Market Integrity Issues in Financial Markets

Rizwan T Rahman

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CERTIFICATE

I certify that this thesis has not already been submitted for any degree and is not being submitted as part of candidature for any other degree.

I also certify that the thesis has been written by me and that any help that I have received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

Signature of Candidate

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Rizwan T Rahman

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Preface

Some of the work presented in this dissertation is published as joint work in referred journals.

Chapter 2 is published as: Lepone, A., R. T. Rahman, and J. Y. Yang, 2011, The Impact of European Union Emissions Trading Scheme (EU ETS) National Allocation Plans (NAP) on Carbon Markets, Low Carbon Economy, 2:2, 71-90.

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Synopsis

This dissertation investigates market integrity issues across a range of financial markets. The topics were identified in consultation with the exchanges as of importance to the trading and dealing of securities in financial markets. The essays investigate the leakage of information, information asymmetry, market manipulation, and off-market trading across the carbon, equity, and option markets. The study spans across the European Union Emissions Allowances (EUA) futures market, the Australian Securities Exchange (ASX) equity market, and the Australian Securities Exchange (ASX) option market (AOM). This dissertation extends the research by examining unique datasets not previously available to researchers and investigating emerging market integrity concerns not previously covered in literature. The findings are relevant to the interests of exchanges, investors, regulators, and academics.

The first issue examined in this dissertation is the impact of European Union emissions trading scheme (EU ETS) national allocation plan (NAP) announcements on carbon markets. The study directs its attention to carbon returns and volatility movements around official EU ETS PHASE II announcements. Because the supply and demand in carbon markets operates within constraints set by the ruling government, it creates a level of political risk not present in other markets. Consequently, there is likely to be a higher degree of information asymmetry in carbon markets. A select group of government employees and firm level auditors are apt to information regarding caps and yearly net positions in advance of the market. This creates a concerning information disclosure issue for a market in its infancy. The findings show that Phase II announcements have an influence on both Phase I & II front futures and sole Phase II futures carbon returns. In addition, the results indicate that the announcements have no significant impact on volatility. Together, the findings suggest a systematic leakage of information across all types of announcements.

The second essay examines trade cancellations on the Australian Securities Exchange (ASX). Trade cancellations are trades that are determined to have been made in error by both parties, and are subsequently cancelled. There is evidence of a growing trend of trade cancellations on the ASX and concerns regarding manipulative activity. Results indicate return reversal patterns consistent with manipulative activity following the initial trades. The results also show that prior to the trades, the stocks exhibit higher volume, return, and volatility than a benchmark portfolio. During the trades, the stocks also experience significantly higher abnormal volume, return, and volatility. Further, following the trades, higher abnormal volume and volatility patterns continue. Together, these results are consistent with the empirical findings on market manipulation in the literature.

The final essay examines the impact of large off-market option trades on the Australian Options Market (AOM). The analysis involves an investigation of trade prices, quoted liquidity, cumulative abnormal returns, and price effects surrounding the trades on both the options and underlying equity market. The results reveal that large off-market option trades receive price improvement when compared to the quoted prices at the time of the trade. In addition, examination of bid ask spreads and quotes in 5-minute and 1-hour intervals prior to and following the trades show no significant impact on liquidity. Further, price effect analysis reveals that large off-market option trades experience no significant leakage or permanent price effects. However, there is some evidence of temporary price effects following large off-market option trades. Finally, cumulative abnormal returns in the days surrounding the trades reveal no significant price patterns prior to and following the trades.

Chapter 1: Introduction

Market integrity is essential to the success of an exchange (see O'Hara, 2001). Market integrity refers to the ability of investors to transact in a fair and informed market where prices reflect information. With lacklustre investor confidence and falling trading volumes, regulators around the world are under more pressure than ever to reassure the public that securities markets are fair and efficient. In addition, technological advancement and economic reform has facilitated capital mobility and exchanges must compete for order flow based on their ability to meet these interrelated objectives.

A wide variety of academic research examines market integrity. Much of this literature examines regulatory environments and market integrity from a legal perspective (Fischel and Ross, 1991; Black, 1996; Andrews, 2003). Other theoretical literature attempts to model the possibility of profitable market integrity concerns such as market manipulation (Allen and Gorton, 1992; Kose and Narayana, 1997). In recent years, some empirical focus has shifted towards examining market manipulation and insider trading (Aggarwal and Wu, 2006; Fishe and Robe, 2004).

With the creation of new financial instruments and markets, and the proliferation of technology leading to automated trading, markets are adapting and changing at a phenomenal rate. This has led to many aspects of market integrity in financial markets that have remained unexamined. Thus, the main objective of this dissertation is to investigate emerging market integrity issues in financial markets.

Market integrity is essential in promoting confident and informed participation by firms and investors, thus contributing to an efficient and prosperous economy. A lack of market integrity can deprive honest investors of their capital, reduce investor confidence, increase the cost of capital, and deter order flow. Further, the integrity of financial markets is crucial to support the liquidity and depth necessary to attract investors. This is particularly so in the case of emerging markets in their infancy such as the European Union Emissions Trading Scheme (EU ETS) market for European Union Allowances (EUAs). Therefore, a system of appropriate procedures that maintain market integrity in a market is vital to the orderly functioning of that market.

The study of market integrity is beneficial to both market operators and regulators alike. Market operators play an important role in maintaining confidence in market integrity, while the regulator plays an important enforcement role in investigating behaviour that threatens market integrity and taking action against those who have broken the law. Regulation is primarily directed towards:

(i) using disclosure as the way to keep markets informed; and

(ii) prohibiting certain types of misconduct (notably insider trading and market manipulation).

The proper handling of confidential information promotes market integrity and efficiency by reducing the risk of leaks or insider trading. It empowers entities to manage the timely release (in accordance with the law) of its information in accordance with its continuous disclosure rules. Information disclosure and the handling of confidential information have emerged as key flaws in the European Union Emissions Trading Scheme (EU ETS) market for European

Union Allowances (EUA) following the request made by the European Federation of Energy Traders (EFET, 2006) to the European Commission for carbon price sensitive information that is *accurate, final and published in such a way as to be available to all market participants at the same time.* Therefore the first issue examined in this dissertation is the impact of European Union emissions trading scheme (EU ETS) national allocation plan (NAP) announcements on carbon markets.

Market manipulation is also a major market integrity concern for market operators and regulators. By distorting prices, manipulators create an artificial market in which prices do not reflect information and leads to an unfair market. Manipulation can discourage market participation and lead investors to trade in alternative markets, thereby decreasing liquidity and increasing trading costs. Consequently, manipulation can also lead to an increase in the cost of capital and discourage firms from listing on markets where manipulation is prevalent. Manipulation impairs price discovery through reduced order flow and distorts prices from their equilibrium. This reduces informational efficiency and causes deadweight economic losses due to distorted resource allocation and wealth redistribution (Pirrong, 1995). With the proliferation of new technologies such as broker execution engines and high frequency algorithmic trading, the growing trend of cancelling trades after they have executed and been reported have emerged as a developing concern. These trades can lead to distorted prices among other market wide statistics. Further, there is evidence to suggest that some of these trades are in violation of exchange trading rules and possibly manipulative in nature. Thus, this dissertation initiates the first comprehensive investigation of trade cancellations to understand their magnitude and impact on market integrity.

Market integrity also concerns market quality in the provision of adequate liquidity and fair and informed prices when transacting large trades. Market quality depends on the liquidity of the market and the price impact of trades. One of the key research questions in market microstructure is how market structure can influence the economics of liquidity provision. Market structure defines a set of rules that affect how market participants formulate their trading strategies (O'Hara, 1995). To date, a large amount of theoretical and empirical literature examines block trading or upstairs trading in equity markets (Grossman, 1992; Easley and O'Hara , 1987; Seppi, 1990; Keim and Madhavan, 1996; Madhavan and Cheng, 1997; Smith et al., 2001; Booth et al., 2002; Bessembinder and Venkataraman, 2004; Kraus and Stoll, 1972; Kraus and Stoll, 1972; Holthausen et al., 1987; and Gemmill, 1996). The literature examines the impact of market structure on market quality. However, there exists a lack of empirical evidence for large off-market trades in derivatives markets. Therefore this dissertation contributes to the literature by examining the impact of large off-market trading in the options market.

1.1 Summary

The three essays of this dissertation investigate emerging market integrity issues from three different financial markets. This chapter motivates each issue by illustrating its contribution to the existing literature. Chapter 2 contributes to the literature on information asymmetry and uncertainty in the carbon markets. Chapter 3 contributes to the literature on trade cancellations and market manipulation. Chapter 4 contributes to the literature concerned with the relationship between market structure and liquidity.

The remainder of this dissertation is organised as follows. Chapters 2, 3, and 4 investigate the three issues discussed in this chapter. Each chapter includes the literature review, data and sample, research design, empirical results, and conclusions reached. Overall conclusions are presented in Chapter 5.

Chapter 2: The Impact of European Union Emissions Trading Scheme (EU ETS) National Allocation Plans (NAP) on Carbon Markets.

2.1 Introduction

The first essay examines the impact of information disclosure practices and the handling of confidential information in the European Union Emissions Trading Scheme (EU ETS) market for European Union Allowances (EUA). Information asymmetry and uncertainty is a dominant feature of the cap and trade EU ETS. The two major sources of information asymmetry and uncertainty are derived from the process of setting future emissions caps based on projected figures and past emissions (the supply constraint), and the yearly verification of emission through audits. Inconsistencies in emissions data from different agencies create a level of information asymmetry and uncertainty among market analysts, and diminishes their ability to make accurate assessments of the market (Kanen, 2006).

The EU ETS provides an opportunity to examine the effect of numerous unscheduled and sporadic releases of official information on a single price series. The market for European Union Allowances (EU ETS carbon credits) is also unique in several other ways. First, the asset itself is a product of legislation, where individual governments under the supervision of the European Commission are responsible for setting emissions caps and allocating EUAs to firms.[1] Therefore the National Allocation Plans that are examined essentially set the supply of EUAs, and the Verifications report the demand during the preceding period and the

[1] A European Union Allowance (EUA) gives the holder the right to emit one tonne of carbon dioxide. Each futures contract represents 1,000 EUAs.

remaining supply. Further, because supply and demand in carbon markets operates within constraints set by the ruling government, it creates a level of political risk not present in other markets. Second, there is likely to be a higher degree of information asymmetry in carbon markets. A select group of government employees and firm level auditors are apt to information regarding caps and yearly net positions in advance of the market. Third, futures contracts in Phase II 2008 EUAs traded without a spot market for approximately two years (Frino, Kruk and Lepone, 2010).

Despite these interesting characteristics, the majority of literature focuses on the environmental and political aspect of emissions trading. The common themes out of the handful of studies that do investigate emissions trading from a financial markets perspective are carbon pricing, price discovery, market efficiency, and information asymmetry. [2] Surprisingly, the majority of research focuses on the spot EUA market, even though it accounts for only two percent of the EU ETS trading volume. In this work, we attempt to correct the imbalance in emissions trading literature by examining the European carbon futures market. Futures markets are essential to the development of the EU ETS as they facilitate risk transfer and price discovery, as well as providing a forecast for the marginal cost of abatement. Specifically, this study analyzes the impact of Phase II National Allocation Plans announcements on carbon returns during the period February 2006 through December 2008, during which time more than 170 announcements were released.

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[2] Studies of carbon pricing include Mansanet-Bataller, Tornero, and Mico (2006), Sijm, Neuhoff, and Chen (2006), Alberola, Chevallier, and Cheze (2007), Convery and Redmond (2007), Daskalakis, Psychoyios, and Markellos (2007), and Daskalakis and Markellos (2007a). Studies of information asymmetry and uncertainty in the European carbon market include Mansanet-Bataller and Pardo, 2007; Chevallier, Ielpo, and Mercier, 2008. Studies of carbon market efficiency and price discovery include Daskalakis and Markellos (2007b) and Milunovich and Joyeux (2007).

This study follows the event study approach of Mansanet-Bataller and Pardo (2007). However, this study differs to that of Mansanet-Bataller and Pardo (2007) in focusing mainly on EU ETS Phase II announcements (National Allocation Plans) and Phase I verifications on both the front futures (which include both Phase I & II prices) and the sole Phase II futures prices (December 2008 expiry). The study of Phase II prices and announcements is of greater importance because under the EU ETS, it is the first Kyoto Protocol compliant phase of emissions trading. The EU Phase I emissions trading scheme was initiated as a trial phase to prepare for Phase II in which real abatement was to occur. Subsequently, Phase I EUAs were found to be over allocated. Phase II allocations are more restrictive and are likely to lead to a real reduction and abatement in emissions. As reported on April 1, 2009 by the European Commission after the release of 2008 verified emissions data, the second phase ETS was short in 2008 despite the economic downturn (Capoor and Ambrosi, 2009).

Further, since mid-2006, the majority of EU ETS trading occurs in the Phase II December 2008 expiry carbon contract (Frino et al., 2010). Therefore the study of Phase II announcements and its impact on both the front futures and Phase II futures returns is likely to yield more robust conclusions regarding the impact of carbon announcements on carbon returns and volatility. This will provide further insights into the operation of the EU ETS into the future, and may highlight regulatory factors that can be improved upon.

An advancement of this study is that we source the earliest date on which an official announcement becomes public by searching through both official and carbon specific news databases. This is an attempt to address a limitation in the Mansanet-Bataller and Pardo (2007) study that does not account for information that becomes public before the official announcement date. Information leakage occurred most notably in Phase I when several member states released their 2005 emissions data ahead of the European Commission's official release date (Frino et al., 2008).

The remainder of this chapter is organised as follows. Section 2.2 describes the literature and develops several testable hypotheses. Section 2.3 outlines the current process of releasing official information on the EU ETS. Section 2.4 describes the data and sample. Section 2.5 sets out the research design, and presents the empirical results. Section 2.6 summarises the chapter.

2.2 Literature Review

This section reviews the literature related to the issues examined in this study. In turn, based on the literature reviewed, a number of testable hypotheses are developed. This section is structured as follows. Section 2.2.1 provides a review of the literature concerned with carbon market liquidity and volatility. Section 2.2.2 offers a review of the literature that examines the merits of the EU ETS allocation plan methodology. Section 2.2.3 reviews the literature on information asymmetry and uncertainty in carbon markets. Section 2.2.4 uses the literature reviewed to develop testable hypotheses that are tested subsequently in this study.

2.2.1 Carbon Market Liquidity & Volatility

Theory stipulates that the price of permits under the EU ETS should establish the marginal cost of emissions reductions that is sufficient to meet the allocation cap set in within the scheme (Betz, 2006). However in practice the scheme has experienced impediments in the form of substantial price volatility and liquidity costs.

Frino, Kruk, and Lepone (2010) investigate the market microstructure of EU ETS futures markets during the period April 2005 to June 2008. The study investigates liquidity by examining volume, volatility, bid-ask spreads, depth, and market impact costs for ECX CFI contracts. Frino, Kruk, and Lepone (2010) note a monotonic increase in liquidity represented by increased volume and decreased quoted and effective spreads. They also report that the tick size was reduced in 2007 as trading volume increased, however, they do not identify the changing tick size as a factor that influences liquidity directly, in contrast to Bessembinder (2003). Furthermore, Frino, Kruk, and Lepone (2010) note increasing market impact and total price effects with increasing trade sizes. They conclude that larger trades incur greater market impact costs, while small trade sizes actually experience price reversals, consistent with a developing market.

Based on their findings Frino, Kruk, and Lepone (2010) suggest that trades are increasingly being executed by informed traders. Benz and Hengelbrock (2008) similarly find evidence of increased liquidity for both the ECX and Nord pool futures markets, and signal considerably larger increases in liquidity for the more liquid ECX market, consistent with Chowdhry and Nanda (1991) and Admati and Pfleiderer's (1988) arguments that liquidity encourages further liquidity.

Kruger (2008) found the main contributors to carbon price volatility under the EU ETS were fuel prices, weather, and policy developments. Betz (2006) examined EU ETS carbon price volatility and concluded that the underlying reason for the volatility is the fact that the EU ETS is a relatively new market and new markets generally require time to realise real price discovery. Furthermore, it becomes difficult for a market structured like the EU ETS, with a small number of dominant large players to achieve informational efficiency. There are three recent studies which shed some light on this issue with Seifert et al (2008) suggesting some evidence of efficiency based upon a test of autocorrelations, but only using a very small sample. In sharp contrast to this Daskalakis and Markellos (2008) found significant autocorrelations in the data and dismissed the random walk notion as applying to carbon prices. Montagnoli and de Vries (2010) used a series of variance ratio tests to find that the EU ETS was inefficient during Phase I but efficient during the first period of Phase II. This suggests that the carbon market shows the first signs of maturation after the learning and trial period of Phase I.

Lepone, Sacco, and Yang (2013) investigate long-horizon weak form market efficiency in the Phase II EU ETS Carbon Futures Market. Using data that spans trades in both Phase I and Phase II futures they find evidence of a significant structural change to the EU ETS from Phase I to Phase II and support for the efficient market hypothesis during Phase II (2008–2010), similar to Montagnoli and de Vries (2010). Furthermore, their results suggest that documented improvements in market quality, increasing trading activity, and removal of Phase I market frictions have fostered improvements in market efficiency into and during Phase II.

Though the carbon market is clearly still at a pilot stage of development, there is evidence to suggest that the carbon allowance market is starting to show some signs of efficiency as a centre of price discovery and dissemination and that in the near future it is likely to grow in size and scope of complexity (Bettelheim and Janetos 2010).

2.2.2 EU ETS Allocation Plans

There are three particular issues of importance with the allocation of caps in the EU ETS. The first is the fact that allocation was essentially free, with minor exceptions, for the first two phases that essentially triggered a "free allocation" (or grandfathering—i.e., giving companies permits based on historical output or emissions) versus auctioning. Second, the trading scheme only applied to a portion of the emissions, thereby creating potential inefficiencies between the traded and non-traded sectors. Third, the highly decentralized nature of the process in phase 1 of the EU ETS, which was mainly the responsibility of member states had perverse incentive effects.

National Allocation Plans (NAPs) were the instruments each member state used to decide how many allowances would be allocated and who would get them. The most comprehensive review of these issues, but especially the realties and the implications of allocation in the first phase are to be found in Ellerman, Buchner, and Carraro (2007) and Buchner, Carraro, and Ellerman (2006).

