first section examines how the venture capital investment process functions and the factors that might lead to it having particular significance for third party investors in IPOs. The second section examines the existing empirical literature of the role of venture capitalists in the IPO process. Existing research on the activities Australian venture capitalists is also examined here.

2.5.1 Nature of the venture capital investment process

Venture capital refers to an equity, or equity-type, investment in a high growth potential small or medium sized, often technology based, unlisted enterprises (SMEs). With this type of investment the VC assumes a proportion of the business risk in return for the potential rewards associated with the rapid growth. VCs provide financing and expertise to those firms, which by virtue of their small size and limited asset base, are unable to access public capital markets or bank finance (Brophy 1984). Due to the high risk associated with this type of investing, VCs will closely monitor their investment by taking one or more seats on the board of directors. Through their direct involvement in the company VCs are able to use their expertise to facilitate the development of the company. However the need to closely monitor each investment

[72] In particular see Gompers (1998).

made limits the VCs scope to invest in numerous portfolio companies and hence restricts the ability of SMEs to access this form of financing. This definition is consistent with those used by the professional bodies[73] and scholars engaged in research in this field.[74]

Venture capitalist funds are usually organised as a limited partnership agreements that consist of one or more general partners (the venture capitalists) plus a number of limited partners (fund investors, usually institutions and high net worth individuals).[75] The VC's compensation for managing the fund typically consists of two components; a management fee and some form of carried interest. The management fee is used by the VC to cover salaries and expenses and is charged as a percentage of committed capital.[76] The carried interest represents the VCs portion of the fund's gains. Usually the VC is entitled to around 20 per cent of the profits allocated to the limited partners of the fund.[77] Limited partners are not entitled to participate in the operational decisions of the fund but are compensated for this with their liability being limited to the amount of committed capital. The limited liability partnerships typically dissolve after ten or twelve years, with distributions from the fund being made to the limited

[73] Such as the National Venture Capital Association (NVCA), British Venture Capital Association (BVCA), European Venture Capital Association (AVCA), and Australian Private Equity and Venture Capital Association Limited (AVCAL).

[74] The term *private equity* is also used by practitioners and academics to describe this type of financing (together with development capital, distressed investments and mezzanine capital). They are sometimes (incorrectly) used interchangeably. See Cornelius (1999) for a more detailed discussion of the differences between these two forms of financing.

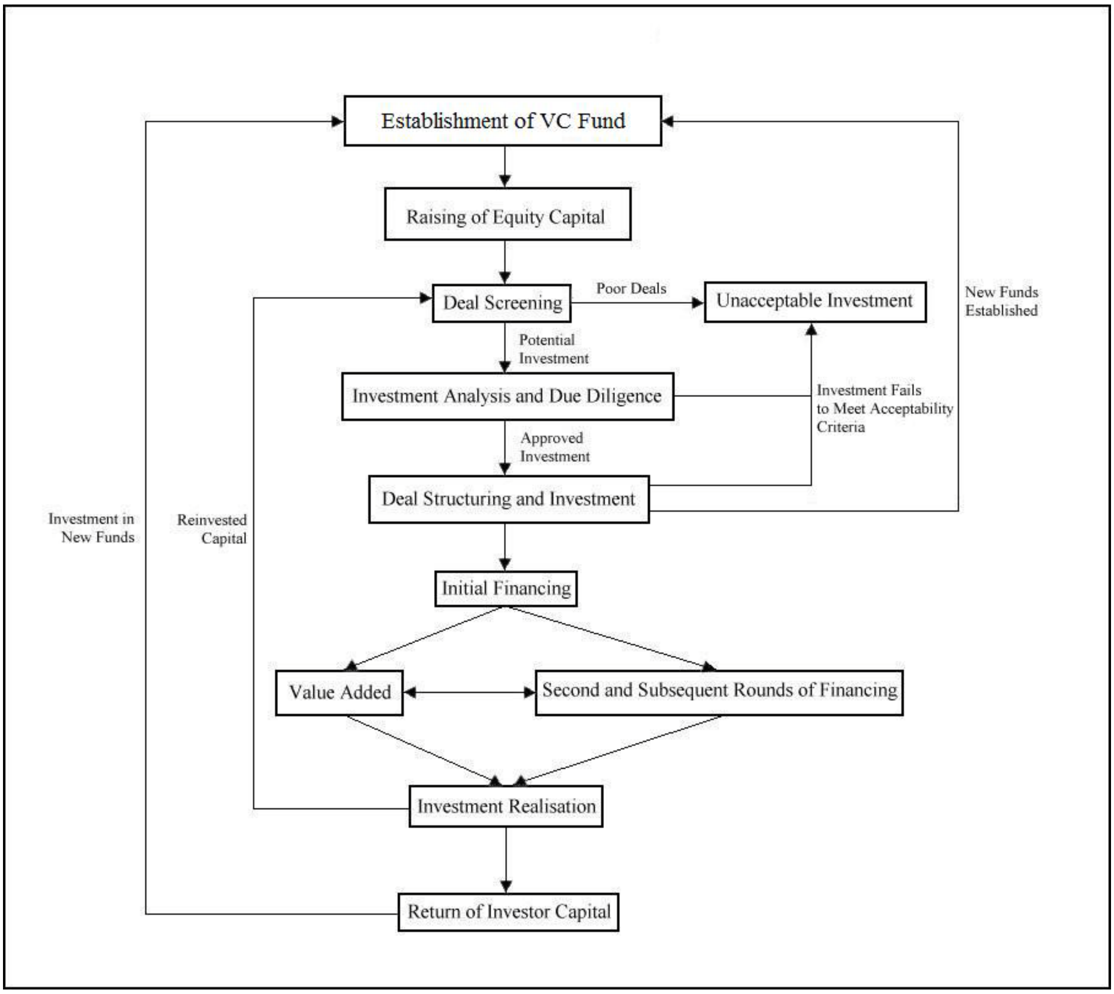
[75] Previous research has found that 80% of US venture capital firms were organised as limited partnership agreements (Sahlman 1990, Porter 1992).

[76] Sahlman (1990) and Gompers and Lerner (2000a) suggest that the management fee is typically around 1.5 to 3 percent of the committed capital or net asset value of the fund.

[77] The 20 percent carried interest figure is taken from the Australian Venture Capital Association (AVCAL) website as being representative of the industry standard. Sahlman (1990), Gompers (1998) and Gompers and Lerner (2000a) also quote this figure as being typical of the US.

partners at this time[78].

Figure 2.1: The Venture Capital Investment Process



The need for professionalism in the process resulted in the development of a reasonably formalised approach to venture capital investing, beginning with the establishment of the fund and moving through to the distributions of stock and capital to the limited partners at the dissolution of the fund. This approach is illustrated in Figure 2.1. As this diagram illustrates, the process of investing in venture capital is

[78] This form of organisational structure "…imposes a healthy discipline, forcing VCs to take the necessary, but painful, step of terminating underperforming firms in their portfolios." (Gompers and Lerner 2000a:19)

complex and involves many subjective decisions on the part of the VC. This process will be examined in the remainder of this section.

The use of the limited partnership structure for venture capital funds raises a number of potential agency conflicts between the goals of the venture capital manager and the fund's investors (Gompers 1996, 1998). Given that the traditional mechanisms of corporate governance, for example an active board of directors or the market for corporate control, are not available within limited partnership arrangements, the terms of the partnership agreement (which will cover the entire life of the fund) are the primary means by which the limited partners can curb these potential conflicts. Restrictive covenants and compensation have become important instruments for aligning the incentives of the VC firm with those of the investor. Therefore, considerable effort is expended at the establishment of the venture capital fund to ensure the partnership agreement contains the incentives needed to align the venture capitalists goals with those of the investor at a cost that the investor considers to be appropriate (Gompers and Lerner 1996; Sahlman 1990).

Once a venture capital fund is established, the general partners of the fund begin the process of signing on limited partners and raising the fund's required investment capital. This process usually involves some form of 'road trip', whereby the VCs solicit contributions to the fund from institutional investors and high net worth individuals (and in some rare cases private retail investors). This solicitation often takes the form of a presentation, or series of presentations, by the VC to potential investors, outlining key aspects of the fund that would complement their existing investment portfolio. These include factors such as the type of fund (direct investment, fund of fund, etc), the stage of investment of the fund (for example early stage, late stage, balanced, sector or industry specific, etc), the life of the fund, the size of the fund, the investment philosophy of the fund managers, the track record of the fund managers and so on. In essence the role of the fund manager at this point in the venture capital cycle is to 'sell' the fund to potential investors (Sahman 1990; Bygrave and Timmons 1992; Wright and Robbie 1998; Gompers and Lerner 2000a, 2000b).

Previous research has demonstrated a potential investor's willingness to commit capital to a private equity fund is often dependent upon the strength of the initial public offering (IPO) market (Bygrave and Timmons 1992; Gompers 1998; Gompers and Lerner 2000b; Jeng and Wells 2000). It has been shown that the cyclical nature of venture capital fund raising since its inception in the 1940s was in part driven by returns in the IPO market. When the IPO market was 'hot', and investors were receiving substantial returns from their equity investments in companies going public, they were inclined towards putting additional funds into venture capital and, thus, gaining additional exposure to growth companies before they reach the IPO stage. In this way investors expected to profit from the surge in interest in newly floated companies. However, when the IPO market exhibited a downturn then investors would withdraw their capital from the risky venture capital market and instead direct it towards safer investments. This in turn created a downturn in the ability of VCs to raise additional funds as investor interest in the sector waned. Because this phenomenon was dependent upon the investor appraising the strength or weakness of the IPO market, the impact upon venture capital fund raising tended to be lagged at least one year.

Black and Gilson (1998) demonstrated the attitude of a country's banking and finance sector towards risk could also impact upon the success of fund raising by VCs within that country. In a country where the banking sector was prepared to accept the high level of risk that financing venture capital deals entails, and finance deals directly, then that sector could act as a substitute for the VCs. This would reduce the amount of investment capital available to the independent VCs, as the banking sector becomes a direct competitor rather than a general partner in the manager's venture capital fund.

After the venture capital fund has been established and the investment capital committed, the VC must commence the task of investing the funds raised. Tyebjee and Bruno (1984) in a survey of VCs in the US found that 90 per cent of deals in their sample originated as unsolicited cold calls from entrepreneurs. They found the VCs' typical response was to request the entrepreneur send them a business plan. The other significant source they identified was referrals from prior investees and personal acquaintances, banks or investment brokers. Many of those deals referred by other VCs were instances of the referrer being prepared to act as the lead investor and seeking other funds with which to syndicate the deal. Additionally a VC may be proactive in the deal generation process by actively searching for potential investments.

The VC typically receives more applications for funding than there are funds available, and must therefore set up screening criteria to select proposals for further analysis. This is an involved process, known as deal screening. Wells (1974) found that for seven venture capital funds the annual number of proposals received ranged between 120 and 1,000 making it essential that screening criteria be used to reduce this to a more manageable number. Emphasizing the importance of the deal screening process, Golis (1998) stated that 75 per cent of applications are screened out at this point in the venture capital cycle. Tyebjee and Bruno (1984) identified four criteria that a VC would use to screen potential investments down to a manageable level: (i) size of the investment[79] and investment policy of the venture capital fund, (ii) the technology and market sector of the venture[80], (iii) the geographic location of the venture[81], and (iv) the stage of financing of the venture.

Potential venture capital deals that are not rejected during the deal screening process are then subject to a more detailed analysis to determine if the potential investee firm represents a suitable addition to the VCs investment portfolio. Of particular concern to the VC is the level of information asymmetry between themselves and the entrepreneur. That is, the VC is expected to make an investment decision relying on information about the entrepreneur that has been supplied by the entrepreneur – creating a potential adverse selection problem. These high levels of information asymmetry may lead the manager to misjudge and invest in unviable companies or reject viable deals. Hence the manager must undertake a detailed analysis of the

[79] An important caveat to the upper limit though is the ability to syndicate investments. Syndicating investments allows venture capital funds to invest in high entry cost deals in collaboration with other venture capital funds, without limiting their ability to effectively manage the risk of their portfolios through diversification.

[80] "The venture capitalist is investing in more than a company. Implicitly, he/she is investing in the future of a particular technology or market." (Tyebjee and Bruno, 1984:1057)

[81] Venture capitalists tend to specialise in geographic locations and thus spatial proximity between the venture capitalist and the potential portfolio company is a consideration for those fund managers during the deal screening process (Tyebjee and Bruno 1984; Bygrave and Timmons 1992; Gupta and Sapienza 1992; Norton and Tenenbaum 1993; Sorenson and Stuart 2001; Chen et al. 2010).

potential portfolio company. This process, known a due diligence, is undertaken in order to minimise the investment risk by gaining a greater insight into the elements that create value within the company; the management team, the product, and the market potential of the investee firm.[82] Extensive research has been carried out on the criteria used by VCs to evaluate new ventures (Wells 1974; Poindexter 1976; Tyebjee and Bruno 1981; MacMillan et al. 1985; Knight 1986) and the sources of information used by VCs to undertake due diligence (Chan 1983; Arnold and Moizer 1984; Dixon 1991; Pike et al. 1993; Muzyka et al. 1996; Wright and Robbie 1996a). The final decision rests with the VC firm's investment committee.

Previous studies have shown (Arnold and Moizer 1984; Sahlman 1990; Wright and Robbie 1996a) that discounted cash flows (DCF) or earnings multiples (PE ratio) are the most frequently used methods for valuing an unlisted company. When using the discounted cash flows technique the VC must consider a benchmark internal rate of return (IRR) that will be used to discount cash flows and determine the company's value. Wright and Robbie (1996a), in their survey of 114 VCs found that the benchmark IRR used to evaluate expected after tax returns was a mean of 29.2 per cent (median 30 per cent). They found this result to be consistent with previous research such as Dixon (1991). They also found that the required benchmark was higher for early stage investments than was the case for later stage investments. This is consistent with the principle that riskier early stage investments attract a higher required rate of return than is the case for later stage investments.

The VC may make use of syndication as a mechanism for controlling risk.

[82] This risk is also minimised by providing financing in a series of 'rounds' or 'stages'. This enables a review of the company's performance before committing additional funds.

Syndication occurs when a VC invites other venture capitalists to invest in an entrepreneurial firm. This is usually achieved by one of the VCs acting as lead investor, taking responsibility for continuation decisions and taking an active role in overseeing the company, whilst the other syndicate members are play a less active role (although they may still hold board seats) (Lerner 1994a). Gompers and Lerner (2000a) identified a number of reasons why VCs syndicate their investments. Firstly, they argued that syndication allowed the VCs to diversify their portfolio risk by investing in multiple companies; many more than would be possible if they were the sole investor in each deal. This is view is supported by practitioners such as Robert J. Kunze of Hambrecht and Quist who stated:

> Most financing involves a syndicate of two or more venture [capital] groups, providing more capital availability for current and follow-on cash needs. Syndication also spreads the risk and brings together more expertise and support. These benefits pertain only to start-up financing requiring the venture capitalists first investment decision. There are different strategies and motivations for syndication in follow-on financing. [Robert J. Kunze, Humbrecht and Quist 1990 quoted in Gompers and Lerner (2000a:187)]

Secondly, Gompers and Lerner (2000a) argue that syndication of deals would enable the VC to garner a second opinion on the investment opportunity, thus potentially acting as another mechanism for reducing the adverse selection problem VCs face when assessing new investments. Bygrave and Timmons (1990) believe that syndication for the purposes of sharing information is as important, if not more important, than the spreading of risk. They argued that the higher number of VCs syndicating investments in high-technology and early stage deals, as opposed to lower the levels of syndication observed in low-technology and later stage deals, indicates that they are inviting other VCs to participate in their deals in order to gain from their expertise and gather a second opinion.

Once the decision has been made to commit capital to the company the VC faces a constant agency problem. The nature of investing in unlisted equities means that the investor's access to information about the ongoing operations of the company is considerably more limited than a similar investment in listed equities, where the firm is constantly under the scrutiny of capital market participants. The problem of how to deal with the agency conflicts over the life of the investment can, at least partially, be overcome through a careful structuring of the investment process (Chan et al. 1990; Sahlman 1990). The VC deals with this problem several ways; (i) by structuring the investments so that they keep firm control over them (staging finance), (ii) by creating appropriate compensation schemes that provide the entrepreneur with the right incentives (signing over equity when performance milestones are achieved), (iii) by active involvement in the company (in effect acting as consultants and holding board seats), and (iv) by preserving mechanisms that make their investments liquid (through the use of hybrid securities and put options within the financing contract that enable them to force repurchase by the portfolio company).

Many authors (Cooper and Carleton 1979; Chan 1983; Amit et al. 1990; Admati and Pfleiderer 1994; Gifford 1997; Bergemann and Hege 1998; Neher 1999; Elitzur and Gavious 2003) have empirically examined the relationships between VCs and entrepreneurs, particularly with reference to the staging of investments. These have resulted in various multistage decision models and game theories that attempt to determine what the optimal financing decision is at each stage of the financing cycle.

VCs are typically actively involved in the companies in which they have investments. Sahlman (1990:508) described the functions performed by the VC in the operations of their portfolio company as follows:

> Venture capitalists sit on the board of directors, help recruit and compensate key individuals, work with supplies and customers, help establish tactics and strategy, play a major role in raising capital, and help structure transactions such as mergers and acquisitions. They often assume more direct control by changing management and are sometimes willing to take over day-to-day operations themselves. All of these activities are designed to increase the likelihood of success and improve return on investment: they also protect the interests of the venture capital fund and ameliorate the information asymmetry.

Gorman and Sahlman (1986) argue though that the VCs do not spend an inordinate amount of time directly involved with the management of their portfolio companies. Rather they found that the VCs tend to intervene only cursorily in the day-to-day operations of the company. They also found that the degree of involvement varies with the stage of investment, with early stage portfolio companies typically requiring two hours of attention per week by the lead investor whilst later stage investments require less attention. The authors also determined that lead investors visit their portfolio companies approximately one and half times per month and stay for an average 5 hours. The non-lead investors usually visit about half as often and only stay for about two-thirds of the time of the lead investor. However, work carried out by

Elango et al. (1995) found that whilst later stage venture capital fund managers spent more time evaluating a potential investment, once the investment was made they found no difference in the time spent assisting the portfolio company between early- and late-stage VCs. Elango et al. (1995) did, however, find that investors could be grouped into three categories based upon the amount of time they devoted to assisting the portfolio companies, with the most active group averaging over 35 hours per month per investment whilst the least active group averaged less than seven hours.

Venture capitalists are also typically represented on the portfolio company's board. Early work by Rosenstein (1988) examined characteristics of the board of directors of a typical high technology company receiving venture capital financing. He found that:

> …the board is typically small, with outsiders rather than management in control; further, at least some of the outside members were found to have a high degree of expertise and a close working relationship with management. Board meetings are frequent and deal actively with key issues and with the review of how strategy is working and what changes in strategy may be required. (Rosenstein, 1988:159)

Furthermore, Rosenstein (1988) states that boards in those companies receiving venture capital financing have a high level of power relative to management and that this power is more than just financial power, but also in terms of the expertise and contacts of the VC. This research, consistent with that of Sahlman (1990), implies that the VCs contribution to the success of the venture involves more than simply their financial contribution but that they are able to make an important contribution to the operational and strategic decision making of the company. Research carried out by

MacMillan et al. (1988) found that VCs were involved in four distinct areas of the firms operations: development and operations, management selection, personnel management, and financial participation. Of these areas though, the authors found that the highest degree of involved occurred with respect to financial operations whilst the lowest degree of involvement was in the area of ongoing operations. Work by Gomez-Mejiia et al. (1990), in examining the post-investment activities of VCs in high technology firms, found that they were deeply involved in establishing policies and monitoring managerial activities of the firms. When respondents to the MacMillan et al. (1988) questionnaire were asked if they could change their involvement how would that have done so, the majority of respondents indicated that they would have increased their involvement in activities requiring the a low time commitment and decreased their involvement in activities requiring a high time commitment. This suggests that time considerations play an important part in determining the degree of the VC's involvement in their portfolio companies and that, presumably, this is directly correlated to the size of their investment portfolio. According to Gifford (1997) this is a rational response by the VC who has limited time to allocate between improving current ventures and evaluating new projects for possible investment. Thus the VC allocates time in a manner which maximises the overall value of the portfolio, possibly at the expense in individual portfolio companies.

However, follow up work by Rosenstein et al. (1993), in a study of 98 venture capital-backed high technology firms, found that the CEOs of these firms did not, on average, rate the value of advice from a VC any higher than other members of the board. Although, where the lead venture capitalist was rated as a top 20 firm, then on average, the CEO's did rate their advice significantly higher than the advice of other outside board members. Rosenstein et al. (1993) found instead that the areas in which the CEO's rated the outside board members as most helpful were as a sounding board, interfacing with the investor group, monitoring operating performance, monitoring financial performance, recruiting/replacing the CEO, and assistance with short-term crises. Rosenstein et al. (1993) also found that this assistance was rated higher for early-stage rather than later-stage companies. These results suggest that CEO's question the value of VCs' contributions beyond simply the provision of capital and, therefore contrary to previous research, raised questions about the 'value-added' that VCs contributed to the success of the venture. In support of this, Murray (1994) shows that finance was the only area in which VCs' skills were rated by entrepreneurs to be greater than those of other parties.

Research carried out by Beecroft (1994) suggests that the VC's ability to add value to the venture can be the result of the skills they possess, with managers employed by captive funds tending to be more financial skills oriented whilst those employed by independents tend to have greater industrial skills. This is supported by the findings of Sapienza et al. (1996), in a study of venture capital investing in the US and the three largest venture capital markets in Europe (UK, Netherlands and France), who found that VCs with operating experience in the portfolio company's core industry added significantly more value than those with less industry-specific experience.

Another factor that may impact upon the degree of 'value added' by the VC is the frequency of interaction between the fund manager and the portfolio company's CEO. Sapienza and Gupta (1994) argued, within an agency framework, that even when management is a significant shareholder, agency problems might persist as a result of disagreements regarding how to prioritise operating goals. Empirical analysis carried out by Sapienza and Gupta (1994) found that when the level of goal congruence between the lead VC and the firm CEO is low (often as the result of minimal new venture experience on the part of the CEO) then the frequency of interaction between the VC and the CEO will be greater. Thus, the monitoring time for the VC correlates, at least in part, positively with the degree of new venture inexperience of the portfolio company's CEO. This is supported by the findings of Sapienza et al. (1996) who found that the amount of 'value-added' is strongly related to the amount of face-to-face interaction between the VC-CEO pairs and to the number of hours the VC devoted to each portfolio company.

Research carried out by Sweeting (1991) and Hatherly et al. (1994), looking at the UK, found that informal personal relationships are an important component of venture capital governance and that formal powers need to be used sparingly, and only when things go wrong, in order to remain effective. Lerner (1995), in research examining the degree intensity of scrutiny that VCs exhibit with respect to their investments, found that the involvement of VCs on the board increases around the time of CEO turnover. He also found that the number of outsiders on the board remains constant. This finding is consistent with the notion that VCs are willing to take an active hand in the event that the progress of the investment deviates from the benchmarks established at the time of the initial investment of capital.

Ehrlich et al. (1994) examined the differences in assistance provided to a sample of entrepreneurial firms, located in Southern California, from two different types of investors: VCs and private investors. The authors found that whilst the entrepreneurs perceived both types of investors to be involved in similar sets of activities with respect to assisting the firm, the VCs were perceived to be setting more difficult performance targets for the firm. They also found that VCs were providing more detailed feedback more frequently to the management team. The authors argued that other private investors were perhaps unable to allocate the same amount of time to the portfolio firm because of outside activities they were involved in. They reasoned that this was not a problem for entrepreneurs with managerial experience but that managers with more technical or scientific knowledge needed this extra attention. Based on their finding, Ehrlich et al. (1994) concluded that VCs were able to add more value to entrepreneurs with good technical or scientific skills but limited managerial experience, whereas those with more managerial experience were better suited to alternative sources of financing.

Sweeting and Wong (1997) examined the approached to post-investment activities by a UK VC and found they took a more 'hands-off' approach to their investments than was the case for US VCs. They found that the venture capital managers were selecting investee firms that were compatible with this approach and that they used a process of 'feedback learning' from previous investments to identify these potential investees. They also found that trust was an integral part of the investment process and that achieving that trust required careful and considered nurturing. This investment pattern is perhaps well suited to the more experienced entrepreneurs identified in the findings of Ehrlich et al. (1994).

In addition to the value-adding/monitoring roles they undertake during this stage of the venture capital investment process, the VC must also make decisions regarding additional financing. Rosenstein (1988) found that VCs would undertake reviews of the business plan when a new round of funding is required. When objectives laid out in the business plan have not been achieved the VC may withhold funding or, more likely, force a fundamental rethink of strategy before supplying the necessary capital. In extreme cases the VC may enforce the removal and replacement of the CEO before providing the additional capital. Thus the supply of additional rounds of financing is closely related to the performance of the firm.

Lan (1991) theoretically demonstrated how venture capitalists add value to the firms in their investment portfolio. He argued that each stage of financing is itself an option to invest at the next stage. He found that a venture capitalists "...appreciation of the industry or product market and technology required to gain the competitive edge adds value to the firm by extending its product possibility frontier" (Lan 1991:139). He argues that a venture capitalists extensive due diligence and industry knowledge means that they are better able to overcome the information symmetry driven market collapse predicted by Ackeroff (1970). Lan argued that VC investment decisions provide a signal to third party capital providers of the firm's quality. He also argued the provision of capital to the firm by VCs also avoids opportunity loss due to wealth constraints of the entrepreneur. Finally, Lan believed that VC participation in the firm would reduce credit risk (and thus should reduce debt funding costs).

Gompers (1995) examined the structure of staged venture capital investments when agency and monitoring costs exist. Gompers argued that staged venture capital infusion helps keep the owner/manager on a 'tight leash' and reduces the potential losses from bad decisions. This argument predicts that the duration of funding and hence the intensity of monitoring should be negatively related to the expected agency costs. This means also that venture capitalists should concentrate their investment activities in early stage ventures and high technology industries where information asymmetries are significant and therefore the value of monitoring activities is greatest.[83] Using a random sample of 794 US firms that received venture capital financing between January 1961 and July 1992, Gompers found evidence that those companies that subsequently go public received significantly more dollar value of funding and more financing rounds that those which were exited through some other mechanism.[84] This suggests that VC sells off or liquidates those firms without potential. Furthermore, firms in industries with high market to book values (which serves as proxy for growth prospects) and R&D intensive industries were found to have received more venture capital financing than other firms. Lerner (1995) also looked more closely at the monitoring activities of venture capitalists by examining changes in the composition of the board of portfolio companies around the time the CEO is replaced.[85] Using a sample of 271 US biotechnology firms listed in the *Venture Economics* database as having received VC financing between 1978 and 1989, Lerner found a significant increase in the number of venture capitalist board members between the second last and last financing round when there has been a

[83] Gompers argues that the entrepreneur's equity stakes are essentially call options. This is because their holding are often junior to the preferred equity position of the venture capitalist and this creates an incentive to pursue high variance strategies like rushing a product to market without adequate testing. This gives rise to agency costs for the VC.

[84] For the sample; 22.5% of firms went public through the IPO process, 23.8% were sold through trade sales, 15.6% were liquidated or went bankrupt, and 38.1% were still private companies.

[85] The replacement of the CEO is used as a proxy for a crisis that would necessitate greater monitoring by the VC.

change in the CEO during that period. Cross-sectional regressions found that the exit of the CEO increases the number of venture capitalists directors from 0.25 to 1.59.

One of the critical skills that differentiate a successful VC from a less successful one is the ability to profitably exit from an investment.[86] The primary reason for this is the structure of venture capital funds. Due to the fact that the majority of venture capital funds are organised as ten to twelve year limited partnership agreements, the general partners strive to exit their investments by this time to provide a return to the limited partners. Also given that not all of the available funds are going to be distributed in the first year of the funds existence this means that on average the investor has to exit the investments in between three and seven years from the time of the initial investment (Gompers 1996). If the investment is not realised by that time it becomes what VCs refer to as a "living dead" investment. This is an investment which is self-sustaining but which does not provide the investors a return sufficient to compensate them for the risk they have borne over the life of the investment (Ruhnka et al. 1992). The exit mechanisms available to venture capitalists are; (i) initial public offering[87], (ii) sale to another firm, (iii) management buy-in/management buy-out, (iv) undertaking a turnaround, and (v) liquidation or write-off (Wright and Robbie 1998; Gladstone and Gladstone 2004). This dissertation will focus on the first method.

According to Wall and Smith (1997) most VCs were reactive rather than proactive when considering the exit strategy for a new investment. They tended to start

[86] Not only to provide adequate returns to investors to compensate them for the risk involved in investing in venture capital but also because of the links between capital raising and a successful track record for exits.
[87] Megginson and Weiss (1991) dispute the claim that the IPO is an 'exit' (at least in the US) since venture capitalists typically retain large shareholdings and board seats long after the firm's public listing.

considering the exit strategy only after the investment had reached, as far as the venture capitalists were concerned, "maturity". The main reason that authors (Bygrave and Timmons 1992; Ruhnka et al. 1992; Wall and Smith 1997; Black and Gilson 1998; Brouwer and Hendrix 1998; Golis 1998; Mahur 1999; Neidorf 1999) have identified for this reactive strategy is the fact that most VCs consider an initial public offering (IPO) as the preferred exit strategy. The primary advantage for the VC of an IPO exit is the perception that they will receive a higher price (return) in the public market. Mahur (1999:31) supports this perception when he states "venture capitalists still prefer to take their companies public because the public markets tend to pay more for the stock than do sophisticated buyers in the trade".