The second-phase (2008–2012) allocations are carefully dissected in Neuhoff et al. (2006). Burtraw (2001) provides an overview of the issues regarding the grandfathering versus auctioning debate and their impact on economic efficiency. Cramton and Kerr (2002) also examine the merits of grandfathering versus auctioning and find that an auction of carbon permits is the best way to achieve domestic carbon caps designed to limit global climate change.

Bohringer, Hoffmann, and Manrique-de-Lara-Penate (2006) examine the inefficiencies inherent in splitting the market between the trading and the non-trading sectors. Essentially the paper concludes that the main efficiency problem of the EU ETS is the separated carbon markets that do not allow for equalized abatement costs between ETS and non-ETS sectors. Bohringer and Lange (2005) address the optimal design of grandfathering schemes by investigating how different allocation schemes can affect the outcome of an emissions trading scheme like the EU ETS. They find that an emission trading scheme with updated grandfathering based on emissions can in fact be cost-effective.

The issue of auctioning, and its implications, has continued to be a subject of considerable analysis, with the analytical community's broad consensus in favour of auctioning running into the realpolitik of securing initial agreement from key stakeholders, for whom free allocation was a prerequisite.

2.2.3 Information Asymmetry and Uncertainty in Carbon Markets

Information asymmetry and uncertainty is a dominant feature of the cap and trade EU ETS. The two major sources of information asymmetry and uncertainty are derived from the process of setting future emissions caps based on projected figures and past emissions (the supply constraint), and the yearly verification of emission through audits. Inconsistencies in emissions data from the different agencies create a level of information asymmetry and uncertainty among market analysts and diminish their ability to make accurate assessments of the market (Kanen, 2006). Emissions data published by the European Environment Agency and the EU transaction log differs substantially. They are collected according to different procedures and sector definitions and sometimes by different government bodies. In addition, the allocation and reporting process for the national allocation plans in Phase I and Phase II lacked transparency and hence led to further uncertainty.

Mansanet-Bataller and Pardo (2007) study the effect of Phase I and Phase II information releases on Phase I prices during the period October 2004 through May 2007. They document that returns are significantly higher on days when the European Commission released additional information and approved Phase I National Allocation Plans. Their results also reveal significantly higher returns after the 2005 verifications and significantly lower returns following 2006 emissions announcements. The study suggests that differences in the EU ETS being short or long during the trading period affected the opposite returns to the verifications data. These results provide evidence that information regarding Phase I NAPs and verifications have a material effect on Phase I carbon prices.

Further, they also examine returns and volatility surrounding the announcement days. The study documents significant returns preceding Phase I National Allocation Plan notification, Phase I NAP additional information, Phase II National Allocation Plan notification, and 2005 verifications announcements. In concert with their finding that volatility is not significantly different following announcements, their study reveals a systematic leakage of information preceding EU ETS announcements.

Following Mansanet-Bataller and Pardo (2007), Miclăuş, Lupu, Dumitrescu, and Bobircă (2008) also examine the effect of EU ETS Phase I & II National Allocation Plans and Verifications announcements on both spot and futures prices by testing the AR(1)-GARCH(1,1) model. The AR-GARCH model in their case presents the markets' expectations, and is used to provide forecast returns in the period around the event. Their methodology analyses both the daily differences in the realised and expected returns as well as the cumulated differences for the period around the event. Consistent with Mansanet-

Bataller and Pardo (2007), trends in the cumulated abnormal returns in their study preceding the event suggest that the information about the event is known by some part of the market in advance. They also find that verifications announcements have a greater effect on market dynamics than NAP announcements.

Similarly, Chevailler, Ieplo, and Mercier (2008) examine the impact of the 2006 emissions verification announcement on changes in investors' risk aversion on the European Carbon Market using options and futures market data. They test the hypothesis that strong reversals in investors' anticipations occur during the 2006 compliance event, and in addition, that the level of volatility decreases after the diffusion of information by the EC which tends to dissipate previously misleading trading information on this new market. The study empirically recovers risk aversion adjustments on the period 2006-2007 by first estimating the risk-neutral distribution from option prices, and then the actual distribution from futures on the European Climate Exchange. Their study uncovers a shift in the level of risk aversion on the EU ETS following the publication of the 2006 verified emissions data by the EC on April 30, 2007. Further, they observe lower levels of volatility for contracts of maturity December 2008 and December 2009 during the time period after the 2006 compliance event. This latter result suggests that Phase I verification information has a strong market effect.

Frino, Kruk, and Lepone (2010) suggest that regulators need to ensure the timely dissemination of all price-sensitive information in line with the findings of Mansanet-Bataller and Pardo (2007) and Miclăuş et al (2008) that suggest a systematic leakage of information prior to official announcements. The Frino, Kruk, and Lepone (2010) study finds a positive and statistically significant permanent price effect indicative of informed trading. They conclude that the potential for insider trading in the market may potentially harm investor confidence and lower uninformed trading and liquidity (Madhavan et al., 1999).

Kalaitzoglou and Ibrahim (2013) analyze trading behaviour through non-price order flow variations as a source of information revelation in the European Carbon Futures Market. They define three regime specifications motivated by three behavioural trading patterns: informed trading characterized by high volume and short duration, uninformed or non-discretionary trades that arrive randomly, and fundamental or discretionary trades that have lagged behaviour. The empirical results reveal that private information is indeed revealed in the rate of order flow, as measured by trading intensity. Informed traders seem to act first and, at least to a sizable proportion, before price changes, in support of the proposition of Glosten and Milgrom (1985) of the intense activity of the informed.

Kalaitzoglou and Ibrahim (2013) also find evidence that informed trading behaviour is followed by similar, but slightly delayed and less intense, activity of discretionary liquidity traders. Their delayed order flow prolongs the effect, or revelation, of the information that the order flow of the informed has started. They follow a learning process and act as 'informed' to a third much larger group of uninformed or non-discretionary liquidity traders that are present in the market. The order flow of this third group is characterized by longer duration and lower trading intensity. The behaviour of the informed and fundamental groups gives credence to Kyle's (1985) strategic activity of traders.

In contrast, Ibikunle et al. (2013) use the Huang and Stoll (1997) spread decomposition model to discover that higher levels of information asymmetry are present during the after market close period/hour than at any other interval/hour during the normal trading day. They also find evidence that contribution to price discovery is a function of liquidity. Their findings reveal that less liquid contracts are the highest contributors to price discovery, even though they are informationally inefficient.

2.2.4 Hypothesis Development

The European Union Emissions Trading Schemes provides a unique opportunity to examine the effect of numerous unscheduled and sporadic releases of official information on a single price series. Furthermore, the EU ETS cap and trade system, a product of legislation, provides a market that is exposed to a higher level of political risk than other markets. This introduces a higher degree of information asymmetry and uncertainty within the market. This study sets out to examine the impact of these information releases on the price, in a market operating with inherently higher informational asymmetry and uncertainty. This study also aims to investigate whether the political and bureaucratic framework that essentially creates the market supply constraint introduces any market integrity concerns regarding the way in which information regarding the National Allocation Plans and Verifications is handled.

Empirically, the prior literature has examined the impact of National Allocation Plan and Verifications announcements on the Phase I carbon price series. The literature (Mansanet-Bataller and Pardo, 2007; and Miclăuş et al., 2008) finds that returns are significantly higher on days when the European Commission released additional information and approved Phase I National Allocation Plans. Their results also reveal significantly higher returns after the 2005 verifications and significantly lower returns following 2006 emissions announcements. The findings suggest that differences in the EU ETS being short or long during the trading period affected the opposite returns to the verifications data. Furthermore, they uncover that trends in abnormal returns preceding the announcements suggest that the information about the event is known by some part of the market in advance.

Together, the studies provide findings that suggest that higher returns are to be expected on the day of the announcements of National Allocation Plan and Verifications official information releases. Furthermore, they present evidence of a systematic leakage of information during Phase I announcements that lead to abnormal returns prior to the announcements.

However, these findings are all based on Phase I of the EU ETS, which was initiated as a trial phase to prepare for Phase II in which real abatement was to occur. In this study we focus mainly on EU ETS Phase II announcements (National Allocation Plans) and Phase I verifications on both the front futures (which include both Phase I & II prices) and the sole Phase II futures prices (December 2008 expiry). Phase II prices and announcements are likely to yield differing results as it is the first Kyoto Protocol compliant phase of emissions trading. Furthermore, Phase I EUAs were found to be over allocated. Phase II allocations are more restrictive and are likely to lead to a real reduction and abatement in emissions. These differences suggest that it is difficult to predict the impact of Phase II announcements on carbon prices. Hence, the following hypotheses are tested in this study.

$\text{Hypothesis}_{2,1}$: Phase II National Allocation Plan announcements lead to significantly higher returns on announcement days.

$\text{Hypothesis}_{2,2}$: Phase II National Allocation Plan announcements lead to significantly higher returns on the days preceding the announcement day.

Mansanet-Bataller and Pardo (2007) find that volatility is not significantly different following NAP and Verifications announcements. Presenting further evidence for their suggestion of systematic leakage of information. In contrast, Chevailler et al. (2008) find that the level of volatility decreases after the diffusion of the 2006 Verifications information by the EC that led to dissipating previously misleading trading information on the market.

As the above discussion indicates, it is difficult to predict the impact of the NAP and Verifications announcements on volatility. Hence, the following hypothesis is tested in this study.

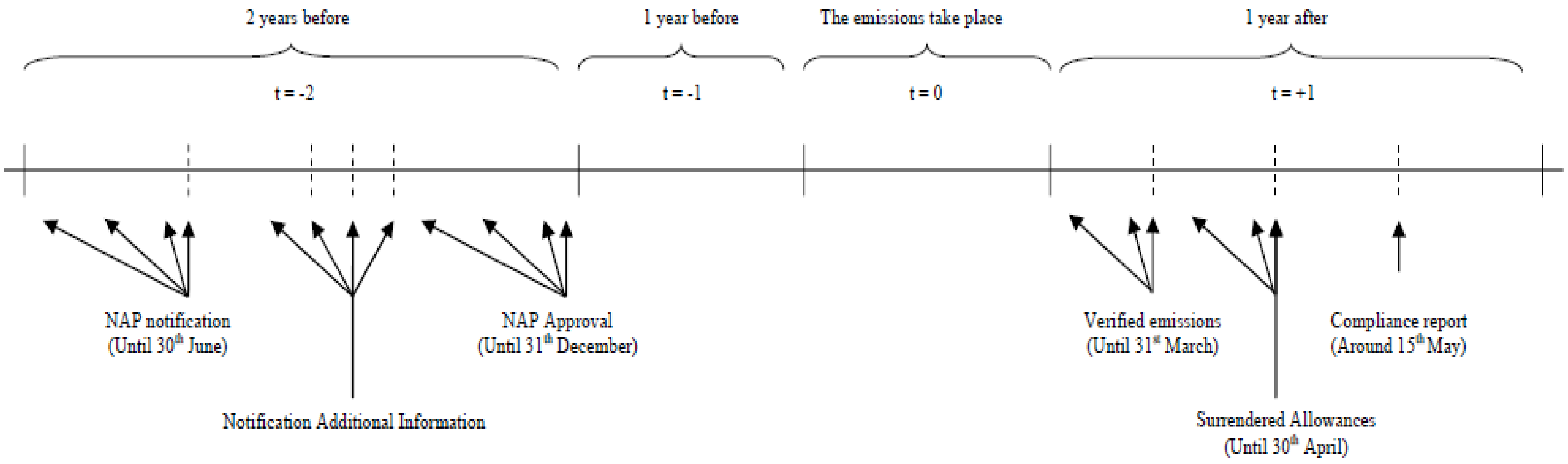
$Hypothesis_{2,3}$: NAP and Verifications announcements have no impact on volatility.

2.3 Release of Information in the EU ETS

The NAP is the document in which Member States determine both the total quantity of CO_2 allowances available in the Member State and the allocation made to each installation covered by the Scheme, which must subsequently be approved by the European Commission. The Draft of this document must be published for public consultation before the Member State final version is delivered to the European Commission. Once the NAP is notified, the European Commission has 3 months for its assessment, and subsequent publication of the corresponding Commission Decision. It is compulsory that the European Commission approves the NAP of each country. If it is not the case, the NAP will be modified until the European Commission approves it. All NAPs must be submitted to the European Commission by the end of June two years before the start of the corresponding Phase, so that the final NAP can be approved at the end of that year. The procedure makes it difficult to know in advance the exact date of publication of new information (Mansanet-Bataller and Pardo, 2007). Figure 2-1 depicts this process graphically.

Figure 2-1 National Allocation Plans and Verifications

This Figure shows how the deadlines are organised in the EU ETS. Two years before the compliance period, NAPs have to be submitted before 30 June to the European Commission. They have to be approved before 31 December of the same year. When the real emissions take place two years later, the verified report has to be presented by each of the companies before 31 March to their respective governments. Then before 30 April, the companies must surrender the allowances that correspond to their real emissions. On 15 May, the compliance report of the Member States is published.



Source: Mansanet-Bataller and Pardo (2007)

Participating companies are required to indicate the amount of emitted CO_2 of the previous calendar year by March 31, and surrender the allowances by April 30 each year. The number of allowances must be equal to the total verified emissions from that installation during the preceding calendar year. Additionally, around 15 May, the Members States must submit a report of the verified emission to the European Commission including all the companies in the country covered by the European Directive. When this information is published, the agents in the market know whether the companies are long or short in respect of the allowances that they have received from their governments.

The various types of announcements are divided into two categories: news strictly related to National Allocation Plans (NAPs) and news related to the Verification of Emissions (VER). In the first group we have 11 sub-categories of events: the First Draft of the NAP, Second Draft of the NAP, Initial Notification of the NAP to the European Commission, Second Notification of the NAP to the European Commission, Notification of Additional NAP Information related to the NAP to the European Commission, NAP Approval by the European Commission, NAP Conditional Approval, NAP Amendment, NAP Amendment Additional Information, NAP Amendment Approval, and Other announcements that relate to the EU ETS such as administrative changes. In the second group, the Verification of Emissions, there are 3 subcategories: verified emissions for the year 2005, verified emissions for the year 2006, and verified emissions for the year 2007. All dates on which more than one different type of announcement occurred are eliminated from the sample for robustness.[3]

[3] An analysis that includes all the announcements does not produce results that are qualitatively different. These are available upon request from the authors.

2.4 Data and Sample

Trading of emission allowance futures contracts is primarily performed through the European Climate Exchange (ECX) in the Netherlands. Since the ECX does not allow spot EUA trading, it uses Powernext spot prices as a reference for the futures contracts. The ECX accounts for approximately 87% of the total exchange-based futures contract transactions in Europe (Frino et al., 2010). To analyse the influence of NAP related announcements on carbon prices, we are interested in the most representative series of EUA prices. Therefore from 1 February, 2006 to the end of the sample (31 December, 2008), we use the ECX nearest Carbon Futures Instrument (CFI) contract for the front futures analysis and the ECX CFI with December 2008 expiry for sole Phase II price analysis. Table 2-1 reports the contract specifications for ECX CFI futures. Mansanet-Bataller and Pardo (2007) report that the ECX has the greatest volume among all carbon markets.

Table 2-1 ECX CFI Contract Specifications

The Table below reports the contract specifications for ECX CFI futures.

Contract	ECX CFI Futures
Unit of trading	1 lot = 1,000 CO2 EU Allowances (EUAs) 1 EUA = entitlement to emit 1 tonne of CO2 or equivalent
Minimum trade size	1 lot
Quotation	Euro (€) and Euro cent (c) per metric tonne
Tick size	€0.01 per tonne (€10 per lot)*
Max. price fluctuation	No limit
Contract months	Monthly - September 2006 to March 2008 (Phase I) Yearly - December expired 2008 to 2012 (Phase II)
Expiry day	Last Monday of contract month
Trading hours	07:00 - 17:00 UK local time
Settlement price	Trade-weighted average during the daily closing period (17:00 - 17:15) with Quoted Settlement Prices if liquidity is low.
Settlement and delivery	Physically settled. Transfer of EUAs in a national registry three days after last trading dat (LTD + 3 delivery)
Margin	All open contracts marked-to-market daily

*The tick size decreased from €0.05 to €0.01 on 27 March 2007.

Source: www.theice.com and the Handbook of World Stock, Derivative & Commodity

ECX futures contracts data is sourced from the Reuters DataScope Tick History (RDTH) Database provided by SIRCA, which includes every bid and ask price submitted each day (together with accurate time stamps). The underlying asset of the futures contract is 1,000 spot EUAs, with the most liquid contracts being those with annual (December) maturities. All futures contracts that expire in December of each year between 2006 and 2008 are used. The data correspond to the daily average mid-point of intraday quotes calculated from every quote update within a day.

Finally, carbon prices are tested for stationarity, using the Augmented Dickey – Fuller (ADF) test. A well-documented stylized fact of financial time series data is their non-stationarity.[4] Panel A of Table 2-2 presents results of the ADF Unit Root tests for both the front futures and sole Phase II price series. Additionally, various statistics of carbon returns are calculated. Panel A of Table 2-2 shows that carbon prices contain a unit root (i.e. they are non-stationary). In order to render the series stationary, log-returns are taken. That is, continuously compounded returns are constructed as $r_{c,t} = ln(P_{c,t} / P_{c,t-1})$, where $P_{c,t}$ is the carbon price at time *t*. Panel A of Table 2-2 shows the unit root results for log-returns of the carbon price series to be stationary. Furthermore, results in Panel B of Table 2-2 indicate the normality hypothesis for the carbon returns series is rejected. The Shapiro-Wilk test statistics indicate that carbon returns series are non-normally distributed. The series present much fatter tails than a normal distribution. In total, 179 NAPs and 20 Verifications announcements are analysed. The announcements data includes 24 First Draft NAP announcments, 8 Second Draft NAP announcements, 27 Initial NAP notifications, 7 Second NAP notifications, 54 Additional NAP information announcements, 7 NAP Approvals, 21

[4] This non-stationarity property is related to the fact that most of financial time series data exhibit "random walk" behaviour.

NAP Conditional Approvals, 8 NAP Ammendments, 12 NAP Ammendment Additional information announcements, 7 Ammendment Approvals, and 4 Other announcements. Table A-1 in the appendix presents all the separate announcments and their corresponding release dates.