Bygrave and Timmons (1992), in a study of how 26 venture capital funds exited 442 investments between 1970 and 1982, found that gains were produced by IPO's (1.95 times investment), acquisitions (0.40 times), company buybacks (0.37 times) and secondary sales (0.41 times). Losses were suffered in liquidations (-0.34 times investment) and write-offs (-0.37 times). In a follow-up chapter in Wright and Robbie (1999), Bygrave and Timmons reported that IPO's remained the exit route of choice for US venture capital firms between 1992 and 1994. Gompers (1995) reported the results of a 1988 Venture Economics review of returns on venture capital that found that VC-backed IPO's yielded an average return of 59.5 per cent per year (or 7.1 times invested capital returned over 4.2 years). Acquisitions offered average returns of 15.4 per cent per year (or 1.7 times the invested capital over 3.7 years) whilst liquidations lost 80 per cent of their value over 4.1 years. From this Gompers (1995) concluded that IPO's offered the most attractive returns to investors. Lerner (1997:27) agreed, stating "private equity [VC] investors exit most successful investments through taking them public".[88] Lerner (1994b) found that IPOs backed by more experienced VCs are better able to time their IPOs by going public when equity values are high and using private financings when values are lower.

2.5.2 The role of venture capitalists in the IPO process

A number of studies have examined the role that venture capitalists play in the public offering of companies in their fund portfolios. These studies have led to the development of a number of theoretical models of impact of VC involvement in the IPO process. This section will examine the development of those models and the subsequent testing of them by other scholars.

Amit et al. (1990) investigated analytically, within the principal-agent framework (Harris and Raviv 1978; Holmstrom 1979), the decisions of entrepreneurs to develop their ventures independently or with the assistance of venture capitalists. The problem framework for this analysis is that the venture capitalist is uncertain about the entrepreneur's talent when making a potential venture investment. The entrepreneur's *talent* is their ability (skill, experience, ingenuity, leadership, etc) "...to combine tangible and intangible assets in new ways and deploy them to meet customer needs in a manner that could not easily be imitated" (Amit et al. 1990:1233). This talent may be known to the entrepreneur but unknown to the venture capitalist. The authors suggest that the inability of the VC to assess the venture founder's core attributes may affect both the decisions of entrepreneurs to involve outsiders and the prices venture capital firms may be willing to pay for new ventures. This gives rise to an adverse

[88] Many other authors have reported similar findings (Black and Gilson 1998, Gannon 1999, Golis 1998, Brouwner and Hendrix 1998, Ruhkna et al. 1992).

selection and moral hazard problem.

To understand this problem the authors modelled the entrepreneur's optimal behaviour under three information settings; (i) *the entrepreneur's skills are common knowledge* – under these conditions all risk adverse entrepreneurs would involve risk neutral VC's, as the risk share dominates the agency relationship, (ii) *there is information asymmetry regarding entrepreneur's skill levels* – then adverse selection means that only less profitable ventures will be sold whilst more profitable would be retained by the entrepreneur without outside involvement, and (iii) *there is information asymmetry reading the entrepreneurs skill levels but the entrepreneur can invest to reveal his skill* – under these conditions there will always be some selling out by less skilful entrepreneurs who do not generate a signal about their abilities. They also find that it is not a general result that high-ability entrepreneurs either necessarily generate or necessarily develop the venture alone. In both the later two settings the authors found that the equilibrium price paid for the investment is one that yields a zero NPV for the least skilled entrepreneur. The implications of this *adverse selection hypothesis* is that, in general, VC funding will be provided to the least attractive new ventures with the implication that VC-backed IPOs will be, in general, less attractive then non-VC-backed IPOs.

Barry et al. (1990) examined the influence of VC monitoring of their portfolio companies on the IPO process. With previous research indicating that VCs hold significant equity stakes and play an active role in monitoring their portfolio companies (through holding board seats, providing consulting and industry contacts, and staging investments) the authors sort to determine if this had any impact upon the market's perception of the value of companies brought to the market by venture capitalists. The study used a sample of 433 VC-backed IPOs and 1,123 non-VC-backed IPOs on US equity markets over the period 1978 to 1987.[89] In their sample they found that VCs held an average of 34.3% of the pre-IPO equity in the listing firms and 25% held at least 50% of the pre-IPO equity. On average VCs sold 6.6% of their pre-IPO shares (although 58% were found to have retained all of their equity holding post listing). The average VC still held 17.8% equity in the firm one year after the public listing.

Barry et al. (1990) found evidence that VC-backed IPOs exhibit higher underpricing of 2.78% (8.43% mean) compared non-VC backed IPOs with median underpricing of 1.29% (7.47% mean).[90] This result was not statistically significant. They also found evidence that VC-backed IPOs use more prestigious underwriters than non-VC-backed IPOs.[91] Their results indicated that VC-backed IPOs have a lower earnings yield (higher P/E ratio) than non-VC-backed IPOs although they suggested this was due to the nature of the industries that VC invest in rather than an effect of VC participation. In order to test the effects of VC participation on underpricing the authors regressed underpricing against a series of control variables for VC monitoring quality and underwriter quality.[92] The results indicated that underpricing is reduced (i)

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[89] Venture capitalists were identified using the *Venture Capital Journal* and *Pratt's Guide to Venture Capital Sources*.
[90] Underpricing was calculated as the percentage change by the end of the first trading day from the offer price. This is also referred to as the initial return in the IPO literature.
[91] Underwriter prestige is measured using Carter and Manaster (1990) underwriter ranks, on an ordinal scale of 0-9.
[92] Variables for venture capitalist monitoring skill used were; Number of VCs holding equity, Length of time the lead VC had been on the board, Age of the lead VC, Number of prior IPOs the VC had successfully brought to market, Funds under management, Fraction of pre-IPO equity held by the lead VC.

the larger the number of VCs owning equity in the issuers, (ii) the longer the lead VC has served on the company's board, (iii) the older the venture capitalist is, (iv) the larger the number of prior IPOs in which the lead VC participated, (v) the larger the fraction of issuers equity owned by the VC.[93] They concluded that the quality of monitoring services appears to be recognised by capital markets in lower underpricing for IPOs with better monitors.

Megginson and Weiss (1991) expanded upon the work of Barry et al. (1990) by formalising the expected effect of venture capital participation in the IPO process. Building on the certification hypothesis of Booth and Smith (1986), Megginson and Weiss argued that the presence of venture capitalists, as investors in a firm going public, can certify that the offering price of the issue reflects all available and relevant inside information. This has become known as the *certification hypothesis*. Megginson and Weiss examined the certification model by testing three hypotheses; (i) VC-backed IPOs should have higher quality underwriters and auditors as well as larger institutional following than non-VC-backed IPOs, (ii) VC-backed IPOs should have lower underpricing as well as lower issuing costs than non-VC-backed IPOs, and (iii) VC's should have high ownership levels before and after the IPO. Megginson and Weiss used a matched sample of 320 VC-backed IPOs and 320 non-VC-backed IPOs on US equity markets over the period 1983 to 1987 to examine these three hypotheses.[94]

[93] The Funds under management variable was not found to be significant in determining underpricing.
[94] VC-backed and non-VC-backed IPOs were matched on the basis of having the same industry classification (three digit SIC classification) and as closely as possible the same size. Time was not one of the matching criteria. Venture capital backing was identified using the *Venture Capital Journal*. Underwriter quality was measured using market share. Auditor quality was based on whether or not the firm was one of the 'Big eight' accounting firms.

Megginson and Weiss found that VC-backed IPOs are younger than their equivalent non-VC-backed counterpart which they suggested was evidence that venture capitalists were able to bring the companies to the market quicker. VC-backed IPOs exhibited evidence of higher quality underwriters and auditors. They also had significantly higher institutional shareholdings than non-VC-backed firms. They found evidence of lower underpricing for VC-backed IPOs, lower underwriter compensation and other issuing costs which resulted in a higher ratio of net proceeds to offer amount (and first trading day amount) for VC-backed firms. Regressing underpricing and underwriter spreads against various control variables[95] (including VC presence) the authors found venture capitalist participation lead to a significant reduction in both dependent variables. VCs were also found to hold significant portions of the equity both before the IPO (36.6 per cent) and after the commencement of trading (26.3 per cent). These results supported the certification hypothesis.

Jain and Kini (1995) test the proposition that VCs can continue to add value to their portfolio companies after the IPO process by comparing post-IPO operating performance of a sample of VC-backed IPOs and non-VC-backed IPOs.[96] Their sample consisted of 136 VC-backed IPOs matched to 136 non-VC-backed IPOs on US equity markets for the period 1976 to 1988.[97] Operating performance up to three years after listing was measured using two cash flows; (i) operating return on assets,

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[95] Control variables were; VC backing dummy, offer amount, underwriter quality and age of the issuing firm.

[96] The evidence that venture capitalists continue to hold equity stakes and board positions after the listing of the firm forms the basis for the expectation that their participation would continue to add value to the company (Barrey et al. 1990, Sahlman 1990, Megginson and Weiss 1991).

[97] As with Megginson and Weiss (1991) the matching criteria used was three digit SIC classification and offering amount.

and (ii) operating cash flows deflated by total assets. The authors found that VC-backed IPOs have higher median IPO offering size and offer price in comparison to their non-VC-backed counterparts. Whilst both groups exhibited a decline in operating performance post listing, that decline was faster for non-VC-backed IPOs relative to the VC-backed IPOs using both operating performance measures. Cross-sectional regressions of operating performance with control variables for market expectations found that VC-backed IPOs exhibit superior operating performance in the period after listing over the three-year measurement interval. Thus, the authors concluded that VC participation adds value to post-IPO operating performance and signals quality to other market participants at the time of the public offering. This supports the certification hypothesis of venture capitalist participation.

Lin (1996) also provides evidence of the certification role played by VCs in the IPO process. Lin tests two predictions stemming from the certification hypothesis; that VC-backed IPOs should exhibit lower underpricing and lower underwriter spreads at the time of offering relative to non-VC-backed IPOs due to the signal of quality that the VCs equity position indicates to other market participants. Lin used a sample of 497 VC-backed and 2,137 non-VC-backed IPOs on US equity markets between 1979 and 1990.[98] He found evidence that VC-backed IPOs use more prestigious underwriters and are able to do so with significantly lower underwriter spreads.[99] VC participation was shown to have a negative effect on underpricing (although this result was not significant). Cross-sectional regressions of underpricing against VC

[98] VC participation was identified using the *Venture Capital Journal* and *Pratt's Guide to Venture Capital Sources*.
[99] Underwriter prestige is ranked using the Cater and Manaster (1990) rankings.

reputation[100] and four control variables[101] found that underpricing was positively related to the offering size, negatively related to the VC's shareholding and negatively related to VC prestige. Lin concluded that these results were consistent with the previous findings that venture capitalist participation certifies the value of the listing company to potential third party investors.

Gompers (1996) develops and tests the hypothesis that younger (less experienced) venture capital firms take companies public earlier that older (more experienced) venture capital firms in order to establish a reputation and successfully raised capital for new funds. This has become known as the *grandstanding hypothesis*. Gompers tests a number of predictions based upon this hypothesis; (i) there will be a shorter interval until the next fundraising after an IPO for younger VCs relative to older VCs, (ii) companies brought to the market by younger VCs will be less well developed (younger) than those brought to the market by older VCs, (iii) younger VCs will have spent less time on the board of their portfolio companies than older VCs, and (iv) IPOs backed by younger VCs will exhibit greater underpricing than those backed by older VCs. To test these predictions Gompers uses two samples; 433 VC-backed IPOs on US equity markets between January 1978 and December 1987[102], and all IPOs for 62 VC funds between August 1983 and July 1993. Gompers classifies the venture capitalist who has been on the board the longest as the lead VC (as opposed to Barry et al. 1990 who use the largest equity holding as a proxy for the lead VC). Gompers classifies VCs established less than six years prior to the IPO as 'young' and those

[100] VC reputation was proxied using VC age and amount of funds under management.
[101] Control variable were log of offering size, age of issuing firm, pre-IPO shareholding of lead VC and underwriter rank.
[102] This is the same sample used by Barry et al. 1990.

established six or more years prior to the IPO as ‘old’.[103]

The results demonstrated that companies backed by more inexperienced VCs were younger at the time they were brought to the market and that the VC had spent less time on the board than those backed by more experienced VCs. IPOs backed by younger VCs also exhibited greater mean (median) underpricing of 13.6 per cent (6.7 per cent) compared to 7.3 per cent (2.7 per cent) for those backed by older VCs. Younger VCs were also demonstrated to have held smaller mean (median) equity stakes in their portfolio companies at the time of the offering of 32.1 per cent (28.7 per cent) compared to 37.7 per cent (37.1 per cent) for older VCs. Gompers suggests this indicates that younger VCs bear the costs of early IPOs with smaller equity stakes. Cross-sectional regressions demonstrated a positive relationship between the number of companies taken public and the size of the next capital raising. Gompers also demonstrated that younger VCs raise money after IPOs sooner than older VCs (eight to nine months sooner). The results supported the hypothesis that younger VC firms rush their companies to market in an effort to establish a reputation of success for future capital raisings.

Brav and Gompers (1997) investigated the long-run market underperformance of VC-backed versus non-VC-backed IPOs.[104] They argued that if the involvement of a venture capitalist certifies the offering to third party investors then this should be incorporated into the price (through lower underpricing) and the long-run stock price performance ought to be similar for the two groups (VC-backed versus non-VC-

[103] Gompers states the results are not sensitive to cut-offs between four and ten years prior to the IPO.
[104] Ritter (1991) and Loughran and Ritter (1995) had previously documented a pattern of severe long-run underperformance in IPOs over a twenty year period.

backed offerings). However, they argue that if the market underestimates the importance of a venture capitalist in the pricing of new issues than the long-run performance might differ. To examine the long-run effects the authors used a sample 934 VC-backed IPOs on US equity markets from 1972-1992 and 3,407 non-VC-backed IPOs on US equity markets from 1975-1992.[105,106] The authors found that for equal weighted buy and hold returns over five years, VC-backed firms earned 44.6 per cent on average, whilst non-VC-backed firms earned 22.4 per cent. VC-backed firms also exhibited higher wealth relatives (using various benchmarks) over the five-year holding periods of around 0.95 compared to 0.86 for non-VC-backed firms.[107] Using the Fama and French (1993) three factor model the authors find that documented IPO underperformance is driven by non-VC-backed IPOs (even after controlling for size and book-to-market in time series regressions). VC-backed IPOs were demonstrated not to have exhibited long-run underperformance using this model. The authors also demonstrated that the long-run underperformance was not an IPO effect since they found that similar size and book-to-market firms that have not issued equity perform as poorly as IPOs over the sample period. This supports the certification hypothesis.

Lin and Smith (1998) examined the relationship between venture capitalist selling decisions and reputation during the IPO process. They hypothesize that VC firms balance the costs of continued involvement and ownership against the adverse market

[105] VC participation was identified using the *Venture Capital Journal* and other sources.
[106] The authors noted a low incidence of mergers over the sample period; 11.2% of the VC-backed IPOs and 9.7% of the non-VC-backed IPOs merge within the first five years of listing. Also 7.5% of VC-backed and 13.3% of non-VC-backed IPOs in the sample are delisted within five years of the IPO.
[107] Wealth relatives are calculated as (1+ buy and hold return on IPO)/(1+ buy and hold return on benchmark portfolio). The benchmarks used were S&P 500 index, Nasdaq composite, NYSE/AMEX value-weighted index, NYSE/AMEX equal-weighted index, size and book-to-market (5x5), and Fama-French industry portfolio.

reaction to insider selling. The authors argue that the venture capitalist will seek to liquidate their holdings in listed companies in order to free up their limited advisory for other potential ventures.[108] Maintaining a large shareholding after the public offering can obligate the venture capitalist to an ongoing monitoring role (due to contractual obligations and fiduciary relationships) that may not be the best use of their unique skill set (which is specialised towards advising early stage companies). They also argued that the VC will seek to minimise the adverse reaction by developing a reputation for selling shares that are not overpriced. The study used a sample of 497 VC-backed IPOs and 2,136 non-VC-backed IPOs on US equity markets between 1979 and 1990.[109] The authors found that VC-backed IPOs go public more quickly than non-VC-backed firms (VC-backed firms have on average only been incorporated half as long as non-VC-backed firms). Consistent with previous research they also found the quality of underwriters used by VC-backed firms was significantly higher than for non-VC-backed IPOs.[110] They suggest that their findings imply that it is the underwriter rather than the venture capitalist that is performing the certification function.

However, they also argue that their findings were not consistent with the grandstanding hypothesis since the average age for VC-backed firms was 7.5 years and none of them was even close to the average age for non-VC-backed firms of 15 years. They also find evidence of significant declines in long-term venture capitalist ownership (only 12.3 per cent of venture capitalists are still shareholders after 3 years)

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[108] Also they state that equity cannot be distributed to the limited partners of the fund during the 'lock-up' period (of between 6 months to 2 years) after listing. This restriction is critical given the life of a typical limited partnership agreement is between ten and twelve years.

[109] VC participation was identified using the *Venture Capital Journal* and *Pratt's Guide to Venture Capital Sources*.

[110] Underwriter quality was measured using Cater and Manaster (1990) rankings.

and directorships. Their results indicated that the lead VC is more likely to sell at the IPO when they have an established reputation and that VCs with an established reputation will refrain from selling unless the IPO is expected to be significantly and materially underpriced. This did not hold for VCs with less established reputations. These results suggest little evidence of support for either IPO certification or grandstanding by venture capitalists.

Hamao et al. (2000) examine the long-run performance of VC-backed IPOs in the Japanese market. This market is different from the US market (which most prior research is focused upon) because most of the VCs in Japan are subsidiaries of securities firms rather than independent organisations. The authors suggested that these firms faced potential conflicts of interest between their role as investors in their portfolio companies and the goals of the parent firm to which they are aligned. Thus, the authors test two hypotheses; the certification hypothesis and a 'conflict of interest' hypothesis.[111] The study used a sample of 210 VC-backed and 246 non-VC-backed IPOs on the Japanese OTC market between 1989 and 1995.[112] The authors found little evidence of strong monitoring being performed by Japanese VCs with shorter holding periods, fewer board seats and smaller equity stakes (average of 5.92 per cent of the equity) than previous research reported for US firms. The study found evidence of significant underpricing (average 19.8 per cent) at the time of listing and poor three-year returns measured against an industry or size matched non-IPO portfolio, although

[111] The conflict of interest hypothesis is largely based on the possibility that the securities firm to which the venture capitalists is affiliated has an incentive to more aggressively market (and set a higher offering price for) any offering in which it is indirectly a shareholder (through its VC subsidiary) than would be the case if it was acting solely as a financial intermediary. This hypothesis assumes that not all investors are sufficiently sceptical about firm quality which would enable hyping of the stock to be successful.

[112] The majority of the venture capitalist firms were affiliated with either a bank or securities firm. Seventy five per cent were affiliated with the lead underwriter of the offer.

the wealth relative was 0.851 which was higher than the 0.8 reported in Loughran and Ritter (1995) but lower than the 0.86 to 0.95 reported by Brav and Gompers (1997). They also found evidence that Japanese VCs sell significant portions of their equity holdings in the IPO (post IPO holding are on average 40 per cent below the pre-IPO levels) unlike their US counterparts.[113] Cross-sectional regressions of 355 IPOs between 1989 and 1994[114] matched by industry classification and size found evidence that foreign or independent VC-backed IPOs were underpriced at the time of the IPO but exhibit positive average long-run returns (unlike other VC-backed and non-VC-backed IPOs). However, once other determinants of performance were controlled for[115], the authors found that VC-backed IPOs were less underpriced and had better long-run performance than non-VC-backed IPOs (confirming the certification hypothesis) except in the case of affiliates of the lead underwriter where the conflict of interest hypothesis seemed to prevail.

Francis and Hasan (2001) examined the pre-market underpricing of VC-backed and non-VC-backed IPOs using a stochastic frontier approach and maximum likelihood estimates to separate pre-market and post-market effects on IPO underpricing. Using a sample of 415 VC-backed IPOs[116] and 428 non-VC-backed IPOs on US equity markets between 1990 and 1993 the authors find evidence consistent with previous research that VC-backed IPOs are associated with more prestigious underwriters[117] and lower underwriter compensation. This is consistent with the certification

[113] Foreign or independent VCs in Japan were found to have sold most of their holdings during or shortly after the IPO.
[114] The shorter cut-off was to enable three year holding periods.
[115] Independent variables were; log of proceeds, log of book-to-market ratio, log of firm age, subscription ratio, institutional lag, and VC and regulatory regime dummies.
[116] VC-backing was identified using the *Venture Capital Journal*.
[117] Underwriter prestige is determined using Carter et al. (1998) rankings.

hypothesis. However, the authors also found that underpricing of VC-backed IPOs was, on average, higher than for non-VC-backed IPOs. They determined that this initial return was determined not only by factors such as third party certification and public information about the offering, but also by inefficiencies in the initial offer price of VC-backed IPOs suggestive of deliberate pre-market underpricing.

Barnes and McCarthy (2002) examined whether the effects of the grandstanding hypothesis (Gompers 1996) occur in the United Kingdom. They test whether young venture capitalists grandstand by bringing companies to the market earlier than older venture capitalists in an effort to build a reputation and successfully raise more capital in future funds. The study used a sample of 85 VC-backed IPOs on UK equity markets during the period July 1992 to December 1999.[118] The study found that listing companies were significantly younger if the VC was younger but there was no difference in the level of underpricing between young or old venture capitalists. They also found no evidence of a difference in the quality of underwriter used in the offering.[119] There results suggested that differences in underpricing instead related more to offering characteristics than VC reputation. Unlike previous research they also found younger VCs did not appear to bear significant costs of rushing investments to the market in the form of reduced ownership stakes at the issue nor did younger VCs time their IPOs closer to their follow-on funds than more established VCs. Overall, the authors found little evidence of grandstanding behaviour in their results.

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[118] Venture capitalists were identified using a list produced by the British Venture Capital Association. In order to be classified as VC-backed the venture capitalists stake had to be at least 3% of all the shares outstanding.

[119] Underwriter prestige was ranked using the league tables published annually by the *International Financial Review* (IFR).

Franzke (2003) examined the certification hypothesis for IPOs in Germany's *Neuer Markt*. She examined two implications of the certification hypothesis; (i) the more prestigious the venture capitalist, and the bigger their equity stake, the lower should be the level of underpricing at the IPO, and (ii) the higher the participation ratio[120] the lower the level of underpricing. The study used a sample of 300 IPOs that went public on the Neuer Markt between March 1997 and March 2002.[121] The sample consisted of 79 VC-backed IPOs[122], 160 non-VC-backed IPOs and 61 companies that received 'bridge financing'. Franzke argued that, due to their shorter holding periods, the bridge financing providers were not expected to provide the same degree of certification as the venture capitalists. The study found 52.44 per cent average underpricing for VC-backed IPOs and 48.38 per cent for non-VC-backed firms, although the difference was not significant. Using a two stage least square regression of underpricing and non underwriter expenses, the author found no evidence to support the certification hypothesis. It was found that more prestigious venture capitalists (prestige was ranked on three age categories) experience greater underpricing (average 75.32 per cent) compared to their less prestigious counterparts (average 39.16 per cent).

Wang et al. (2003) examined both the certification and grandstanding/adverse selection hypotheses in the Singaporean market. They argued that, with only twenty years of venture capital experience, Singapore represented a good location to test the

[120] The participation ratio was defined as number of old shares sold in the IPO divided by the number of pre-IPO shares.
[121] The Neuer Markt closed in 2003.
[122] Venture capitalists were identified using prospectuses and *German Venture Capital Association* and *European Venture Capital Association* membership lists.

applicability of the existing theories on venture capitalist participation in the IPO process in an emerging market. The study used a sample of 82 VC-backed IPOs[123] matched with 82 non-VC-backed IPOs over the period 1987 to 2001.[124] In order to test the two hypotheses the study examined three performance measures; IPO performance, post-IPO operating performance and post-IPO market performance. The authors argued that the different hypotheses gave different empirical predictions in both IPO and post-IPO performance. In the IPO process, the certification model predicts lower underpricing and lower IPO cost for VC-backed IPOs whereas the grandstanding/adverse selection models predict higher underpricing and higher IPO costs. In post-IPO operating and market performance, the certification model predicts VC-backed IPOs with exhibit better performance compared to non-VC-backed IPOs but that that outperformance with decline over time as the VC withdraws whereas the adverse selection/grandstanding model predicts that VC-backed IPOs with underperform compared to non-VC-backed IPOs.

The study found that VC-backed firms were younger at the time of the IPO, had lower underpricing (when hot issue periods were excluded) and had higher underwriter quality than non-VC-backed IPOs. This implied some support for the certification hypothesis however this did not translate into lower issuing costs of VC-backed firms. They found various measures of post-IPO performance of VC-backed firms declined faster than those of non-VC-backed firms, which contradicted the previous findings of Jain and Kini (1995), and suggested support for the grandstanding/adverse selection model. The post-IPO market results were inconclusive. However, when Wang et al.

[123] Venture capitalists are identified using IPO prospectuses.
[124] IPOs are matched according to industry classification, size and year. This is similar to the technique used by Megginson and Weiss (1991).

(2003) partitioning their sample into longer and shorter investment VC duration and young and old venture capitalists the authors were able to find evidence that firms backed by older VC and those that had longer VC support exhibited evidence of lower underpricing and better post-IPO performance which implies support for the certification hypothesis. Those backed by younger venture capitalists and those that had shorter VC support exhibited higher underpricing and weaker post-IPO performance which the authors argued supported the adverse selection/grandstanding hypothesis.

Lee and Wahal (2004) also examined the certification and grandstanding hypotheses of venture capitalist participation in the IPO process. They used an extensive matched sample of 2,208 VC-backed IPOs[125] and 2,208 non-VC-backed IPOs in US equity markets over the period 1980 to 2000.[126] The authors found that differences between underpricing for VC-backed versus non-VC-backed IPOs was non stationary. For the full sample, they found VC-backed firms exhibited a higher degree of underpricing than non-VC-backed firms. However when replicating the periods of Megginson and Weiss (1991) and Barry et al. (1990) they found, consistent with those studies, that VC-backed IPOs exhibited a lower degree of underpricing than their non-VC-backed matched counterparts. They found that the tech boom of 1999 to 2000 accounted for most of this difference. In order to better assess the impact of venture capital participation, the authors then used a two-stage regression technique to endogenize the receipt of venture financing without imposing linearity or function form restrictions. This was an attempt to remove the bias of the choice of venture

[125] Information on VC firms, dates, funding etc was obtained from *Venture Economics* database and *Pratt's Guide to Venture Capital Sources*.
[126] IPOs were matched according to three-digit SIC code, closest net proceeds and listing dates within 2 years of each other.

financing.[127] Using this technique the authors found the selection bias-adjusted average IPO underpricing was 18 per cent with VC-backed firms being five to ten per cent higher than their non-VC-backed counterparts.[128] Regressing the time until the next capital raising against VC reputation[129] and various control variables, the authors found VC reputation, underpricing, the interaction between VC age and underpricing, and the interaction between number of previous IPOs and underpricing, to be significant in determining the timing of the next round of capital raising. This implied strong support for the grandstanding hypothesis.

Chiang and Lo (2007) used a microstructure approach to investigate the certification and adverse selection/grandstanding models for VC-backed and non-VC-backed IPOs in Taiwan. The study examined relative spreads, information asymmetry cost and price volatility in the period immediately after listing on the exchange. The empirical prediction was that if the certification effects outweighed the adverse selection/grandstanding effects then each of microstructure measures would be lower. If, however, the adverse selection/grandstanding effects outweighed the certification effects then each of those measures would be higher. The study used a matched sample of 34 VC-backed and 34 non-VC-backed IPOs on the Taiwan stock exchange between April 1999 and March 2002.[130] The variables were measured daily over a period commencing four days after listing and ending thirty days after listing. The authors found no differences in effective spreads between the two groups, the information asymmetry costs were smaller for VC-backed IPOs for days four through

[127] In essence this technique sort to match the venture capital receiving firm with one that reflects what *it* would have been like had the founders *not made the choice* to use venture capital financing.
[128] This result was significantly higher in the 1999-2000 period.
[129] VC reputation was proxied using the age of the VC firm and number of previous IPOs.
[130] As with previous studies the matching was done by industry, market size and IPO timing.

six (but not significantly) and volatility was larger for VC-backed IPOs (again not significantly). Further cross-section regressions yield little further evidence to support either model.

Wong and Wong (2008) examined the roles of venture capitalists in the IPO process in the emerging venture capital market of Hong Kong. They examined three theoretical models; (i) the dynamic strategies model[131], (ii) the certification model, and (iii) the adverse selection/grandstanding model. The study used a sample of 67 VC-backed IPOs[132] and 291 non-VC-backed IPOs on the Hong Kong market from 1999 to 2003. The authors examined IPO valuation, post-IPO operational performance and post-IPO market performance. The study found evidence of significantly larger underpricing for VC-backed IPOs than non-VC-backed IPOs. Regressing underpricing against a VC dummy and various control variables[133] found VC participation significant. It was also found that VC-backed IPOs exhibited lower operational performance, using various measures, then non-VC-backed firms in the two years after the IPO although there were not significant differences between the market performances of the two groups. Thus the author's concluded there was some support for the grandstanding model.

Limited academic research has been carried out on venture capitalist activities in the Australian market. There has been some work on the economic importance of venture

[131] The authors suggest this model postulates that a firm with good prospects would underprice more in the IPO in order to create a favourable market for future equity offerings. Thus they argue VC-backed firms (if the VCs can add value) should be more underpriced than non-VC-backed firms. The authors do not explain why the VCs, who presumably sit on the board and plan on exiting the firm at some point, would support this strategy.

[132] Venture capitalists were identified using the *Journal of Asian Venture Capital*.

[133] Control variables were; age, log of proceeds, log of market capitalisation, log of assets, log of sales and industry.

capital and the role of government policy in encouraging its continued development (Wan 1989, 1991; Ryan 1990). Wan (1991) also noted that, consistent with overseas evidence, Australian venture capitalists widely used hybrid securities and, unlike their overseas counterparts, there was an increasing trend by venture capitalists to look to some form of dividend or interest payment rather than relying solely on the capital gain on exit. However, these early papers did little to address the relationship between the activities of venture capitalists and the success of their portfolio companies.

Cumming et al. (2005) examined the impact on venture capital fundraising of various value added activities and found that significantly more capital is allocated to venture capitalists that provide financial and strategic/management expertise to their portfolio companies than those venture capitalists that provide only marketing/administrative expertise. Alavi et al. (2008) found that IPOs that contain a large block of non-managerial investors (such as VCs) tend to offer more shares to the public than those dominated by owner/managers. They suggest this is because they are more concerned about exiting than retaining control and their presence tends to increase issue size and costs. Suchard (2009) examined the participation of venture capitalists in the boards of their investment companies and found that whilst they tend to hold a lower number (percentage) of board seats than their US counterparts, their portfolio companies do exhibit a higher number (percentage) of independent directors, particularly those with relevant industry experience. These results are consistent with the view that venture capitalists add value to their portfolio companies through their involvement. This implies support for the certification hypothesis.

da Silva Rosa et al. (2003) examined IPO underpricing, and long-run performance for a period of 24 months after the IPO. They used a sample of 38 VC-backed IPOs[134] and 295 non-VC-backed IPOs on the Australian Securities Exchange between 1991 and 1999. They found that the VC-backed companies exhibited higher underpricing than non-VC-backed companies although the differences were insignificant. Likewise, they found that VC-backed companies exhibited a slightly lower long-run performance than non-VC backed companies but again the differences were insignificant. Thus, the authors were unable to find support for neither the certification hypothesis nor the grandstanding hypothesis.

2.5.3 Summary

The unique nature of venture capital investment process holds important implications for how equity market participants perceive the involvement of a venture capitalist in the initial public offering process. Their role in screening potential new investments, conducting detailed due diligence, staging capital rounds, actively monitoring their investee companies, and bringing their specialised skills to their portfolio suggests a positive effect that has led to the development of the certification model. However, the existence of information asymmetry and structure of VC fund raising activities has also led to the development of an adverse selection/grandstanding model.

Existing empirical literature has yielded mixed results with evidence of support for both of these models. This literature is summarised in Table 2.5. Furthermore, much of the existing literature is focused on US markets, where venture capital investments

[134] Venture capitalists were identified using IPO prospectuses and the membership directory of the *Australian Venture Capital Association* (AVCAL).

have enjoyed a long history and the VC process is well developed. Very limited and inconclusive research has been carried on less developed venture capital markets such as Australia. The last chapter of this dissertation will address this shortfall by comprehensively examining both of these models in light of the Australian experience.

Table 2-5
Major Empirical Literature on the Role of Venture Capitalists in the IPO Process

This table provides a summary of the empirical literature examining the role of venture capitalists (VC) in the IPO process. The table provides details of the market, study VC (and non-VC) sample size and period, performance intervals examined (IPO performance, post-IPO operating performance, and post-IPO market performance) where 'X' indicates that interval was examined, and the findings for the two models (Certification/Monitoring and/or Grandstanding/Adverse Selection) where 'Y' indicates support for the model and 'N' indicates no conclusive finding.

	Market	Sample		Performance Interval			Model Support	
		VC (non-VC) Size	Period	IPO	Post-IPO Operating	Post-IPO Market	Certification/ Monitoring	Grandstanding/ Adverse Selection
Barry et al. (1990)	US	453 (1,123) IPOs	1978-1987	X			Y	
Megginson and Weiss (1991)	US	320 (320) IPOs	1983-1987	X			Y	
Jain and Kini (1995)	US	136 (136) IPOs	1976-1988		X		Y	
Lin (1996)	US	497 (2,137) IPOs	1979-1990	X			Y	
Gompers (1996)	US	433 (-)IPOs‡	1978-1987	X				Y
Brav and Gompers (1997)	US	934 (3,407) IPOs	1975-1992			X	Y	
Lin and Smith (1998)	US	497 (2,136) IPOs	1979-1990	X			N	N
Hamao et al. (2000)	Japan	210 (246) IPOs	1989-1995	X		X	Y	
Francis and Hasan (2001)	US	415 (428) IPOs	1990-1993	X			Y	
Barnes and McCarthy (2002)	UK	85 (-)IPOs	1992-1999	X			N	N
Franzke (2003)	Germany	79 (160) IPOs	1997-2002	X			N	N
Wang et al. (2003)	Singapore	82 (82) IPOs	1987-2001	X	X	X	Y	Y
De Silva Rosa et al. (2003)	Australia	38 (295) IPOs	1991-1999	X		X	N	N
Lee and Wahal (2004)	US	2,208 (2,208) IPOs	1980-2000	X				Y
Chiang and Lo (2007)	Taiwan	34 (34) IPOs	1999-2002			X	N	N
Wong and Wong (2008)	Hong Kong	67 (291) IPOs	1999-2003	X	X	X		Y

‡ plus a second sample of all IPOs for 62 VC firms between August 1983 and July 1993.

2.6 Hypotheses Development

This section considers the literature reviewed in sections 2.2 to 2.5 to develop several testable hypotheses that will be analysed in the ensuring chapters.

2.6.1 Stock Returns around Corporate Earnings Announcements

The economic link between corporate earnings releases and security prices is well established in existing accounting and finance literature. Investors, upon the release of a corporate earnings statement, will revise upwards (downwards) their perception of the intrinsic value of the firm's securities and, where current market price deviates from that perceived value, purchase (sell) securities until a new equilibrium level is reached. The first set of research questions seek to provide greater insight into the intraday speed of the price response to corporate earnings announcements.

Market efficiency (Fama 1965, 1970; Jenson 1978), rational expectations equilibrium (Radner 1968, 1972), and strategic trader behaviour models (Kyle 2985; Holden and Subrahmanyam (1992) posit a rapid price adjustment in the marketplace to the information contained in corporate earnings announcements. Such a rapid reaction would preclude investors from profiting by trading on any new information contained within the announcement. Dealer information and inventory models, however, suggest that factors such as the degree of information asymmetry (Diamond and Verrecchia 1981; Glosten and Milgrom 1985; Easley and O'Hara 1987; Blume et al. 1994) and market marker inventory levels (Stoll 1978; Amihud and Mendelson 1980;

Copeland and Galai 1983; Ho and Stoll 1983) would also influence the speed with which prices incorporate the content of any new information release.

Existing empirical literature (Patell and Wolfson 1984; Lee 1992; Francis et al. 1992; Greene and Watts 1996) provides some evidence of different response speeds based on the timing of the information release (whether the announcement was released during normal trading hours or outside of normal trading hours). Furthermore, Greene and Watts (1996) demonstrated that the speed of response appeared to be contingent upon the type of trading system used by the exchange.[135] Thus, the first hypothesis to be examined in chapter three of the dissertation represents a test of the applicability of previous findings in a market which operates an open electronic central limit order book (CLOB) with automatic trading halts for market sensitive announcements made during normal trading hours.

Hypothesis$_{3,1}$: There is a difference between the speed of price adjustment for corporate earnings announcements made during normal trading hours and those made outside of normal trading hours.

The literature in section 2.3.2 reviewed the empirical studies on strategic timing of corporate earnings announcements by firm managers in order to minimise the adverse effects of negative information releases. The evidence was mixed. Some research suggested managers were engaging in such behaviour (Patell and Wolfson 1982; Damadaran 1989; Bagnoli et al. 2005; DellaVigna and Pollet 2009; Kothari et al. 2009) whereas others found little evidence the strategic timing of corporate earnings

[135] Greene and Watts (1996) compared the NYSE and NASDAQ.

announcements (Doyle and Magilke 2009; Truong 2010). As with the previous hypothesis, none of the existing studies have examined this issue in a market in which trading halts are automatically implemented following the release of market sensitive information during normal trading hours. The second hypothesis tested in chapter three will examine whether such a difference in information release procedures has any impact upon strategic timing by firm managers.

Hypothesis$_{3,2}$: Announcements made after the close of trading and/or on Fridays are more likely to contain negative earnings news than announcements made before the market opens or during normal trading hours on Monday through Thursday.

Existing research has suggested that the relationship between corporate earnings announcements and abnormal stock returns is a function of the surprise contained within the announcement (Patell and Wolfson 1984; Woodruff and Senchack 1988; Lee 1992; Francis et al. 1992; Greene and Watts 1996; Lee and Park 2000; Kothari et al. 2009; Truong 2010). Scholars have examined many different techniques for establishing the surprise contained within corporate earnings announcements; the change from the previous reported earnings per share (Damodaran 1989); the sign of the difference between the reported earnings and the consensus analysts forecast (Patell and Wolfson 1984; Woodruff and Senchack 1988; Kotheri et al. 2009), the revision of analyst’s forecasts (Jennings and Starks 1985), and the magnitude of the difference between the reported earnings and the consensus analysts forecast (Lee 1992; Francis et al. 1992; Greene and Watts 1996; Lee and Park 2000; Bagnoli et al. 2005; DellaVigna and Pollet 2009; Doyle and Magilke 2009; Truong 2010). This is the focus of the third hypothesis examined in chapter three.

Hypothesis$_{3,3}$: The abnormal stock returns around corporate earnings announcements are positively related to the degree of earnings surprise contained within the announcement.

Collectively these hypotheses represent an investigation into the efficiency of an open electronic central limit order book market in impounding the information contained within corporate earnings announcements.

2.6.2 Algorithmic Trading around Corporate Earnings Announcements

The relatively recently rise of algorithmic trading has meant that many aspects of this phenomenon are yet to be explored in academic literature. Previous scholarly literature has tended to address how the increase in algorithmic trading, and in particular high frequency trading, has impacted upon market quality (Brogaard 2010; Hasbrouck and Saar 2011; Hendershott et al. 2011; Hendershott and Riordan 2011), or how improvements in the market technology that facilitate algorithmic trading have impacted upon market quality (Hendershott and Moulton 2010; Riordan and Storkenmaier 2011). The question of how algorithmic traders behave around corporate earnings announcements has not been empirically tested in existing literature. This dissertation seeks to fill that gap.

Fabozzi et al. (2011) suggested that algorithmic traders could exploit their time advantage by placing orders before the market reacts to the information content within the earnings announcement. They did not empirically test this proposition. This would imply an increase in liquidity demanding trades by algorithmic traders following the release of information announcements. Hendershott and Riordan (2011) found evidence that algorithmic traders demand more liquidity to move prices towards the efficient price in response to information. On the other hand, Riordan and Storkenmaier (2011) found that reducing system latency resulted in liquidity suppliers being able to impound information into quotes before liquidity demanders can exploit their information advantage. Hendershott et al (2011) found algorithmic trading results in lower adverse selection costs and improves price discovery associated with trading whilst Brogaard (2010) found that high frequency traders supply more liquidity rather than demand more liquidity around information releases. These results were consistent with the Riordan and Storkenmaier findings. Thus, there are arguments to explain algorithmic traders increasing both the amount of liquidity they demand and the amount of liquidity they supply following the release of corporate earnings announcements. The implication of both of these arguments is that there should be an increase in the amount of algorithmic trading activity immediately after the release of the information announcement. The first hypothesis tests this proposition.

Hypothesis$_{4,1}$: Algorithmic traders utilise their speed advantage over other market participants and therefore there is an increase in the amount of algorithmic trading activity immediately after the release of corporate earnings announcements.

There is some evidence in the previous research that algorithmic traders are 'better informed' than other market participants. Hendershott and Riordan (2011) found evidence that algorithmic trader's liquidity demanding trades impound significantly more information than corresponding orders by human traders. They suggested this implied algorithmic traders have more private information than human traders. Brogaard (2010) found evidence that high frequency traders have more private information than other market participants. Previous literature (Holden and Subrahmanyam 1992; Lee et al. 1993; Foster and Viswanathan 1996; Krinsky and Lee 1996; Barclay et al. 2003; Chae 2005; Cho 2007; Chordia et al. 2008) found evidence that informed traders would commence their trading activities in the pre-announcement period to utilise their information advantage. If algorithmic traders (collectively) have more private information than other market participants this would imply an increase in algorithmic trading activity prior to the release of the earnings announcement. The second hypothesis tests this proposition.

Hypothesis$_{4,2}$: Algorithmic traders are informed investors and therefore their trading activity will increase in the pre-announcement period as they act upon their informational advantage before returning to normal levels in the post-announcement period.

Algorithmic traders consist of a broad group of market participants with a wide ranging set of goals. Those traders using agency algorithms are primarily interested in minimising the adverse market impact of large trades. Traders making use of proprietary algorithms, on the other hand, seek to profit from changes in data information and events. Previous research (Chordia et al. 2001; Chae 2005; Fabiano 2008) indicates that discretionary liquidity traders (who do not possess private information) will postpone trading around earnings announcements until the information asymmetry is resolved. Brogaard (2010) found evidence that high frequency traders avoid trading with informed investors. Therefore, if the proportion of algorithmic traders without private information exceeds those with that information then the aggregate level of algorithmic trading would decline in the period immediately prior to the release of the information as the traders withdraw from the market until the information asymmetry is resolved. The third hypothesis on algorithmic trading tests this argument.

Hypothesis$_{4,3}$: Algorithmic traders are discretionary liquidity (uninformed) investors and therefore their trading activity will decrease prior to the announcement and remain below normal levels until the information asymmetry is resolved.

Research on the impact of reduced latency in electronic markets indicates that increased speed results in higher levels of algorithmic trading. Hendershott et al. (2011) found that the introduction on Autoquote on the NYSE resulted in an increase in message traffic of around 2 messages per minute. Hendershott and Moulton (2010) and Riordan and Storkenmaier (2011) also found similar results for other improvements in market trading technology. The fourth hypothesis in this section tests whether the introduction of co-location by the Australian Securities Exchange (ASX) has had an impact upon the patterns of algorithmic trading observed around corporate earnings announcements.

Hypothesis$_{4,4}$: The introduction of co-location has caused changes in the observed trading patterns of algorithmic traders around corporate earnings announcements.

Collectively these hypotheses represent an examination of the activities of algorithmic traders around corporate earnings announcements. This is an area which had not previously been empirically investigated.

2.6.3 Venture Capitalists and the Initial Public Offering Process

The existing scholarly research on the role of venture capitalists in the initial public offering process suggests two main models; the certification/monitoring model and the adverse selection/grandstanding model. This research has generally focused on the US venture capital market with very limited research on less well developed markets. The fifth chapter of this dissertation will empirically examine these models in the context of the Australian venture capital market, which is structurally different from its US counterpart.[136]

The certification/monitoring model posits that the participation of a venture capitalist in the IPO process will certify the value of the offering to third party investors (Megginson and Weiss 1991). This is a function of the venture capital investment process whereby the venture capitalist; selects potential new investments out of a range of ventures seeking scarce capital (Wells 1974; Tyebjee and Bruno 1984), rigorously investigates their potential future growth prospects through a stringent due diligence process (Wells 1974; Poindexter 1976; Tyebjee and Bruno 1981; Chan 1983; Arnold and Moizer 1984; MacMillan et al. 1985; Knight 1986; Dixon 1991; Pike et al. 1993; Muzyka et al. 1996, Wright and Robbie 1996a), generally takes large equity stakes and board seats on those firms they provide capital to (Rosenstein 1988;

[136] de Silva Rosa et al. (2003) previously found no support for either model in Australia.

MacMillan et al. 1988; Sahlman 1990; Rosenstein et al. 1993), stages financing contingent upon achieving prespecified goals (Cooper and Carleton 1979; Chan 1983; Amit et al. 1990; Admati and Pfleiderer 1994; Gifford 1997; Bergemann and Hege 1998; Neher 1999; Elitzur and Gavious 2003; Gompers 1995), activity participates in assisting their portfolio companies to develop their full potential (Gorman and Sahlman 1986; Sahlman 1990; Lan 1991; Elango et al. 1995; Lerner 1995), before finally bringing them to market when they have reached a sufficient level of development. Previous research by Barry et al. (1990), Megginson and Weiss (1991), Jain and Kini (1995), Lin (1996), Brav and Gompers (1997), Hamoa et al. (2000), Francis and Hasan (2001), and Wang et al. (2003) found evidence in support of this model. The first hypothesis tests whether the predictions of the certification model hold in the Australian market.

Hypothesis$_{5,1}$: Venture capital-backed IPOs exhibit better IPO performance and better post-IPO operating and market performance (although with the difference declining over time) than non venture capital-backed IPOs.

The adverse selection/grandstanding model posits that the participation of a venture capitalist in the IPO process provides a negative signal about the value of the offering to third party investors (Amit et al. 1990; Gompers 1996). Amit el at (1990) argued the 'promising' new ventures would be self-funded since more-capable entrepreneurs would not need to share the risk and therefore would not seek external financing. 'Average' new ventures on the other hand, would require venture capital financing since less-capable entrepreneurs would seek to share their risk. This gives rise to an adverse selection problem for the venture capitalist in finding promising new ventures to invest in. Furthermore, Wang et al (2003) argued that this problem would be more severe the earlier the stage of the venture capitalists investment. The grandstanding hypothesis (Gompers 1996) predicts that younger venture capital firms have a strong incentive to bring companies to market prematurely in order to establish a track record of IPO success. Venture capital funds are usually structured as limited partnerships and the funds have a typical life of ten years (Sahlman 1990). This means that the venture capitalist must regularly attempt to raise new capital in order to establish new funds (Sahlman 1990; Bygrave and Timmons 1992; Wright and Robbie 1998; Gompers and Lerner 2000a, 2000b; Jeng and Wells 2000). This is likely to be more easily accomplished if the venture capitalist has a proven track record of success. Also, given that a portion of the venture capitalists remuneration, the *management fee*, is charged as a percentage of this committed capital, the venture capitalist has a strong personal incentive to devote considerable time and energy towards ensuring the success of the capital raising process (Gompers 1996, 1998). Together these structural and remuneration factors could give rise to grandstanding by younger venture capital firms. Previous research by Gompers (1996), Wang et al. (2003) and Lee and Wahal (2004) found support for this model. The second hypothesis tests whether the predictions of the adverse selection/grandstanding model hold in the Australian market.

Hypothesis$_{5,2}$: Venture capital-backed IPOs exhibit worse IPO performance and worse post-IPO operating and market performance (with an increasing difference over time) than non venture capital-backed IPOs.

These hypotheses are not necessarily mutually exclusive. Older venture capital firms are likely to be more experienced in identifying promising ventures and more skilled at successfully bringing them to market, whereas younger venture capitalists might be more likely to suffer the consequences of adverse selection or to need to bring companies to market prematurely in order to support future capital raising. The third hypothesis tests whether there are differences, based upon the experience of their VC-backers, between the performance of VC-backed IPOs in the Australian market.

Hypothesis$_{5,3}$: IPOs backed by more experienced venture capital firms exhibited better IPO performance and better post-IPO operating and market performance than those backed by less experienced venture capital firms.

The findings of these tests enhance our understanding of the role played by venture capitalist backing of IPOs in a market where venture capital has a shorter history than is typically the case for most previous research in this field.

Chapter 3: Stock Returns around Corporate Earnings Announcements

3.1 Introduction

The first essay of this thesis empirically examines the intraday speed of stock price response to corporate earnings announcements. Using data from the Australian Securities Exchange (ASX) this chapter investigates this issue in a market which operates an open electronic central limit order book (CLOB), with exchange initiated trading halts for market sensitive announcements made during normal trading hours. Theoretical models of market efficiency prescribe a rapid adjustment of prices to a new equilibrium level following the release of corporate earnings announcements. Market microstructure models though suggest that this reaction speed may be tempered by the degree of information asymmetry between market participants and dealer inventory levels. Existing empirical literature on the intraday adjustment to earnings announcements provides evidence of differences in speed of price response based upon the timing of the announcement (Patell and Wolfson 1984; Lee 1992; Francis et al. 1992; Greene and Watts 1996) and the type of trading systems used by the market (Francis et al. 1992). The inconclusive nature of this evidence requires further investigation.

The findings of this chapter are presented in accordance with the documented hypotheses derived in Section 2.6.1. Specifically the chapter investigates three main hypotheses. The first hypothesis ($H_{3,1}$) predicts that there will be a difference between the speed of price adjustment for corporate earnings announcements made during normal trading hours and those made outside of normal trading hours. The second hypothesis ($H_{3,2}$) predicts that announcements made after the close of trading and/or on Fridays are more likely to contain negative earnings surprises than announcements made before the market opens or during normal trading hours on Monday through Thursday. The third hypothesis ($H_{3,3}$) predicts that the abnormal stock returns around corporate earnings announcements are positively related to the degree of earnings surprise contained within the announcement.

The remainder of this chapter is organised as follows. Section 3.2 discusses the institutional detail of information disclosure procedures on the Australian Securities Exchange (ASX). Section 3.3 describes the dataset and provides summary statistics of the sampled data. Section 3.4 outlines the research design. Section 3.5 presents the empirical results and a summary of the primary findings. Finally section 3.6 provides a concluding summary of the chapter.

3.2 Institutional Detail

The Australian Securities Exchange (ASX) operates an open electronic central limit order book trading system known as the Integrated Trading System (ITS).[137] As of the financial year ended 30 June 2011, the ASX had 2,247 listed entities with a combined market capitalisation of AUD 1.35 trillion. An average of 570,000 daily trades took place on the market with an average daily trade value of AUD 5.3 billion.[138] Trades are executed on a price then time priority and unexecuted limit orders are visible to all

[137] This system has recently (November 2010) been replaced by ASX Trade. The ITS system was in operation from October 2006 until November 2010.
[138] Figures sourced from ASX Ltd 2011 Annual Report.

market participants. Between 10:00 and 10:10 EST/EDT stocks are opened using a single price auction procedure and closing occurs randomly between 16:10 and 16:12 EST/EDT using a similar single price auction procedure.[139] Normal trading occurs between 10:10 and 16:00 EST/EDT.

Under Chapter 3 of the ASX Listing Rules, companies listed on the ASX are required to disclose to the exchange, prior to its release to any other source, any information that may influence the decision by an investor to buy or sell the company's securities. Specifically, ASX Listing Rule 3.1 states:

> Once an entity is or becomes aware of any information concerning it that a reasonable person would expect to have a material effect on the price or value of the entity's securities, the entity must immediately tell the ASX that information.

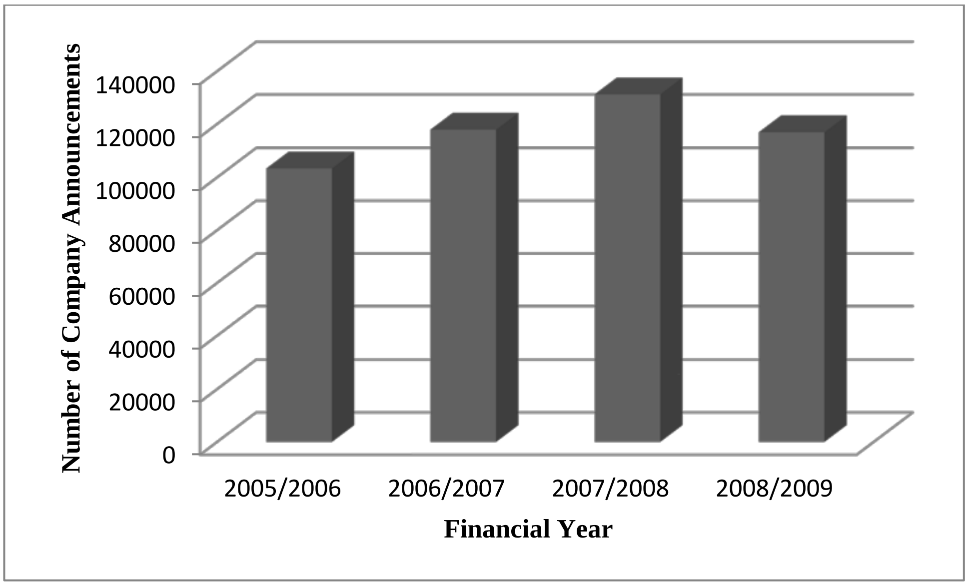
Listing Rule 3.1A outlines the exceptions to this rule. The entity is not required to disclose the information where all of the following criteria are satisfied; (i) a reasonable person would not expect to be disclosed, (ii) the information is confidential and the ASX has not formed the view that the information has ceased to be confidential, and (iii) one or more of the following applies [it would be a breach of law to disclose the information, the information concerns an incomplete proposal or negotiation, the information comprises matters of supposition or is insufficiently definite to warrant disclosure, the information is generated for internal management purposes of the entity, and/or the information is a trade secret].

[139] The same algorithm is used to calculated opening and closing prices on the ASX.

Figure 3.1

Total Market Announcements Released on ASX

This figure depicts the total number of company announcements released on the ASX over the financial years 2005/2006 to 2008/2009. Figures are taken from the ASX Annual Reports and ASX Markets Supervision Quarterly Activity Reports.



Where the information is not subject to one of these exceptions, the company is required to immediately submit the announcement in electronic form to the ASX. Under Chapter 16 of the ASX Market Rules, if the exchange receives information which, in the opinion of the designated ASX officer, is *market sensitive* a trading halt may be imposed. For announcements made during normal trading hours the exchange enforced trading halt is typically ten minutes in duration.[140] During that time the company's securities are placed in the *pre-open phase*, which means that limit orders can be entered, deleted and modified but no trades occur.[141] The information is then released by ASX ComNews in two stages. The first stage contains the headline for display on trading terminals whilst the second stage contains the full document in

[140] Trading halts for takeover announcements extend for up to 1 hour.
[141] Market orders cannot be placed during the pre-opening phase.

PDF format. This service is available directly through the ASX website or through information vendors such as Bloomberg, IRESS and Reuters. Trading halts end at a time announced by the ASX. At the end of the halt interval the stock is opened using the same single price call auction algorithm used for the opening and closing call markets. The stock then resumes normal trading. Figure 3.1 provides an illustration of the total number of information announcements released through the ASX each financial year over the period 2005/2006 to 2008/2009.

3.3 Data

The initial sample used in the study consisted of the final earnings announcements for the 100 stocks in the S&P/ASX 100 index for the financial years 2005/2006 through to 2008/2009. The S&P/ASX 100 index comprises 100 of the largest Australian companies on the Australian Securities Exchange (ASX), weighted in the index according to each company's market capitalisation. The date and time of the annual earnings announcement was taken from the *SIRCA Australian Company Announcements (ACA)* database containing details of the earnings announcement for each of the respective companies. These statements are issued by the ASX Company Announcements Office (CAO) through the Integrated Trading System (ITS) and provide subscribers with all company announcements lodged with the ASX. The announcements are date and time stamped. Since ASX listing rules require listed companies to release any information that might have a material effect upon the company's stock price to the exchange prior to the release to the general market, these announcement times should represent the first opportunity an investor would have to react to the public release of the earnings information. To avoid any possible problems caused by inaccuracies in the recorded time of the earnings announcement the ACA database times are cross referenced with those reported by the *Thompson Reuters I/B/E/S* database. Any discrepancies between these two times are further investigated to pinpoint the exact announcement time. The inability to resolve the conflict between these two sources for 118 announcements in the initial sample resulted in their elimination from the study. This left a study sample of 282 earnings announcements during the observation period.

Table 3.1

Announcement Sample Composition

This table provides summary statistics of the announcement sample. Panel A provides details of the number of announcements in the sample released during various intervals throughout the trading day. "Before Trading" is defined as announcements occurring between 7:00 and the market open at 10:10 EST/EDT. "After Trading" is defined as announcements occurring between 16:12 and 18:00 EST/EDT. No announcements occurred after this time. Panel B provides details of the number of announcements in the sample released on each calendar day.

Panel A: Sample announcement by clock time

Time of Release (EST/EDT)	Number of Earnings Announcements
Before Trading	213
10:00-11:00	12
11:00-12:00	14
12:00-13:00	15
13:00-14:00	2
14:00-15:00	4
15:00-16:12	7
After Trading	15
Total during normal trading hours	54
Total outside of normal trading hours	228

Panel B: Sample announcements by calendar day

Day of Release	Number of Earnings Announcements
Monday	33
Tuesday	48
Wednesday	87
Thursday	79
Friday	35
Total	282

Table 3.1 provides a breakdown of the announcement sample. The final sample of 282 announcements was partitioned into two subsamples based upon announcement time. Those announcements that were made during trading hours on the ASX (approximately 10:10 to 16:12pm[142] EST/EDT) are classified as part of the 'trading hours' subsample. Those announcements that were made either before the market opened (prior to 10:00 EST/EDT) or after the close of trading (after 16:12 EST/EDT) are classified as part of the 'overnight' subsample.

Two sets of data were collected for the companies in the sample. Both datasets were constructed from the *SIRCA Australian Equities Tick History* database. The first dataset consisted of executed trade price data recorded to the nearest hundredth of a second. To minimise the possible impact of bid-ask bounce a second dataset was constructed using the midpoint of the bid-ask spread at each examination interval.[143] This second set of data provided a comparative set of information with which to enhance the accuracy of conclusions drawn. Due to the fact the data comes directly from an automated trading system this provided information of uncommon accuracy and reliability.

The data for the test sample was collected for a three-day event period window consisting of the trading day prior to the announcement, the announcement day and the trading day after the announcement. The control sample data was collected for the

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[142] The ASX uses a random opening procedure to open trading in the morning. Under the opening procedure stocks are opened in staged sets at different times based upon the first letter of their ASX code. This also fluctuates by up to 15 seconds each day. This is designed to minimise the impact of front running by traders. Hence the 10am start is not necessarily the opening time for any individual stock. Likewise the market ceases trading at a random time around 16:10-16:12 each trading day.