Table 2-2 Augmented Dickey - Fuller Test and Statistics of Carbon Returns

Panel A of this table shows the results of the Augmented Dickey - Fuller test for the carbon prices and returns. The critical values for the rejection of the null hypothesis of the existence of a unit root are -3.4336, -2.8621 and -2.5671 for 1%, 5%, and 10% significance levels respectively (MacKinnon, 1991). In Panel B the descriptive statistics for carbon returns are shown.

Panel A:
Augmented Dickey - Fuller Test Statistics for Carbon Prices and Returns

Phase I & II Front Futures

	ADF Statistic (Tau)	Pr < Tau
Carbon Prices	-2.63	0.0871
Carbon Returns	-22.71	<.0001

Phase II (Dec, 2008) Futures

	ADF Statistic (Tau)	Pr < Tau
Carbon Prices	-3	0.036
Carbon Returns	-17.13	<.0001

Panel B:
Descriptive Statistics of Carbon Returns

Phase I & II Front Futures

	r_c
Mean	-0.000775
Median	-0.002370
Standard Deviation	0.293817
Skewness	6.450795
Kurtosis	161.5743
Shapiro-Wilk	0.227434

Phase II (Dec, 2008) Futures

	r_c
Mean	-0.000823
Median	-0.000819
Standard Deviation	0.027997
Skewness	-1.050538
Kurtosis	8.864452
Shapiro-Wilk	0.917092

2.5 Research Design and Empirical Results

2.5.1 Influence of Announcements on Carbon Returns

If security prices reflect all currently available information, then price changes must reflect new information. Therefore, it is possible to measure the importance of an event of interest by examining price changes during the period in which the event occurs. We apply event study methodology to the return series constructed to examine carbon return behaviour around NAP and Verification related events. Following Mansanet-Bataller and Pardo (2007), we use two approaches; a regression method, and the Constant Mean Adjusted Return model.

2.5.1.1 Regression Method

The regression approach involves modelling daily abnormal returns as coefficients of dummy variables for the event period and the returns before and after. The dummy variables are used to parameterize the effects of each particular event. An advantage of this approach is that it takes into account distributional aspects such as volatility clustering, leptokurtosis or the presence of ARCH effects.

Following the methodology of Mansanet-Bataller and Pardo (2007), the following is estimated:

$$r_{C,t}=\theta' x_t + \beta E_t+\varepsilon_t \tag{2-1}$$

where $r_{C,t}$ is the carbon return, x_t includes a constant term and non-event related explanatory variables and E_t includes the dummy variables representing each of the events considered. Each event variable is equal to one on the announcement day, zero otherwise.

The non-event related variables include the energy commodities variables that are used as explanatory variables of carbon prices.[5] Following Mansanet-Bataller and Pardo (2007), the most representative prices of oil and natural gas in Europe are selected. To account for the series of energy variables that better fits the front futures contract of carbon, the front contract for the energy variables is also constructed. That is, the contract for the energy variables with the closest maturity to the maturity of the carbon contract considered is selected. All series data are obtained from the Reuters Database. The futures contract on WTI Crude Oil is quoted in USD per barrel; the futures contract on Natural Gas is quoted in GBP per therm. Both values are converted into Euros using the daily exchange rate data available from the European Central Bank.[6] As with carbon prices, energy prices also present a unit root, and are thus converted into stationary returns by taking first logarithm differences.

The information announcment dummy variables are analysed in two ways. In the first model, the effect of one dummy variable for each type of event described (NAPs and Verifications) is considered grouped together. That is, the NAP dummy variable includes all NAP related events, while the Verifications dummy includes all verifications related events. In the second model, the NAP and Verifications grouped dummy variables are separated into 14 dummy regressors (explained in the section 2.3 Release of information in the EU ETS) and the regressions re-estimated. For each type of event, the dummy variables are constructed with ones on the days of announcements of its type, and zero otherwise. The regressions are estimated for both the front futures prices and the sole Phase II prices (December 2008 expiry). All regressions are estimated by applying the Newey-West covariance matrix estimator that is consistent with the presence of heteroskedasticity and autocorrelation. The results of the regressions are presented in Tables 2-3 and 2-4.

[5] Robustness tests reveal that that the current models are specified correctly and no other determinant variables are identified.
[6] See http://www.ecb.int

The estimated regressions for the Phase I & II front futures are presented in Table 2-3. Only in the regression with the dummy variables considered separately are any event coefficients statistically different from zero (see Model 2 in Panel A). The significant variables include WTI Crude Oil returns, Notification of Additional NAP Information, NAP Conditional Approval, and NAP Amendment Approval. These findings suggest that news related to Phase II of the EU ETS affects the front futures contracts that mainly consist of prices from Phase I of the scheme. In addition, all the significant announcements have negative coefficients. This may imply that the EUA market deduced that Phase I EUAs were over allocated by observing the restrictive nature of the NAPs for Phase II. These results are in contrast with that of Mansanet-Bataller and Pardo (2007) who find that Phase II announcements had no significant impact on front futures prices during the period October 2004 through May 2007. A possible explanation is that NAP announcements related to the conditional approval of NAPs and amendments are significant, and these announcements usually arise later in the NAP setting process and are not captured in the sample period examined by Mansanet-Bataller and Pardo (2007).

Table 2-3 Regression Model Results - Front Futures

Panel A presents the estimates of Model (1) and Model (2). In Model (1) the regression of CO_2 returns has been calculated on energy variables and dummy variables considered grouped. In Model (2) the regression of CO_2 returns has been calculated on energy variables and dummy variables considered separately. Panel B reports the R^2, the Adjusted R^2, the Akaike Information Criteria (AIC) and the Schwarz Criteria (SC).

Panel A: Estimates of Model 1 and Model 2 for the Phase I & II Front Futures

	Model 1		Model 2	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
α	-0.0108	-1.4001	0.0034	0.3627
$r_{g,t}$ (Natural Gas returns)	-0.2559	-1.0226	-0.2593	-0.9969
$r_{c,t}$ (WTI Crude returns)	0.7062	2.4669	0.8024	2.4806
ALL NAPs	0.0629	1.2747		
ALL Verifications	0.0083	0.2235		
First Draft of the NAP			-0.0027	-0.1990
Second Draft of the NAP			0.0054	0.5369
Initial Notification of the NAP			-0.0015	-0.1237
Second Notification of the NAP			0.0548	1.2014
Notification of Additional NAP Information			-0.0300	-2.1984
NAP Approval			-0.0018	-0.0270
NAP Conditional Approval			-0.0510	-2.4132
NAP Amendment			0.0076	0.5672
NAP Amendment Additional Information			-0.0484	-1.0303
NAP Amendment Approval			-0.2091	-2.2038
Verification 2005			0.0050	0.0611
Verification 2006			-0.1054	-1.9440
Verification 2007			-0.0034	-0.2407
Other			-0.1356	-1.8906

Panel B: Goodness of Fit Measures

	Model 1	Model 2
R^2 squared	0.011658	0.008686
R^2 - Adjusted	0.006337	-0.013012
Akaike criterion	0.330704	0.365793
Schwarz criterion	0.361569	0.470734

Additionally, the coefficients associated with verifications of emissions for 2006 are marginally significant at the 10% level, and are negative. This is explained by the fact that verified emissions were long in 2006. However, the results differ from that of Mansanet-Bataller and Pardo (2007) who find that 2005 verifications also have a significant negative impact on the front futures. On further inspection, it is revealed that the initial primary 2005 verifications announcements were eliminated from the sample because of other confounding announcements on the same days. Those that remain were late verifications data from individual smaller countries.

Assessment of the Phase I & II regression results in Table 2-3 reveal that the coefficients of determination (R^2) are extremely low, and fail to explain more than 1.2% of the variation in carbon returns. Regressions estimated on Phase II (December 2008) returns in Table 2-4, however, yield superior coefficients of determination at 9.7% and 10.3%, respectively. Panel A of Table 2-4 reveals that both Natural Gas returns and WTI Crude Oil returns are highly significant at the 1% level, with both having a positive effect on carbon returns. Panel B reveals similar results for the energy variables. A possible reason that Gas and Oil returns are not significant in explaining carbon returns in Phase I & II front futures, but significant in explaining carbon returns variation in Phase II prices, is that the trial phase EUAs were over-allocated. For a fuel switching price to arise, which would make energy commodities viable explanatory variables of carbon returns, there would have to be a lower supply than demand for EUAs. This provides further support for our motivation in examining Phase II prices.

Table 2-4 Regression Model Results - Phase II Futures

Panel A presents the estimates of Model (1) and Model (2). In Model (1) the regression of CO_2 returns has been calculated on energy variables and dummy variables considered grouped. In Model (2) the regression of CO_2 returns has been calculated on energy variables and dummy variables considered separately. Panel B reports the R^2, the Adjusted R^2, the Akaike Information Criteria (AIC) and the Schwarz Criteria (SC).

Panel A: Estimates of Model 1 and Model 2 for the Phase II (December, 2008) Futures

	Model 1		Model 2	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
α	-0.0009	-0.9114	-0.0006	-0.6422
$r_{g,t}$ (Natural Gas returns)	0.0629	2.6924	0.0627	2.8153
$r_{c,t}$ (WTI Crude returns)	0.3581	7.5568	0.3571	7.7499
ALL NAPs	0.0006	0.2464		
ALL Verifications	-0.0018	-0.0765		
First Draft of the NAP			0.0001	0.0216
Second Draft of the NAP			-0.0008	-0.5330
Initial Notification of the NAP			-0.0045	-1.1531
Second Notification of the NAP			-0.0014	-0.2688
Notification of Additional NAP Information			-0.0023	-0.5008
NAP Approval			0.0115	0.5126
NAP Conditional Approval			0.0125	2.5178
NAP Amendment			0.0091	3.6979
NAP Amendment Additional Information			-0.0005	-0.0425
NAP Amendment Approval			-0.0136	-11.4151
Verification 2005			-0.0093	-0.1837
Verification 2006			-0.0138	-1.0521
Verification 2007			0.0056	1.0235
Other			0.0000	0.0010

Panel B: Goodness of Fit Measures

	Model 1	Model 2
R^2 squared	0.0973	0.1037
R^2 - Adjusted	0.0923	0.0838
Akaike criterion	-4.4812	-4.4558
Schwarz criterion	-4.4500	-4.3498

Similar to Table 2-3, only in the regression with the dummy variables considered separately are any of the announcement dummy variable coefficients statistically different from zero (see Model 2 in Panel A). Both NAP Conditional Approval and NAP Amendment have a significant positive effect on carbon returns, while NAP Amendment Approval has a highly significant (at the 1% level) negative effect on carbon returns. This may suggest that on conditional approval by the European Commission or the request for amendments to the submitted NAP, the market overreacts on average. The subsequent price reduction on news of the amendment approval corresponds to a correction of the market. The results from Table 2-4, together with the results from Table 2-3, suggest that news concerning NAPs following their NAP conditional approval or requests for amendments to the NAP by the European Commission are the most significant announcements concerning NAPs in Phase II. Examining the sample announcements data, it is quickly apparent that a very small minority of NAPs are approved initially, with most progressing to conditional approvals and requests for amendments. This may explain the findings, and also suggest that in Phase II, the European Commission took a more hard-line approach to the approval of NAPs.

Concerning verifications announcements, all the verifications dummy variables are insignificant in explaining any of the variation in Phase II carbon returns. This result is expected as the verifications announcements all relate to Phase I of the EU ETS. In addition, because there is no inter-phase banking of EUAs between Phase I and Phase II, these announcements have no bearing on the Phase II EUA supply or prices.

Overall, the results suggest that carbon returns do react to Phase II announcements, although their impact is greater in Phase II futures. However, because of the uncertain and volatile nature of the market, and inefficiencies in its administration, we require an assessment of the days surrounding an announcement to adequately interpret the results. Furthermore, following McKenzie et al. (2004), the use of all available data could lead to spurious inferences when carbon returns do not present a normal return constant over time (Mansanet-Bataller and Pardo, 2007). Additionally, when examining regulatory events on the carbon market, the formal date or the day the information becomes public may not coincide with the date when the new information reaches the market. This is due to the high level of information asymmetry present in the infant stage EU ETS and the extensive consultation that takes place with stakeholders prior to announcement, as discussed earlier. In this case, the use of the regression approach may have little power to reject the null hypothesis of no effect on the carbon price as the price response to the formal announcement will only reflect the announcment relative to expectations (conditioned by the consultation process). Based on this, we extend the analysis to include the Truncated Mean model analysis that allows a broader range of days to be analyzed.

3.5.1.2 Truncated Mean Model

Following Mansanet-Bataller and Pardo (2007), the truncated mean model approach is adopted, which is a truncated version of the Constant Mean Return Model (Brown and Warner, 1985). The abnormal returns are measured as the difference of the returns in *t* minus a mean return from some benchmark of the estimation period. However, the benchmark return is a truncated average of the estimation period. That is, to calculate the truncated mean return, the largest and smallest 10% of returns during the estimation period are excluded. As a sole commodity (carbon prices) is examined, which is affected by a large quantity of closed and sporadic announcements, the objective is to minimize the effect of large surprises in the estimation period.

$\bar{r}_{a,\tau}$ is defined as the truncated mean for the announcement day *"a"* and the *2*l* days surrounding (*l* is the number of days in the prediction period before the announcement, which coincides with the number of days after it). To calculate this truncated mean, this study proceeds as follows:

1. This study considers the announcement day as the reference day ($t = 0$).

2. The estimation period is defined as the days included in the interval from t_1=- *(τ+l) 1* to t_2= -*(l+1)*. τ = 10, 20 and 30 are considered. Therefore, following Milonas (1987) the estimation periods have effectively τ days and finish *l+1* days before the announcement.

3. The τ returns of the estimation period are re-ordered from the smallest to the largest, such that r_1 is the smallest return in the estimation period and r_τ the largest, with τ = 10, 20 and 30, respectively.

4. *k* is defined as the number representing 10% of the estimation period and consequently it is the number of returns that will be excluded from each of the extremes: *k* = τ * *p* where τ is the number of days in the estimation period and p = 10%.[7]

Given that *k* is an integer, following Wilcox (2001), the truncated mean is calculated as:

$$\bar{r}_{\mathrm{a},\tau} = \frac{1}{n-2k} \sum_{i=k+1}^{n-k} r_i \qquad (2\text{-}2)$$

where r_i is the i^{th} return of the estimation period after ordering. Additionally, for any announcement "*a*", a standardized excess return $ZR_{a,t}$ is calculated for each day of the prediction period.[8] The standardized excess returns are the excess returns standardized by the truncated standard deviation in the estimation period, calculated using the same procedure as in the mean case. The expression for the standardized excess returns is:

$$ZR_{\mathrm{a},\tau,\mathrm{t}} = \frac{r_{a,t} - \bar{r}_{a,\tau}}{\sigma_a} \qquad (2\text{-}3)$$

For each of the *(2*l+1)* days of the prediction period, the portfolio standardized excess returns is calculated, which is an equally weighted portfolio of the standardized excess returns:

$$\overline{ZR}_{\mathrm{a},\tau,\mathrm{t}} = \frac{1}{N} \sum_{n=1}^{N} ZR_{\mathrm{a},\tau,\mathrm{t}}$$

[7] Note that *k* is 1, 2, and 3 in the case of an estimation period of 10, 20, and 30 days, respectively.

[8] The prediction period has (*2*l + 1*) days.

(2-4)

where N is the number of announcements of a specific type of event. The null hypothesis is whether the portfolio excess returns are equal to zero on the day of the announcement (t = 0).

Following Mansanet-Bataller and Pardo (2007), three different scenarios are considered. Panel A of Tables 2-5 and 2-6 present results when considering all the announcements released in the sample period. The results are grouped in NAPs and Verifications and Table 2-5 illustrates the results when examining the Phase I & II front futures, while Table 2-6 examines Phase II (December 2008) futures. The second scenario considers only the announcements that do not have another announcement in the three previous days. These results are presented in Panel B of Tables 2-5 and 2-6. The third scenario is limited to the announcements where no other announcements are released in the six days surrounding it. All three scenarios are considered, each more restrictive than the previous, in order to assess whether the results are robust given that surrounding announcements could be leading to confounding findings. These results are presented in Panel C of Tables 2-5 and 2-6. Additionally, the same analysis is undertaken by substituting the returns series by the residual series of the regression of carbon returns, taking as independent variables the energy variables from the previous section.[9] The results are presented in Panels A, B and C of Table 2-5 and 2-6.[10]

Tables 2-5 and 2-6 document that there are many events with statistically significant differences before the announcement date. This occurs when the complete sample (Panel A), and the other two scenarios (Panels B and C) are considered. This suggests that the market

[9] The specification of the regression is $r_{c,t} = \alpha + \beta_1 r_{g,t} + \beta_2 r_{c,t} + \epsilon_t$.
[10] We only present the results with the returns (residuals) standardized with the truncated mean and variance of the estimation period of 10 days. The results of the standardized returns with the truncated mean and variance of the estimation period of 20 and 30 days are qualitatively similar.

anticipates the impact of the news prior to the announcment and may possibly hint at a level of information leakage during the consultation period. Additionally, most of the announcement days present statistical significance, suggesting that the new information has an effect on the price series when it becomes public.

Table 2-5 Truncated Mean Model Results – Front Futures

In this Table we present the results of the test with the null hypothesis that the portfolio excess returns are equal to zero. In our case we perform this test for the day of the announcement, the 3 previous days and the 3 next days. In Panel A we present the results with the complete sample. In Panel B we consider the announcements days where there has not been an announcement within the 3 previous days. Finally, in Panel C we consider the announcement days where there has not been an announcement within the 6 days around the announcement. The first column in the Table presents the days ("0" is the announcement day). The next four columns refer to the standardized returns and the last 4 columns to the standardized residuals of Model 1 in the previous Table regression. The ZRt mean column shows the mean of the portfolio of the standardized returns (residuals) for each of the event groups (NAPs and Verification), and the p-value column shows the p-value of the test. Number refers to the number of times an announcement of each kind of event has been produced.

Panel A: All announcements considered.

	Returns				Residuals			
	ALL NAPs		ALL Verifications		ALL NAPs		ALL Verifications	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	-0.4491	0.0000	-2.3484	0.0000	0.0275	0.7595	-1.2435	0.0000
-2	0.4393	0.0000	-1.4315	0.0000	0.8326	0.0000	-1.5929	0.0000
-1	-0.5132	0.0000	-1.9966	0.0000	-0.5135	0.0000	-2.4266	0.0000
0	1.0002	0.0000	-2.5557	0.0000	0.8751	0.0000	-3.8448	0.0000
1	-2.6907	0.0000	-4.8835	0.0000	-2.4941	0.0000	-6.9974	0.0000
2	0.4405	0.0000	-6.2177	0.0000	0.6439	0.0000	-8.1976	0.0000
3	-0.3941	0.0000	-7.6080	0.0000	-1.3347	0.0000	-9.5946	0.0000
Number	124		11		124		11	

Panel B: Announcements without any other announcement 3 days before.

	Returns				Residuals			
	ALL NAPs		ALL Verifications		ALL NAPs		ALL Verifications	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	0.2660	0.0967	-0.8824	0.0776	2.0553	0.0000	0.0829	0.8683
-2	-0.0403	0.8011	-2.1632	0.0000	1.7087	0.0000	-3.0198	0.0000
-1	0.1327	0.4071	-2.6841	0.0000	0.0047	0.9766	-2.3527	0.0000
0	1.4412	0.0000	1.8645	0.0002	2.2176	0.0000	0.9269	0.0638
1	-2.3473	0.0000	-17.1697	0.0000	-1.8431	0.0000	-19.5371	0.0000
2	-3.9144	0.0000	-5.5336	0.0000	-4.9059	0.0000	-6.3544	0.0000
3	0.3975	0.0130	0.4278	0.3922	1.0239	0.0000	1.8585	0.0002
Number	39		4		39		4	

Panel C: Announcements without any other announcement 3 days on either side.

	Returns				Residuals			
	ALL NAPs		ALL Verifications		ALL NAPs		ALL Verifications	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	0.7089	0.0060	-0.6654	0.3467	4.8996	0.0000	0.1418	0.8410
-2	0.3144	0.2234	-2.2495	0.0015	3.7597	0.0000	-1.4847	0.0358
-1	-0.4632	0.0728	-3.4980	0.0000	-1.1300	0.0000	-4.1473	0.0000
0	-1.0108	0.0001	0.3189	0.6520	-1.0699	0.0000	0.4499	0.5246
1	-1.4787	0.0000	-2.3920	0.0007	-1.0767	0.0000	-2.2469	0.0015
2	0.0609	0.8135	0.3247	0.6461	-1.0043	0.0001	2.0581	0.0036
3	2.9829	0.0000	-1.3717	0.0524	4.0501	0.0000	0.6343	0.3697
Number	15		2		15		2	

Table 2-6 Truncated Mean Model Results – Phase II Futures

In this Table we present the results of the test with null hypothesis that the portfolio excess return are equal to zero. In our case we perform this test for the day of the announcement, the 3 previous days and the 3 next days. In Panel A we present the results with the complete sample. In Panel B we consider the announcements days where there has not been an announcement within the 3 previous days. Finally in Panel C we consider the announcements days where there has not been an announcement within the 6 days around the announcement. The first column in the Table presents the days ("0" is the announcement day). The next four columns refer to the standardized returns and the last 4 columns to the standardized residuals of Model 1 in the previous Table regression. The ZRt mean column shows the mean of the portfolio of the standardized returns (residuals) for each of the event groups (NAPs and Verification), and the p-value column shows the p-value of the test. Number refers to the number of times an announcement of each kind of event has been produced.

Panel A: All announcements considered.

	Returns				Residuals			
	ALL NAPs		ALL Verifications		ALL NAPs		ALL Verifications	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	-0.1838	0.0407	-1.1863	0.0001	0.0683	0.4467	-1.4209	0.0000
-2	-0.5076	0.0000	-1.5164	0.0000	-0.3617	0.0001	-1.4948	0.0000
-1	-0.0308	0.7320	-1.7113	0.0000	0.1778	0.0478	-2.1793	0.0000
0	-0.5196	0.0000	-1.8274	0.0000	-0.3923	0.0000	-1.1827	0.0001
1	0.0162	0.8571	-3.3307	0.0000	-0.1842	0.0403	-2.5033	0.0000
2	0.3954	0.0000	-3.4139	0.0000	0.4183	0.0000	-2.1346	0.0000
3	-0.2579	0.0041	-4.0402	0.0000	-0.3260	0.0003	-2.6905	0.0000
Number	124		11		124		11	

Panel B: Announcements without any other announcement 3 days before.

	Returns				Residuals			
	ALL NAPs		ALL Verifications		ALL NAPs		ALL Verifications	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	0.6277	0.0001	-0.2550	0.6101	0.7736	0.0000	0.3380	0.4991
-2	-1.2986	0.0000	-2.6091	0.0000	-1.3230	0.0000	-2.9444	0.0000
-1	0.7475	0.0000	-1.6009	0.0014	0.8514	0.0000	-1.8199	0.0003
0	-0.6489	0.0001	1.0215	0.0411	-0.5685	0.0004	0.7575	0.1297
1	1.1793	0.0000	-6.7492	0.0000	0.1853	0.2472	-7.0955	0.0000
2	1.4828	0.0000	-0.0168	0.9732	1.2651	0.0000	0.5334	0.2860
3	0.1567	0.3279	0.5628	0.2603	0.1103	0.4908	1.2869	0.0101
Number	39		4		39		4	

Panel C: Announcements without any other announcement 3 days on either side.

	Returns				Residuals			
	ALL NAPs		ALL Verifications		ALL NAPs		ALL Verifications	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	0.3820	0.1390	-0.6654	0.3467	0.2439	0.3449	0.1657	0.8148
-2	-2.9883	0.0000	-2.2495	0.0015	-2.8924	0.0000	-2.3902	0.0007
-1	0.5349	0.0383	-3.4980	0.0000	0.5376	0.0373	-4.5007	0.0000
0	-2.0054	0.0000	0.3189	0.6520	-1.4588	0.0000	0.8007	0.2575
1	3.7518	0.0000	-2.3920	0.0007	1.5065	0.0000	-2.5011	0.0004
2	2.4106	0.0000	0.3247	0.6461	1.7142	0.0000	1.8891	0.0075
3	1.5976	0.0000	-1.3717	0.0524	0.6414	0.0130	-0.2258	0.7495
Number	15		2		15		2	

For a more in-depth examination of which type of announcement is relevant to the market, the events considered separately are analysed. The results for the most restrictive scenario, the one considering only the announcements without any other announcement in the six days surrounding it, are presented in Tables 2-7 and 2-8. Examining Panel A of both tables, it is apparent that within the NAP announcements category, only on the days of the Initial NAP Notification are there significant positive returns across both the Phase I & II front futures and the sole Phase II futures. In contrast, the remaining types of announcements in the NAP category, such as Additional NAP info, NAP Approval, NAP Conditional Approval, NAP Amendment Additional Info, and Amendment Approval all exhibit a significant negative reaction. For Phase II futures, it may reflect that the market tends to price in a restrictive cap when member states initially notify the EC of their NAP. Therefore, on subsequent amendments and conditional approvals, the market reduces its perceived expectation of a very restrictive cap and hence the negative reactions. In addition, although the Phase II NAPs are more restrictive and will result in an average cut of nearly 7% below the 2005 emission levels, the inclusion of offsets undermines this claim. This may be another reason for the negative reactions to the majority of Phase II NAP announcements.

Reviewing the reactions on the days surrounding Verifications announcements (2005 and 2007), the results suggest that they fail to cause a significant reaction on the day of the announcement.[11] However, there are significant price movements leading up to the announcement day. This confounding discovery may suggest that there is considerable leakage of verifications data before the information becomes public, and

[11] Verifications for 2006 are not in the analysis because they were eliminated from the sample as they had other announcements in the 6 days surrounding it.

that the information is already impounded into prices. These findings lend further credence to the allegations of a high degree of information asymmetry and possible insider trading concerning EU ETS official announcements. The leakage of information is further pronounced when considering the most restrictive scenario in which there are no other announcements in the 6 days surrounding the announcement of interest. In many cases, the significant price reaction leading up to an announcement is also in the same direction. This again suggests the existence of information leakage.

Panel B of Tables 2-7 and 2-8 present the results when the residual series are considered, and confirm the finding that the market reacts before (or on) the day of the official announcement. Several other announcements such as Initial NAP Notification, Additional NAP Info and NAP Amendment Additional Info also lead to significant reactions beyond t=0 in Phase I & II front futures, while Additional NAP Info, NAP Amendment Additional Info, and NAP Amendment Approval all cause significant reactions beyond t=0 in the sole Phase II futures. This may suggest that there is uncertainty following information releases in the EUA market, and that it requires several days to resolve the uncertainty and accurately price in the information.

Table 2-7 Truncated Mean Model Results: Events Separated – Front Futures

In this Table we present the results of the test in which the null hypothesis is that the portfolio excess return is equal to zero, for the scenario most restrictive (considering the announcement day without any other announcement on the six days surrounding it). In our case we perform this test for the day of the announcement, the 3 previous days and the next 3 days. Panel A (B) present the results for the returns (residuals of the regression of Model 1 in Table II & III) taking into account exclusively the announcements without any other announcement 3 days before and after it. In all cases the ZR mean column shows the mean of the portfolio of the standardized returns for each of the events considered, and the p-value column shows the p-value of the test. Number refers to the number of times an announcement of each type has been produced. * denotes statistical significance at the 1% level.

Panel A: Results with the Returns series

	First Draft NAP		Initial NAP Notification		Additional NAP Info		NAP Approval		NAP Conditional Approval		NAP Ammendment Additional Info		Ammendment Approval		Verification 2005		Verification 2007	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	-1.3099	0.0233	-4.6476	0.0000	5.4844	0.0000	-0.4178	0.5546	-9.9273	0.0000	0.1494	0.8813	0.2911	0.7709	-3.9905	0.0001	2.6598	0.0078
-2	-5.5094	0.0000	-7.6383	0.0000	6.3348	0.0000	0.3130	0.6580	2.6993	0.0069	-5.2550	0.0000	-1.5920	0.1114	-1.8214	0.0685	-2.6776	0.0074
-1	-1.2728	0.0275	-1.1904	0.2339	-0.9661	0.0308	1.0438	0.1399	3.1270	0.0018	-6.3464	0.0000	3.7069	0.0002	-3.2650	0.0011	-3.7310	0.0002
0	1.9077	0.0010	6.3023	0.0000	-1.5619	0.0005	-2.6032	0.0002	-0.4401	0.6599	-12.7321	0.0000	-2.9905	0.0028	0.4065	0.6844	0.2313	0.8171
1	-0.5729	0.3211	-2.8623	0.0042	-3.7676	0.0000	0.3130	0.6580	0.1525	0.8788	-0.3973	0.6911	-2.3583	0.0184	-5.0077	0.0000	0.2237	0.8230
2	0.7078	0.2202	-0.1149	0.9085	0.7910	0.0770	0.3130	0.6580	0.2460	0.8057	-10.3449	0.0000	4.8386	0.0000	-3.0929	0.0020	3.7422	0.0002
3	0.0617	0.9149	0.4521	0.6512	3.4524	0.0000	0.3130	0.6580	-0.6645	0.5064	20.0081	0.0000	4.2553	0.0000	-2.6136	0.0090	-0.1297	0.8968
Number		3		1		5		2		1		1		1		1		1

Panel B: Results with the Residuals series

	First Draft NAP		Initial NAP Notification		Additional NAP Info		NAP Approval		NAP Conditional Approval		NAP Ammendment Additional Info		Ammendment Approval		Verification 2005		Verification 2007	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	-0.3488	0.5457	-2.7948	0.0052	17.5665	0.0000	-0.9478	0.1801	-9.5762	0.0000	0.1740	0.8619	0.4715	0.6373	-5.2720	0.0000	5.5264	0.0000
-2	-2.9767	0.0000	-7.6125	0.0000	15.7594	0.0000	-0.1832	0.7955	2.5393	0.0111	-4.8808	0.0000	-1.1499	0.2502	1.5998	0.1097	-4.5300	0.0000
-1	1.3331	0.0209	-4.8699	0.0000	-3.3573	0.0000	0.7965	0.2600	2.7696	0.0056	-5.4164	0.0000	3.5615	0.0004	-3.8622	0.0001	-4.2888	0.0000
0	-0.3092	0.5923	7.9124	0.0000	-1.4139	0.0016	-2.1112	0.0028	-0.3934	0.6940	-10.7361	0.0000	-2.3792	0.0174	0.3535	0.7237	0.5107	0.6096
1	0.4587	0.4269	-3.6964	0.0002	-3.4158	0.0000	0.1968	0.7808	0.2187	0.8269	-0.4596	0.6458	-1.7721	0.0764	-2.4007	0.0164	-2.0493	0.0404
2	-1.2732	0.0274	4.7718	0.0000	-2.3690	0.0000	0.2289	0.7461	0.0409	0.9674	-8.1647	0.0000	4.3436	0.0000	-1.0331	0.3016	5.0109	0.0000
3	-0.1923	0.7391	3.6554	0.0003	5.0136	0.0000	-0.2914	0.6803	-0.6152	0.5384	16.0083	0.0000	3.6736	0.0002	1.5194	0.1286	-0.3919	0.6952
Number		3		1		5		2		1		1		1		1		1

Table 2-8 Truncated Mean Model Results: Events Seperated – Phase II Futures

In this Table we present the results of the test in which the null hypothesis is that the portfolio excess return is equal to zero, for the scenario most restrictive (considering the announcement day without any other announcement on the six days surrounding it). In our case we perform this test for the day of the announcement, the 3 previous days and the next 3 days. Panel A (B) present the results for the returns (residuals of the regression of Model 1 in Table II & III) taking into account exclusively the announcements without any other announcement 3 days before and after it. In all cases the ZR mean column shows the mean of the portfolio of the standardized returns for each of the events considered, and the p-value column shows the p-value of the test. Number refers to the number of times an announcement of each type has been produced. * denotes statistical significance at the 1% level.

Panel A: Results with the Returns series

	First Draft NAP		Initial NAP Notification		Additional NAP Info		NAP Approval		NAP Conditional Approval		NAP Ammendment Additional Info		Ammendment Approval		Verification 2005		Verification 2007	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	-3.5919	0.0000	-5.5658	0.0000	1.4548	0.0011	7.3746	0.0000	-5.0173	0.0000	2.4492	0.0143	4.5832	0.0000	-3.9905	0.0001	2.6598	0.0078
-2	-19.9123	0.0000	-10.1226	0.0000	1.6944	0.0002	6.7554	0.0000	0.8945	0.3710	2.9014	0.0037	-0.9804	0.3269	-1.8214	0.0685	-2.6776	0.0074
-1	-0.7119	0.2176	5.1078	0.0000	0.2491	0.5776	-0.2819	0.6902	6.2884	0.0000	-3.0389	0.0024	-2.8124	0.0049	-3.2650	0.0011	-3.7310	0.0002
0	-0.9286	0.1078	5.6758	0.0000	-2.3993	0.0000	-6.6001	0.0000	-2.7645	0.0057	-4.3156	0.0000	-1.2485	0.2119	0.4065	0.6844	0.2313	0.8171
1	17.7824	0.0000	1.7209	0.0853	0.5567	0.2132	0.7229	0.3066	2.8590	0.0043	-3.7886	0.0002	-1.4100	0.1585	-5.0077	0.0000	0.2237	0.8230
2	2.9102	0.0000	-2.0113	0.0443	3.2430	0.0000	8.6674	0.0000	2.4379	0.0148	1.7191	0.0856	0.7976	0.4251	-3.0929	0.0020	3.7422	0.0002
3	-0.2835	0.6234	3.5712	0.0004	2.7995	0.0000	5.2110	0.0000	1.9657	0.0493	2.1178	0.0342	0.8921	0.3723	-2.6136	0.0090	-0.1297	0.8968
Number		3		1		5		2		1		1		1		1		1

Panel B: Results with the Residuals series

	First Draft NAP		Initial NAP Notification		Additional NAP Info		NAP Approval		NAP Conditional Approval		NAP Ammendment Additional Info		Ammendment Approval		Verification 2005		Verification 2007	
Days	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value	ZRt mean	p-value
-3	-1.5074	0.0090	-4.9478	0.0000	0.3022	0.4992	5.1663	0.0000	-3.4037	0.0007	2.5697	0.0102	4.6536	0.0000	-5.5056	0.0000	5.8545	0.0000
-2	-16.1461	0.0000	-11.9966	0.0000	1.0389	0.0202	4.2234	0.0000	0.7478	0.4546	2.2538	0.0242	-2.4726	0.0134	-0.3796	0.7042	-4.4088	0.0000
-1	1.2073	0.0365	2.7830	0.0054	0.3840	0.3905	-1.0830	0.1256	3.9867	0.0001	-2.8040	0.0050	-2.2393	0.0251	-4.0018	0.0001	-4.9986	0.0000
0	-1.8183	0.0016	7.4953	0.0000	-1.2541	0.0050	-2.6079	0.0002	-1.5615	0.1184	-4.1012	0.0000	-3.3857	0.0007	0.7385	0.4602	0.8625	0.3884
1	5.5842	0.0000	1.4477	0.1477	1.5212	0.0007	0.4698	0.5064	2.9453	0.0032	-3.2445	0.0012	-2.6265	0.0086	-4.3270	0.0000	-0.6706	0.5025
2	1.3295	0.0213	1.5843	0.1131	2.5341	0.0000	8.1444	0.0000	1.5285	0.1264	1.9800	0.0477	0.0100	0.9920	-2.6081	0.0091	6.3922	0.0000
3	-0.6653	0.2492	7.1540	0.0000	3.3550	0.0000	2.9351	0.0000	2.0052	0.0449	2.0199	0.0434	-2.2687	0.0233	-0.6396	0.5224	0.1701	0.8650
Number		3		1		5		2		1		1		1		1		1

2.5.2 Influence of Announcements on Carbon Volatility

This section reviews the impact of Phase II NAPs and Phase I Verifications announcements on carbon return volatility. This allows an examination of whether there is a systematic leakage of information. As the announcements are mainly unscheduled and sporadic, it is expected that upon becoming public, there will be a higher degree of volatility as the news is priced in. However, if there is no change in volatility, it may suggest a systematic leakage of information before it becomes public.

To test the difference in volatility before and after the event, two tests are undertaken – the Brown-Forsythe test and the sign test. Consistent with the previous section, both the return series and the residual series of the regression are used.