[143] Bid-ask bounce occurs in trade price information as the result of one trade taking place at the bid price and then a successive trade taking place at the ask price. This could create the illusion of an information-induced return over an interval when the equilibrium price remains unchanged and could lead to false conclusions.

corresponding weekdays for a period of ten weeks prior to, and ten weeks subsequent to, the event day. This meant that, for example, if the announcement was on a Tuesday then the control period was calculated using values on Monday (the corresponding pre-announcement weekday), Tuesday (the corresponding announcement weekday) and Wednesday (the corresponding post-announcement weekday) for ten weeks before and ten weeks after the announcement date. This was a much longer control period than previous intraday papers used.[144]

For the final parts of the study consensus earnings forecasts of up to 29 brokers in the period immediately prior to the earnings announcement was collected.[145] The most recent consensus forecast prior to the release of the announcement reported on the *Thompson Reuters I/B/E/S* database was recorded for each announcement. The equally weighted aggregate of these forecasts was used as a proxy for the market expectations of the firm's EPS and hence the difference between this aggregate forecast and the actual earnings announcement is taken to reflect the unanticipated component (earnings surprise) of the earnings announcement. This is consistent with the method used by previous empirical research to proxy earnings surprise.[146]

3.4 Research Design

The four data sets (overnight trade prices, trading hours' trade prices, overnight midpoint bid-ask spread and trading hours' midpoint bid-ask spread) were then used

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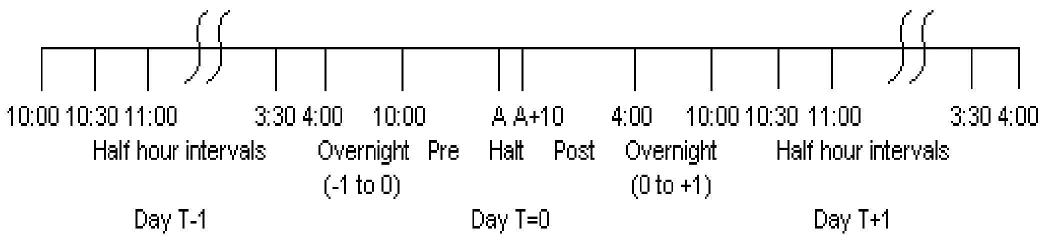
[144] For example Patell and Wolfson (1984) used five randomly selected non-event days for the control period.
[145] The precise number of analyst forecasts varies from stock to stock and year to year.
[146] See for example, Patell and Wolfson 1984; Woodruff and Senchack 1988; Lee 1992; Francis et al. 1992; Greene and Watts 1996; Lee and Park 2000; Bagnoli et al 2005; DellaVigna and Pollet 2009; Doyle and Magilke 2009; Kothari et al. 2009; Truong 2010).

to calculate returns over a series of measurement intervals. Figure 3.2 illustrates the return intervals used for the two trading hours' subsamples. Each half-hour interval on the pre-announcement day and the post-announcement day is treated as an observation period. Half-hour intervals were selected as they represent a suitable compromise between the problem nonsynchronous trading, that can affect very short measurement intervals, and the misspecification problem that can affect longer-term intervals. Furthermore Mucklow (1994), in an examination of the impact of market microstructure factors upon intraday event studies, found that provided the appropriate statistical measures were used the selection of the measurement interval did not ultimately impact upon the general applicability of the conclusions drawn. The time period from the end of the closing call market one day to the end of the opening call market following morning is treated as a single interval and labelled the 'overnight' interval. This is done on the basis that no trading can occur over this period and hence the close to open return represents a potential reaction or re-appraisal of information by the market over that period.

Figure 3.2: Return Measurement Intervals for the Trading Hours Subsamples



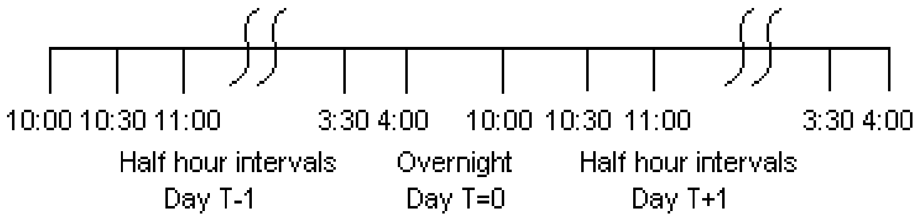
Where A is defined as the announcement time and A+10 is the end of the trading halt following the earnings announcement.

The event day is treated as three distinct unequal length periods. The first measurement period on the event day is labelled the 'pre' measurement interval and consists of the time from the first trade during normal trading of the day to the commencement of the trading halt. This interval can be thought of as measuring the impact of any private information that reaches the market prior to the official announcement being released by the ASX. The next measurement period on the event day is the ‘halt’ interval. This interval represents the time in which trading in the stock is suspended by the ASX to allow the market time to assess the impact of the information release and thus minimise the impact of any overreaction. Therefore this interval extends from the commencement of the trading halt (shortly before the time of the announcement) to the single price auction at the end of the pre-opening phase (the end of the trading halt). The third measurement period on the event day is labelled the ‘post’ interval. This interval is measured from the end of the trading halt through to the last trade during normal trading that day. This interval represents the period of adjustment that follows the announcement. Any delayed reaction to the earnings announcement (beyond the trading halt) will be captured during this interval. If an announcement occurs within the last ten minutes of normal trading there will be no ‘post’ announcement measurement interval.

Each of these return intervals is measured relative to each announcement and hence the length of each of the event day intervals varies depending upon the time of the day in which the earnings announcement was made. The same procedure is used for the midpoint subsample to ensure consistency except that the midpoint of the bid-ask spread is used instead of the executed trade price at the beginning and end of each interval.

Figure 3.3 illustrates the calculation of the return intervals for the two overnight subsamples. It follows the same procedure outlined for the trading hours' subsamples with half-hour intervals being calculated for the pre- and post-announcement days. The difference comes with the treatment of the event day, T=0. The event day is defined as the overnight period during which the announcement was made. For announcements made after the close the first opportunity the market has to react to the information contained within the announcement is the opening call market the next day. Likewise, for announcements made prior to the commencement of trading at 10:00 investor's first opportunity to respond is the opening call market that day.

Figure 3.3: Return Measurement Intervals for the Overnight Subsamples



The control period returns are calculated using the exact same procedure for the ten weeks prior and subsequent to the three-day event window, with the unequal event day measurement intervals for the control period being treated identically to the event day. This ensures that the noise effects of intraday data are appropriately controlled for in the analysis.

Returns over each interval are calculated using the logarithmic return metric equation 3.1.

$$R_{i,n} = In\left(\frac{P_{i,t}+D_{i,t}}{P_{i,t-1}}\right) \qquad \textbf{(3.1)}$$

Where

$R_{i,n}$ = the log return for stock *i* over the interval *n* (*t-1* to *t*)

$P_{i,t}$ = the price of stock *i* at time *t* (the end of the measurement interval)

$D_{i,t}$ = the dividend paid on stock *i* during time period *t* (if any)

$P_{i,t-1}$ = the price of stock *i* at time *t-1* (the beginning of the measurement interval)

Muckow (1994) argued that logarithmic returns eliminate the bias induced in a return metric by the bid-ask spread and price discreteness. As this is a serious concern when using intraday data, logarithmic returns are used in this study. This raw return model is used as the calculation for each time interval rather than mean-adjusted or market adjusted models because Mucklow (1994) finds that for periods of less than sixty minutes the use of unadjusted (raw) returns resulted in well specified statistical tests. Likewise, Brown and Warner (1980, 1985) found in event study research that even the simplest model, the constant mean return model, often yields similar results to other more sophisticated models. MacKinlay (1997) states that this lack of sensitivity to the model can be attributed to the fact that the variance of abnormal return is frequently not reduced much by choosing a more sophisticated model.

Another problem frequently encountered in intraday event study research is noncontinuous trading. This occurs where the stock does not trade in a given measurement interval. Trades at discrete time intervals are not a problem if the equilibrium prices do not change between trades. In this case the price at any point in time is simply the last trade price. If however the equilibrium prices do change during the period in which no trading occurs then there are price adjustment delays. For example if stock *i* trades a price P_{it} in time period *t* and then does not trade again until period *t+4* then the return for interval *t* to *t+1* is not clearly evident. This problem is overcome by using a quasiaccrual method of measuring the interval returns. This method allocates the return evenly over the period's *t+1* to *t+n*. Using such an approach implicitly assumes the equilibrium prices change uniformly over the nontrading period. This is the technique that has been employed in this study.

To determine the speed of the market's reaction to the information contained within the earnings announcement two statistical tests are used to determine if the returns calculated for each of the event window period are significantly different from those of the corresponding control period. Significant differences imply a period of price adjustment in that measurement interval compared to 'normal' conditions for that security. Paired sample T-test scores and Mann-Whitney-Wilcoxon Z scores are used to detect significant differences between the event window returns and control period returns, assuming normal and non-normal distributions respectively. Examining the number of intervals relative to the time of the announcement that price adjustments are taking place enables a test of the hypothesis ($H_{3,1}$) that there are differences in the speed of reaction between the two subsamples.

To examine whether managers strategically time the release of earnings reports the announcements were partitioned into two subsamples; (i) those announcements which are released after the close of trading and/or on Friday, and (ii) those announcements that are released prior to or during trading on Monday through Thursday. The earnings surprise was then determined for each subsample. The earnings surprise was calculated using equation 3.2.

$$ES_{i,t} = \frac{EPS_{i,t} - AF_{i,t}}{AF_{i,t}} \qquad \textbf{(3.2)}$$

Where

$ES_{i,t}$ = Earnings surprise for stock *i* in year *t*

$EPS_{i,t}$ = Actual earnings per share for stock *i* in year *t*

$AF_{i,t}$ = Consensus analyst forecast of the expected EPS for stock *i* in year *t*

Those measurement intervals that were found to be significantly different from their corresponding control period were regressed against the size of the earnings surprise in order to determine if that difference represented a reaction to the information content or simply a response to other market factors. The regression model is given in equation 3.3.

$$R_{i,t} = \alpha + \beta ES_{i,t} + \varepsilon \qquad \textbf{(3.3)}$$

Where

$R_{i,t}$ = the return calculated for stock *i* in the significant event time interval *t*

α = the constant component of the return

β = the coefficient of the earnings surprise variable

$ES_{i,t}$ = the earnings surprise variable for stock *i* in year *t*

The t-statistics and corresponding p-values for the coefficient of the earnings surprise variable are reported for the regressions. This tests the third hypothesis that predicts that the abnormal stock returns around corporate earnings announcements are positively related to the degree of earnings surprise contained within the announcement.

3.5 Empirical Results

The average percentage returns for the overnight trade interval subsample are shown in Table 3.2. As expected the ‘overnight’ interval return of approximately 0.302 per cent is shown to be highly significant using the Wilcoxon-Mann-Whitney non-parametric test (at the 5 per cent confidence level) although the T-test for the same interval is not statistically significant. This reflects the first opportunity the market has to trade upon the earnings announcement after it is released. This result is consistent with previous intraday research which suggests the market reacts quickly to the release of new information in the overnight period (Patell and Wolfson 1984; Lee 1992; Greene and Watts 1996; Lee and Park 2000).

Table 3.2
Trade Returns for the Overnight Subsample

This table details the intraday trade interval returns accompanying annual earnings announcements. [a] Measurement intervals are defined as 30 minute intervals relative to the announcement day t=0. The overnight interval is the period from the close of trading at 16:12 until the open the following morning at approximately 10:10. All of the announcements within this subsample fall within that period. [b]Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Measurement Interval[a]		Announcement Subsample: Number of Observations	Announcement Subsample: Average Return (%)	Control Subsample: Number of Observations	Control Subsample: Average Return (%)	Paired-samples T-score[b]	Mann-Whitney Z-score[b]
T-1	10:00-10:30	228	0.0388	4560	-0.0069	0.363	-1.006
	10:30-11:00	228	-0.0164	4560	-0.0113	-2.519**	-0.247
	11:00-11:30	228	0.0662	4560	0.0000	1.346	-0.044
	11:30-12:00	228	0.0308	4560	0.2154	-0.323	-0.440
	12:00-12:30	228	-0.0392	4560	-0.0151	-0.716	-1.048
	12:30-1:00	228	-0.0616	4560	-0.0023	-1.289	-0.125
	1:00-1:30	228	-0.0108	4560	-0.0187	-0.179	-0.197
	1:30-2:00	228	-0.0013	4560	0.0051	-0.363	-0.349
	2:00-2:30	228	-0.0236	4560	0.0160	0.020	-0.826
	2:30-3:00	228	0.0063	4560	-0.0387	0.214	-0.668
	3:00-3:30	228	0.0085	4560	0.0073	-0.222	-1.382
	3:30-4:00	228	0.0162	4560	0.0243	0.350	-0.106
T=0	Overnight	228	0.3023	4560	0.0945	1.042	-1.957**
T+1	10:00-10:30	228	-0.0189	4560	0.0175	-0.360	-0.091
	10:30-11:00	228	-0.0492	4560	-0.0107	-0.506	-0.020
	11:00-11:30	228	-0.0252	4560	-0.0236	-0.024	-0.711
	11:30-12:00	228	-0.0646	4560	-0.0120	-0.962	-0.694
	12:00-12:30	228	0.0255	4560	-0.0084	0.674	-1.726
	12:30-1:00	228	0.0314	4560	-0.0011	0.829	-0.455
	1:00-1:30	228	-0.0638	4560	-0.0134	-1.506	-0.084
	1:30-2:00	228	0.0270	4560	0.0092	0.535	-0.756
	2:00-2:30	228	-0.0238	4560	-0.0100	-0.224	-0.024
	2:30-3:00	228	-0.0107	4560	-0.0137	0.061	-0.056
	3:00-3:30	228	0.0971	4560	0.0146	-1.599	-1.728
	3:30-4:00	228	-0.0178	4560	0.0012	-0.249	-1.632

The ‘10:30-11:00’ interval on day T-1 is also found to be significant using the t-test (at the 5 per cent confidence level) but not under the Wilcoxon-Mann-Whitney non-parametric test. This result does not appear to be consistent with any likely implications of the overnight earnings announcement since there is little reason to believe that information leakage would occur during that specific time interval. No other measurement interval returns on the day prior to the announcement or the day following it are shown to be significantly different from those of the control period using either statistical test.

Table 3.3 provides the average percentage returns for the trading hours’ interval subsample. The ‘halt’ interval return of approximately -0.154 per cent is shown to be significant at the 5 per cent confidence level using both the parametric and non-parametric tests. This interval corresponds to the ‘overnight’ interval in the overnight subsample in that it reflects the first opportunity the market has to disseminate and trade upon new information. Other intervals to exhibit significance differences between the event window returns and the control period returns were the ‘2:30-3:00’ interval on day T-1 (at the 5 per cent confidence level for both tests), the ‘3:00-3:30’ interval on day T-1 (at the 5 per cent confidence level for the t-test and the 10 per cent confidence level for the Wilcoxon-Mann-Whitney non-parametric test), the ‘overnight (0 to +1)’ period following the announcement (at the 5 per cent confidence level for the t-test and the 10 per cent confidence level for the Wilcoxon-Mann-Whitney non-parametric test), and the ’10:00-10:30’ interval on day T+1 (at the 5 per cent confidence level for both tests). The ’11:00-11:30’ interval on day T+1 was also significant using the Wilcoxon-Mann-Whitney non-parametric test (at the 10 per cent confidence level) but not using the t-test.

Table 3.3
Trade Returns for the Trading Hours' Subsample

This table details the intraday trade interval returns accompanying annual earnings announcements. [a] Measurement intervals are defined as 30 minute intervals relative to the announcement day t=0. The overnight interval is the period from the close of trading at 4pm until the open the following morning at approximately 10am. The 'pre' period is the interval from open to the announcement time. The 'halt' period is the interval from the announcement time until the first trade after the halt. The 'post' period is the interval from the first trade after the halt until the close. [b]Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Measurement Interval[a]		Announcement Subsample Number of Observations	Announcement Subsample Average Return (%)	Control Subsample Number of Observations	Control Subsample Average Return (%)	Paired-samples T-score[b]	Mann-Whitney Z-score[b]
T-1	10:00-10:30	54	0.1255	1080	-0.0503	1.350	-1.050
	10:30-11:00	54	-0.0452	1080	0.0271	-0.673	-0.754
	11:00-11:30	54	-0.0391	1080	-0.0241	0.318	-0.458
	11:30-12:00	54	0.0261	1080	-0.0041	0.415	-1.035
	12:00-12:30	54	-0.0318	1080	-0.0024	-0.393	-0.044
	12:30-1:00	54	-0.0020	1080	0.0161	-0.374	-0.178
	1:00-1:30	54	-0.0230	1080	0.0069	-0.447	-0.961
	1:30-2:00	54	-0.0094	1080	0.0239	-0.590	-0.015
	2:00-2:30	54	0.0529	1080	-0.0361	1.281	-1.065
	2:30-3:00	54	0.2149	1080	0.0396	2.354**	-2.233**
	3:00-3:30	54	-0.1792	1080	-0.0059	-2.305**	-1.627***
	3:30-4:00	54	0.1102	1080	0.0577	1.429	-1.375
T=0	Overnight (-1 to 0)	54	0.2787	1080	-0.0191	0.919	-0.665
	Pre	54	-0.0991	1080	0.0076	-0.554	-0.074
	Halt	54	-0.1540	1080	0.0270	-1.724**	-2.277**
	Post	51	-0.5289	1020	-0.0532	-0.660	-0.838
	Overnight (0 to +1)	54	0.7242	1080	0.1569	1.779**	-1.848***
T+1	10:00-10:30	54	-0.3660	1080	-0.0166	-1.680**	-2.011**
	10:30-11:00	54	-0.1616	1080	0.0072	-1.069	-1.493
	11:00-11:30	54	-0.1538	1080	0.0075	-1.234	-1.789***
	11:30-12:00	54	0.0198	1080	0.0334	-0.172	-0.177
	12:00-12:30	54	-0.1557	1080	0.0013	-1.541	-0.932
	12:30-1:00	54	-0.0038	1080	-0.0125	0.132	-0.562
	1:00-1:30	54	-0.0579	1080	0.0245	-1.328	-1.212
	1:30-2:00	54	0.0416	1080	-0.0126	0.855	-1.672
	2:00-2:30	54	-0.0349	1080	-0.0273	-0.129	-0.207
	2:30-3:00	54	0.2025	1080	-0.0016	1.251	-1.168
	3:00-3:30	54	-0.1429	1080	-0.0034	-1.459	-1.050
	3:30-4:00	54	0.0337	1080	-0.0382	0.639	-0.355

Patell and Wolfson (1984) found a similar result in their research for the periods after the announcement although they did not divide their sample upon the basis of whether the announcement occurred during or after trading. Francis et al. (1992) also found evidence of reactions to announcements made during normal trading hours extending into the overnight period on the announcement date. They argued that the overnight period is the first opportunity for news to be disseminated to those traders who are unable to execute intraday trading strategies and hence the ‘overnight’ (0 to +1) and ‘10:00-10:30’ on day T+1 interval returns reflect their reactions to the information release. More recent work by Greene and Watts (1996) found that the opening price on the NYSE fully impounds the value of the information in the stock price for overnight announcements but for announcements made during trading the response is spread evenly over the several trades after the information release.

As with the overnight subsample period, there is evidence of significant differences between the returns of the observation sample and the control sample prior to the release of the information. In this case though, these intervals are close to the end of trading (and therefore perhaps represent the activities of informed traders acting on information leakage). No other sample interval returns over the examination period show any significant difference from their corresponding control period returns. It is also interesting to note that the immediate ‘post’ announcement returns are not significantly different from the control period returns, which indicates that the immediate adjustment to the information content in the earnings announcement is taking place quickly during the halt period rather than spilling into the trades after the single call price is determined at the end of the trading halt. It should be noted that the number of observations in the sample and control period changes due to the fact that three announcements were made shortly before the market closed and hence no ‘post’ interval is recorded for those announcements.

These results appear to confirm the expectations of the first hypothesis. The evidence of significant differences between the returns in periods other than the immediate post announcement interval for announcements made during normal trading hours is different from the reaction pattern observed for announcements made outside of normal trading hours. This does not allow a rejection of the null hypothesis that there is no difference between the speed of price adjustment for corporate earnings announcements made during normal trading hours and those made outside of normal trading hours. To confirm the robustness of these results the midpoint of the bid-ask spread returns are also examined.

Tables 3.4 and 3.5 provide the average percentage returns for the overnight and trading hours’ subsample using the midpoint of the bid-ask spread rather than executed trade prices. The results for the overnight subsample presented in Table 3.4 illustrate the same results as those for the executed trades’ subsample. The ‘overnight’ measurement interval return of 0.3884 per cent is shown to be significant at the 5 per cent level for both the parametric and non-parametric tests. Unlike the executed trade returns subsample, the ‘10:30-11:00’ interval on day T-1 is no longer significant. No other measurement interval returns are significantly different from their corresponding control period return, which is consistent with the notion that the market is able to impound the value of the new information for overnight announcements in the opening call market the following day.

Table 3.4
Midpoint BAS Returns for the Overnight Subsample

This table details the intraday midpoint of the bid-ask spread interval returns accompanying annual earnings announcements. [a] Measurement intervals are defined as 30 minute intervals relative to the announcement day t=0. The overnight interval is the period from the close of trading at 16:12 until the open the following morning at approximately 10:10. All of the announcements within this subsample fall within that period. [b]Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

		Announcement Subsample		Control Subsample			
Measurement Interval[a]		Number of Observations	Average Return (%)	Number of Observations	Average Return (%)	Paired-samples T-score[b]	Mann-Whitney Z-score[b]
T-1	10:00-10:30	228	0.0245	4560	-0.0147	0.288	-0.947
	10:30-11:00	228	-0.0288	4560	-0.0321	-0.351	-0.161
	11:00-11:30	228	0.0503	4560	0.0144	0.442	-0.624
	11:30-12:00	228	0.0121	4560	0.0932	-0.245	-0.847
	12:00-12:30	228	0.0755	4560	-0.0628	-0.812	-1.214
	12:30-1:00	228	-0.0583	4560	-0.0892	-0.466	-0.954
	1:00-1:30	228	0.0201	4560	-0.0368	-0.315	-0.397
	1:30-2:00	228	-0.0144	4560	0.0187	-0.387	-0.355
	2:00-2:30	228	-0.0268	4560	0.0584	0.149	-0.843
	2:30-3:00	228	0.0364	4560	0.0477	0.018	-0.129
	3:00-3:30	228	0.0095	4560	0.0155	-0.122	-0.982
	3:30-4:00	228	0.0188	4560	0.0342	0.263	-0.111
T=0	Overnight	228	0.3884	4560	0.0749	1.754**	-2.142**
T+1	10:00-10:30	228	-0.0247	4560	0.0189	-0.361	-0.154
	10:30-11:00	228	-0.0384	4560	0.0010	-0.906	-0.140
	11:00-11:30	228	-0.0133	4560	-0.0457	-0.129	-0.845
	11:30-12:00	228	-0.0786	4560	-0.0348	-0.356	-0.484
	12:00-12:30	228	0.0189	4560	-0.0243	0.875	-1.124
	12:30-1:00	228	0.0723	4560	-0.0624	0.330	-0.671
	1:00-1:30	228	-0.0327	4560	-0.0404	-0.846	-0.610
	1:30-2:00	228	0.0328	4560	0.0987	0.444	-0.720
	2:00-2:30	228	-0.0657	4560	-0.0670	-0.020	-0.034
	2:30-3:00	228	-0.0414	4560	-0.0636	0.969	-0.403
	3:00-3:30	228	0.0776	4560	0.0988	-1.551	-0.864
	3:30-4:00	228	-0.0154	4560	0.0511	-0.097	-0.679

Table 3.5
Midpoint BAS Returns for the Trading Hours' Subsample

This table details the midpoint of the bid-ask spread interval returns accompanying annual earnings announcements. [a] Measurement intervals are defined as 30 minute intervals relative to the announcement day t=0. The overnight interval is the period from the close of trading at 4pm until the open the following morning at approximately 10am. The 'pre' period is the interval from open to the announcement time. The 'halt' period is the interval from the announcement time until the first trade after the halt. The 'post' period is the interval from the first trade after the halt until the close. [b]Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

		Announcement Subsample		Control Subsample			
Measurement Interval[a]		Number of Observations	Average Return (%)	Number of Observations	Average Return (%)	Paired-samples T-score[b]	Mann-Whitney Z-score[b]
T-1	10:00-10:30	54	0.1552	1080	-0.0901	1.198	-1.116
	10:30-11:00	54	-0.0822	1080	0.0229	-0.279	-0.639
	11:00-11:30	54	-0.0057	1080	-0.0117	0.752	-0.764
	11:30-12:00	54	0.0174	1080	-0.0555	0.242	-1.144
	12:00-12:30	54	-0.0134	1080	-0.0315	-0.756	-0.816
	12:30-1:00	54	-0.0715	1080	0.0801	-0.162	-0.187
	1:00-1:30	54	-0.0667	1080	0.0437	-0.382	-0.949
	1:30-2:00	54	-0.0815	1080	0.0903	-0.434	-0.957
	2:00-2:30	54	0.0844	1080	-0.0240	1.050	-1.061
	2:30-3:00	54	0.1815	1080	0.0806	1.932**	-2.184**
	3:00-3:30	54	-0.1476	1080	-0.0084	-2.289**	-1.998**
	3:30-4:00	54	0.1174	1080	0.0893	1.120	-1.283
T=0	Overnight (-1 to 0)	54	0.1105	1080	-0.0194	0.777	-0.412
	Pre	54	-0.0435	1080	0.0162	-0.587	-0.380
	Halt	54	-0.1779	1080	0.0403	-1.883**	-2.123**
	Post	51	-0.3022	1020	-0.0797	-0.864	-0.836
	Overnight (0 to +1)	54	0.6651	1080	0.1964	1.987**	-1.939***
T+1	10:00-10:30	54	-0.2789	1080	-0.0397	-1.680**	-2.011**
	10:30-11:00	54	-0.1340	1080	0.0040	-1.379	-1.206
	11:00-11:30	54	-0.0895	1080	0.0497	-0.937	-0.915
	11:30-12:00	54	0.0022	1080	0.0016	-0.034	-0.218
	12:00-12:30	54	-0.1304	1080	0.0109	-1.149	-0.912
	12:30-1:00	54	0.0500	1080	0.0016	0.464	-0.715
	1:00-1:30	54	-0.0810	1080	0.0999	-1.363	-1.300
	1:30-2:00	54	0.0407	1080	-0.0694	0.817	-1.665
	2:00-2:30	54	-0.0253	1080	-0.0116	-0.295	-0.222
	2:30-3:00	54	0.1294	1080	-0.0427	1.146	-1.298
	3:00-3:30	54	-0.0909	1080	-0.0623	-0.946	-0.963
	3:30-4:00	54	0.0219	1080	-0.0546	0.907	-0.770

Table 3.5 presents the percentage returns for the trading hours' subsample using the midpoint of the bid-ask spread. The results from this table are generally consistent with those for the executed trades' subsample. The 'halt' interval percentage return of -0.1779 per cent is shown to be significantly different from its corresponding control period return for both the parametric and non-parametric tests (at the 5 per cent confidence level for both tests). As with the executed trade subsample, the other intervals to exhibit significance differences between the event window returns and the control period returns were the '2:30-3:00' interval on day T-1 (at the 5 per cent confidence level for both tests), the '3:00-3:30' interval on day T-1 (at the 5 per cent confidence level for both tests), the 'overnight (0 to +1)' period following the announcement (at the 5 per cent confidence level for the T-test and the 10 per cent confidence level for the Wilcoxon-Mann-Whitney non-parametric test), and the '10:00-10:30' interval on day T+1 (at the 5 per cent confidence level for both tests).

The most significant difference between the two subsamples is the weak significance found in the '11:00-11:30' interval using executed trade returns is not significant at all using midpoint quote. Otherwise both return measurement techniques yield almost identical results suggesting that bid-ask bounce does not significantly affect the results when dealing with frequently traded companies such as those in the ASX 100 index.

Overall the results for the overnight subsample suggest that the price impact of the announcement is impounded within the opening call market but for announcements made during normal trading hours the price reaction appears to extend beyond the immediate period after the announcement to encompass both the overnight period (that is the opening call market) and the commencement of trading the following day. Likewise, there are significant returns late in the trading session on the day prior to the announcement, possibly caused by investors speculating on the outcome of the announcement.

Previous research has suggested that managers have an incentive to strategically time information announcements. Patell and Wolfson (1982) found evidence that managers are more likely to release bad news after the close of trading whilst good news is more likely to be released during trading. Damodaran (1989) found evidence that Friday announcements are more likely to contain bad news. In each case this represents an attempt by the firm's manager to reduce the adverse price consequences that stem from poor earnings announcements. Thus, the second hypothesis investigated in this chapter predicts that announcements made after the close of trading and/or on Fridays are more likely to contain negative earnings surprises than announcements made before the market opens or during normal trading hours on Monday through Thursday.

Table 3.6 presents the results of partitioning the announcements into two subsamples; (i) those that are made after the close and/or on Fridays, and (ii) those that are made before or during normal trading on Monday to Thursday. The mean earnings surprise for the two subsamples was almost identical. For announcements made after the close and/or Friday the reported EPS was 2.843 per cent below the consensus analysts forecast. For announcements made before the market opens or during normal trading hours the reported EPS was 2.877 per cent below the consensus analysts forecast. The median result for after close and/or Friday announcements was slightly lower compared to the median result for the before the market opens or during normal trading hours announcements, -0.66 per cent and -0.094 per cent respectively. However, neither of these results was significant using either parametric or nonparametric tests.