2.5.2.1 Brown and Forsythe Test

The Brown-Forsythe test allows testing for seasonality in the unconditional variance. The Brown-Forsythe test statistic is calculated as:

$$F = \frac{\sum_{j=1}^{J} n_j(\bar{D}\cdot j - \bar{D}\cdot\cdot)^2}{\sum_{j=1}^{J}\sum_{t=1}^{n_j}(D_{tj} - D\cdot_j)^2}\,\frac{N-J}{J-1}$$

(2-5)

where $D_{tj} = \left|r_{tj} - \widehat{M}\cdot_j\right|$; r_{tj} is the return for the day *t* and the interval *j*; $\widehat{M}\cdot_j$ is the sample median return for the interval *j* over the relevant n_j days; $\bar{D}\cdot j = \sum_{t=1}^{n_j}\left(\frac{D_{tj}}{n_j}\right)$ is the mean absolute deviation from the median $\widehat{M}\cdot_j$ for the time interval *j*; and $D_{..}$ =

$\sum_{j=1}^{J}\sum_{t=1}^{n_j}\left(\frac{D_{jt}}{N}\right)$ is the grand mean where $N = \sum_{j=1}^{J} n_j$. The test statistic is distributed $F_{J-1,N-J}$ under the null hypothesis of equality of variances across the J time intervals.

Following Mansanet-Bataller and Pardo (2007), applying this test to the peculiarities of the sample is coherent with the idea of minimising the effects of large surprises in the estimation period. Specifically, a prediction period of 10 days separated into two sub-periods, both of 5 days is considered. The first sub-period consists of the 5 days preceding the announcement and the second sub-period includes the announcement day and the following 4 days. Therefore, the division of the prediction period is the announcement day.

The results of the Brown-Forsythe test applied to the announcement days without any other announcement on the 6 days around it are presented in Panels A and B of Tables 2-9 and 2-10. This sample is chosen for two reasons. First, following these criteria the analysis is consistent with the more restrictive analysis of the impact of the announcements on carbon returns presented in the previous section. Second, if the test is only applied to announcement days without any other announcement during the 10-day prediction period, the sample will be drastically reduced. Additionally, the Brown-Forsythe test uses the mean absolute deviation from the median, and thus the possible extreme values provoked by an announcement in the prediction period will not distort the results.

Focusing on Panel A of Tables 2-9 and 2-10, the results for the Brown-Forsythe test for both the return series and the residual series are similar. If we consider the variables grouped in NAPs and Verifications (Panel A), in both cases the null hypothesis is never rejected. Furthermore, NAP announcements lead to a higher variance after the announcement only in 7% of the cases when examining Phase II returns.

Table 2-9 Equality Test Results – Front Futures

This table presents the results of two equality tests. Panel A (B) shows the results of the Brown- Forsythe test for the carbon returns and the residuals series considered grouped (separated). Panel C (D) shows the p-value for the standardized returns and residual series sign test for the variables considered grouped (separated). In all cases, the null hypothesis is that the variance during the 5 days preceding the announcement day is equal to the variance in the period made up of the announcement day and the next 4 days. In Panel A and B, the times the null hypothesis is rejected is expressed in percentage. The different rows present the results for the possible alternative hypotheses. The last row shows the total number of announcements of each type of event. In order to be consistent with the previous analysis, the announcement days considered are those without any announcements on the 6 days around it. For both Panel C and D, the series are standardized with the truncated mean and variance of a period of 10 days.

Panel A: Brown-Forsythe test for events considered grouped

		Returns		*Residuals*	
Null Hypothesis	Alternative Hypothesis	NAPs	VER	NAPs	VER
$\sigma_0=\sigma_1$	$\sigma_0\neq\sigma_1$	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0%	0%	0%	0%
Number of announcements =		15	2	15	2

Panel B: Brown-Forsythe test for events considered separated

Returns

Null Hypothesis	Alternative Hypothesis	First Draft	Initial Notfication	Additional Info	Approval	Conditional Approval	Ammendment Additional Info	Ammendment Approval	VER 2005	VER 2007
$\sigma_0=\sigma_1$	$\sigma_0\neq\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
Number of announcements =		3	1	5	2	1	1	1	1	1

Residuals

Null Hypothesis	Alternative Hypothesis	First Draft	Initial Notfication	Additional Info	Approval	Conditional Approval	Ammendment Additional Info	Ammendment Approval	VER 2005	VER 2007
$\sigma_0=\sigma_1$	$\sigma_0\neq\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
Number of announcements =		3	1	5	2	1	1	1	1	1

Panel C: Sign test for the events considered grouped					
		Returns		*Residuals*	
Null Hypothesis	ernative Hypoth	NAPs	VER	NAPs	VER
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0.3036	0.2500	0.6964	0.2500
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0.8491	1.0000	0.5000	1.0000
Number of announcements =		15	2	15	2

Panel D: Sign test for the events considered separated

Returns

Null Hypothesis	Alternative Hypothesis	First Draft	Initial Notfication	Additional Info	Approval	Conditional Approval	Ammendment Additional Info	Ammendment Approval	VER 2005	VER 2007
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0.5000	0.5000	0.5000	0.7500	0.5000	1.0000	0.5000	0.5000	0.5000
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0.8750	1.0000	0.8125	0.7500	1.0000	0.5000	1.0000	1.0000	1.0000
Number of announcements =		3	1	5	2	1	1	1	1	1

Residuals

Null Hypothesis	Alternative Hypothesis	First Draft	Initial Notfication	Additional Info	Approval	Conditional Approval	Ammendment Additional Info	Ammendment Approval	VER 2005	VER 2007
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0.5000	1.0000	0.8125	0.7500	0.5000	1.0000	0.5000	0.5000	0.5000
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0.8750	0.5000	0.5000	0.7500	1.0000	0.5000	1.0000	1.0000	1.0000
Number of announcements =		3	1	5	2	1	1	1	1	1

Table 2-10 Equality Test Results – Phase II Futures

This Table presents the results of two equality tests. Panel A (B) shows the results of the Brown- Forsythe test for the carbon returns and the residuals series considered grouped (separated). Panel C (D) shows the p-value for the standardized returns and residual series sign test for the variables considered grouped (separated). In all cases, the null hypothesis is that the variance during the 5 days preceding the announcement day is equal to the variance in the period made up of the announcement day and the next 4 days. In Panel A and B, the times the null hypothesis is rejected is expressed in percentage. The different rows present the results for the possible alternative hypothesis. The last row shows the total number of announcements of each type of event. In order to be consistent with the previous analysis, the announcement days considered are those without any announcements on the 6 days around it. For both Panel C and D, the series are standardized with the truncated mean and variance of a period of 10 days.

Panel A: Brown-Forsythe test for events considered grouped

		Returns		*Residuals*	
Null Hypothesis	Alternative Hypothesis	NAPs	VER	NAPs	VER
$\sigma_0=\sigma_1$	$\sigma_0\neq\sigma_1$	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	7%	0%	7%	0%
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0%	0%	0%	0%
Number of announcements =		15	2	15	2

Panel B: Brown-Forsythe test for events considered separated

Returns

Null Hypothesis	Alternative Hypothesis	First Draft	Initial Notfication	Additional Info	Approval	Conditional Approval	Ammendment Additional Info	Ammendment Approval	VER 2005	VER 2007
$\sigma_0=\sigma_1$	$\sigma_0\neq\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0%	0%	20%	0%	0%	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
Number of announcements =		3	1	5	2	1	1	1	1	1

Residuals

Null Hypothesis	Alternative Hypothesis	First Draft	Initial Notfication	Additional Info	Approval	Conditional Approval	Ammendment Additional Info	Ammendment Approval	VER 2005	VER 2007
$\sigma_0=\sigma_1$	$\sigma_0\neq\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0%	0%	20%	0%	0%	0%	0%	0%	0%
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0%	0%	0%	0%	0%	0%	0%	0%	0%
Number of announcements =		3	1	5	2	1	1	1	1	1

Panel C: Sign test for the events considered grouped					
		Returns		*Residuals*	
Null Hypothesis	ernative Hypoth	NAPs	VER	NAPs	VER
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0.5000	0.2500	0.6964	0.2500
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0.6964	1.0000	0.5000	1.0000
Number of announcements =		15	2	15	2

Panel D: Sign test for the events considered separated										
Returns										
Null Hypothesis	Alternative Hypothesis	First Draft	Initial Notfication	Additional Info	Approval	Conditional Approval	Ammendment Additional Info	Ammendment Approval	VER 2005	VER 2007
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0.5000	0.5000	0.5000	1.0000	0.5000	1.0000	0.5000	0.5000	0.5000
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0.8750	1.0000	0.8125	0.2500	1.0000	0.5000	1.0000	1.0000	1.0000
Number of announcements =		3	1	5	2	1	1	1	1	1
Residuals										
Null Hypothesis	Alternative Hypothesis	First Draft	Initial Notfication	Additional Info	Approval	Conditional Approval	Ammendment Additional Info	Ammendment Approval	VER 2005	VER 2007
$\sigma_0=\sigma_1$	$\sigma_0>\sigma_1$	0.5000	0.5000	0.9688	0.7500	0.5000	1.0000	0.5000	0.5000	0.5000
$\sigma_0=\sigma_1$	$\sigma_0<\sigma_1$	0.8750	1.0000	0.1875	0.7500	1.0000	0.5000	1.0000	1.0000	1.0000
Number of announcements =		3	1	5	2	1	1	1	1	1

Panel B of Tables 2-9 and 2-10 present results where the events are considered separately for both Phase I & II front futures. None of the announcements provoke any change in carbon variance, when examining both returns and residuals. For Phase II futures, only Additional NAP information announcements cause an increase in carbon variance following the announcement in 20% of the cases, both for returns and residuals. Finally, in no case is the null hypothesis rejected when considering the announcements related to the verification of emissions.

Overwhelmingly, the results illustrate that the majority of announcements cause no statistical difference in variance following the announcement. In the isolated case where the variance before and after the announcement is statistically different, an increase of the variance is detected after the announcement. These results are consistent with the notion that NAP related announcements do not have a significant effect on carbon volatility.

2.5.2.2 Sign Test of Carbon Variance

Following Mansanet-Bataller and Pardo (2007) and Milonas (1987), the equality test of the variance of the standardized excess returns is undertaken to completely assess the equality of the variance before and after announcements. Consistent with the previous analysis, this test is also applied to the residual series. Specifically, the period that comprises of the 5 previous days to the announcement is separated from the period comprised of the day of the announcement and the next 4 consecutive days. Then the equality of the variances of the standardized returns explained in the Truncated Mean Model section is tested with $l = 5$ between the two sub-periods. As in the case of the Brown-Forsythe test, and for the same reasons, the sample period of the announcements without any other announcements during the 6 days surrounding it is considered.

The null hypothesis of the sign test is that the variance of the standardized returns (residuals) during the five days preceding the announcement of a particular event is equal to the variance of the standardized returns (residuals) in the period starting from the announcement day and finishing 4 days after. This is represented as follows:

$$H_0 : \sigma_0^2 = \sigma_1^2 \qquad or \qquad H_0 : \theta = P(X > \sigma_0^2) = P(X < \sigma_1^2) = 0.5$$

That is, if the sample data for each type of event is consistent with the hypothesized variance value for this particular event, half of the sample observations related to the event will lie above σ_0^2 and half below. Thus, the number of observations larger than K can be used to test the validity of the null hypothesis. The two possible alternative hypotheses are:

$$H_1 : \sigma_0^2 > \sigma_1^2 \qquad and \qquad H_1 : \sigma_1^2 > \sigma_0^2$$

As the distribution of the random variable K is the binomial probability with parameters N and θ, with $\theta = 0.5$, the rejection region for the $H_1 : \sigma_0^2 > \sigma_1^2$ for an α-level test is:

$$K \epsilon \ R \qquad for \qquad K \leq k_\alpha$$

where k_α ‘ is chosen to be the largest integer which satisfies:

$$P(K \geq k_\alpha' | H_0) = \sum_{i=k_\alpha}^{N} \binom{N}{i} (0.5)^N \leq \alpha$$

where N is the number of announcements of a particular event. For $H_1 : \sigma_1^2 > \sigma_0^2$, the rejection region for an α-level test is:

$$K \epsilon \ R \qquad for \qquad K \geq k_\alpha$$

where k_α is chosen to be the smaller integer which satisfies:

$$P(K \geq k_\alpha | H_0) = \sum_{i=k_\alpha}^{N} \binom{N}{i} (0.5)^N \leq \alpha$$

The results of the one-side tests for the events considered grouped are shown in Panel C of Tables 2-9 and 2-10, and the results of the test for the events considered separately are in Panel D.[12] In both cases, the p-value is presented for the two possible alternative hypotheses. As shown in Panels C and D of Table 2-9, for all of the events, the carbon returns present the same variances before and after the event unanimously (all p-values are larger than $\alpha = 0.05$). In the case of the residuals series, it is not possible to reject the null hypothesis and consequently we cannot reject the equality of variances of the residual series before and after the announcement. The results of the tests are the same for all types of events, independent of whether the variables are considered grouped together or separately. These results are consistent with the results obtained with the previous test, and indicate a statistically insignificant effect of Phase II EU ETS NAP announcements on carbon volatility.

[12] In this case, the returns and residuals are standardized with the truncated mean and variance of a period of 10 days.

2.6 Summary

This essay examines the extent to which participants in the carbon market perceive EU ETS NAP and Verifications announcements to possess informational value. The study directs its attention to carbon returns and volatility movements around official EU ETS Phase II announcements.

Results demonstrate that Phase II NAP announcements have a significant effect on Phase II futures contracts. In contrast, Phase I verifications announcements have no effect on the Phase II futures returns. This is consistent with the information inherent in Phase I verifications and the no banking of allowances between phases restriction. The findings also detect significant returns on days leading up to both NAP and Verifications information becoming public. Furthermore, there is no evidence of significant differences in the volatility of carbon returns before and after NAP and Verifications announcements. Together, the findings suggest a systematic leakage of information across all types of announcements.

Chapter 3: An Investigation of Trade Cancellations on the Australian Stock Exchange (ASX)

3.1 Introduction

Trade cancellations are executed market trades that were originally made in error or unintentionally violated market rules and regulations and are subsequently cancelled. Trades are cancelled 'when brokers reach mutual agreement that a particular trade should not have happened and they both agree to cancel the trade on behalf of their clients.' An ASX Review on *Algorithmic Trading and Market Access Arrangements* reports that 'there has been a significant increase in trade cancellations, as a result of an increase in the number of wash trades, and this is consistent with the increased use of algorithms.'[13] Furthermore, an article in the Sydney Morning Herald reports that 'an ASX review identified a four-fold increase in potentially illegal "wash trades" in 2009.'[14]

The proportion of ASX executed trades that are subsequently cancelled is increasing. In January 2009, 11,000 (0.16%) trades were cancelled. This increased to 43,000 (0.39%) trades in August 2009. The vast majority of trades that are cancelled are crossings, and an increasing number of these are being cancelled after the close of trading (up from 33% in January 2009, to 60% in August 2009). Crossings are trades in respect of which a single Trading Participant acts (on its own account or on behalf of a client) on both sides of the trade. The prevalence of

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[13] ASX Review – Algorithmic Trading and Market Access Arrangements, 8 February 2010.
[14] ASX: you still need us to protect against computer trades, February 9, 2010, Sydney Morning Herald.

cancelled crossings has raised concerns about an increase in 'wash trades', which may technically be in breach of ASX rules and the law. Wash trades occur where a trader places a buy order against a sell order for the same beneficial owner. The ASX Market Rule Guidance Note 1 currently anticipates wash trades as a result of algorithmic trading and provides the following guidance:

"ASX recognises that program trading and AOP trading sourced from different trading engines or origins may result in the "accidental" Crossing of principal orders with no change in beneficial ownership. ASX takes the view that principal trading of this type which results in a transaction with no change in beneficial ownership is less likely to be considered creating of a false or misleading appearance of active trading in any Product or with respect to the market for, or the price of, any Product if:

• *the Trading Participant has not pre-arranged the entry of the Bids or Offers;*
• *the same* Authorised *Person does not enter both sides of the Crossing; and*
• *it can be* demonstrated *that the Orders originated from a defined program or algorithm-driven trading strategy application."*

Trade cancellations provide 'wash trade' manipulators with the ability to conduct their market misleading trading without incurring the transactional costs as the trades are subsequently cancelled.

Wash trades are problematic because both the wash trade itself and the subsequent cancellation (if any) may detrimentally impact the market by creating a false appearance of activity. Wash trades can also directly alter the price of shares if they are executed above or below market rates. Where trade cancellations occur after the close of trading or on T+1, for example it could also affect intra-day Time Weighted Average Price (TWAP) strategies and the calculation of daily Volume Weighted Average Prices (VWAPs), impacting other market users.

Recently there has been some concern generated by high frequency algorithmic trading. The proportion of complaints relating to algorithmic trading has risen from about 10% of complaints directed to ASX Surveillance in early 2009 to about 30% by the third quarter. Similarly, an ASX review also identified a four-fold increase in potentially illegal "wash trades" in 2009. The relationship between increased wash trades and increased algorithmic trading is that as brokers and clients employ an increasing range of different trading strategies (connecting many different algorithms to a trading platform at a given time), the likelihood that bids and offers entered from those algorithms will inadvertently execute against each other in the market increases.

Thus, this essay initiates the first comprehensive investigation of trade cancellations to understand their magnitude and the impact on market integrity. Specifically, this essay (i) reports the growth of trade cancellations between 2006 and 2009, (ii) measures the impact of trade cancellations on Daily Volume Weighted Average Price (VWAP), and (iii) examines trade cancellations for return reversal, return, volume, and volatility patterns consistent with market manipulation. Essentially this essay draws from theoretical and empirical research on market manipulation and applies it to the case of trade cancellations. Therefore, this study also contributes to the literature on emerging forms of market manipulation.

The remainder of this chapter is organised as follows. Section 3.2 describes the literature and develops several testable hypotheses. Section 3.3 explains trade cancellations in detail. Section 3.4 describes the growth of trade cancellations on the ASX between 2006 and 2009. Section 3.5 examines the impact of trade cancellations on the daily volume weighted average price. Section 3.6 looks at trade cancellations and return reversals. Section 3.7 examines the impact of trade cancellations on return, volume, and volatility. Section 3.8 summarises the chapter.

3.2 Literature Review

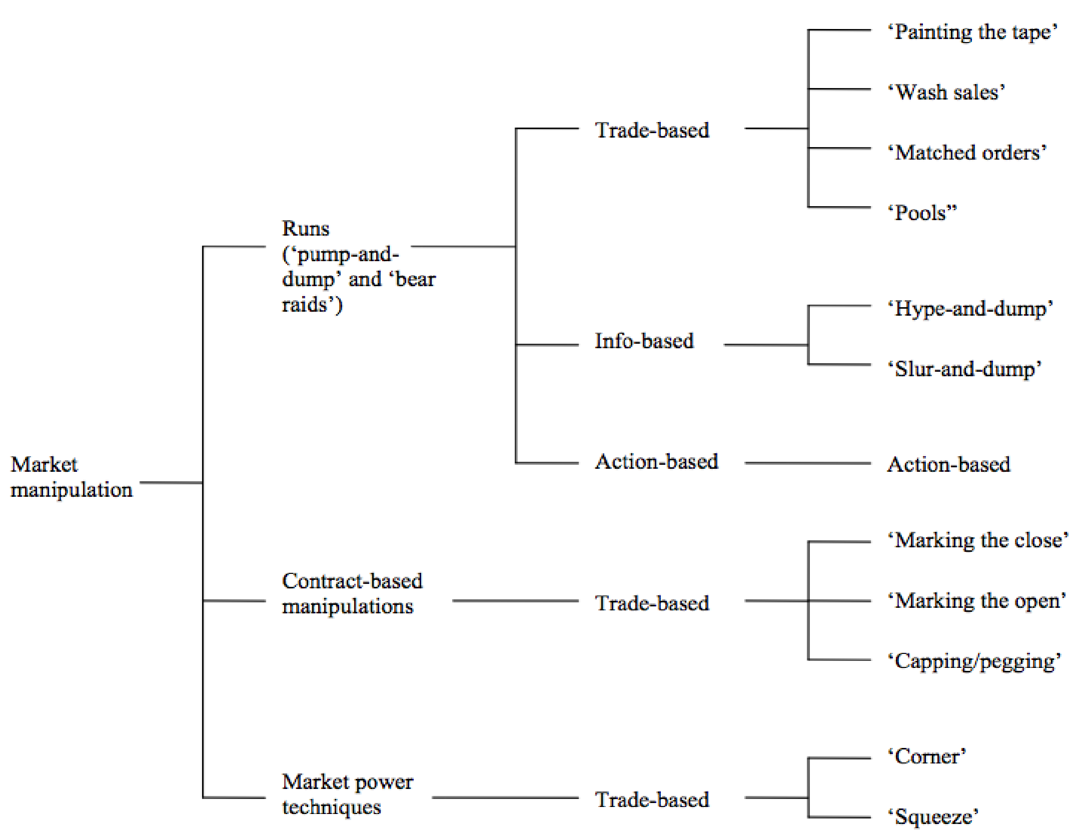
This section reviews the literature related to the issues examined in this study. This section is organised in a manner so as to highlight the areas of the existing literature upon which this study builds. In turn, based on the literature reviewed, a number of testable hypotheses are developed. This section is structured as follows. Section 3.2.1 focuses on the literature that examines the different forms of market manipulation. Section 3.2.2 sheds light specifically on the literature that examines trade-based market manipulation. Section 3.2.3 takes a closer look at 'pump-and-dump' trade-based manipulation. Section 3.2.4 reviews the evidence in literature of return reversals and market manipulation. Section 3.2.5 uses the literature reviewed to develop testable hypotheses that are tested subsequently in this study.

3.2.1 Forms of Market Manipulation

'Market manipulation' as a generic term encompasses many distinct and widely varied strategies. Putnins (2012) presents a simple taxonomy of the most common types of market manipulation in Figure 3-1. At the broadest level, manipulation is divided into runs, contract-based manipulations, and market power techniques. Within these groups, manipulation is further broken down into trade-based, information-based, and action-based forms following Allen and Gale (1992). The following overview explains two levels on which manipulation can be grouped and then provides a definition of the individual techniques.

Figure 3-1 Taxonomy of Market Manipulation

This figure presents a taxonomy of the most common types of market manipulation, developed by Putnins (2012). Market manipulation is categorized based on methods and techniques.



The first broad category of manipulation is titled 'Runs' by Putnins 2012. He goes onto explain that a run is a form of manipulation designed to profit by first taking either a long or a short position in a stock, inflating or depressing the stock's price, while at the same time attracting liquidity to the stock, and finally reversing the position at the profitable inflated or deflated price. He refers to runs that inflate a stock's price as 'pump-and-dump' manipulation, the type of manipulation we focus on in our study. The stock 'pumping' can take anywhere from a matter of hours to several years and make use of techniques such as rumour mongering, wash sales, and pooling by several manipulators. 'Bear raids', conversely, are a form of run in which the manipulator takes a short position in the stock, manipulates its price downwards by inducing others to sell, and covers his position at a depressed price. A distinguishable common feature of runs is that the manipulator profits directly from the manipulated market by inducing investors to trade at inflated or depressed prices.

Putnins 2012 defines 'contract-based manipulation' as those instances where the manipulator profits from a contract or market that is external to the manipulated market. An example is where a manipulator takes a position in a derivatives contract and profits by manipulating the underlying market price. A distinguishing factor from 'runs' type manipulation is that 'contracts-based' manipulation does not require the manipulator to induce others to trade at manipulated prices and therefore tends to be more mechanical by nature.

The third category of manipulation in Putnins 2012 considers manipulators that utilize an aspect of market power. This can be in the form of a controlling position in the supply of a security. They are similar to 'contract-based' manipulation in that they are mechanical in nature and similar to 'runs' in that they exploit participants of the manipulated market in order to profit.

Previous to Putnins 2012, Allen and Gale (1992) defined three main forms of market manipulation based on how they are conducted. These included trade-based, information-based, and action-based manipulation. Trade-based manipulation relies on the manipulator to trade in the security in order to directly influence the price. Information-based manipulation is based on the manipulator releasing false information or rumours about a security in order to indirectly influence the price. Action-based manipulation relies on the manipulator taking a course of action that may either directly or indirectly influence the value or perceived value of a security. An example of action-based manipulation would be a scenario in which a management team of a company runs the firm sub-optimally in order to depress the price before a management buy out (MBO). Therefore, the three broad categories of manipulation defined by Putnins (2012) can be further classified into trade-, information-, and action-based manipulation.

Additionally, each form of market manipulation can also involve a wide variety of techniques, particularly trade based manipulation[15]. Several of the most prevalent techniques include: 'wash trades' which involve sales in which there is no change in the beneficial owner i.e. the same beneficial owner is behind the buy and sale order, or similarly 'matched orders' which involve the same method but involve different but colluding parties placing matching buy and sell orders at the same time for the same price and volume. 'Pools' are also based on the same

[15] See Cumming and Johan (2008) for a list of the techniques targeted by market surveillance authorities.

premise of creating a false appearance of trading volume and activity but involve a group of manipulators trading shares back and forth among themselves. ‘Painting the tape’ utilizes the power of a public display reporting facility in order to create the impression of trading activity through a series of transactions. ‘Hype-and-dump’ schemes are an increasingly popular method of manipulation with the popularity of Internet forums and social media. It involves the dissemination of false information or rumours via the media, Internet, or other means with the intent to inflate a stock price. They are also referred to as ‘slur-and-dump’ when the intent is to depress the stock price.

‘Marking the close’ (also known as closing price manipulation and ‘high closing’) involves buying or selling securities at or shortly before the close in an effort to alter the closing price. ‘Marking the open’ is similar, but involves influencing the opening price rather than closing price. Closing and opening price manipulation are common techniques for contractual manipulation as the payoffs from contracts are often based on either the open or close price of a security on a particular date. ‘Pegging’ and ‘capping’ refer to placing orders that effectively prevent a price from moving up or down. This is often done to ensure a derivatives contract expires in or out of the money. ‘Corners’ and ‘squeezes’ involve the manipulator securing a controlling position in the supply of an asset and/or a derivative contract and then using their position to manipulate the price by exploiting investors that need the underlying asset to close out short positions.

In summary the definition of market manipulation refers to the interference with the free and fair operation of a market, conducted with the intent to create a misleading price or misleading trading activity. Previous literature has divided market manipulation into runs, contract based manipulation, and manipulation using market power. Furthermore, each form of manipulation has been categorized into how each is conducted, including action-, information- and trade-based techniques. We have also reviewed the numerous techniques within each category.

3.2.2 Trade-based Manipulation

Among Allen and Gale's (1992) three classifications of manipulation, trade based manipulation is arguably the more difficult to detect and rule out. The detection of trade-based manipulation becomes difficult as a result of the trader manipulating a stock simply by buying and selling, without taking any publicly observable actions to alter the value of the firm or releasing false information to change the price. Trade based market manipulation is the focus of our study. Allen and Gorton (1992) argue that a natural asymmetry between liquidity purchases and liquidity sales exists that gives rise to profitable trade-based manipulation. They posit that if liquidity motivated sales are more likely than liquidity motivated purchases, then buy orders are more likely to be informed and therefore have a larger effect on prices. Allen and Gale (1992) use a Glosten and Milgrom (1985) framework and a manipulator that mimics an informed trader with positive information about the stock in order to demonstrate how trade based manipulation can be profitable in the presence of information asymmetry.

In the seminal Glosten and Milgrom (1985) model, this asymmetry between liquidity purchases and sales allows an uninformed manipulator to generate a profit by executing a series of buys to bid the price up and then sell the stock causing a relatively smaller decrease in price.

Information asymmetry is of critical importance to the success of both models of trade-based manipulation.

Aggarwal and Wu (2006) extend on the above models and demonstrate that in addition, the presence of information seekers (or arbitrageurs) in a market where information asymmetry exists can further exasperate the effects of trade-based manipulation by creating a greater competition for shares. This ultimately has the effect of making trade based manipulation easier for the manipulator and deteriorating informational efficiency.

Building on the previous models, Chakraborty and Yilmaz (2004a, 2004b) demonstrate that in the Glosten and Milgrom (1985) and Kyle (1985) models, informed traders can also benefit from manipulating the market. They illustrate that in a market where the existence of an informed trader is uncertain and there is a large lag before private information is fully revealed to the market, informed traders can profit by initially trading in the opposing direction to their information. They achieve this by creating increased uncertainty and distorting the market thereby allowing them to retain their informational advantage for a longer period and extract higher profits over a longer period. This effect is even more pronounced when there are many competitive rational traders who hold more noisy information than the insider but more accurate information than the market maker, as the competitive rational traders follow the insiders trades in equilibrium (Chakraborty and Yilmaz, 2008).

In addition to the simple act of trading in order to distort prices and induce profits a number of studies model how other properties such as derivatives securities, events, or specific market design features can also give rise to other profitable trade based manipulation techniques. Jarrow (1994) demonstrated that in an economy with a stock market, money market account, and a derivative security, the introduction of the derivative security generates market manipulation trading strategies that would otherwise not exist. Gerard and Nanda (1993) find that strategic informed traders can profit off seasoned equity offerings by short selling a stock just prior to the offering to place downward pressure on the price and then more then cover their position by purchasing stocks in the offering at a discount price. They would finally liquidate their remaining position at a profit when the stock price is eventually restored to its fair value. In Fishman and Hagerty (1995) a manipulator takes advantage of the Securities Exchange Act (1934) mandatory disclosure rule for large trades. The manipulator first declares large buy trades, thereby forcing prices up, and then sells the position anonymously in a series of small trades. Similarly, John and Narayanan (1997) and Huddart et al. (2001) also examine the effect of mandatory disclosure laws on the incentives of insiders to manipulate. Kyle (1984), Vila (1987) and Allen et al. (2006) model corners and squeezes in which manipulators can essentially set prices by obtaining a controlling fraction of the supply of stock on the market. In Vila (1989) and Bagnoli and Lipman (1996) the manipulator trades in order to create the impression of a takeover bid to induces a price run-up and ultimately profit by selling at an inflated price.

Studies also illustrate that trade based manipulation can exploit the feedback effect from financial markets to the real value of a firm in order to distort resource allocation and profit. This occurs as result of directors using their company’s stock price as a signal in making decisions about the company’s investments. Goldstein and Geumbel’s (2008) model manipulators that aggressively short sell shares to depress prices and negatively influence company investment decisions. The manipulators eventually profit by covering their positions at depressed prices as a result of the negative investment decisions. Khanna and Sonti (2004) demonstrate the feedback effect in the opposing direction where long-term shareholders manipulate prices upwards to encourage value creating investment. In both cases manipulators take advantage of market mechanisms to distort the efficient allocation of resources within a company.

In this section we conclude that trade-based manipulation is not only restricted to the impact of the manipulative transactions themselves, but also relies on the subsequent actions of other traders, features of certain securities, events, and market mechanisms.

3.2.3 Evidence on “pump-and-dump” trade-based manipulation

Allen and Gale (1992) and Aggarwal and Wu (2006) both present theoretical and empirical evidence of “pump-and-dump” manipulation. Aggarwal and Wu also empirically analyze 51 of 142 ‘pump- and-dump’ manipulation cases during 1990-2001 from the US Securities and Exchange Commission (SEC) litigation releases. They find that the minimum length of a manipulation period is two days, the median is 202 days and the maximum is 1,373 days, highlighting the variation in the nature of pump-and-dump manipulation. Their analysis reveals that manipulated stocks generally experience a price increase during the manipulation period, a subsequent decrease during the post-manipulation period, and increased volatility. Their sample of cases is more concentrated in illiquid stocks where informed insiders such as management, substantial shareholders, market makers, or brokers conduct most of the manipulation. However, Aggarwal and Wu (2006), like most empirical studies of prosecution cases, suffer from sample selection bias as a result of only examining prosecuted manipulation cases.

Mei et al. (2004) propose a model in which manipulators can strategically take advantage of investors' behavioural biases and manipulate the price process to profit. They consider three types of traders, behaviour-driven investors who are loss averse (dispositional effect), arbitrageurs, and a manipulator who can influence asset prices. They show that, due to the investors' behavioural biases and the limit of arbitrage, the manipulator can profit from a "pump-and-dump" trading strategy by accumulating the speculative asset while pushing the asset price up, and then selling the asset at high prices. Since nobody has private information, manipulation here is completely trade-based. In an empirical test of the model developed by Mei et al. (2004), they find that "pump-and-dump" operations have led to higher return, increased volatility, larger trading volume, short-term price continuation and also long-term price reversal during the manipulation period. Moreover, small stocks are found to be more subject to the effects of manipulation. This possibility poses a new challenge for regulators. As the manipulator relies on neither inside information nor visible actions his manipulation is difficult to be detected and ruled out.

In the first laboratory experiment on price manipulation Hanson et al. (2006) study 12 participants trading stock and cash in an electronic limit order book market. In this market manipulation setting, half of the participants are given monetary incentives to manipulate the stock price. Their main finding is that manipulators are unable to distort price accuracy because other traders counteract the actions of the manipulators.

In another experiment that can be considered similar to trade cancellations, Camerer (1998) attempts to manipulate horse racing odds by making bets and then cancelling them shortly before the race. Although making and then cancelling a bet is costless. In the experiment Camerer finds that cancelled bets placed by the experimenter do not distort prices.

In a completely different approach Khwaja and Mian (2005) examine trading records of likely manipulators rather than market prices and find evidence of 'pump-and-dump' market manipulation by brokers in Pakistan's main stock exchange. Their findings reveal brokers earn at least 8% higher returns on their own trades and neither market timing nor liquidity provision offer sufficient explanations for this result.

Gallagher et al. (2009) find evidence of fund managers manipulating closing prices to influence their fund's reported performance. Gallagher et al. find that on the last day of the quarter, fund managers tend to purchase illiquid stocks in which they already hold overweight positions in a bid to 'pump' up the prices and increase the value of the fund.

3.2.4 Market manipulation and Return Reversals

Comerton-Forde and Putnin□s (2011) examine 184 cases of closing price manipulation by prosecuted fund managers, top company management, brokers, and substantial shareholders. The cases are all a result of prosecution by the SEC between 1997 and 2009. Their findings reveal that episodes of closing price manipulation are associated with large increases in day-end returns, subsequent return reversals, increased trading volume, and wider spreads.

Blocher et al. (2009) examine whether fund managers holding short positions manipulate prices down with short selling on the last trading day of the year. They find increased levels of short selling in the last hour of the last trading day of the year for stocks that have large short interest. The short selling is accompanied by poor returns and subsequent reversals at the beginning of the year.

Stoll and Whaley (1987), and Chamberlain, Chueng and Kuan (1989) find empirical evidence of significantly higher price mean reversals on the expiration day of index futures/option contracts in comparison to month-ends or quarter-ends without index futures/options expiration in the US markets. All of these results are consistent with return reversals following episodes of market manipulation.

3.2.5 Hypothesis Development

Following the arising market integrity concerns regarding the growing number of trade cancellations on the ASX, this study aims to investigate whether trade cancellations can be a source of market manipulation. As it is a novel area of study there is no prior literature on trade cancellations specifically. However, this study can draw from the wide literature available on market manipulation. Market manipulation can be broken down into several categories based on the characteristics and methods involved. Only the forms of market manipulation in the literature that present similarities to the characteristics of trade cancellations are considered.

Firstly, if trade cancellations are to be used as a means of manipulation than it will certainly be classified as 'trade-based' manipulation. Furthermore, the introduction to trade cancellations highlights the fact that the majority of trade cancellations can also be classified as potential 'wash trades', which in the manipulation literature will fall under 'pump-and-dump' manipulation.

Allen and Gale (1992) and Aggarwal and Wu (2006) both present theoretical and empirical evidence of "pump-and-dump" manipulation. Their analysis reveals that manipulated stocks generally experience a price increase during the manipulation period, a subsequent decrease during the post-manipulation period, and increased volatility. Khwaja and Mian (2005) examine trading records of likely manipulators in 'pump-and-dump' market manipulation schemes and find return results consistent with Allen and Gale (1992) and Aggarwal and Wu (2006). Furthermore, in an empirical tests Mei et al. (2004) find that "pump-and-dump" operations lead to higher return, increased volatility, larger trading volume, short-term price continuation and also long-term price reversal during the manipulation period. Moreover, small stocks are found to be more subject to the effects of manipulation.