Table 3.6

Strategic Timing of Earnings Announcements

This table examines the hypothesis that announcements made after the close of trading and/or Friday are more likely to contain negative earnings surprises than announcements made at other times. The announcement sample was partitioned into two groups: (i) those announcements that were released after the market ceased trading and/or on Fridays, and (ii) those announcements that were released before or during trading on Monday through Thursday. Earnings surprise is measured as the reported EPS minus the consensus forecast EPS scaled by the consensus forecast EPS. T-Test and Mann-Whitney scores are reported for the test that the mean earnings surprise is negatively larger for after close and/or Friday earnings announcements. Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

	After close and/or Friday announcements	Monday-Thursday announcements
Number of Announcements	50	232
Mean (Median) Earnings Surprise	-0.02843	-0.02877
	(-0.00666)	(-0.00094)
Standard Deviation	0.18253	0.09985
T-Test F-Score	0.013	-
Mann-Whitney Z-Score	-0.625	-

This means for this sample of announcements made on the ASX there does not appear to be any evidence of strategic timing. Announcements made after the close of trading and/or on Friday contain no more ‘bad’ news than announcements released before the market opens or during normal trading. Therefore, the null hypothesis of there being an equal likelihood of ‘bad’ news being released before the market opens or during normal trading on Monday to Thursday as there is after the market closes and/or on Friday cannot be rejected.

In order to investigate whether the significant returns identified previously are related to the informational content of the earnings announcement, the earnings surprise is regressed against each of those measurement interval returns. This should confirm whether those significantly different returns reflect the investor's revaluation of the stock price in light of the revealed information content of the EPS announcement or if they are a reflection of speculative or noise trading. For the two trading hours' subsamples the significant intervals were '2:30-3:00' and '3:00-3:30' on day T-1, 'halt', 'overnight (0 to +1)' on the day of the announcement and '10:00-10:30' and '11:00-11:30' on day T+1. For the two overnight subsamples the only significant interval was the overnight period containing the announcement time.

The results for the regressions on the trade generated returns subsample are presented in Table 3.7. Panel A of Table 3.7 contains the value of the coefficient of earnings surprise for the overnight subsample. The coefficient is positive indicating 'good' news results in an upward price revision and 'bad' news results in a 'downward' price revision. As we would expect the t-statistic and p-values for both the 'overnight' measurement interval are significant at the 1 per cent level. The R-squared of the regression is 22.5 per cent with the adjusted R-squared value of 19.70 per cent. This result implies that the market reaction identified earlier is the outcome of the market re-evaluation of the intrinsic value of the stock based upon the new information contained in the earnings announcement. This is consistent with our expectations of the third hypothesis which predicts that the abnormal stock returns around corporate earnings announcements are positively related to the degree of earnings surprise contained within the announcement.

Table 3.7
Trade Price Returns Regressions

Results of the ordinary least squares regression of the magnitude of the earnings surprise against the statistically significant returns around the announcement period – trade generated returns subsample. [a]Measurement intervals are defined as 30 minute intervals relative to announcement day t=0. The overnight interval is the period from the close of trading at 4pm until the open the following morning at approximately 10am. The 'pre' period interval is from open to the announcement time. The 'halt' period is the interval from the announcement time until the first trade after the halt. The 'post' period is the interval from the first trade after the halt until the close. [b]T-statistic of the test of the null hypothesis of the coefficient is equal to zero against the alternative hypothesis that the coefficient is greater than zero. Corresponding P-values are also given. [c]R-squared and adjusted R-squared values of the proportion of variability in the respective interval return explained by the earnings surprise variable.

Panel A: Overnight announcement subsample returns

Measurement Intervals[a]		Earnings Surprise Coefficient	T-statistic (P-value)[b]	Constant	T-statistic (P-value)[b]	R-Sq[c]	R-Sq (Adj)[c]
T=0	Overnight	0.325	3.533 (0.001)	0.005	1.406 (0.163)	22.5%	19.7%

Panel B: Trading hours' announcement subsample returns

Measurement Intervals[a]		Earnings Surprise Coefficient	T-statistic (P-value)[b]	Constant	T-statistic (P-value)[b]	R-Sq[c]	R-Sq (Adj)[c]
T-1	2:30-3:00	0.224	1.214 (0.235)	0.002	3.087 (0.005)	5.0%	1.6%
	3:00-3:30	0.250	1.364 (0.183)	-0.002	2.508 (0.018)	6.2%	2.9%
T=0	Halt	0.338	3.693 (0.001)	0.003	1.046 (0.217)	32.7%	27.8%
	Overnight (0 to +1)	0.018	0.435 (0.667)	0.007	2.244 (0.033)	5.0%	2.9%
T+1	10:00-10:30	0.096	0.495 (0.625)	-0.004	-1.983 (0.058)	4.2%	3.0%
	11:00-11:30	-0.084	-0.421 (0.678)	-0.002	-1.208 (0.238)	7.7%	3.3%

Table 3.8
Midpoint BAS Returns Regressions

Results of the ordinary least squares regression of the magnitude of the earnings surprise against the statistically significant returns around the announcement period – midpoint generated returns subsample [a]Measurement intervals are defined as 30 minute intervals relative to announcement day t=0. The overnight interval is the period from the close of trading at 4pm until the open the following morning at approximately 10am. The 'pre' period interval is from open to the announcement time. The 'halt' period is the interval from the announcement time until the first trade after the halt. The 'post' period is the interval from the first trade after the halt until the close. [b]T-statistic of the test of the null hypothesis of the coefficient is equal to zero against the alternative hypothesis that the coefficient is greater than zero. Corresponding P-values are also given. [c]R-squared and adjusted R-squared values of the proportion of variability in the respective interval return explained by the earnings surprise variable.

Panel A: Overnight announcement sample returns

Measurement Intervals[a]		Earnings Surprise Coefficient	T-statistic (P-value)[b]	Constant	T-statistic (P-value)[b]	R-Sq[c]	R-Sq (Adj)[c]
T=0	Overnight	0.399	3.488 (0.001)	0.003	1.245 (0.201)	21.4%	18.6%

Panel B: Trading hours announcement sample returns

Measurement Intervals[a]		Earnings Surprise Coefficient	T-statistic (P-value)[b]	Constant	T-statistic (P-value)[b]	R-Sq[c]	R-Sq (Adj)[c]
T-1	2:30-3:00	0.184	1.307 (0.414)	-0.001	3.364 (0.005)	2.0%	1.6%
	3:00-3:30	0.158	1.471 (0.132)	0.005	1.495 (0.220)	5.4%	2.8%
T=0	Halt	0.436	3.937 (0.001)	0.003	1.112 (0.156)	29.5%	25.4%
	Overnight (0 to +1)	0.111	0.947 (0.714)	0.004	1.847 (0.056)	4.2%	3.1%
T+1	10:00-10:30	0.085	0.593 (0.647)	-0.003	-1.943 (0.059)	3.0%	2.1%
	11:00-11:30	-0.064	-0.682 (0.415)	-0.001	-1.299 (0.148)	4.1%	3.4%

Panel B of Table 3.7 contains the results for the trading hours' subsample. For the trading hours' subsample the 'halt' measurement interval coefficient is positive and is significant at the 1 per cent level and with an adjusted R-squared of approximately 28 per cent. Those intervals in the 'during' trading hours subsample that were previously found to have significantly different returns over the observation period from the control period; the '2:30-3:00' and '3:00-3:30' on day T-1, the 'overnight' (0 to +1), and the '10:00-10:30' and the '11:00-11:30' on day T+1; were not found to be related to the size of the earnings surprise. This suggests that the significant returns observed earlier were not a function of the information content of the earnings announcement.

Table 3.8 contains the output of the regressions for the midpoint of the bid-ask spread generated subsamples. Panel A of Table 3.8 provides the results for the regression on the significant measurement interval, 'overnight' for the overnight subsample. As predicted the coefficient of earning surprise is positive (0.399) and significant at the 1 per cent level. The R-squared values of the regression are between 19% and 21% and hence are of acceptable levels. This result is consistent with the values obtained for the trade generated returns data set contained in Table 3.7 Panel A and hence supports the tested hypothesis.

Panel B of Table 3.8 provides the outcomes for the regressions of the trading hours subsample returns. Again the 'halt' period return exhibits a positive coefficient with a very high level of significance when regressed against the earnings surprise variable (0.001 p-value). This result is consistent with the findings of the executed trades' subsample. Also no other measurement intervals are shown to have any significant relation to the size of the earnings surprise, which is also consistent with the executed trades' subsample shown in Table 3.7 Panel B. This provides further evidence that the differences in returns between the event period and the control period are not the related to the information content contained in the earnings announcement which is consistent with the premise of capital market efficiency.

Overall, these results enable a rejection of the third null hypothesis that the abnormal stock returns around corporate earnings announcements are unrelated related to the degree of earnings surprise contained within the announcement. For both subsamples (trading hours and overnight) and for both return measurement techniques (executed trade returns and mid-point of the BAS) the measurement interval immediately after the earnings announcement exhibits abnormal return activity that is significantly positively related to the degree of earnings surprise contained within the announcement. No other measurement periods exhibit significant results.

3.6 Summary

These results have a number of important implications for our understanding of the way in which security prices impound the information content of corporate earnings announcements. When examining the returns for various measurement intervals around earnings announcements, this study found evidence of abnormally large returns, relative to the control period, for a number of intervals before and after the announcement time. This is consistent with a number of previous studies. Patell and Wolfson (1984) found evidence of abnormal returns in the overnight period and the first 30 minutes of trading on the following trading day after earnings announcements.

Francis et al. (1992) found evidence that abnormal returns for announcements made during normal trading hours extended into the overnight period after the announcement. They also found evidence that the abnormal returns following overnight announcements extended beyond the market opening the following day. The findings of this study appear to confirm these results. These findings were robust to executed trade price and midpoint of the bid-ask spread measures of returns.

However, when the measurement intervals are regressed against a proxy for the unexpected component of information in the announcement it was revealed that only the interval immediately after the release was found to be significant. This was the case regardless of whether the announcement was made before, during, or after normal trading hours. This result demonstrates that, in terms of return measures, in an open electronic central limit order book (CLOB) with exchange enforced trading halts is able to rapidly impound the information content of corporate earnings announcements. This supports the notion of capital market efficiency.

Furthermore, there was no evidence of strategic timing by firm managers. This is consistent with recent academic research on strategic timing (Doyle and Magilke 2009; Truong 2010). An examination of the unexpected component of earnings for announcements made after the close of trading and/or on Fridays found they exhibited a strikingly similar mean earnings surprise to those announcements made before or during normal trading on Mondays to Thursdays. This could be a function of the speed of response findings which imply a rapid price adjustment regardless of release time. This would reduce the incentive to engage in strategic timing. In addition, exchange enforced trading halts following the release of a market sensitive announcements would negate the need to create a ‘natural halt’ by delaying the release until after the close of trading.

Chapter 4: Algorithmic Trading around Corporate Earnings Announcements

4.1 Introduction

The second essay of this thesis empirically examines the trading activities of algorithmic traders around corporate earnings announcements. With exchanges investing considerable resources into improving market access arrangements and reducing system latency there is considerable interest amongst policy makers about what impact algorithmic trading has on equity markets. Existing research has focused upon exploring the general trading activities of algorithmic traders (Prix et al. 2007; Brogaard 2010), the impact algorithmic traders (or high frequency traders) have had upon market quality (Brogaard 2010; Hendershott and Riordan 2011; Hendershott et al. 2011; Hasbrouck and Saar 2011), or the impact of technology on algorithmic trading (Hendershott and Moulton 2010; Riordan and Storkenmaier 2011). However, our understanding of how algorithmic traders behave around corporate information releases is limited due to the scarcity of scholarly literature in this area. The second essay of this dissertation will fill some of that knowledge gap. Using data from the Australian Securities Exchange (ASX) this chapter investigates this issue by examining the patterns of message traffic, as a proxy for algorithmic trading, around the release of annual earnings announcements.

The findings of this chapter are presented in accordance with the documented hypotheses derived in Section 2.6.2. Specifically the chapter investigates four main hypotheses. The first hypothesis ($H_{4,1}$) predicts that algorithmic traders utilise their speed advantage over other market participants and therefore there is an increase in the amount of algorithmic trading activity immediately after the release of corporate earnings announcements. The second hypothesis ($H_{4,2}$) predicts that algorithmic traders are informed investors and therefore their trading activity will increase in the pre-announcement period as they act upon their informational advantage before returning to normal levels in the post-announcement period. The third hypothesis ($H_{4,3}$) predicts that algorithmic traders are discretionary liquidity (uninformed) investors and therefore their trading activity will decrease prior to the announcement and remain below normal levels until the information asymmetry is resolved. The final hypothesis ($H_{4,4}$) predicts that the introduction of co-location has caused changes in the observed trading patterns of algorithmic traders around corporate earnings announcements.

The remainder of this chapter is organised as follows. Section 4.2 discusses the institutional detail of the introduction of co-location by the Australian Securities Exchange (ASX). Section 4.3 describes the dataset and provides summary statistics of the sampled data. Section 4.4 outlines the research design. Section 4.5 presents the empirical results and a summary of the primary findings. Finally section 4.6 provides a concluding summary of the chapter.

4.2 Institutional Detail

The Australian Securities Exchange (ASX) provides a number of mechanisms to facilitate algorithmic trading by its clients. The introduction of Automated Order Processing (AOP) rules in 1997 provided the framework for Participants to offer

Direct Market Access (DMA) to their clients. DMA gives clients the ability to connect directly[147] with the limit order book. Whilst most DMA clients are not engaged in algorithmic trading, DMA is seen as a prerequisite for algorithmic trading (Karagozoglu 2011). In December 2008 the ASX commenced offering co-location services to its Market Participants to facilitate DMA and algorithmic trading. Co-location enabled Market Participants to place their trading equipment and assigned ITS Gateway machines within the same physical data centre as the ASX ITS primary matching engine. This arrangement was designed to enable high speed market data and trade execution at 'near zero' network latency.[148] To facilitate the speedy roll-out of the facility the service was initially only available to Participants on a limited, first come first serve basis. The service was subsequently expanded with the completion of the Australian Liquidity Centre (ALC) facility in November 2011 as part of the introduction of ASX Trade.[149]

The ASX does not require Participants to pre-specify whether they will be algorithmic trading themselves or whether their clients will be algorithmic trading. In fact, a Participant may not know whether its clients are engaged in algorithmic trading since the client is not required to disclose the reason behind any individual decision to initiate an order on the ASX. ASX does not require Participants to identify specific algorithms that are in use. However, ASX can, either directly or indirectly, obtain this information if necessary. ASX Market Surveillance (ASXMS) can ask a Participant for details of trading to assist in investigation and enforcement activity. Additionally, the ASX or ASXMS can determine with a reasonable degree of certainty via analysis

[147] The ASX requires that Participants maintain adequate filters to detect trades that may breach the law or trading rules.
[148] "New Co-location Hosting Service for ASX Participants", *ASX Media Release*, 3 July 2008.
[149] "ASX Australian Liquidity Centre", *ASX*, 2011.

of trade data, which orders are generated by an algorithm (ASX Review 2010). External market participants are unlikely to have access to this information and are limited to making inferences about algorithmic trading via patterns in trading activity or message traffic.

4.3 Data

The initial sample used in the study consisted of the final earnings announcements for the 200 stocks in the S&P/ASX 200 index for the financial years 2007/2008 and 2008/2009. The S&P/ASX 200 index comprises 200 of the largest Australian companies on the Australian Securities Exchange (ASX), weighted in the index according to each company's market capitalisation. The date and time of the annual earnings announcement was taken from the SIRCA *Australian Company Announcements (ACA)* database containing details of the earnings announcement for each of the respective companies. These statements are issued by the ASX Company Announcements Office (CAO) through the Integrated Trading System (ITS) and provide subscribers with all company announcements lodged with the ASX. The detail of the release of these announcements was provided in the previous chapter. As with the previous essay, to avoid any possible problems caused by inaccuracies in the recorded time of the information announcement all announcement times were cross-referenced with those reported by the *Thompson Reuters I/B/E/S* database. Any discrepancies between these two times are further investigated to pinpoint the exact announcement time. The inability to resolve the conflict between these two sources for 34 announcements in the sample resulted in their elimination from the study.

Given that any algorithmic trading, in particular high frequency trading, decision may rely on the speed of response to the announcement any announcements that were made prior to the commencement of normal trading or after the close of normal trading were eliminated from the sample. That meant only announcements made between 10:10 am and 16:00pm EST/DST were included in the sample. This left a sample of 110 earnings announcements during the sample period, of which 52 were before co-location was introduced and 58 were after.

Table 4.1 Panel A provides a breakdown of the announcement sample by clock time categorised into half-hour intervals throughout the day. Announcements are made each half-hour interval during the trading day, with a high concentration in the two intervals immediately after the opening call market. Panel B shows the sample announcements partitioned into two subsamples relative to the introduction of co-location by the ASX in late 2008. The two partitions consist of approximately half the sample each. Many companies are common to both subsamples due to the fact that they release their corporate earnings announcements at approximately the same day and time each year. Panel C shows the breakdown of firms in the sample by market capitalisation. The average firm market capitalisation in the sample is $4,148.88 million whilst the median figure is $1,301.88 million. The figures are slightly higher for the pre co-location subsample but these differences are not significant.

Order flow data used in the study was sourced from the *SIRCA Australian Equities Tick History* order book database. This database contains all order entries, modifications, cancellations, executed trades, and traded volume for supported instruments time-stamped to the nearest millisecond.

Table 4.1
Announcement Sample Composition

This table provides summary statistics of the announcement sample. Panel A provides details of the number of announcements in the sample released during half-hour intervals throughout the trading day. Panel B provides details of the number of announcements prior to and subsequent to the introduction by the ASX of co-location hosting. Panel C provides details of the market capitalisations of the firms on the announcement sample.

Panel A: Sample announcement by clock time

Time of Release (EST/EDT)	Number of Earnings Announcements
10:10-10:29	29
10:30-10:59	22
11:00-11:29	5
11:30-11:59	5
12:00-12:29	12
12:30-12:59	9
13:00-13:29	4
13:30-13:59	5
14:00-14:29	4
14:30-14:59	4
15:00-15:29	2
15:30-16:00	9
Total Sample Announcements	110

Panel B: Sample announcement partitioned around ASX co-location hosting

Time of Release (EST/EDT)	Pre Co-location Announcements	Post Co-location Announcements
10:10-10:29	12	17
10:30-10:59	10	12
11:00-11:29	2	3
11:30-11:59	0	5
12:00-12:29	9	3
12:30-12:59	4	5
13:00-13:29	2	2
13:30-13:59	3	1
14:00-14:29	2	2
14:30-14:59	2	2
15:00-15:29	1	1
15:30-16:00	5	4
Total Announcements	52	58

Panel C: Announcement firm market capitalisations

	Mean ($m)	Median ($m)	Maximum ($m)	Minimum ($m)
All sample	4,148.88	1,301.88	42,356.68	77.46
Pre Co-location	4,392.88	1,378.14	42,356.68	77.46
Post Co-location	3,943.41	1,259.68	34,932.77	92.43
t-statistic (p-value)	-0.308 (0.759)			

Consensus analyst forecast EPS and actual EPS, number of reporting analysts, and enterprise value data for each firm in the sample was sourced from the *Thompson Reuters I/B/E/S* database. As with the study in the previous chapter, the equally weighted aggregate of these forecasts was used as a proxy for the market expectations of the firm's EPS and hence the difference between this aggregate forecast and the actual earnings announcement is taken to reflect the unanticipated component (earnings surprise) of the earnings announcement. Market capitalisation data for each company in the sample at the time of the announcement was sourced from the *Morningstar DatAnalysis* database.

4.4 Research Design

Many of the existing studies on algorithmic trading (or high frequency trading) have focused upon markets in which this type of trading activity can be explicitly identified, such as the Deutsche Böerse *Xetra* trading system (Prix et al. 2007; Hendershott and Riordan 2011; Riordan and Storkenmaier 2011), or have used data on the trading activities of the AT/HFT firms themselves (Brogaard 2010). However, Hendershott et al. (2011) demonstrated that for a market in which algorithmic trading activity is not explicitly identified, the rate of electronic message traffic can serve as an effective proxy. They argued that this is the method most commonly used by market participants, exchanges and other market venues. The reason for using the rate of electronic message traffic as a proxy is that algorithmic trading activity has been demonstrated to exhibit high frequency of order submission, amendments and deletions. For example, Hasbrouck and Saar (2011) provided an example of a security for which, during a 78 second interval on 2 October 2007, orders to sell 100 shares were submitted (and quickly cancelled) 142 times. They also reported that during much of this period there was no activity other than these messages.

Therefore, the rate message traffic has been used as a proxy for algorithmic trading in this study to identify the patterns in algorithmic trading activities around corporate earnings announcements. In the case of the ASX, electronic message traffic consists of order submissions, deletions, amendments and executed trades that are submitted via the ITS trading system. The amount of message traffic in each measurement interval is identified using equation 4.1.

$$MT_{i,t} = \sum Enter_{i,t} + \sum Delete_{i,t} + \sum Amend_{i,t} + \sum Trade_{i,t} \qquad \textbf{(4.1)}$$

Where:

$MT_{i,t}$ = Raw message traffic for security i in measurement interval t

$Enter_{i,t}$ = New orders submitted for security i in measurement interval t

$Delete_{i,t}$ = Existing orders deleted for security i in measurement interval t

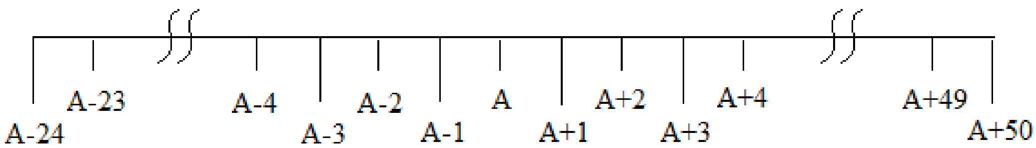
$Amend_{i,t}$ = Existing orders amended for security i in measurement interval t

$Trade_{i,t}$ = Executed trades for security i in measurement interval t

This metric captures all new limit (*Enter*) and market (*Trade*) orders submitted, together with all deletions (*Delete*) and amendments (*Amend*) of exiting orders for each sample security in the measurement intervals around the announcement date.

For the purposes of examining the rate of electronic message traffic, the trading days surrounding the corporate earnings announcements were broken up into a number of measurement intervals. Message traffic was calculated for a series of approximately half-hour intervals commencing twelve trading hours (around two trading days) prior to the time of the information release and continuing for twenty five trading hours (around four trading days) after the announcement. Half-hour intervals were chosen as they represent the most common measurement intervals used in previous intraday event studies (Patell and Wolfson 1984; Lee 1992; Francis et al. 1996; Lee and Park 2000). The sample was carefully screened to ensure that no other market sensitive announcements were made by the sample firms during this period. No such announcements were found. Figure 4.1 illustrates how the half-hour intervals were constructed around the announcement time.

Figure 4.1 Message Traffic Measurement Intervals around Corporate Earnings Announcements



Where A is defined as the announcement time and +/- indicates how many half-hour periods after or prior to the announcement the interval occurs.

On the day of the announcement the half-hour intervals were centred on the exact time of the information release. This meant that if an announcement occurred at, for example, 13:10 EST/DST then interval ‘A+1’ extended from 13:10 to 13:40 EST/DST, interval ‘A+2’ extended from 13:40 to 14:10 EST/DST, interval ‘A-1’ extended from 12:40 to 13:10 EST/EDT, and so on. Due to the amount of volume that is traded during those times, the opening and closing call markets are included in the half-hour measurement intervals where they occur. Hence the measurement intervals run from 10:00 to 16:12 EST/EDT each trading day. Where a potential interval has less than 30 minutes, which may occur in the first and last interval of the announcement day the following procedure was used; (i) if the remaining portion was 10 minutes or less then it was merged into the previous/succeeding interval, or (ii) if the remaining portion was 11 minutes or longer than is was treated as a separate (shorter) interval. For days other than the day of the announcement, the measurement intervals were calculated for each half-hour commencing at 10:00 EST/EDT (including the opening call market) and extending through to end of the closing call market at 16:12 EST/EDT.

To isolate the effect of the earnings release from other intraday effects a control sample was also constructed. For each security in the announcement sample a randomly selected date was chosen one to three weeks prior to the information release date. On this randomly selected date a proxy 'announcement time' was established at exactly the same time as the firm's actual announcement date. Then measurement intervals were constructed in precisely the same manner as described for the event window. This control window was carefully screened for any market sensitive announcements and where such announcements were found a different period was selected. This process was repeated until an announcement free period was determined. This control sample was then used to determine 'normal' levels of message traffic exogenous to the corporate earnings announcement.

To compensate for the slight differences between measurement periods caused by uneven intervals, the raw message traffic metric was standardised by the length of each individual measurement interval to get a measure of message traffic per minute. This metric is calculated using equation 4.2.

$$MTM_{i,t} = \frac{MT_{i,t}}{Time_t} \qquad \textbf{(4.2)}$$

Where:

$MTM_{i,t}$ = Message traffic per minute for security *i* in measurement interval *t*

$MT_{i,t}$ = Raw message traffic for security *i* in measurement interval *t*

$Time_t$ = The length of time in minutes of measurement interval *t*

Two methods were then used to determine the statistical significance of any abnormal message traffic per minute (*MTM*) during the event window measurement intervals. Firstly, an independent sample T-test and a Mann-Whitney-Wilcoxon U test was used to detect any significant differences between the *MTM* in each event window measurement interval from its corresponding control measurement interval, assuming normal and non-normal distributions respectively. Secondly, a single sample t-test was used to determine if the change in abnormal message traffic per minute (defined as the event window *MTM* minus the corresponding control period *MTM*) from one measurement interval to the next measurement interval around the announcement was significantly different from zero. Determining which measurement intervals exhibit significantly different levels of message traffic per minute enables an investigation of which of the three hypotheses ($H_{4,1}$; $H_{4,2}$; $H_{4,3}$) outlined at in section 4.1 seems mostly likely to describe the behaviour of algorithmic traders around corporate earnings announcements.

However, to establish causality of any detected abnormal trading activity, and to determine whether the introduction of co-location by the ASX has had any impact on any detected trading patterns, a pooled regression model is constructed. The specification of the regression model is given in equation 4.3.

$$AbMTM_{i,t} = \alpha + \beta_1 ES_i + \beta_2 Analysts_i + \beta_3 LogEnt_i + \beta_4 LogVolume_{i,t} + \beta_5 Time_i + \beta_6 Colocation \qquad \textbf{(4.3)}$$

Where *AbMTM* is the abnormal message traffic per minute for security *i* in interval *t*, *ES* is the unexpected component (earnings surprise) of the earnings announcement for firm *i*. Given the relationship between earnings surprise and abnormal returns around corporate earnings announcements established in the previous chapter, it is possible that any increase in message traffic is attributable to an increase in general trading activity directly linked to the new information rather than algorithmic trading. This variable controls for that possibility. Earnings surprise is measured as the difference between the actual EPS figure announced and the most recent consensus analyst forecast of the expected EPS for the firm standardised by the security price. *Analysts* is a measure of the number of analysts providing forecasts of the expected EPS for firm *i*. Previous research as revealed that analyst recommendations reveal information to the market and hence a greater number of analysts following the firm is likely to reduce the degree of information asymmetry surrounding the announcement (Lloyd Davies and Canes 1978; Bjerring et al. 1983; Beneish 1991; Brown and Kim 1991; Stickel 1995; Womack 1996; Kim et al. 1997; Asquith et al. 2005; and Green 2006). This helps distinguish whether any abnormal trading activity by algorithmic traders is informed or uninformed. *LogEnt* is the log of the enterprise value at the time of the announcement for firm *i*. Larger firms would be expected to exhibit higher levels of message traffic by virtue of having a larger number of securities on offer in the marketplace and higher levels of media attention of their earnings announcements. This variable is a control for the effects of firm size upon message traffic. *LogVolume* is the log of the aggregate number of firm *i* shares traded in measurement interval *t*. Higher volume of traded securities in a measurement interval may result in higher levels of electronic message traffic without there being an increase in the amount of algorithmic trading. This variable controls for this effect.

Time is a dummy variable set to one if the announcement in made between 10:00 and 10:30 EST/EDT or zero otherwise. Due to a large portion of the announcements in the sample being released just after the opening call market this dummy variable tests whether any observed change in message traffic around the time of the announcement is a function of the transition from the opening call market to normal trading in the interval immediately prior to the release. *Colocation* is a dummy variable that is set to one if the announcement is released prior to the introduction of co-location in December 2008 and zero is the announcement is made after that time. This dummy variable is designed to test the hypotheses ($H_{4,4}$) that predicts that the introduction of co-location has caused changes in the observed trading patterns of algorithmic traders around corporate earnings announcements.

4.5 Empirical Results

Figure 4.2 illustrates the rate of message traffic per minute for each of the half-hour intervals surrounding the announcement release commencing twenty four periods before the announcement and extending through to fifty periods after the announcement.

Figure 4.2

Rate of Message Traffic per Minute for the Event Window (Full Announcement Sample)

This figure shows the rate of message traffic per minute for each of the half-hour measurement intervals commencing 24 periods before the earnings announcement (A-24) and extending through to 50 periods after the release of the announcement (A+50).

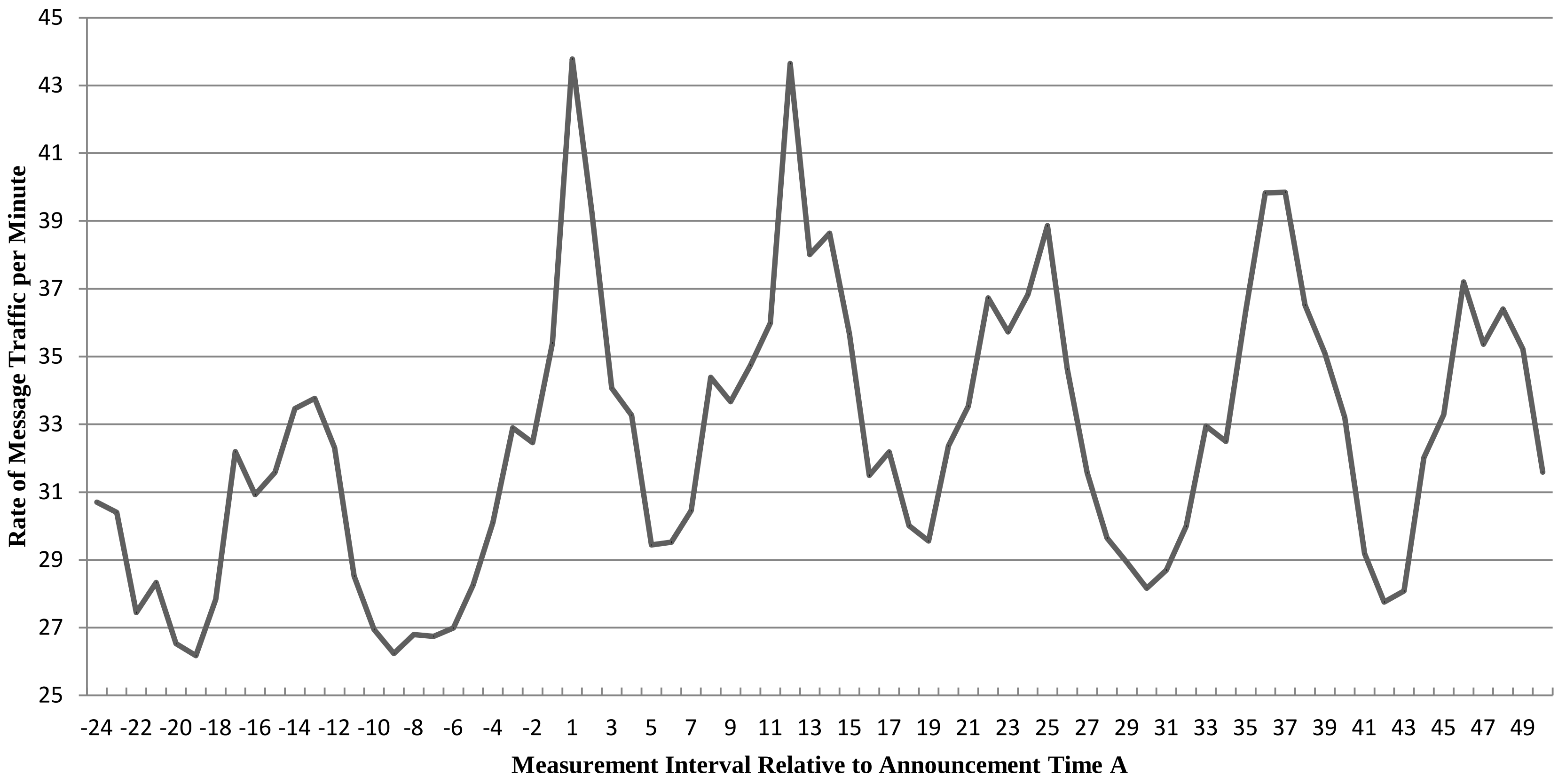
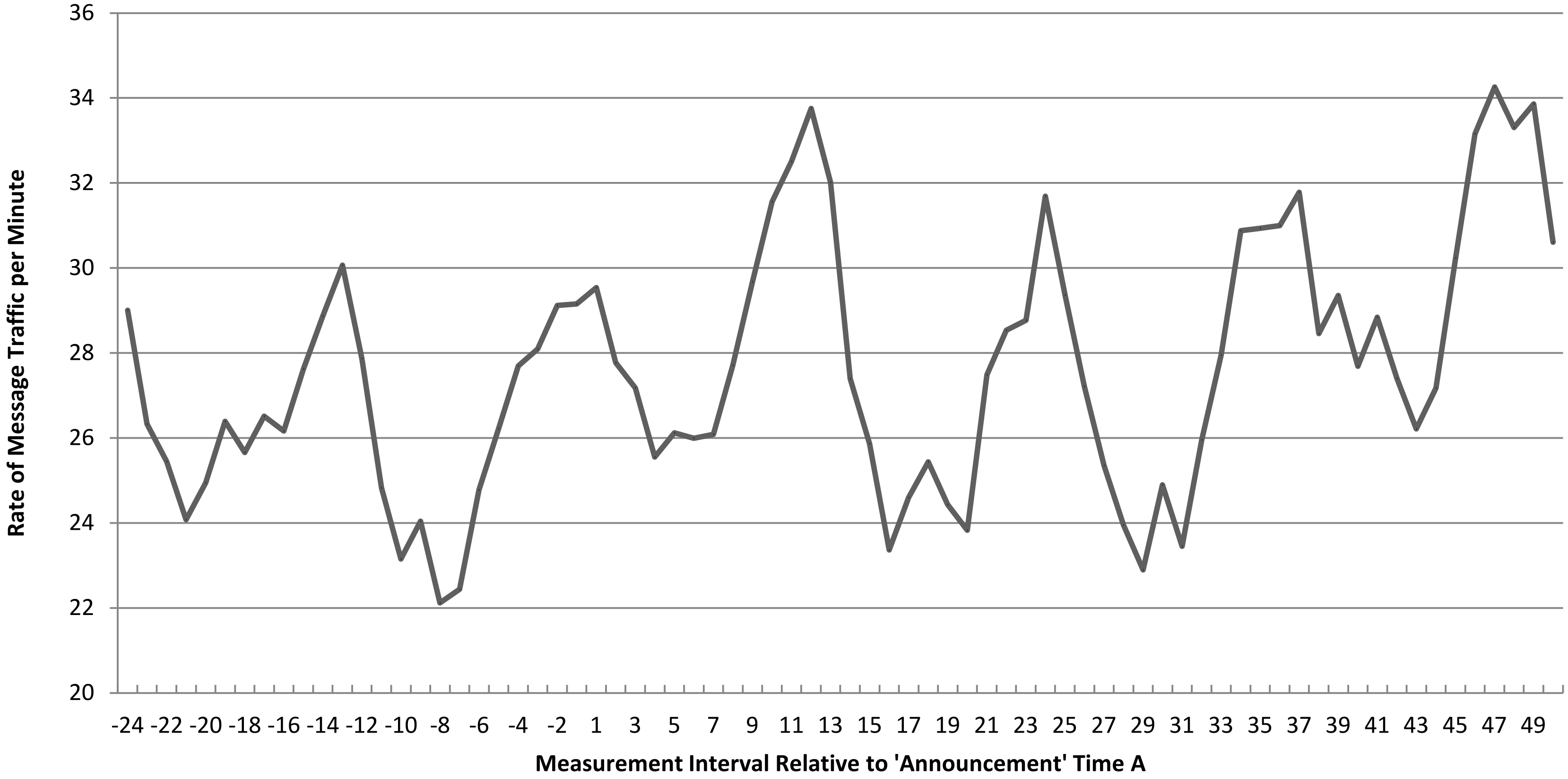


Figure 4.3

Rate of Message Traffic per Minute for the Control Period (Full Announcement Sample)

This figure shows the rate of message traffic per minute for each of the half-hour measurement intervals commencing 24 periods before the control 'earnings announcement' (A-24) and extending through to 50 periods after the time of the control 'announcement' (A+50).



For the event window, message traffic averaged 32.55 messages per minute with a peak of 43.78 messages per minute in the half-hour interval immediately after the release of the corporate earnings announcement. Message traffic levels appear to be elevated for much of the post-announcement period with a gradual decline towards levels consistent with the pre-announcement period near the end of the event window. There is little evidence of elevated traffic levels prior to the information release which does not imply support for the second hypothesis ($H_{4,2}$) that predicts algorithmic traders are informed investors and therefore their trading activity will increase in the pre-announcement period as they act upon their informational advantage before returning to normal levels in the post-announcement period. Nor does there appear to be any evidence in support of the third hypothesis ($H_{4,3}$) which predicts algorithmic traders are discretionary liquidity (uninformed) investors and therefore their trading activity will decrease commencing prior to the announcement and remain below normal levels until the information asymmetry is resolved. Rather the elevated message traffic per minute immediately after the announcement is more consistent with the prediction of the first hypothesis ($H_{4,1}$) that algorithmic traders utilise their a speed advantage over other market participants and therefore there is an increase in the amount of algorithmic trading activity immediately after the release of corporate earnings announcements.

Figure 4.3 illustrates the rate of message traffic per minute in each half hour measurement interval for the control window. During the control period, message traffic averaged 27.62 messages per minute which is 37 per cent below the interval average for the event window. This is suggestive of a difference relative to the event window intervals. Both figures illustrate patterns of peaks and troughs roughly consistent with the timing of the opening and closing call markets (periods of elevated trading volume) relative to the large grouping of announcements in the sample made between 10:10 and 11:00 EST/EDT.

Figure 4.4 illustrates the level of abnormal message traffic around the corporate earnings announcements for the full sample. For each measurement interval the message traffic during the control window (as illustrated in Figure 4.3) is subtracted from the message traffic during the event window (as illustrated in Figure 4.2) to obtain an illustration of the pattern of abnormal (or excess) message traffic per minute during each of the measurement intervals surrounding the announcement. This figure clearly illustrates the abnormally elevated message traffic in the interval immediately after the time of the earnings release. Message traffic increases by 14.25 messages per minute during this half-hour period.

Figures 4.5 and 4.6 illustrate the pattern of message traffic per minute for the pre and post co-location subsamples. For the pre co-location subsample message traffic averaged 21.1 messages per minute during the event window. This was very similar to the 21.8 messages per minute average for the corresponding control period (not shown). However, in the half-hour interval immediately after the announcement, message traffic peaked at 31.28 messages per minute. For the post co-location sample there is evidence of an overall elevation in message traffic, with an average of 40.8 messages per minute during the event window (compared to 32.08 messages per minute during the control period). Again, message traffic peaks in the interval immediately after the announcement (54.13 messages per minute).

Figure 4.4

Rate of Abnormal Message Traffic per Minute for the Event Window (Full Announcement Sample)

This figure shows the rate of message traffic per minute for each of the half-hour measurement intervals commencing 24 periods before the earnings announcement (A-24) and extending through to 50 periods after the release of the announcement (A+50) minus the rate of message traffic for the corresponding control period interval.

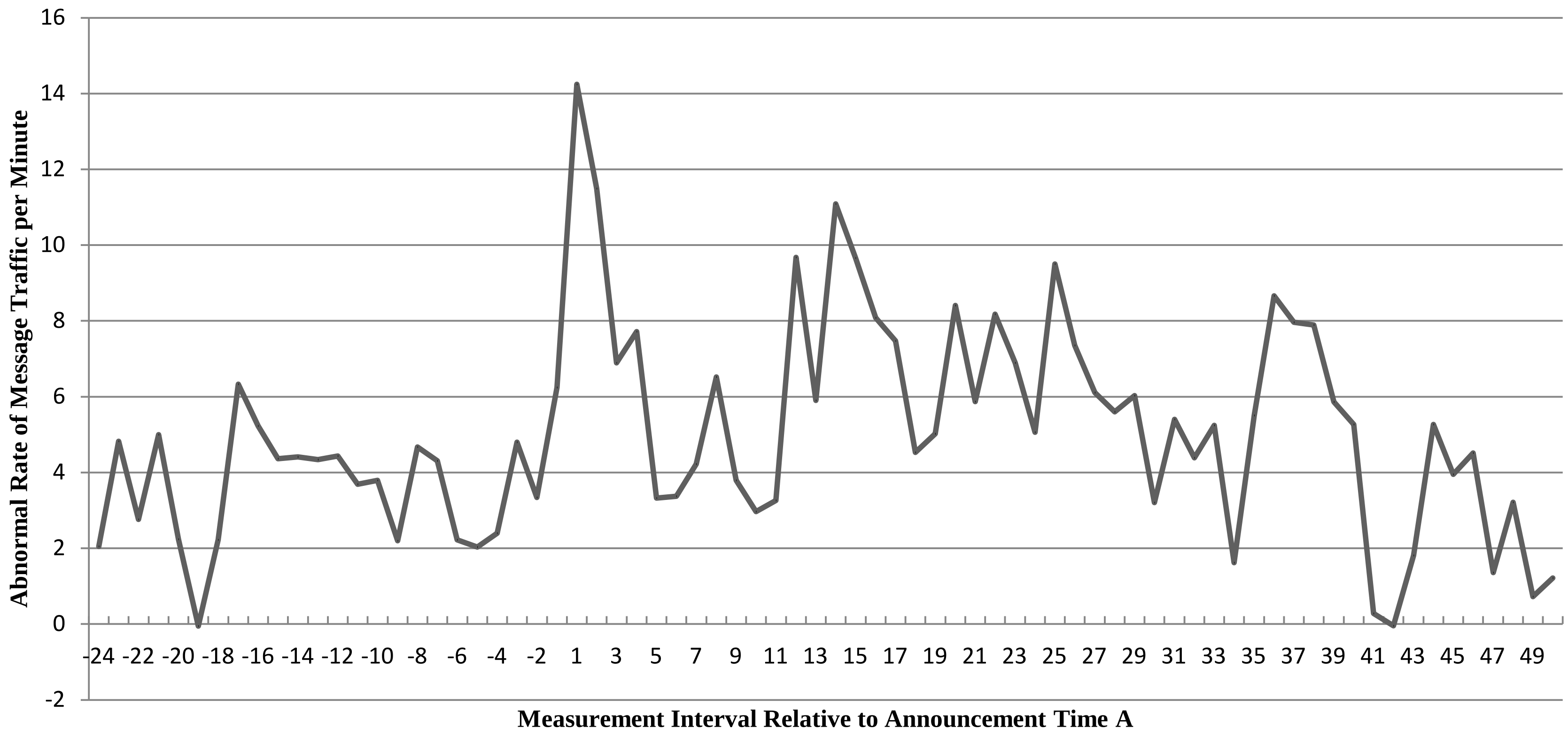


Figure 4.5

Rate of Message Traffic per Minute for the Event Window (Pre Co-location Announcement Sample)

This figure shows the rate of message traffic per minute for each of the half-hour measurement intervals commencing 24 periods before the earnings announcement (A-24) and extending through to 50 periods after the release of the announcement (A+50).

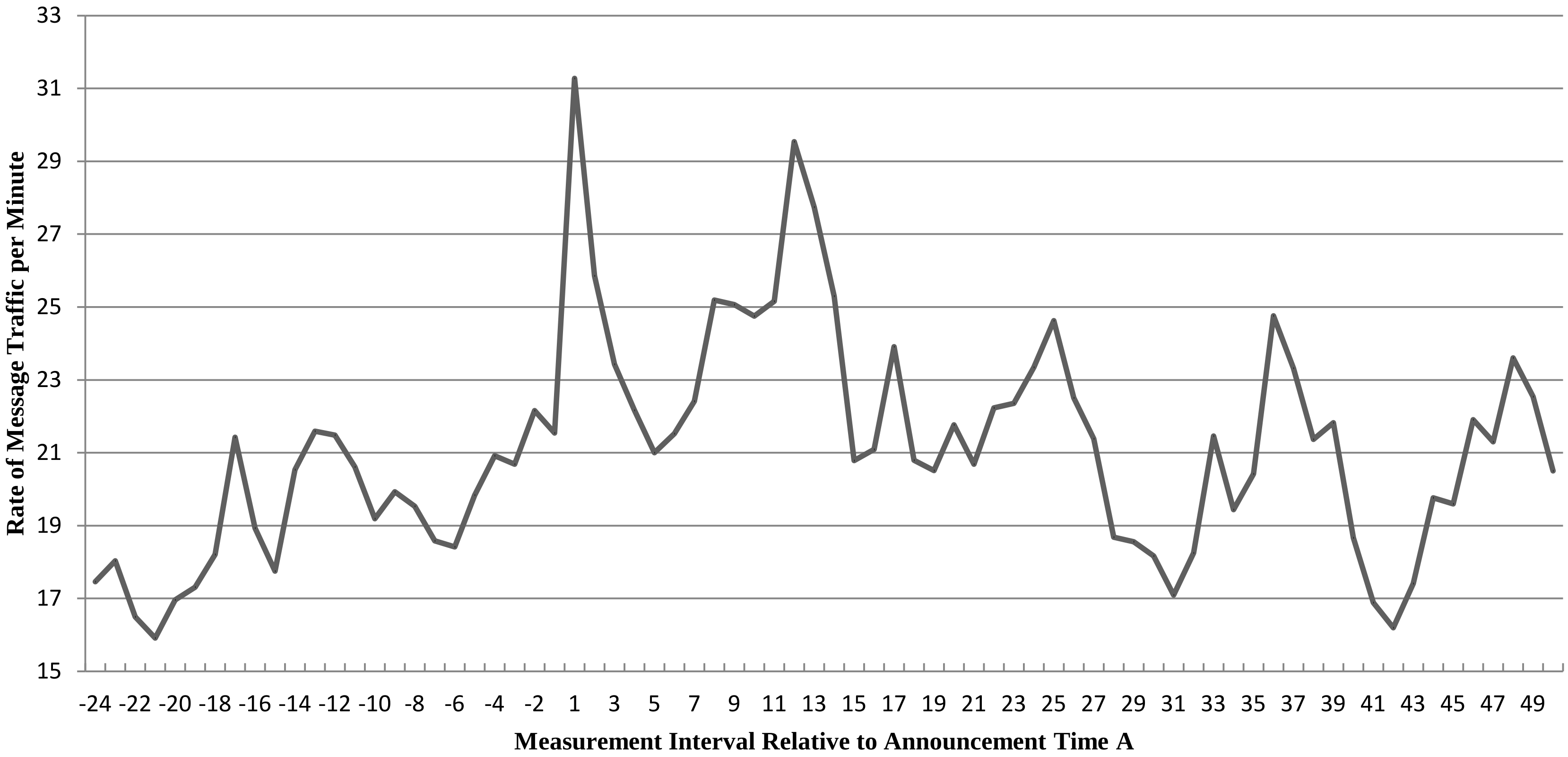
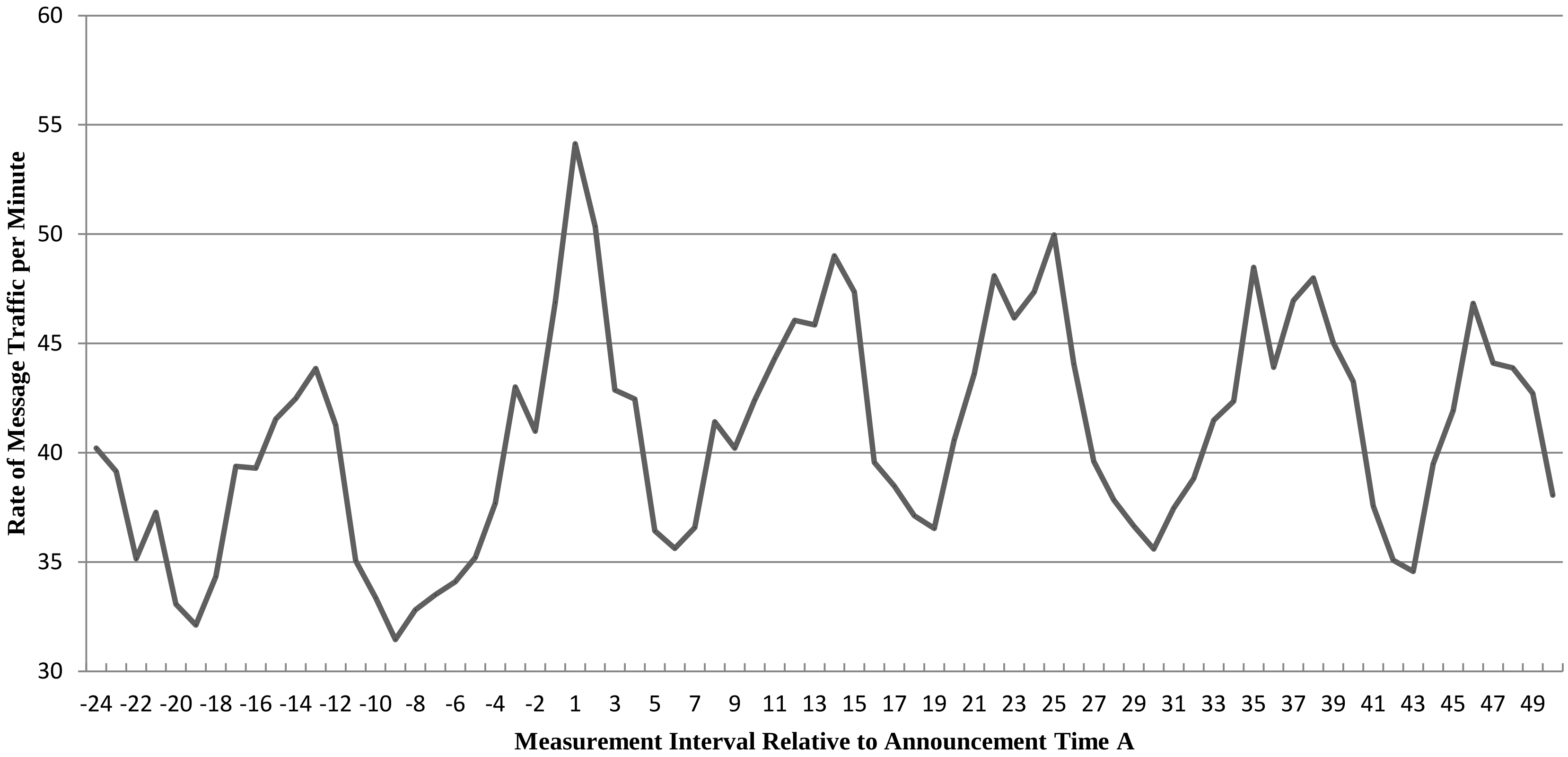


Figure 4.6

Rate of Message Traffic per Minute for the Event Window (Post Co-location Announcement Sample)

This figure shows the rate of message traffic per minute for each of the half-hour measurement intervals commencing 24 periods before the earnings announcement (A-24) and extending through to 50 periods after the release of the announcement (A+50).



These findings provide support for the fourth hypothesis ($H_{4,4}$) that predicts that the introduction of the co-location facility by the ASX would magnify the effects of any observed patterns in algorithmic trading activities around corporate earnings announcements.

To examine whether the patterns of elevated message traffic observed in Figure 4.2 through to Figure 4.6 represent significant changes from normal levels of message traffic per minute several statistical tests were undertaken. Firstly, the differences between the means for each of the event periods and the corresponding control period measurement intervals were tested for significance using an independent sample t-test and a Mann-Whitney-Wilcoxon U test. The results for intervals A-24 through to A+24 are presented in Table 4.2.[150] As expected, the measurement interval immediately after the announcement with 43.781 messages per minute is found to be significant at the 5 per cent level using the t-test and the 10 per cent level using the Mann-Whitney-Wilcoxon U test. Furthermore, the message traffic per minute in the second interval after the announcement (commencing 30 minutes after the earnings release and extending to 60 minutes after the earnings announcement) was also found to be significantly elevated when compared with its corresponding control period (significant at the 10 per cent level using both statistical tests). There is also weak evidence of significantly elevated message traffic levels in interval A+8 (significant at the 10 per cent level using the Mann-Whiney-Wilcoxon test but insignificant using the t-test) and in interval A+20 (significant at the 10 per cent level using the t-test and the 5 per cent level using the Mann-Whitney-Wilcoxon test). There is no evidence of any elevated levels of message traffic before the announcement.

[150] No intervals outside of this range were found to be significant and are omitted in the interests of table clarity.

Table 4.2
Difference between the Message Traffic per Minute during the Event Period and the Corresponding Control Period

This table details the mean message traffic per minute (MTM) for the measurement intervals during the event period and the corresponding control period. [a] Measurement intervals are defined as the number of half-hourly periods before (-) or after (+) the announcement time (A). [b] Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Measurement Interval[a]	MTM during the Event Period	MTM during the Control Period	Independent Sample T-score[b]	Mann-Whitney Z Score[b]
A -24	30.706	29.006	0.272	-0.065
A -23	30.398	26.327	0.684	-0.312
A -22	27.445	25.443	0.458	-0.081
A -21	28.333	24.076	0.869	-0.330
A -20	26.534	24.943	0.340	-0.087
A -19	26.180	26.388	-0.045	-0.340
A -18	27.837	25.659	0.472	-0.457
A -17	32.194	26.512	1.156	-0.541
A -16	30.926	26.161	0.967	-0.306
A -15	31.581	27.620	0.777	-0.444
A -14	33.463	28.868	0.901	-0.495
A -13	33.769	30.068	0.710	-0.026
A -12	32.306	27.869	0.830	-0.606
A -11	28.517	24.826	0.748	-0.626
A -10	26.946	23.154	0.838	-1.093
A -9	26.237	24.041	0.489	-0.401
A -8	26.795	22.122	1.179	-1.039
A -7	26.746	22.436	1.204	-0.720
A -6	26.997	24.773	0.567	-0.341
A -5	28.250	26.218	0.483	-0.499
A -4	30.097	27.697	0.515	-0.483
A -3	32.897	28.095	0.975	-0.371
A -2	32.457	29.120	0.673	-0.012
A -1	35.401	29.156	1.123	-0.148
A +1	43.781	29.535	2.238**	-1.760***
A +2	39.259	27.770	1.844***	-1.573***
A +3	34.068	27.174	1.276	-0.984
A +4	33.264	25.547	1.467	-1.145
A +5	29.442	26.121	0.703	-0.673
A +6	29.521	25.989	0.757	-0.662
A +7	30.456	26.083	0.987	-0.366
A +8	34.389	27.705	1.277	-1.664***
A +9	33.667	29.674	0.788	-1.141
A +10	34.743	31.563	0.564	-0.883
A +11	35.982	32.508	0.628	-1.269
A +12	43.643	33.751	1.402	-1.333
A +13	38.009	32.018	0.920	-0.431
A +14	38.637	27.394	1.554	-1.058
A +15	35.661	25.867	1.482	-1.079
A +16	31.493	23.362	1.655	-0.859
A +17	32.184	24.593	1.432	-0.646
A +18	30.012	25.440	0.944	-0.869
A +19	29.560	24.436	1.218	-0.913
A +20	32.367	23.827	1.746***	-1.972**
A +21	33.539	27.487	1.138	-1.616
A +22	36.727	28.532	1.327	-1.412
A +23	35.724	28.771	1.201	-1.649
A +24	36.831	31.686	0.845	-1.364

To confirm the robustness of these results a second test was undertaken. A single sample t-test was utilised to test whether the change in abnormal message traffic per minute (message traffic per minute in the event period minus the message traffic per minute in the corresponding control period) in each measurement interval from the previous measurement interval was significantly different from zero. The results for intervals A-23 through to A+24 are presented in Table 4.3.

The evidence from Table 4.3 supports the previous findings. The increase of 7.999 messages per minute in the interval immediately following the release of the earnings announcement from the proceeding interval is significantly different from the corresponding change in the control period (significant at the 1 per cent level). This elevated message traffic declines slightly in the following interval with an abnormal decline of 2.757 messages per minute although this result is not significant (consistent with the higher difference in MTM in interval A+2 shown in Table 4.2). There is a significant decline of 4.594 messages per minute between intervals A+2 and A+3 (5 per cent confidence level) and of 4.396 messages per minute between intervals A+4 and A+5 (1 per cent confidence level). This suggests that it takes approximately 2.5 hours for message traffic to return to a more 'normal' level following the release of the corporate earnings announcement.

There is also evidence significant changes in the abnormal message traffic levels between intervals A+11 and A+12 (1 per cent level), intervals A+13 and A+14 (5 per cent level) and intervals A+19 and A+20 (10 per cent level). No intervals prior to the release of the earnings report show signs of significant changes in the level of abnormal message traffic per minute.

Table 4.3
Change in the Abnormal Message Traffic per Minute during the Event Period

This table details the change in abnormal message traffic per minute (AbMTM) between each measurement interval and the previous measurement interval. Single sample T-test examines whether the change in abnormal message traffic per minute in each interval is significantly different from zero. [a] Measurement intervals are defined as the number of half-hourly periods before (-) or after (+) the announcement time (A). [b] Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Measurement Interval[a]	Change in AbMTM from previous interval	Single Sample T-score[b]
A -23	2.741	1.353
A -22	-2.061	-0.788
A -21	2.235	1.365
A -20	-2.700	-1.383
A -19	-2.290	-1.172
A -18	2.271	0.987
A -17	3.007	1.480
A -16	-1.099	-0.628
A -15	-0.812	-0.378
A -14	0.097	0.062
A -13	0.349	0.200
A -12	0.223	0.107
A -11	-0.746	-0.407
A -10	0.101	0.077
A -9	-1.595	-1.226
A -8	2.476	1.129
A -7	-0.363	-0.333
A -6	-2.086	-1.145
A -5	-0.192	-0.103
A -4	0.368	0.251
A -3	2.401	1.292
A -2	-1.464	-0.952
A -1	2.908	1.263
A +1	7.999	2.733*
A +2	-2.757	-1.095
A +3	-4.594	-2.144**
A +4	0.823	0.519
A +5	-4.396	-2.801*
A +6	0.017	0.013
A +7	0.849	0.502
A +8	2.303	1.133
A +9	-2.730	-1.131
A +10	-0.824	-0.463
A +11	-0.293	0.149
A +12	6.412	2.692*
A +13	-3.770	-1.349
A +14	5.184	2.251**
A +15	-1.425	-0.825
A +16	-1.582	-0.825
A +17	-0.609	-0.333
A +18	-2.942	-1.180
A +19	0.494	0.298
A +20	3.385	1.961***
A +21	-2.537	-1.124
A +22	2.305	1.181
A +23	-1.281	-0.581
A +24	-1.834	-1.119

These results allow us to reject two of the previously outlined hypotheses. Both parametric and nonparametric tests of the differences between the message traffic per minute during the periods surrounding the earnings announcement, and the corresponding control periods, find no evidence of significantly elevated message traffic prior to the time of the release of the earnings announcement. Likewise, there is no evidence of any significant change in abnormal message traffic in any of the intervals leading up to the announcement release. Therefore, hypothesis ($H_{4,2}$) can be formally rejected. Algorithmic traders do not increase their trading activity in the lead-up to an earnings release. Such activity, if present, would have indicated that algorithmic traders were more informed than other market participants.