Taken together, the following hypotheses examine whether the effects of trade cancellations share similarities with the effect of 'pump-and-dump' manipulation.

Hypothesis$_{3,1}$: Returns increase between the initial trade and its subsequent cancellation.

Hypothesis$_{3,2}$: Volatility increases from the initial trade and continues after the trade cancellation.

Hypothesis$_{3,3}$: Trading volume increases between the initial trade and its subsequent cancellation.

The literature also presents evidence of return reversals following episodes of market manipulation. Comerton-Forde and Putnin□s (2011) reveal that episodes of closing price manipulation are associated with large increases in day-end returns and subsequent return reversals. Blocher et al. (2009) examine manipulative short selling and find that it is accompanied by poor returns and subsequent reversals. Stoll and Whaley (1987), and Chamberlain et al. (1989) find empirical evidence of significantly higher price mean reversals on the expiration day of index futures/option contracts in comparison to month-ends or quarter-ends without index futures/options expiration in the US markets. All of these results are consistent with return reversals following episodes of market manipulation. Therefore the following hypothesis is also tested.

Hypothesis$_{3,4}$: Significant return reversals follow trades that are subsequently cancelled.

3.3 What are Trade Cancellations?

Trade cancellations are executed market trades that were originally made in error or unintentionally violated market rules and regulations and are subsequently cancelled. Trades are cancelled 'when brokers reach mutual agreement that a particular trade should not have happened and they both agree to cancel the trade on behalf of their clients.'

ASX's equity market trade cancellation process during the sample of our study (2006 to 2009) had been in place under the ASX Operating Rules since 2004. Under these rules, participants are required to report error trades to the ASX within 15 minutes of the error trade being executed. Upon receipt of the request, ASX would as soon as possible send a message to the market notifying that a cancellation had been requested. ASX would then evaluate a potential error trade, or in the case of a dispute may ask the Dispute Governors Committee (DGC) to review or guide ASX's decision on cancellation. The Dispute Governors Committee was formed to gain a degree of impartiality on the determination of cases deserving trade cancellation. The approach to resolution on ASX Markets was to either reject a request to cancel a deal, facilitate an agreement between counterparties to cancel a deal, or unilaterally cancel a deal. Cancellation was required to be effected by end T+1 at the latest. As a result of these rules and procedures it was common for a large number of trade cancellations on the

ASX to occur up until the close of trading on T+1. Where a decision regarding cancellation of a trade had been effected, ASX would notify the affected Participants of the decision and send a message to the market.

Two key error types covered by the trade cancellation powers are trading system errors and disorderly market errors. Trading system errors involve an incorrect Trading Message submitted by a stockbroker or by the ASX, or other error by a Market Participant of the ASX that relates to the Market Transaction. Examples include incorrect market information errors such as the ASX system error disseminating trades with an incorrect settlement date or the purging of orders entered before a security's suspension to be removed from the trading system that prevents investors trading into securities that may experience a dramatically falling price. Disorderly market error involves securities being traded at levels that are far removed from their market value. Examples include the incorrect entry of stocks and/or prices by brokers into the trading system at the terminal.

During the sample period (July 2006 to October 2009), brokers were required to provide a reason for the trade cancellation in the form of a 'trade reversal code' which are outlined below:

- B - Incorrect Broker
- D - Data Entry Error
- O - Other
- P - Incorrect Price

- S - Incorrect Stock
- V - Incorrect Volume

Only D, O, P, and V are present in the sample. Once a decision was made, ASX Trading Operations & Markets would then notify the Australian Securities Exchange Markets Supervision (ASXMS) office (mandated to supervise futures, equities, clearing and settlement at the ASX) of the trade cancellation and the reason provided.

Table 3-1 Trade Reversal Code Frequency

This table reports the Trade Reversal Codes and their frequency in the sample. The Trade Reversal Code is submitted by brokers as a reason for a trade cancellation request. The Trade Reversal Codes are as specified: D (Data Entry Error), O (Other), P (Incorrect Price), and V (Incorrect Volume).

Trade Reversal Code	*Number*	*Percent (%)*
D	622,862	95
O	30,346	5
P	4	0
V	1	0
	653,213	100

As can be seen in Table 3-1, the majority of trade cancellations (95%) in the sample occur as a result of 'D' or 'data entry error' also known as the case of 'fat-finger trading' in the 2010 'Flash Crash'. Most of the remaining trade cancellations (4.6%) are classified under 'O' or 'Other'. Unfortunately, there is no exact definition for the 'Other' category provided by the ASX, apart from the fact that it does not suitably fit into any of the other categories. In the sample there are 4 trade cancellations as a result of 'P' – 'incorrect price' and only 1 trade cancellation as a result of 'V' – 'incorrect volume'.

The fundamental intention of ASX's trade cancellation policy (TCP) is to provide a mechanism for cancelling and removing from the trade data any trades that are clearly erroneously priced. Such trades detract from the integrity of the price formation process, as the trade may not be a reflection of genuine supply and demand.

3.4 The Growth of Trade Cancellations on the ASX from 2006 to 2009

This section reports the magnitude of trade cancellations on the ASX from 2006 to 2009 and outlines growth trends. Figure 3-2 demonstrates that the prevalence of trade cancellations both in terms of total traded volume and value has increased in 2007 before stabilizing in 2009. Although trade cancellations as a proportion of traded volume remained very much the same in October 2009 as in July 2006 at around 0.50%, trade cancellations as proportion of total traded value almost doubled from 0.69% to 1.16%.

Figure 3-2 All ASX Listed Stocks

This figure reports the traded volume and value of all cancelled trades as a percentage of all ASX trades during the sample period. The graph is for the period July 2006 to October 2009.

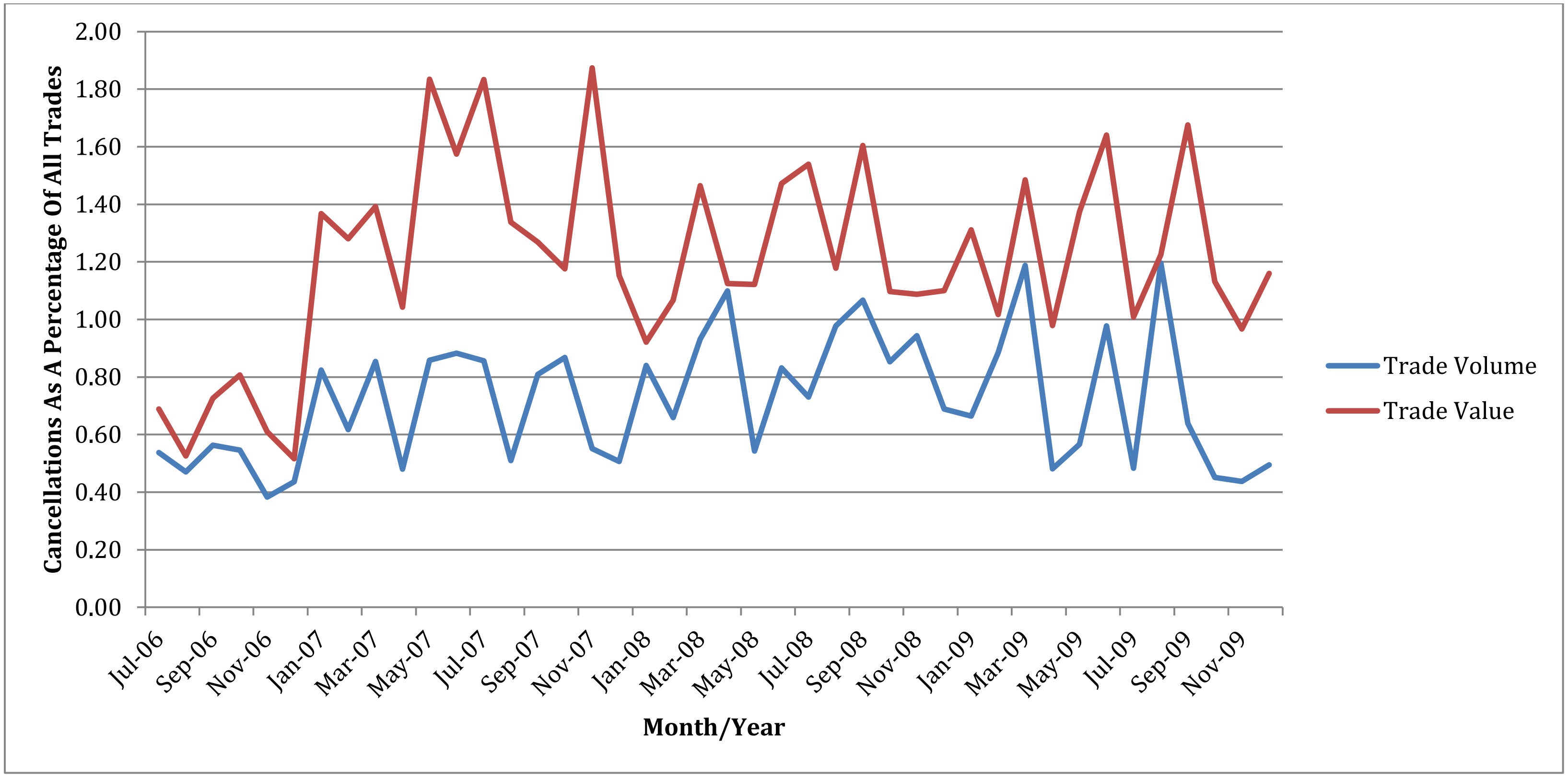
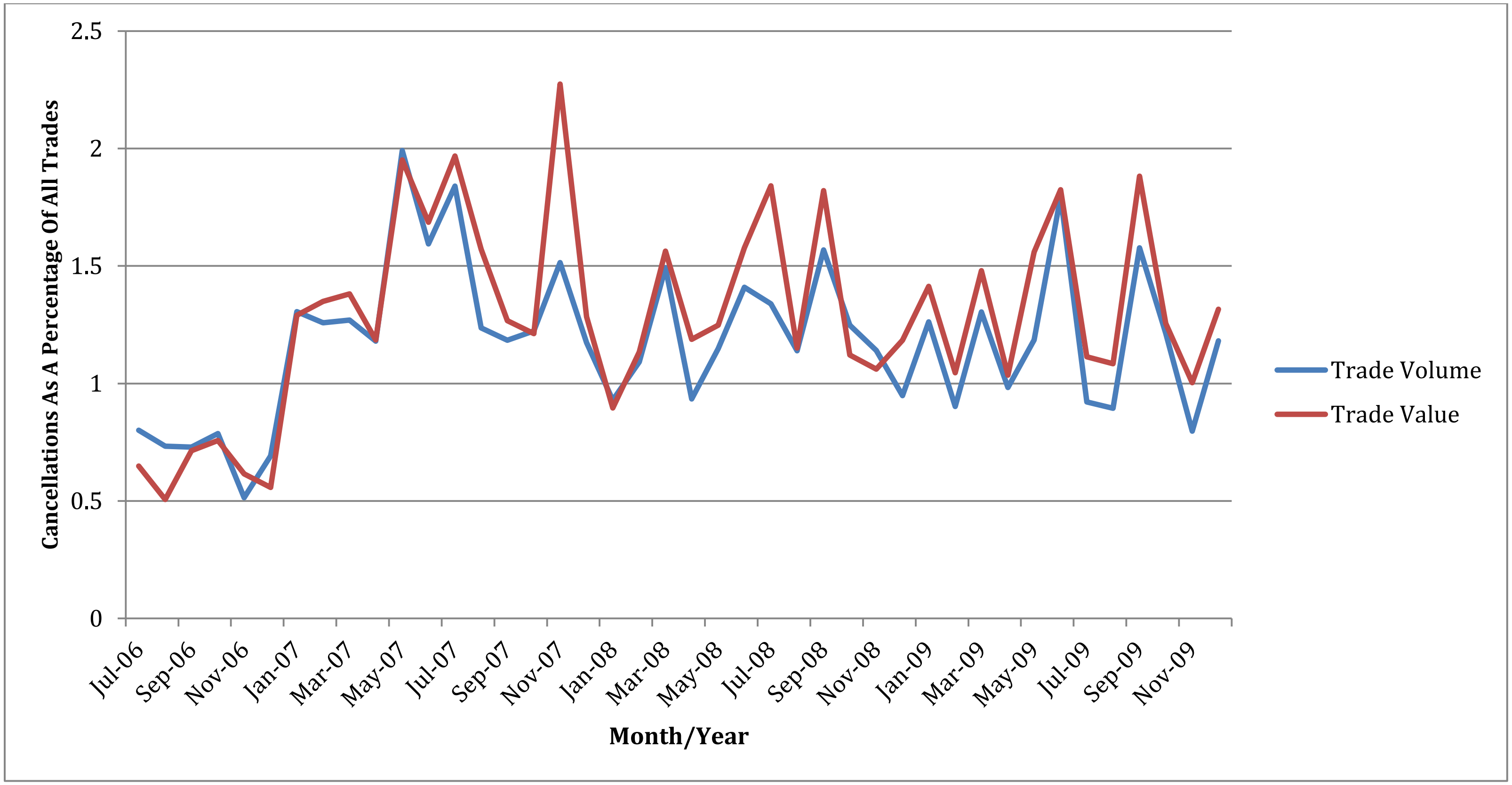


Figure 3-3 ASX Top 50 Stocks

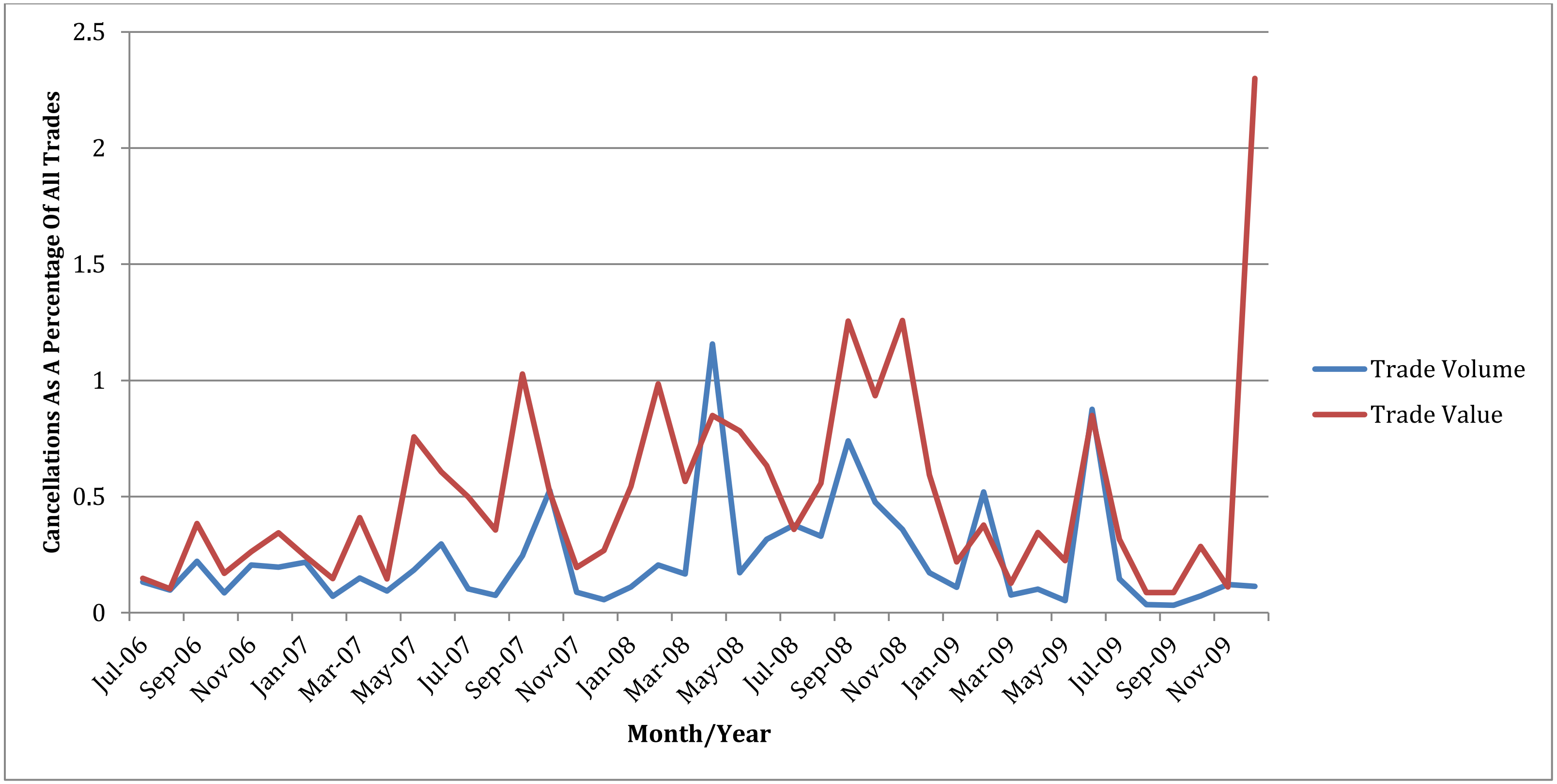
This figure reports the traded volume and value of all cancelled trades as a percentage of all ASX trades in the top 50 capitalisation stocks during the sample period. The graph is for the period July 2006 to October 2009.



Trade cancellations as proportion of all trades within the 50 largest stocks listed on the ASX exhibit a steady increase both in terms of total traded volume and value (Figure 3-3). Trades cancellations as a proportion of all traded volume on the ASX increased from 0.8% in July 2006 to 1.18% in October 2009. Similarly, trade cancellations as a proportion of all traded value on the ASX increased from 0.65% in July 2006 to 1.32% in October 2009.

Figure 3-4 ASX Smallest 501+ Stocks

This figure reports the traded volume and value of all cancelled trades as a percentage of all ASX trades in the lowest capitalisation stocks (those that are below the top 500 stocks, approximately 1,500 stocks) during the sample period. The graph is for the period July 2006 to October 2009.



The greatest increase in trade cancellation activity is revealed to be among the smallest listed stocks on the ASX (Figure 3-4), which include approximately 1,500 stocks that fall below the top 500 listed stocks.[16] Although trade cancellations as a proportion of total traded value in the smallest stocks remained roughly the same from 0.13% in July 2006 to 0.11% in October 2009, trade cancellations as a proportion of traded value ballooned from 0.15% to 2.3% over the same period. The figures above make it clear that by 2009, a significant proportion of all executed trades are subsequently cancelled and a growing cause for concern.