There is also no evidence of a decline in algorithmic trading around corporate earnings announcements. The tests of differences between message traffic per minute during the event window measurement intervals and corresponding control period intervals demonstrate that message traffic per minute is significantly elevated immediately after the earnings release. There is no evidence of a decline in algorithmic trading prior to the information release consistent with the predictions of the third hypothesis ($H_{4,3}$). The test of change in abnormal message traffic per minute between measurement intervals around the release also preciptated a significant increase in message traffic in the period immediately after the information release. Thus, the third hypothesis is also rejected.

Instead these results provide strong support for the first hypothesis ($H_{4,1}$) which predicts that algorithmic traders utilise their speed advantage over other market participants and will therefore increase their trading activity immediately after the earnings release. The message traffic per minute is significantly elevated in the half-hour interval immediately after the announcement with the change test indicating the process of returning to normal message traffic levels commences in the second half-hour interval after the announcements and accelerates in the third and fifth half-hour intervals after the announcement. After the fifth measurement interval (approximately 2.5 hours) the message traffic levels remain largely consistent with the corresponding control period after this time. These results were statistically significant.

To further investigate the relationship between message traffic in the half-hour immediately following the corporate earnings release, the information contained within the earnings announcement, and the impact of the introduction of co-location services by the ASX, a series of OLS regression models are examined. The results of these regressions are reported in Table 4.4. Any elevation in message traffic following the release of a corporate earnings announcement might simply be the result of non-algorithmic traders increasing their trading activity in response to the information content of the announcement. If that were the case then one would expect the coefficient of the earnings surprise variable to be significantly positive. However, the coefficient for earnings surprise was not found to be statistically significant. This result confirms that elevated message traffic is not a function of the earnings surprise and is thus more likely to be the result of an increase in algorithmic trading activity. The results also indicate firm size (as proxied by enterprise value), traded volume, and reduced information asymmetry (as proxied by the number of analysts reporting on the security) play a role in influencing the amount of message traffic following a corporate earnings announcement but the significantly positive intercept (1 per cent level) confirms that these factors do not explain the rate of message traffic.

Table 4.4
Announcement Interval Message Traffic Regressions

This table presents the OLS regression estimates related to the level of message traffic per minute during the half-hour interval measurement immediately after the release of the corporate earnings announcement on a series of independent control variables. Independent control variables used are; Earnings surprise [*ES*], number of analysts [*Analysts*], log of enterprise value [*LogEnt*], time dummy [*Time*], co-location dummy [*Colocation*], and log of volume stock traded [*LogVolume*]. Standardised beta coefficients are reported expected for the intercept which is unstandardised. Corresponding t-statistics are reported in brackets. Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Intercept (*t-statistic*)	ES (*t-statistic*)	Analysts (*t-statistic*)	LogEnt (*t-statistic*)	Time (*t-statistic*)	Co-location (*t-statistic*)	LogVolume (*t-statistic*)	F-Value	Prob>F	Adj R-squared
44.809 (8.395)*	0.101 (1.026)						1.053	0.307	0.001
-11.495 (-1.18)		0.531 (6.388)*					40.787	<0.0001	0.275
-149.795 (-6.681)*			0.655 (8.793)*				77.309	<0.0001	0.423
39.887 (6.526)*				0.121 (1.239)			1.536	0.218	0.005
31.277 (4.077)*					0.211 (2.203)**		4.855	0.03	0.035
-115.808 (-3.185)*						0.398 (4.428)*	19.606	<0.0001	0.151
-198.864 (-6.512)*	0.036 (0.508)	0.193 (2.297)**	0.524 (6.204)*	0.028 (0.39)	0.175 (2.371)**	0.139 (1.787)**	19.322	<0.0001	0.519

The coefficient of the time dummy variable was found to be insignificant. The time dummy variable was set to one if the announcement was made between 10:10 and 10:30 EST/EDT or zero otherwise. Due to the fact that many of the announcements in the full sample were made in the half-hour period immediately after the opening call market, any significant change in message traffic levels might have been a function of measurement interval time rather than earnings release.[151] However, the insignificant result indicates that message traffic activity was not a function of opening call market.

The coefficient for co-location was found to be positive and significant. As predicted the introduction of the co-location facility by the ASX has had a significantly positive impact upon the amount of message traffic in the interval immediately after the information release. Previous research found that reduced system latency resulted in an increase in algorithmic trading activity (Hendershott and Moulton 2010; Hendershott et al. 2011; Riordan and Storkenmaier 2011). The positive coefficient for co-location confirms the findings previously identified in Figures 4.5 and 4.6 that algorithmic trading is higher in the interval immediately after the earnings release for announcements made after the introduction of co-location compared to those made prior to its introduction. This result is consistent with those previous findings and confirms the fourth hypothesis ($H_{4,4}$).

As a further test of robustness of these results, the analysis was repeated using deletions per minute rather than message traffic per minute. Many previous studies have identified algorithmic trading activity as exhibiting high frequencies of order submissions and subsequent deletions (Prix et al. 2007; Brogaard 2010; Hendershott

[151] 26.36 per cent of the announcements in the sample were released between 10:10 and 10:30 EST/EDT.

et al. 2011; Hasbrouck and Saar 2011). Hence, evidence of elevated deletions per minute should corroborate the previous findings on patterns of message traffic activity.

The results for deletions per minute during the event period, and the corresponding control period, for measurement intervals A-24 to A+24 are present in Table 4.5. The results for deletions per minute are largely consistent with the results for message traffic per minute reported in Table 4.2. There is an elevation in deletions per minute in the period immediately preceding the announcement (significant using the t-test but not the Mann-Whitney-Wilcoxon U test) which does not appear in the full message traffic sample. There is a considerable increase in deletions to 5.688 deleted orders per minute (compared to 3.772 deleted orders per minute in corresponding control period) in the interval immediately after the earnings release. Deletions per minute are also elevated above normal levels in the second interval after the earnings announcement (5.147 deletions per minute compared to 3.617 deletions in the corresponding control period). There is some weak evidence of significantly elevated deletions in several of the other post-announcement intervals using the parametric test but these findings are not supported by the non-parametric test. Overall, these results mirror the findings for message traffic per minute.

The results for the regressions of deletions per minute during the half-hour interval immediately following the earnings release against the same independent control variables used for the message traffic data are presented in Table 4.6. These results also support the findings for the message traffic data.

Table 4.5
Difference between the Deletions per Minute during the Event Period and the Corresponding Control Period

This table details the mean deletions per minute (DM) for the measurement intervals during the event period and the corresponding control period. [a] Measurement intervals are defined as the number of half-hourly periods before (-) or after (+) the announcement time (A). [b] Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Measurement Interval[a]	DM during the Event Period	DM during the Control Period	Independent Sample T-score[b]	Mann-Whitney Z Score[b]
A -24	4.033	3.834	0.258	-0.199
A -23	4.134	3.286	1.190	-0.220
A -22	3.746	3.275	0.841	-0.217
A -21	3.899	3.334	0.834	-0.137
A -20	3.510	3.426	0.138	-0.516
A -19	3.440	3.804	-0.569	-0.275
A -18	3.679	3.481	0.331	-0.145
A -17	4.131	3.534	0.952	-0.475
A -16	3.875	3.534	0.511	-0.009
A -15	3.923	3.450	0.758	-0.723
A -14	4.136	3.683	1.078	-0.439
A -13	4.649	4.042	0.872	-0.006
A -12	4.274	3.655	0.935	-0.396
A -11	3.850	3.381	0.744	-0.434
A -10	3.625	2.947	1.259	-0.694
A -9	3.542	3.125	0.731	-0.059
A -8	3.741	2.927	1.454	-0.603
A -7	3.589	3.177	0.808	-0.608
A -6	3.675	3.485	0.347	0.000
A -5	3.710	3.767	-0.099	-0.300
A -4	4.036	3.740	0.497	-0.100
A -3	4.624	3.790	1.096	-0.054
A -2	4.244	3.836	0.673	-0.297
A -1	4.927	3.776	1.705***	-0.480
A +1	5.688	3.772	2.442*	-2.430*
A +2	5.147	3.617	1.979**	-1.634***
A +3	4.475	3.783	0.978	-0.591
A +4	4.457	3.391	1.581	-0.824
A +5	3.932	3.579	0.594	-0.399
A +6	3.981	3.468	0.824	-0.231
A +7	4.083	3.538	0.886	-0.030
A +8	4.635	3.703	1.341	-1.140
A +9	4.364	4.185	0.275	-0.500
A +10	4.241	4.135	0.151	-0.357
A +11	4.430	4.097	0.500	-1.006
A +12	5.466	4.311	1.388	-0.834
A +13	4.744	4.150	0.809	-0.352
A +14	4.905	3.420	1.947***	-1.198
A +15	4.546	3.229	1.761***	-0.856
A +16	4.129	2.953	1.944***	-0.995
A +17	4.269	3.290	1.548	-0.663
A +18	3.989	3.400	0.911	-0.625
A +19	4.085	3.368	1.232	-0.546
A +20	4.404	3.081	2.013**	-1.616
A +21	4.353	3.558	1.324	-1.264
A +22	4.669	3.696	1.338	-0.799
A +23	4.433	3.612	1.236	-1.359
A +24	4.694	4.145	0.772	-1.173

Table 4.6
Announcement Interval Deleted Orders Regressions

This table presents the OLS regression estimates related to the level of deleted orders per minute during the half-hour interval measurement immediately after the release of the corporate earnings announcement on a series of independent control variables. Independent control variables used are; Earnings surprise [*ES*], number of analysts [*Analysts*], log of enterprise value [*LogEnt*], time dummy [*Time*], co-location dummy [*Colocation*], and log of volume stock traded [*LogVolume*]. Standardised beta coefficients are reported expected for the intercept which is unstandardised. Corresponding t-statistics are reported in brackets. Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Intercept (*t-statistic*)	ES (*t-statistic*)	Analysts (*t-statistic*)	LogEnt (*t-statistic*)	Time (*t-statistic*)	Co-location (*t-statistic*)	LogVolume (*t-statistic*)	F-Value	Prob>F	Adj R-squared
5.807 (8.665)*	0.071 (0.718)						0.515	0.475	0.005
-0.731 (-0.583)		0.492 (5.764)*					33.229	<0.0001	0.235
-14.253 (-4.552)*			0.539 (6.488)*				42.095	<0.0001	0.283
5.426 (7.051)*				0.065 (0.661)			0.437	0.510	0.004
4.069 (4.242)*					0.218 (2.281)**		5.202	0.025	0.038
-7.953 (-1.664)***						0.272 (2.880)*	8.295	0.005	0.065
-16.707 (-3.778)*	-0.001 (-0.017)	0.225 (2.316)**	0.429 (4.399)*	-0.001 (-0.016)	0.193 (2.265)**	0.040 (0.446)	10.437	<0.0001	0.357

The number of analysts and firm value were found to be a significant influence on the rate of deleted orders but, as with message traffic results, the intercept value is remains highly significant (at the 1 per cent level). Also the *colocation* dummy variable is once again significant in explaining differences in the rate of deleted orders. These results confirm the robustness of the previous findings that algorithmic trading activity increases in the period immediately after the release of corporate earnings announcements.

4.6 Summary

The evidence presented in this study has a number of important implications for our understanding of the trading behaviour of algorithmic traders around information shocks. Existing research has focused on the general trading activities of algorithmic traders and their impact on market quality. This study focused on how algorithmic traders respond around annual corporate earnings announcements and what effect the introduction of a co-location service had upon this observed behaviour.

There was strong evidence, at least for this sample, that algorithmic traders increase their trading activity around corporate earnings announcements with a significant spike in activity immediately after the information release. After the first thirty minutes following the release this heightened activity begins to decline before returning to more normal levels around two and half hours after the announcement. This finding was robust to controls for other factors potentially influencing message traffic per minute (the proxy for algorithmic trading) such as the information content of the announcement, the expected degree of information asymmetry about the firm, the size of the announcing firm, the time of the announcement and the volume of securities traded. Likewise, the results were robust to using deleted orders per minute as an alternative measure of algorithmic trading.

These findings were consistent with the hypothesis that algorithmic traders utilise their speed advantage over other market participants and will increase their trading activity after corporate earnings announcements to utilise that advantage. Furthermore, the strong evidence of an increase in algorithmic trading following the introduction of the co-location facility by the ASX, especially in the immediate post-announcement period, also supports this hypothesis. Reduced system latency has resulted in higher levels of algorithmic trading in response to corporate earnings announcements, after controlling for exogenous factors, which provides evidence of how increasing the speed of the trading system creates opportunities for trading algorithms to exploit.

There was no evidence of algorithmic traders possessing private information that could be exploited in the immediate pre-announcement period. Algorithmic trading in the twelve trading hours prior to the information release remained insignificantly different from that during a normal non-announcement period. In addition, there was no evidence that algorithmic traders behave in the manner predicted for discretionary liquidity traders. There is no evidence of algorithmic traders withdrawing from the market in the lead-up to the announcement and then remaining inactive until the information asymmetry has been resolved. On the contrary, algorithmic trading activity was found to significantly increase immediately after the information release.

Overall, these results point to algorithmic traders playing an active role in the price adjustment process on the ASX following the release of new information contained in corporate earnings announcements.

Chapter 5: Venture Capitalists and the Initial Public Offering Process

5.1 Introduction

The third essay of this thesis empirically examines the role of venture capitalists (VC) in the initial public offering process. As the existing literature detailed in Chapter 2 demonstrated, venture capital backing can play a substantial role in how other market participants perceive a potential new offering. The *certification/monitoring model* suggests that the presence of a venture capitalist on the register of a new offering can serve to certify the quality of the issue to other market participants. This may reduce the need to underprice the offer and implies improved post-IPO performance relative to non-VC-backed offerings. However, if promising new ventures are more reliant on alternative forms of finance, due to the prohibitive requirements of the venture capitalists, then those firms which have received venture capital financing will be of below average quality. In addition the need to establish a track record of success may encourage newer venture capital firms to rush their portfolio companies to market prematurely. If this is the case, then the *adverse selection/grandstanding model* holds that the presence of a venture capitalist on the registry conveys a negative signal about the quality of the offering to the market. This would necessitate a greater need to underprice the offering and implies a lower post-IPO performance relative to non-VC-backed IPOs.

Existing literature has produced mixed results about which of these effects dominates. Furthermore, the majority of previous studies have examined the effects of VC participation in the IPO process in the United States and Europe. Very limited amount of research has been undertaken into the role of venture capitalists in markets that do not have such a mature VC industry. Using data of VC-backed and non-VC-backed IPOs in the Australian market, this study investigates the implications of venture capital participation in a developing venture capital market.

The findings of this chapter are presented in accordance with the documented hypotheses derived in Section 2.6.3. Specifically the chapter investigates three main hypotheses. The first hypothesis ($H_{5,1}$) predicts that venture capital-backed IPOs exhibit better IPO performance and better post-IPO operating and market performance (although with the difference declining over time) than non venture capital-backed IPOs. The second hypothesis ($H_{5,2}$) predicts that venture capital-backed IPOs exhibit worse IPO performance and worse post-IPO operating and market performance (with an increasing difference over time) than non venture capital-backed IPOs. The third hypothesis ($H_{5,3}$) predicts that IPOs backed by more experienced venture capital firms exhibited better IPO performance and better post-IPO operating and market performance than those backed by less experienced venture capital firms.

The remainder of this chapter is organised as follows. Section 5.2 discusses the institutional detail of the Australian venture capital market and its contrasts with the more commonly studied US venture capital market. Section 5.3 describes the dataset and provides summary statistics of the sampled data. Section 5.4 outlines the research design. Section 5.5 presents the empirical results and a summary of the primary findings. Finally section 5.6 provides a concluding summary of the chapter.

5.2 Institutional Detail

The Australian venture capital industry differs from the more frequently examined markets, such as the United States, in terms of scale, investment focus and the skill sets of the venture capital managers. The Australian venture capital industry is relatively young compared to the United States and Europe. Whilst some venture capital existed in a very embryonic form from 1970 onwards, the industry in its current form did not begin to emerge until 1984. In this year the Commonwealth Government initiated the Management Investment Companies (MIC) Program to encourage venture capital investment in Australia. The Australian Private Equity and Venture Capital Association (AVCAL) state that the market did not grow significantly until the 1990's, when Pooled Development Funds (PDF's) were introduced to replace the MIC scheme (AVCAL 2009). Even with such expansion the Australian VC market remains very small compared to its more mature peers overseas. Australian venture capitalists held around AUD 2 billion in funds under management in 2009, compared to the USD 179.4 billion under management by US venture capitalists in the same year (AVCAL 2009/NVCA 2010). This implies the Australian industry is equivalent of around one per cent of size of the US venture capital industry.[152]

The Australian VC industry also exhibits a different investment focus from the US venture capital industry. Traditional venture capital investments in the US have been directed towards high technology sectors such as health, biotechnology, communications and information technology (Sahlman 1990; Bygrave and Timmons

[152] Calculated using the average December 2009 exchange rate of 0.902931US dollars to 1 Australian dollar.

1992; Gompers and Lerner 2000a). OECD figures report that almost 90 per cent of US venture capital investment activity occurs in these sectors whereas in Australia this figure is only around 20 per cent of investment activity (OECD 2007). Regan and Tunny (2009) suggested that the lack of a large venture-capital financed, high technology sector was possibly a function of the scale and geographical dispersion of economic activity in Australia. They noted in the US there was a concentration of high-tech industries and venture capital activity in a small number of regional clusters, such as Silicon Valley and Boston, whereas no such concentration exists in Australia.

Australian venture capitalists also possess very different qualifications and background experience from their US counterparts. Cornelius (2005) found evidence that in Australia 64 per cent of venture capitalists came to the industry from backgrounds in financial management and consulting. Only 23 per cent of venture capitalists possessed relevant industry experience. In the US however, 54 per cent of venture capitalists came from a background in industry, whereas only 40 per cent came from financial management and consulting backgrounds. Furthermore, the study found evidence of an increasing gap between the skill sets of venture capitalists in Australia and the US. Between 1987 and 2002 there was an increase in the number of venture capitalists in Australia coming from financial management and consulting backgrounds (from 32 per cent to 64 per cent) whereas in the US the opposite occurred (percentage of venture capitalists with relevant industry experience went from 36 per cent to 54 per cent). Cornelius argued that this lack of relevant industry experience was a contributing factor behind the higher concentration on later stage investments in Australia relative to the US.

These systematic differences between the US and Australian venture capital markets suggest the findings of previous literature, which predominantly studies the US, might not be relevant in Australia. Therefore, the Australian venture capital market requires further investigation to determine if these institutional differences translate into performance differences.

5.3 Data

The initial sample consisted of 590 IPOs on the ASX between 1999 and 2005 compiled using the *Connect 4* database. Of these, 52 offerings were found to have venture capital backing. The venture capital-backed IPO's were identified via an inspection of the prospectus of each company in the initial sample. If this process indicated that a venture capitalist was either a director or shareholder in the company, then that company was designated as VC-backed. Venture capitalists were identified using a combination of the register of members maintained by the Australian Private Equity and Venture Capital Association Limited (AVCAL), the Venture Economics *VentureXpert Web* database and other publicly available information. Multiple sources were used in order to confirm the correct identification of the venture capitalists.

Each venture-capital-backed offering was then matched with a non-venture capital-backed company in the same industry, approximately the same size and with a listing date as close to that of the VC-backed company as possible. This matching technique was consistent with that used in previous studies of matched samples (Megginson and Weiss 1991; Jain and Kini 1995; Wang et al. 2003; Chiang and Lo 2007).

Table 5.1
Initial Public Offering Sample Composition

This table provides summary statistics of the matched IPO sample for the period 1999 to 2005. Panel A provides details of the number (percentage) of VC-backed and non-VC-backed offerings in the sample classified by their GICS industry classification. Panel B provides details of the number (percentage) of VC-backed and non-VC-backed offerings categorised according to listing year during the sample period.

Panel A: Sample classified by industry

GICS Industry Classification	Sample Composition			
	VC-backed IPOs		Non-VC-backed IPOs	
Commercial Services & Supplies	2	(3.85%)	2	(3.85%)
Consumer Durables & Apparel	2	(3.85%)	1	(1.92%)
Consumer Services	2	(3.85%)	2	(3.85%)
Energy	2	(3.85%)	2	(3.85%)
Food Beverage & Tobacco	2	(3.85%)	2	(3.85%)
Health Care Equipment & Services	6	(11.54%)	6	(11.54%)
Information Technology	1	(1.92%)	0	(0.00%)
Media	2	(3.85%)	2	(3.85%)
Metals & Mining	6	(11.54%)	7	(13.46%)
Pharmaceuticals & Biotechnology	6	(11.54%)	6	(11.54%)
Pharmaceuticals & Biotechnology & Life Sciences	4	(7.69%)	4	(7.69%)
Retailing	2	(3.85%)	2	(3.85%)
Software & Services	9	(17.31%)	12	(23.08%)
Technology Hardware & Equipment	1	(1.92%)	1	(1.92%)
Telecommunication Services	1	(1.92%)	1	(1.92%)
Transportation	1	(1.92%)	1	(1.92%)
Utilities	1	(1.92%)	1	(1.92%)
GICS Code Not Applicable	2	(3.85%)	0	(0.00%)
Totals	52	(100%)	52	(100.00%)

Panel B: Sample classified by offering year

Offering year	Sample Composition			
	VC-backed IPOs		Non-VC-backed IPOs	
1999	7	(13.46%)	8	(15.38%)
2000	16	(30.77%)	15	(28.85%)
2001	2	(3.85%)	4	(7.69%)
2002	7	(13.46%)	5	(9.62%)
2003	3	(5.77%)	3	(5.77%)
2004	15	(28.85%)	16	(30.77%)
2005	2	(3.85%)	0	(0.00%)
Totals	52	(100.00%)	52	(100.00%)

Table 5.1 contains the summary statistics of the matched sample of VC-backed and non-VC-backed initial public offerings. Table 5.1 Panel A details the industry classification of each of the companies in the announcement sample. Unlike the OECD 2007 figures, the venture capital backed subsample is concentrated in the traditional sectors of health, biotechnology and software and IT services. Table 5.2 Panel B details the announcement sample classified according to listing year. The VC-backed subsample is highly concentrated in the calendar years 2000 and 2004. This is consistent with the previous literature which found that venture capitalists often time their offerings for 'hot' periods in the IPO market (Bygrave and Timmons 1992; Lerner 1994b).

The details of each IPO were sourced from the *Connect 4* database, whilst information on venture capitalist ownership levels and board seats was manually collected from each company's prospectus. Share prices adjusted for dividends and accounting measures were sourced from the *Aspect Huntley FinAnalysis* database. Market index data was sourced from the *SIRCA Australian Equities Tick History* database. Information about the venture capital firms was sourced from the companies themselves (usually via the information contained on the company's website).

5.4 Research Design

This study examines the difference between VC-backed and non-VC-backed IPOs in terms of three performance measures; IPO performance, operating performance after the IPO and the market performance after the IPO. Similar to the technique of Wang et al. (2003), the certification/monitoring model is tested by examining the IPO pricing, size, underpricing, cost and quality of the underwriters and auditors. The adverse selection/grandstanding model is tested by examining company age, operating and financial performance as at the IPO year. In order to determine if the certification/monitoring model or the adverse selection/grandstanding model best explains the VC's influence on the IPO process, the post-IPO operating and market performance is also examined.

IPO pricing is measured using the P/E ratio and book/market ratio. The P/E ratio is defined as the ratio of offering price to earnings per share before the IPO. The book/market ratio is defined as the ratio of net tangible asset per share to the offering price. Wang et al (2003) argue that these two ratios measure the value of the IPO at the offering price. Offering size is measured by the value of the shares on offer to the public in the IPO.

IPO underpricing is defined as the closing price on the first day of trading minus the offering price divided by the offering price. IPO cost is measured using the ratio of net proceeds. The ratio of net proceeds is defined as the net proceeds (excluding all floatation costs in the IPO process) received by the issuing company divided by the total IPO proceeds. IPO underpricing is a complex phenomenon with many potential influences on the degree of underpricing exhibited. To test the causality of venture capital participation on the observed IPO underpricing, an OLS regression model with various independent control variables is used. This model is consistent with those used in previous studies (Barry et al. 1990; Lin 1996; Hamao et al. 2000; Wong and Wong 2008). The regression model is given in equation 5.1.

$$Underpricing_{i,t} = \alpha + \beta_1 VC + \beta_2 LogProc + \beta_3 LogMkt + \beta_4\, B/M\, Ratio + \beta_5 LogUnder + \beta_6 Age + \beta_7 Year \qquad \textbf{(5.1)}$$

Where, *underpricing* is defined as the closing price on the first day of trading minus the offering price divided by the offering price. *VC* is a dummy variable set to one if the IPO is backed by a venture capitalist or zero otherwise. *LogProc* is the log of the proceeds of the IPO (offering size in terms of the amount of capital raised in the IPO. *LogMkt* is the log of the market capitalisation of the firm on the first day of listing. These two variables control for any size effect in the level of underpricing. *B/M Ratio* is the book to market ratio (the ratio of net tangible asset per share to the offering price). This variable is a proxy for the future growth prospects for the firm. *LogUnder* is the log of the underwriter's market share and is used as a proxy for underwriter quality. *Age* is the age of the firm measured from the time of incorporation to the listing date. *Year* is a dummy variable set to one if the listing date is between 1999 and 2000 or zero otherwise. The Dot.com bubble of the mid 90s to late 2000 was known to have had a distorting effect upon underpricing in IPOs. This variable controls for this effect.

Auditor quality is measured using the approach taken by previous researchers (Feltham et al 1991; Megginson and Weiss 1991; Wang et al 2003). The Big Five accounting firms (Arthur Anderson, PwC, Ernst and Young, Deliotte Touche Tohmatsu, KPMG)[153] are differentiated from their smaller competitors. The Big Five are coded 1 and the smaller accounting firms are coded 0. Underwriter quality is defined as the share of IPO deals underwritten by that firm. This is calculated as the

[153] The collapse of Arthur Andersen in 2002 meant that the Big Five became the Big Four in the latter part of the study.

sum of IPO proceeds underwritten by that firm during the sample period 1999 to 2005 for that firm divided by the total proceeds of all IPOs during this period. Previous research supporting the certification model has found a positive relationship between auditor and underwriter quality and the backing of venture capitalists (Megginson and Weiss 1991; Lin 1996; Wang et al. 2003). Venture capitalists are likely to have experience at bringing companies to market in the past and will typically have built up relationships with auditors, underwriters and institutional shareholders. Furthermore, because venture capitalists have their own reputational capital at stake they have an incentive to reveal information truthfully about the new issue. This should enable VC-backed IPOs to attract higher quality auditors and underwriters since it lowers the cost of due diligence for these firms.

Company age is defined as the time span between the year of incorporation of the company itself or its predecessor (for those companies that were restructured prior to going public) and the IPO year. If the company age is shorter for VC-backed companies than for non-VC-backed companies, this would support the grandstanding model, since this model suggests that younger venture capitalists have an incentive to bring companies to the market early in order to establish a track record of success. However, shorter age can also indicate evidence of the monitoring benefits of venture capital participation as firms supported by a VC may reach the stage of requiring access to public funds more quickly than those without such backing.

The operating and financial performance of the company as at the IPO year is measured using debt ratio, return on assets (ROA) in the year before the IPO and return on equity (ROE) in the year before the IPO. Debt ratio is defined as the percentage of total debt to total assets in the last financial year before the IPO (Year -1). ROA is measured as earnings before interest divided by total assets less outside equity interests in the financial year prior to the IPO (Year -1). Likewise, ROE is measured as net profit after tax before abnormal items divided by shareholders equity less outside equity interests in the financial year prior to the IPO (Year -1). The certification/monitoring model predicts that VC-backed offerings will have less need to demonstrate stronger operating performance prior to the offering since the presence of the venture capitalists already attests to the quality of the issue. The adverse selection model, however, predicts that firms with venture capital support will be the 'lemons' and hence have an incentive to window dress operating performance in the year prior to the offering.

Operating performance after the IPO is examined using ROA and ROE in the financial year of the IPO (Year 0) and the two financial years following the IPO (Year's 1 and 2). The change in ROA is also measured to examine improvements or declines in operating performance in the years following the IPO. Change in ROA is calculated as the ROA in the measurement year minus the ROA in the previous year divided by the ROA in the previous year.

The market performance after the IPO is measured using a series of buy and hold excess returns at intervals of three months, six months, one year, two years and three years after the IPO listing date consistent with previous studies (Brav and Gompers 1997; Hamao et al 2000; Wang et al 2003; de Silva Rosa 2003; Wong and Wong 2008). The raw buy and hold stock return in a given period is measured as the closing price (adjusted for dividends) for that period following the IPO minus the first day closing price divided by the first day closing price. Raw returns on the All Ordinaries Accumulation Index (AOAI) are also calculated over each of the holding periods to account for general market movements during these periods. AOAI returns are calculated using the same method as that for the IPO stock returns. Excess returns are then calculated using equation 5.2.

$$ER_{i,t} = R_{i,t} - AOAI_t \qquad \textbf{(5.2)}$$

Where:

$ER_{i,t}$ = The excess return on stock *i* over holding period *t*

$R_{i,t}$ = The return on stock *i* (adjusted for dividends) over holding period *t*

$AOAI_t$ = The return on the AOAI index over holding period *t*

To further test the differences between the market performance of VC-backed and non-VC-backed IPOs *wealth relatives*, similar to those used by Brav and Gompers (1997) and Hamao et al (2000), were also calculated. This variable measures the relative change in wealth for VC-backed IPOs and their matched non-VC-backed equivalent. The wealth relative for each matched pair of firms was then aggregated for the same holding periods relative to the IPO date as the excess returns (that is intervals of three months, six months, one year, two years and three years). A wealth relative of greater than one indicates that the VC-backed firms have outperformed their non-VC-backed peers over that holding period. A value less than one indicates underperformance by VC-backed firms relative to their non-VC-backed equivalents. One-sample T-tests were then used to determine if the aggregate wealth relative for each holding period was significantly different from one.

Each wealth relative was calculated using equation 5.3.

$$WR_{f,t} = \sum_{f=1}^{n} \frac{(1+VCER_{i,t})}{(1+NVCER_{i,t})} \qquad \textbf{(5.3)}$$

Where:

$WR_{f,t}$ = Wealth relative for *f* sample firms over holding period *t*

$VCER_{i,t}$ = Excess return on VC-backed firm *i* over holding period *t*

$NVCER_{i,t}$ = Excess return on matched non-VC-backed firm *i* over holding period *t*

5.5 Empirical Results

The differences between VC-backed and non-VC-backed firms using measures of IPO performance, post-IPO operating performance and post-IPO market performance are reported in this section. The certification role of VCs is examined by studying IPO size, underpricing, cost and quality of underwriters and auditors. The grandstanding theory of VC behaviour is tested by examining company age, operating and financial performance as at the IPO year. Furthermore, by examining the post-IPO operating and market performance differences between VC-backed and non-VC-backed firms it is possible to ascertain whether the certification/monitoring model or adverse selection/grandstanding model is more dominant in describing the role of VCs in the IPO process. The empirical results are divided into subsections based on the type of measures examined. Section 5.5.1 reports the results of IPO performance measures. Section 5.5.2 reports the findings on post-IPO operating performance. Section 5.5.3

details the post-IPO market performance findings. Finally, section 5.5.4 reports the findings on the differences between performances subdivided according to the age (as a proxy for experience) of the VC firm.

5.5.1 IPO performance

The results for the IPO performance measures are given in Table 5.2. VC-backed companies have a lower median book/market ratio (significant at the 5% level) indicating they are able to bring the offering to the market at a higher price per dollar of net tangible assets than non-VC-backed companies. This result is consistent with the certification model and the findings of previous research such as Jain and Kini (1995) and Wang et al (2003). However, the P/E ratios for both VC and non-VC-backed companies are negative, with the median ratio for the VC-backed companies a larger negative, although the difference is not significant. The measure for size, offering proceeds, shows both a larger mean and median for VC-backed companies compared to non-VC-backed companies although the difference is insignificant.

The results for underpricing show that VC-backed companies exhibit a lower median underpricing than non-VC-backed companies, although the difference is not statistically significant. VC-backed IPOs are able to attract higher quality underwriters as measured using underwriter market share (significant at the 5 per cent level using the t-test and 1 per cent level using the non-parametric test). This result is consistent with previous literature (Megginson and Weiss 1991; Lin 1996; Wang et al. 2003).

Table 5.2
IPO Performance Measures

This table presents the IPO performance measures for VC-backed and non-VC-backed matched IPO subsamples listing between 1999 and 2005 on the ASX. Mean (median) results are reported for each variable. Independent sample t-statistics and Mann-Whitney-Wilcoxon Z score are reported for each variable. Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

	VC-Backed IPOs mean (median)	Non-VC-Backed IPOs mean (median)	t-statistic (Z score)	Sample Size (VC/Non-VC)
P/E ratio	-62.26	161.10	-1.133	51/52
	(-7.56)	(-7.22)	(-0.815)	
Book/market ratio	0.43	0.40	0.176	52/52
	(0.26)	(0.34)	(-2.179**)	
Offering proceeds (AUD million)	55.69	37.03	0.531	52/52
	(11.75)	(8.00)	(-1.35)	
Underpricing	25.08%	16.94%	0.673	52/52
	(4.35%)	(8.50%)	(-0.231)	
Ratio of net proceeds	87.67%	88.60%	-0.828	52/52
	(88.82%)	(89.40%)	(-0.163)	
Underwriter quality	7.28%	3.11%	2.150**	52/52
	(1.08%)	(0.311%)	(-2.663)*	
Auditor quality	0.67	0.57	1.206	52/52
	(1.00)	(1.00)	(-1.204)	
Company age (year)	5.67	8.82	-1.672***	52/52
	(4.00)	(5.50)	(-1.693***)	
Debt ratio	27.65%	26.11%	0.200	52/52
	(12.10%)	(13.50%)	(-0.124)	
ROA (Year -1)	-6.87%	-8.42%	0.199	52/52
	(-0.52%)	(-0.99%)	(-0.273)	
ROE (Year -1)	-7.61%	28.81%	0.183	52/52
	(-0.77%)	(-0.87%)	(-0.910)	

Although the certification model also predicts that presence of a VC should increase the net proceeds from the IPO since their participation should lower the risks for other parties involved in the process such as the underwriter. The results however, indicate that the costs are not lower for VC-backed companies than non-VC-backed companies, although the differences are not significant. This result is not consistent with the findings of Megginson and Weiss (1991) who found that the participation of a VC in the IPO process acts to lower the cost of the issue. These results are, however, in line with the findings of Wang et al (2003). The measure of auditor quality shows a higher mean for VC-backed companies than non-VC-backed companies although the median is the same for both and therefore the results were not significant.

The measure of company age shows that venture capitalists are able to bring their companies to the market more quickly with an average duration of 5.67 years (median of 4 years) from the time of incorporation to the date of listing whereas non-VC backed companies had an average duration of 8.82 years (median of 5.5 years) before listing. This result (which is significant at the 10 per cent level) could be interpreted as either support for the certification/monitoring model by illustrating the effectiveness of the monitoring role of the venture capitalist in assisting the rapid development of their portfolio companies (enabling them to bring the companies to the market earlier), or it could indicate support for the grandstanding model by illustrating the venture capitalists prematurely bring their companies to the market. However, the measures of operating and market performance at the time of the IPO [debt ratio, ROA (Year -1) and ROE (Year -1)] for VC-backed companies all exhibit lower median values than those for non-VC-backed which in not consistent with the predictions of the adverse selection/grandstanding model.

The results for the cross sectional analysis of IPO underpricing is reported in Table 5.3. The coefficient for the VC dummy variable is significant but was not found to be significant. Instead offer size, firm size and whether the IPO took place during the Dot.com period plays a more important role in determining the level of underpricing. This result stands in contrast to the findings of Barry et al. (1990), Hamao et al. (2000), Francis and Hasan (2001) but is consistent with the findings of Franze (2003) and Wong and Wong (2008). Also unlike previous findings underwriter quality (as proxied by market share) was not found to significantly influence the level of underpricing (although the coefficient was negative which is consistent with previous findings). These results imply that in the Australian market, company specific factors and general market conditions play a more important role in determine the degree of underpricing than third party certification.

Overall the results of the IPO performance measures indicate some support for the certification/monitoring model in terms of pricing, size although this does not translate into a lower IPO issuing cost. The results of the measures of company age, operating and financial performance do not appear to support the adverse selection/grandstanding model.

Table 5.3
IPO Underpricing Regression Results

This table presents the OLS regression estimates related to the level of IPO underpricing on a series of independent control variables. Independent control variables used are; VC dummy [*VC*], Log of offer proceeds [*LogProc*], log of market capitalisation [*LogMkt*], book to market ratio [*B/M Ratio*], log of underwriter market share [*LogUnder*], firm age [*Age*] and year dummy [*Year*]. Standardised beta coefficients are reported expected for the intercept which is unstandardised. Corresponding t-statistics are reported in brackets. Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Intercept (*t-statistic*)	VC (*t-statistic*)	LogProc (*t-statistic*)	LogMkt (*t-statistic*)	B/M Ratio (*t-statistic*)	LogUnder (*t-statistic*)	Age (*t-statistic*)	Year (*t-statistic*)	F-Value	Prob>F	Adj R^2
1.169 (13.675)*	0.067 (0.673)							0.453	0.502	0.004
0.423 (0.743)		0.861 (2.945)**						20.487	<0.0001	0.212
0.740 (1.081)			-0.063 (2.635)**					33.403	<0.0001	0.148
1.224 (18.883)*				-0.059 (0.599)				0.359	0.550	0.006
1.173 (6.559)*					-0.019 (-0.181)			0.033	0.857	0.000
1.293 (12.848)*						-0.102 (-1.032)		1.065	0.304	0.001
0.526 (0.476)							0.3154 (2.871)**	22.469	<0.001	0.148
0.656 (0.489)	0.144 (1.283)	0.582 (2.168)**	-0.560 (2.197)**	-0.098 (-0.945)	-0.073 (-0.565)	-0.071 (-0.610)	0.237 (2.231)**	48.574	<0.001	0.193

Table 5.4
Post-IPO Operating Performance Measures

This table presents the post-IPO operating performance measures for VC-backed and non-VC-backed matched IPO subsamples listing between 1999 and 2005 on the ASX. Mean (median) results are reported for each variable. Independent sample t-statistics and Mann-Whitney-Wilcoxon Z score are reported for each variable. Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

	VC-Backed IPOs mean (median) (%)	Non-VC-Backed IPOs mean (median) (%)	t-statistic (Z score)	Sample Size (VC/Non-VC)
ROA (Year 0)	-19.78	-10.83	-1.273	52/52
	(-7.37)	(-7.40)	(-0.478)	
ROA (Year 1)	42.24	-26.98	-1.216	49/51
	(-21.13)	(-13.91)	(-0.783)	
ROA (Year 2)	-33.43	-32.69	-0.064	46/50
	(-16.08)	(-14.83)	(-0.440)	
ROE (Year 0)	-23.09	-12.94	-0.659	52/52
	(-8.09)	(-11.07)	(-0.338)	
ROE (Year 1)	-37.15	-42.52	-0.207	49.51
	(-23.88)	(-18.94)	(-0.031)	
ROE (Year 2)	-32.23	-51.96	0.667	46/50
	(-14.45)	(-17.91)	(-0.121)	
Change in ROE in Year 0	-15.47	-41.75	0.844	52/52
	(-7.08)	(-9.34)	(-0.631)	
Change in ROE in Year 1	-12.18	-30.05	0.529	49.51
	(-6.56)	(-4.96)	(-0.197)	
Change in ROE in Year 2	7.88	-8.26	0.414	46/50
	(-0.65)	(-2.03)	(-0.825)	

5.5.2 Operating Performance after the IPO

The results for the operating performance after the IPO measures are given in Table 5.4. These measures examine the operating performance of the VC-backed and non-VC-backed companies in the financial year of the listing date (Year 0) and the two financial years after the listing date (Years 1 and 2). The size of the sample declines over time as some of the companies were eliminated from the sample group due to takeovers or corporate failures.

The results in Table 5.4 show that both VC-backed and non-VC-backed companies exhibit negative ROA and ROE in the year of, and the years immediately following, the listing date. This is true for both the mean and median values. The results for the ROA measure demonstrate lower average and median values for the VC-backed companies than for the non-VC-backed companies in all of the periods measured which is consistent with the adverse selection/grandstanding model although the differences are small and not statistically significant. However, the change in ROE variable exhibits a slower decline for VC-backed companies than for the non-VC-backed companies in Year 0 and Year 2 although a larger decline in Year 1. This result is more in line with the predictions of the certification/monitoring model but again the differences are not statistically significant.

Overall, the results of the operational performance measures do not provide clear evidence of support for either of the prediction models. There is some very weak support for adverse selection/grandstanding model but also some weak support for the certification/monitoring model. These results contrast with those of Wang et al (2003) who found results consistent with the adverse selection/grandstanding and those of Jain and Kini (1995) who found results consistent with the certification/monitoring model.

5.5.3 Market performance after the IPO

The results for the market performance measures after the IPO are given in Table 5.5. Panel A details the mean (median) holding period excess returns over measurement intervals of three months, six months, one year, two years and three years from the listing date. Panel B details the wealth relatives for holding periods of three months, six months, one year, two years and three years from the listing date. As with the operational performance after the IPO measures the sample size of the market performance measures declines as the time from the listing date increases due to takeovers and corporate failures.

The mean and median buy and hold excess returns for the VC-backed companies are higher (although in the six month, one year, two years and three years periods the median values are negative) in all measurements periods (except for the three-month VC-backed mean excess return which is slightly lower). The mean returns on the VC-backed companies are positive in each holding period measured whereas the mean returns on the non-VC backed companies become negative after the first six months (the median returns on both VC-backed and non-VC-backed companies are negative over each of the measurement intervals). Whilst most of these values are not statistically significant the three year excess return are significant (at the 10 per cent level).

Table 5.5
Post-IPO Market Performance Measures

This table presents the post-IPO market performance measures for VC-backed and non-VC-backed matched IPO subsamples listing between 1999 and 2005 on the ASX. Mean (median) results are reported for each variable. Independent sample t-statistics and Mann-Whitney-Wilcoxon Z score are reported for each variable. Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level.

Panel A: Holdings period returns from IPO date

	VC-Backed IPOs mean (median) (%)	Non-VC-Backed IPOs mean (median) (%)	t-statistic (Z score)	Sample Size (VC/Non-VC)
Three month holding period	14.91	15.87	-0.077	52/52
	(0.19)	(-5.00)	(-0.390)	
Six month holding period	13.64	6.91	0.325	48/52
	(-11.17)	(-16.85)	(-0.611)	
One year holding period	4.27	-4.26	0.420	48/52
	(-19.52)	(-28.87)	(-0.718)	
Two year holding period	25.50	-9.34	0.978	46/51
	(-43.82)	(-47.90)	(-0.867)	
Three year holding period	25.25	-45.46	1.820***	43/49
	(-57.58)	(-70.42)	(-1.752***)	

Panel B: Wealth relatives from IPO date

	Wealth Relative	t-statistic	Sample Size
Three month holding period	1.178	1.789***	52
Six month holding period	1.562	2.695*	48
One year holding period	2.201	2.233**	48
Two year holding period	1.482	0.806	46
Three year holding period	1.779	0.964	43

When examining the post-IPO market performance using the wealth relative measure there is evidence of a significant outperformance by VC-backed IPOs against their matched non-VC-backed counterparts. The wealth relative for all holding periods measured is greater than one indicating that VC-backed IPOs outperform non-VC-backed IPOs. The level of outperformance peaks at the one year holding interval before declining in later periods. For the three, six and twelve month holding periods these results are statistically significant (at the 10 per cent, 1 per cent and 5 per cent levels respectively).

These results demonstrate that VC-backed companies outperform non-VC-backed companies after allowing for broad market movements for at least three years following the listing date. Additionally the VC-backed companies continue to outperform even after the mandatory 2-year escrow period has passed.[154] These results are consistent with the predictions of the certification/monitoring model and are also consistent with the findings of Brav and Gompers (1997) who found better long term market performance of VC-backed IPOs over non-VC-backed IPOs.

5.5.4 Differences between performance by VC age

The results for the IPO performance, operational performance after the IPO, and market performance after the IPO, generally support the certification/monitoring model although there was some weak support for the adverse selection/grandstanding model using the operational performance metrics. In this section the performance

[154] 11 March 2002 the mandatory 2-year escrow agreement was removed for VC funds but not for the founders or other promoters of the offering. Approximately 62% of the sample is subject to this restriction with the remainder listing after that date.

differences between IPO companies backed by older VC firms and those supported by younger VC firms are examined to determine if there is any stronger evidence of differences consistent with the predictions of the grandstanding model or if support for the certification/monitoring model is uniform across VC firms regardless of experience. The time between the incorporation of the VC firm and the listing date for each VC-backed IPO is used classify VC age. VC age is then used as a proxy for the experience and prestige of the venture capital firm. The results are shown in Table 5.6.

Table 5.6
Summary Statistics of Age of VC firms

This table shows the mean and median age (and standard deviation) of VC firms in the IPO sample. VC Age is defined as the number of years between the incorporation of the VC firm and the VC-backed IPO listing date.

	Mean (Yrs)	Median (Yrs)	Standard Deviation (Yrs)	Sample Size
VC Age	8.39	7.00	5.28	52

Similar to Gompers (1996) and Wang et al (2003), VC-backed IPOs are partitioned into two subsamples; those backed by more experienced (older) VC firms and those backed by less experienced (younger) VC firms. Using the median age of seven years as the boundary a VC firm is classified as ‘old’ if it’s age is older than seven years and ‘young’ if it’s age is seven years or younger. This boundary is consistent with that used by Gompers (1996) of six years and Wang et al (2003) of eight years. The differences between IPO offering proceeds, underpricing, underwriter and auditor quality, company age, ROA (Years 1 and 2), change in ROA (Years 1 and 2), together with the three month, six month, one year, two year and three years excess returns are examined for the two subsamples. The results are presented in Table 5.7.

The results show that older venture capitalists are able to bring companies to the market at much higher values, with the average offering proceeds of older VC-backed IPOs equal to AUD 105.53 million (AUD 13.50 million median) versus an average offering proceeds of younger VC-backed IPOs equal to a much lower AUD 12.97 million (AUD 9.00 million median). These differences are significant at the 15 per cent level.

The underpricing measure demonstrates lower average underpricing for the older VC-backed IPOs than the younger VC-backed IPOs with the median results showing overpricing for the younger VC-backed IPOs (older VC-backed IPOs exhibit evidence of median underpricing). These results are significant at the 10 per cent level. This suggests that younger venture capitalist firms are less adept at pricing the offer, with their portfolio companies brought to the market either significantly undervalued or, more commonly, overvalued. This is consistent with the predictions of the adverse selection/grandstanding model with younger VC's rushing the companies to market at valuations inconsistent with the market consensus, whereas older VC's are waiting for more favourable conditions to bring their companies to the market resulting in lower underpricing and more 'accurate' pricing. It is also worth noting that the company age variable shows the mean age (but not the median) is lower for younger VC-backed companies than for older VC-backed companies (although these results were not statistically significant) which is also consistent with the grandstanding model.

Table 5.7
VC Age Subsamples Performance Measures

This table presents the IPO performance, post-IPO operating performance and post-IPO market performance measures for old and young VC-backed IPOs listing between 1999 and 2005 on the ASX. VC-backed IPOs are classified as 'old' if the VC age variable is greater than seven years and 'young' if the VC age variable is seven years or less. Mean (median) results are reported for each variable. Independent sample t-statistics and Mann-Whitney-Wilcoxon Z score are reported for each variable. Significance levels: * significant at the 0.01 level; ** significant at the 0.05 level; *** significant at the 0.10 level; **** significant at the 0.15 level.

	Old VC-Backed IPOs mean (median)	Young VC-Backed IPOs mean (median)	t-statistic (Z score)	Sample Size (VC/Non-VC)
Offering proceeds (AUD million)	105.53	12.97	1.495****	24/28
	(13.50)	(9.00)	(-1.506)****	
Underpricing	21.81%	27.89%	-0.273	24/28
	(8.50%)	(-4.09%)	(-1.845***)	
Underwriter quality	10.24%	4.50%	1.716***	24/28
	(1.24%)	(0.88%)	(-1.07)	
Auditor quality	0.83	0.54	2.412**	24/28
	(1.00)	(1.00)	(-2.258**)	
Company age (year)	6.50	4.96	0.889	24/28
	(3.50)	(4.50)	(-0.364)	
ROA (Year 1)	-18.79%	-62.89%	2.355**	23/26
	(4.47%)	(-29.66%)	(-2.224)*	
ROA (Year 2)	-27.81%	-38.16%	-1.925***	21/25
	(-8.43%)	(-35.78%)	(-1.444****)	
Change in ROA in Year 1	-3.16%	-34.48%	2.789**	23/26
	(-0.80%)	(-11.42%)	(-2.875*)	
Change in ROA in Year 2	-6.32%	27.55%	-1.942***	21/25
	(0.40%)	(4.33%)	(-1.731***)	
Three month holding period	19.52%	10.96%	0.488	24/28
	(4.52%)	(-10.30%)	(-0.753)	
Six month holding period	-2.30%	29.58%	-1.005	24/24
	(-14.62%)	(-8.32%)	(-0.515)	
One year holding period	-17.56%	26.09%	-1.694***	24/24
	(-24.48%)	(-3.59%)	(-0.907)	
Two year holding period	-14.86%	65.87%	-1.481****	23/23
	(-39.01%)	(-51.11%)	(-0.165)	
Three year holding period	34.86%	15.18%	0.283	22/21
	(-32.27%)	(-60.72%)	(-0.486)	

Underwriter quality is significantly higher for older VC-backed IPOs than younger VC backed IPOs (at the 10 per cent level). The underwriter for older VC-backed IPOs typically has a 10.24 per cent market share whereas for younger VC-Backed IPOs this figure is 4.50 per cent. Auditor quality shows a significantly (at the 5 per cent level) higher mean result for older VC-backed IPO's than younger VC-backed IPO's. This result is consistent with the predictions of the certification/monitoring model in that portfolio companies of older VC firms are able to leverage the greater expertise and contacts of their more experienced investors than is the case for the portfolio companies of younger VC firms. The mean auditor quality score of the younger VC-backed IPO's of 0.54 is very similar to the value of 0.57 given for non-VC-backed IPO's in Table 5.2.

The post-IPO operating measures of ROA and change in ROA are entirely consistent with the predictions of the grandstanding model. The results (which are all statistically significant) indicated lower ROA for younger VC-backed IPO's in both Year 1 and Year 2 after the listing year. However, the change in ROA improves more quickly for younger VC-backed IPO's, such that by Year 2 the change has become significantly positive. These results confirm that younger VC-backed companies are coming to the market before they are ready (hence the lower ROA values) but that they improve more quickly than the older VC-backed IPO's in the years following their listing as they reach the same level of development as their older VC-backed peers were closer to the date of their public offering. The post-IPO market measures show mixed results with higher buy and hold period returns in the three-month interval and three-year interval for older VC-backed IPOs but higher buy and hold returns for younger VC-backed IPO's in the other measurement intervals. Those results that are statistically significant, the one- and two-year excess returns are not consistent with the adverse selection/grandstanding model which would predict a lower market performance after the IPO.

Overall, there is evidence that older venture capital firms, through their experience, are able to bring their companies to the market more quickly, at higher valuations and with more consistent offering pricing than younger venture capitalist firms. Older VC-backed IPOs also benefit from higher operating performance in the years immediately after the listing. The evidence on younger venture capital firms, however, is more consistent with the adverse selection/grandstanding model. Younger VC-backed IPO's exhibit lower valuations, tended towards the extremes in pricing with either larger underpricing or common overpricing. They also tended to have lower post-IPO operating performance and lower post-IPO market performance but with some evidence that these performance differences diminished over time subsequent to the public offering. These results confirm the hypothesis ($H_{5.3}$) that IPOs backed by more experienced VC firms exhibit better IPO performance and better post-IPO operating and market performance.

5.6 Summary

This study has examined the certification/monitoring model and the adverse selection/grandstanding model using IPO pricing measures and post-IPO operating and market performance measures and has found some significant results. There was some evidence that VC-backed IPO's were brought to the market at higher valuations, more quickly, and with lower median underpricing (although with no corresponding reduction in the issuing costs) than those without the backing of a venture capitalist. This confirms the prediction of the certification/monitoring model and is in contrast to the previous findings of da Silva Rosa et al (2003), who were unable to find any evidence of support for the certification model using IPO pricing measures in Australia. This may be the result of differences in the research method or it could reflect a greater 'maturing' of the Australian market since the earlier study. Also despite the structure and scale differences between the Australian and US venture capital market, these results confirm many of the findings of previous US focused studies.

The post-IPO operating performance measures for all VC-backed IPO's were somewhat mixed with weak evidence for both models but the post-IPO market performance measures showed evidence of support for the certification/monitoring model with consistently stronger post-IPO performance for the VC-backed companies compared to non-VC-backed companies (although both groups exhibited negative returns in each of the measurements intervals). This difference was particularly pronounced when using wealth relative measures of post-IPO. When benchmarked against their matched non-VC-backed peers, the VC-backed IPOs significantly outperformed over all of the holding periods examined.

When the sample was subdivided into older VC-backed IPO's and younger VC-backed IPO's a much clearer picture of the effects of VC participation emerges. There is evidence of support for the certification/monitoring model in older VC firms and evidence of support for the adverse selection/grandstanding model in younger VC firms. This supports the third hypothesis ($H_{5,3}$) that predicts that IPOs backed by more experienced venture capital firms exhibited better IPO performance and better post-IPO operating and market performance than those backed by less experienced venture capital firms. Thus, we would conclude that the experience of the venture capital firm plays a crucial role in determining whether potential investors consider the backing of a VC as beneficial or not to a listing company.

Overall, this study found strong, but not conclusive, support for hypothesis one ($H_{5,1}$) which predicts that venture capital-backed IPOs exhibit better IPO performance and better post-IPO operating and market performance (although with the difference declining over time) than non venture capital-backed IPOs. This suggests that the certification/monitoring model dominates in the Australian market.

Chapter 6: Conclusion

The issues examined within this dissertation are a fundamental part of the functioning of secondary markets and the broader integrity of the financial system. The fair valuation of equity securities is dependent upon information about the nature of future cash flows and inherent risks contained within the security. Thus, the speed by which the information contained in corporate earnings announcements is incorporated into prices, the behaviour of algorithmic traders around such announcements, or the insights that venture capitalist backing of newly listing companies has for third party investors, all serve an important function in influencing the efficiency of the equity market.

The volume of existing literature in Chapter 2 demonstrated the enormous importance that scholars have placed on understanding how these aspects of market efficiency and trading behaviour influence the price formation process. And yet the discordant nature of that research also demonstrated that much more work remains to be done before we have a comprehensive understanding of these phenomena. The three essays of this dissertation represent another step along the path towards that understanding.

The first essay of this dissertation examined the intraday speed of adjustment of stock returns to the information contained in preliminary final earnings announcements by companies on the Australian Securities Exchange (ASX). The mechanisms operating on the ASX are quite different to those operating on the markets that most previous literature has examined. In particular, the existence of automatic exchange enforced trading halts contrasts with the US equity markets that are more frequently studied in existing research. The study found that informationally driven abnormal returns are limited to the pre-open phase immediately after the release of the announcement consistent with the expectations of the efficient markets hypothesis. This occurred regardless of whether the announcement was released during or outside of trading hours. Furthermore there was little evidence of strategic timing of announcements by managers, perhaps as a consequence of the efficient price adjustment process observed. This stands in stark contrast to the previous findings of Patell and Wolfson (1984), Francis et al. (1992), Greene and Watts (1996) and Lee and Park (2000).

This suggests that the exchange enforced trading halts on ASX serve their intended purpose of allowing investors time to consider the implications of the information contained in the announcement prior to commencing trading. This finding has important policy implications for other exchanges around the world that do not enforce trading halts at the time of corporate earnings announcements.

The second essay of the dissertation examined the trading behaviour of algorithmic traders around corporate information releases during normal trading hours. The study found evidence that algorithmic traders significantly increased their trading activity in the period immediately after the information release. This abnormal trading activity was largely confined to the first half-hour interval after the announcement and was unrelated to the degree of surprise contained within the announcement itself. It appears as though algorithmic traders are responding to opportunities created by their speed advantage rather than any information advantage. The evidence that the introduction of co-location has had a significantly positive impact upon the level of algorithmic trading supports this argument.

This is an important finding. There has been a great deal of concern amongst regulators, and the wider financial community, about the implications of the rise in algorithmic trading on market integrity. These results show that, whilst algorithmic trading activity increases around corporate earnings announcements, the increase is not information driven and thus does not imply that algorithmic traders possess an informational advantage over other market participants. This suggests that higher levels of algorithmic trading does not in itself call into question the informational integrity of the exchange.

The third essay of this dissertation examined the role of venture capitalists in the initial public offering process. Using a matched sample of VC-backed and non-VC-backed IPOs on the Australian market, this study found evidence to support the certifying role of venture capitalists. There was evidence that VC-backed IPO's were brought to the market higher valuations, more quickly, and with lower median underpricing (although with no corresponding reduction in the issuing costs) than those without the backing of a venture capitalist. Furthermore VC-backed firms exhibited evidence of better post-IPO market performance than non-VC-backed firms. There was also some evidence of improved post-IPO operating performance for VC-backed IPOs. This confirms the prediction of the certification/monitoring model and is in contrast to the previous findings of da Silva Rosa et al (2003), who were unable to find any evidence of support for the certification model using IPO pricing measures in Australia. Furthermore, when the VC-backed firms were partitioned according to the age of the VC firm there emerged strong evidence that older VC firms are able to certify the quality of the offering to third party investors whereas younger VC firms are more likely to suffer the consequences of adverse selection or to grandstand their portfolio companies.

These results confirm that despite the structural differences between the Australian venture capital market and its more frequently studied US counterpart, venture capitalists behave in a very similar manner. This has important consequences for both the venture capital industry and the wider financial community. These findings confirm to potential investors in venture capital funds, such as superannuation funds, that experienced venture capitalists in Australia are able to add value to their portfolio companies through their involvement and that value is recognised by other participants in the equity market when those companies are taken public. This benefit however does not accrue to less experienced venture capitalists. Furthermore, these results confirm for investors in the IPO market that the presence of an experienced venture capitalist on the registry of a new offering will, on average, led to lower IPO underpricing and improved post-IPO operating and market performance. In essence the presence of a venture capitalist on the registry reduces the information asymmetry surrounding a new offering.

The issues investigated in this dissertation are complex. No single piece of research could claim to have discovered the ‘truth’ about these topics. Nevertheless, the findings of these essays enhance our understanding of these critical aspects of financial market behaviour.

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