[16] Results of trade cancellations for all remaining ASX listed stocks exhibit figures similar to the figures for all ASX listed stocks.

3.5 The Impact of Trade Cancellations on Daily Volume Weighted Average Price (VWAP)

The first metric to be examined to investigate the impact of the growing proportion of trade cancellations is the Daily Volume Weighted Average Price (VWAP). VWAP is the ratio of the total value (the total number of shares traded multiplied by the prices they were traded at) traded to total volume (the number of shares traded) traded over a particular time horizon (usually one day). It is a measure of the average price a stock traded at over the trading horizon. Traders who aim to be as passive as possible in their execution often use VWAP as a trading benchmark. Brokers also use VWAP in algorithmic order execution engines. With the proliferation of algorithm based trading and VWAP being such a widely relied on metric it is the first metric that may be impacted by an increase in trade cancellations and therefore erroneous trades.

3.5.1 Data and Sample

All trade cancellations data from 1 July 2006 to 23 October 2009 are sourced internally from the ASX. For each trade cancellation there is information on the ASX Code, Sales Slip Number, Buyer and Seller Broker ID, Trade Reversal Code, Trade Volume, Trade Price, Trade Value, Trade Condition Codes, the initial Trade Date and Time, and the Reversal Date and Time. In addition, internal ASX trade data on all equities trades on the ASX during the period 1 July 2006 to 23 October 2009 are also sourced. The equities trade data includes the Trade Price, Buyer and Seller Broker ID, Sales Slip Number, Trade Volume, Trade Price, Trade

Value, Trade Condition Codes and the Trade Date and Time. There are a total of 653,213 trade cancellations during this period.

3.5.2 Research Design

Daily VWAP is calculated for all executed trades on the ASX including trades that are subsequently cancelled and for all executed trades excluding those trades which are subsequently cancelled arriving at two Daily VWAP figures for each stock on a trading day. Daily VWAP for each is stock is calculated as follows:

$$p_{Daily\,VWAP} = \frac{\sum_{j=1}^{n} P_j Q_j}{\sum_{j=1}^{n} Q_j}$$

(3-1)

Where $P_{Daily\,VWAP}$ is the Daily Volume Weighted Average Price, J is the current trade within the trading day, n is the total number of trades within the trading day, P_j is the price at which the j'th trade executed at, and Q_j is the quantity of stocks executed at the j'th trade. The change in the Daily VWAP metric as a result of trade cancellations is also examined by calculating the percentage change between the two figures for the Daily VWAP.

3.5.3 Results

Table 3-2 All ASX Listed Stocks

This table reports the average change in VWAP as a result of trade cancellations for each half-year period in each year in the entire sample. The figures are reported as a summary of all trade cancellations in the sample. The 'Half' column specifies the period of the year, with 1 signifying the first half (1 January to 30 June), and 2 signifying the second half (1 July to 31 December). Average Absolute VWAP Change (%) reports the average absolute value of VWAP changes, while Average VWAP Change (%) reports the figure without taking the absolute value.

Year	*Half*	*Average Absolute VWAP Change (%)*	*Average VWAP Change (%)*	*Maximum VWAP Change (%)*	*Minimum VWAP Change (%)*
2006	*2*	0.0249	-0.0122	2.5253	-65.6229
2007	*1*	0.0197	-0.0123	7.7236	-6.4086
2007	*2*	0.0241	-0.0055	5.2273	-17.1321
2008	*1*	0.0259	-0.0043	16.4840	-41.4039
2008	*2*	0.0232	-0.0031	5.7207	-13.2556
2009	*1*	0.0215	-0.0032	7.8663	-8.0559
2009	*2*	0.0124	-0.0031	16.1257	-8.7030

Table 3-2 illustrates that the average magnitude of change in Daily VWAP as a result of trade cancellations (Average Absolute VWAP Change) varies from 0.012% to 0.025% for all ASX listed stocks. However, the maximum and minimum figures highlight the potential impact that trade cancellations can have on a Daily VWAP figure, altering it by up to 65% within one single day in a stock.

Table 3-3 Top 50 ASX Listed Stocks

This table reports the average change in VWAP as a result of trade cancellations for each half-year period in each year in the sample. The figures are reported as a summary of all trade cancellations in the top 50 capitalisation stocks during the sample period. The 'Half' column specifies the period of the year, with 1 signifying the first half (1 January to 30 June), and 2 signifying the second half (1 July to 31 December). Average Absolute VWAP Change (%) reports the average absolute value of VWAP changes, while Average VWAP Change (%) reports the figure without taking the absolute value.

Year	*Half*	*Average Absolute VWAP Change (%)*	*Average VWAP Change (%)*	*Maximum VWAP Change (%)*	*Minimum VWAP Change (%)*
2006	*2*	0.0246	-0.0206	1.0111	-65.6229
2007	*1*	0.0049	-0.0209	0.3049	-0.6267
2007	*2*	0.0071	-0.0004	0.3629	-4.6039
2008	*1*	0.0064	-0.0004	0.9786	-0.7239
2008	*2*	0.0087	-0.0004	1.7933	-3.1300
2009	*1*	0.0072	-0.0007	0.2055	-1.4290
2009	*2*	0.0040	-0.0007	0.5394	-0.4938

The average magnitude of change in Daily VWAP as a result of trade cancellations (Average Absolute VWAP Change) among the top 50 stocks peaked in the second half of 2006 at 0.025% before stabilizing between 0.004% and 0.008% from 2007 to 2009. The maximum and minimum VWAP change figures also reveal less variance since 2007 with the largest change of 4.6% in the second half of 2007.

Table 3-4 ASX Smallest Listed Stocks

This table reports the average change in VWAP as a result of trade cancellations for each half-year period in each year in the sample. The figures are reported as a summary of all trade cancellations in the smallest capitalisation stocks (those that are below the top 500 stocks, approximately 1,500 stocks) during the sample period. The 'Half' column specifies the period of the year, with 1 signifying the first half (1 January to 30 June), and 2 signifying the second half (1 July to 31 December). Average Absolute VWAP Change (%) reports the average absolute value of VWAP changes, while Average VWAP Change (%) reports the figure without taking the absolute value.

Year	*Half*	*Average Absolute VWAP Change (%)*	*Average VWAP Change (%)*	*Maximum VWAP Change (%)*	*Minimum VWAP Change (%)*
2006	*2*	0.2032	-0.1053	2.5253	-11.2110
2007	*1*	0.1758	-0.0990	7.7236	-6.4086
2007	*2*	0.2218	-0.1143	2.8032	-17.1321
2008	*1*	0.2213	-0.0646	16.4840	-41.4039
2008	*2*	0.2105	-0.0405	5.7207	-13.2556
2009	*1*	0.3259	-0.0347	7.8663	-8.0559
2009	*2*	0.2760	-0.0290	16.1257	-4.9190

Average Daily VWAP change as a result of trade cancellations is most pronounced in the smallest stocks listed on the ASX (approximately the smallest 1,500 stocks). Among the smallest stocks, the average magnitude of change in Daily VWAP as a result of trade cancellations (Average Absolute VWAP Change) varies from 0.18% to 0.33%, approximately ten times the average across all stocks listed on the ASX. Maximum and minimum VWAP changes are also similar to those of all listed ASX stocks varying between 2.5% and 41% from 2006 to 2009.

The results reveal a proliferation in the number of trades that are subsequently cancelled on the ASX year on year and a resulting significant impact on the daily reported VWAP figures within stocks on certain days. These findings are more pronounced in the smallest listed stocks on the ASX, and are of a greater concern. Irregularly large changes in VWAP as a result of cancelled trades in most cases is likely to be a result of trades made in error where trades were executed at prices very differet to the current market prices. Nonetheless, the results highlight the potential impact that cancelled trade may have on market price statistics.

3.6 Trade Cancellations and return reversals

This section examines the returns patterns of a subset of trade cancellations on the ASX. Specifically, this section investigates whether a subset of 'crossed' trades that are subsequently cancelled are manipulating the market. The 'crossed' trades in the sample act as a proxy for possible 'wash trades'[17] that have been a cause for concern following the increase in trade cancellations on the ASX. This section examines whether there is evidence of return reversals following the cancellation of these possible wash trades that is consistent with manipulated market prices.

3.6.1 Data and Sample

The data are obtained from an internal database from the ASX. The sample consists of trade-by-trade data for all stocks listed on the exchange and the subsequent trade cancellations. The data on trade cancellations contain a record describing each transaction, including the ASX Code, Sales Slip Number, Buyer and Seller Broker ID, Trade Reversal Code, Trade Volume,

[17] Wash trades occur where a trader places a buy order against a sell order for the same beneficial owner.

Trade Price, Trade Value, Trade Condition Codes, the initial Trade Date and Time, and the Reversal Date and Time. In addition, this data has been merged with order book data from the ASX that provides information on whether the trade was Buyer or Seller initiated. The sample period extends from October 30, 2006 to October 23, 2009. The sample is restricted to normal trading hours for equities markets (10:00 a.m. - 4:12 p.m.). The internal data are combined with order book data sourced from Reuters Data Scope Tick History provided by Securities Industry Research Centre of Asia-Pacific (SIRCA). The data provide the prices of the best bid and ask quotes time stamped to the nearest millisecond. To calculate stock betas and expected returns the ASX All Ordinaries Index values, daily stock prices and monthly market value for each stock are sourced from Datastream. Daily and monthly Treasury Notes yields are sourced from the Reserve Bank of Australia website.

This analysis is limited to only 'crossings' which means all cancelled trades where the Buyer and Seller Broker ID do not match up are eliminated. Initially there are 516,467 unique trade cancellations in the sample period, of which 510,807 are crossings. Since only minimums of 5-minute intervals are examined, all trades that are reversed within a 5-minute interval are eliminated. This leaves 321,841 observations. Further, the study is limited to those instances where only one 'crossed' trade is cancelled in a particular stock on a certain day. This is required to eliminate the confounding effect of other crossed trades that are subsequently cancelled on the same day. Any observation in which the direction of the trade cannot be determined is eliminated. This results in an analysis sample of 14,617 observations; 10,708 of these cancellations occur after market close, while 3,909 are reversed before market close.

Table 3-5 Frequency of Trade Cancellations Before and After Market

This table reports the frequency of trade cancellations before and after market close, and the relevant percentage. The normal trading hours for ASX equities is 10:00 a.m. to 4:12 p.m.

Time of Cancellation	*Number*	*Percent (%)*
After Market Close	10,708	73
Before Market Close	3,909	27
	14,617	100

3.6.2 Research Design

The approach adopted to investigating whether possible 'wash trades' that are subsequently cancelled are consistent with manipulative trade reversal patterns is similar to Comerton-Forde and Putnins (2009). It involves (i) establishing the difference in abnormal return paths for informed trading and manipulative trading; and (ii) identifying likely episodes of manipulation based on abnormal return paths.

Comerton-Forde and Putnins (2009) construct a simple theoretical model of manipulation based on Allen and Gale (1992) to provide predictions about the price paths under informed and manipulative trading. Allen and Gale (1992) only consider trade-based manipulation in which the manipulator simply buys and sells the stock without taking a position in any other market. In addition, they do not allow the possibility of a purchaser of the firm taking actions that alter the value of the firm or releasing rumours.

There is a large amount of theoretical support and some empirical evidence that manipulation leads to reversals in prices. Examples of theoretical models in which the manipulator causes price reversals include Vila (1989), Allen and Gale (1992), Allen and Gorton (1992), Jarrow (1992), Benabou and Laroque (1992), Gerard and Nanda (1993), Bagnoli and Lipman (1996), Van Bommel (2003), Chakraborty and Yilmaz (2004a, 2004b), Aggarwal and Wu (2006) and Allen et al. (2006). In an empirical study of 51 cases of manipulation prosecuted by the US Securities and Exchange Commission (SEC) during 1990-2001, Aggarwal and Wu (2006) find that manipulation is associated with price reversals.

Two theoretical studies, Khanna and Sonti (2004) and Goldstein and Geumbel (2008), differ from the general consensus in the literature in that the price changes brought about by the manipulator do not subsequently reverse to their full extent. This occurs because the initial price changes affect firms' investment decisions, which influence fundamental values. The feedback of prices to fundamental values is likely to take months or years. The focus of this study is on shorter-term manipulation strategies (lasting up to a few hours) and therefore the evidence supporting price reversals is more relevant in our case.

Returns are measured at 5-minute intervals from the time of the trade to the end of the trading day, when a closing price auction takes place. It is proposed that to a high degree a closing price auction will correct any inconsistent prices that result from market manipulation. Abnormal return for a trade in stock i in the 5 minute interval t is the difference between the mid-quote return (thereby minimising microstructure effects such as bid-ask bounce) on stock i in interval t, r_{it}, and the expected return from the CAPM model:

$$AR_{it} = r_{it} - r_{ft} - \beta_i(r_{mt} - r_{ft})$$

(3-2)

In the equation above, r_{ft}, and r_{mt} are returns on one-month Treasury notes, and the return on the ASX All Ordinaries Price Index, respectively, over interval t. Both Treasury notes returns and ASX All Ordinaries Price Index returns are calculated at 5-minute intervals. β_i are the estimates for beta for each stock. The betas are estimated using monthly data from 2004 to 2009.

The cumulative abnormal returns to each trade are calculated by summing the abnormal returns from the interval immediately following a trade:

$$CAR_{it} = \sum_{j=1}^{t} AR_{ij}$$

(3-3)

Informed trading moves prices gradually towards fundamental value, whereas manipulation moves prices away from fundamental value. Then once the manipulator exits the market, prices spring back to fundamental value creating a reversal in returns. The previous subsection establishes that reversals in cumulative abnormal returns are indicative of manipulation, whereas abnormal return continuations are associated with informed trading. The measure of reversal is defined as:

$$Reversal_{it} = \begin{cases} argmin[(CAR_{it}^{max} - CAR_{i0}), (CAR_{it}^{max} - CAR_{iEnd})] \ if \ Buy \ Trade \\ argmax[(CAR_{it}^{min} - CAR_{i0}), (CAR_{it}^{min} - CAR_{iEnd})] \ if \ Sell \ Trade \end{cases}$$

(3-4)

This measure recognizes that for a positive reversal, CAR must increase and subsequently decrease such that CAR_{it}^{max} is above both the CAR at the time of the trade ($CAR_{i0} = 0$) and the CAR at the end of the measurement window (CAR_{iEnd}, measured at the end of the trading day). If CAR increases and remains high, we have a continuation of abnormal returns rather than a reversal and our reversal measure gives a value of zero.

Further, to capture any return reversals that happen as a result of trade cancellation notifications after market close an 'overnight return reversal' metric is also calculated, similar to Putnins (2009). Overnight return reversal is the return from the closing price auction between 4:10pm and 4:12pm to the opening price auction the following morning between 10am and 10:09am.[18] The price auctions at open and close allow for all information to be incorporated into the prices and attempt to reduce transient volatility.

$$Overnight\ Reversal_i = \log(\frac{P_{close}}{P_{open}})$$

(3-5)

Where P_{close} is the closing price on the day of the original trade cancellation and P_{close} is the opening price the following day.

[18] Opening on the ASX takes place at 10:00 am Sydney time and lasts for about 10 minutes. ASX Trade calculates opening prices during this phase. Securities open in five groups, according to the starting letter of their ASX code. Similarly, the Closing Single Price Auction takes place between 4:10pm and 4:12 pm, Sydney time.

3.6.3 Results

Table 3-6 Frequency of Zero and Non-Zero Reversals

This table reports the frequency of zero or non-zero reversals during normal market trading hours for cancelled trades, and the relevant percentages. The normal trading hours for ASX equities is 10:00 a.m. to 4:12 p.m.

Reversal	*Number*	*Percent (%)*
Zero	3,654	25
Non-Zero	10,963	75
	14,617	100

Table 3-7 Frequency of Zero and Non-Zero Overnight Reversals

This table reports the frequency of zero or non-zero reversals during the overnight hours for cancelled trades, and the relevant percentages. The non-normal trading/overnight hours for ASX equities are from 4:13 p.m. the previous day to 10:00 a.m. the following day.

Overnight Reversal	*Number*	*Percent (%)*
Zero	1,937	13
Non-Zero	12,680	87
	14,617	100

Table 3-8 Reversal Statistics – Full Sample

This table reports the statistics for Reversal and Overnight Reversal for the entire sample of trade cancellations. 'Number of 5-minute intervals' specifies the number of 5 minutes intervals from the time of the initial trade to either market close or trade cancellation. 'Absolute Reversal' and 'Absolute Overnight Reversal' present the statistics for the absolute value of Reversal and Overnight Reversal, respectively.

Statistic	*Number of 5-minute Intervals*	*Reversal*	*Absolute Reversal*	*Overnight Reversal*	*Absolute Overnight Reversal*
n = 14,617					
MEAN	41	0.0002	0.0049	-0.0002	0.0157
p-value	0.00	0.07	0.00	0.58	0.00
MIN	3	-0.2231	0.0000	-3.7007	0.0000
MAX	75	0.2069	0.2231	0.7588	3.7007
STD	26	0.0102	0.0089	0.0412	0.0381

Considering the ‘reversal’ metric takes into account the direction of the initial trade, a non-zero reversal figure for a trade is evidence that is consistent with a trade reversal no matter the direction. Table 3-6 shows that in our sample 75% or 10,963 trades exhibit non-zero return reversals following the initial trade. Further, Table 3-7 also highlights that 87% of all cancelled trades in our sample also experience an overnight return reversal following the trade cancelation. This may provide evidence that the closing price auction is not sufficient in correcting a distorted market price, and that the trade cancellation notice (after-market close) is required to reveal the extent of the distortion to the market.

Table 3-8 summarises the reversal findings for our entire sample. It identifies that the average wash trade takes place three hours and twenty-eight minutes before market close. This is an indicator of the potential length of time that prices may remain distorted after the initial wash trade. The average reversal across all cancelled wash trades is 0.02% (significant at the 10% level). However, a standard deviation of 1.02%, and minimum and maximum reversal figures of 22.31% and 20.69%, respectively, highlights the large variance of reversals among the cancelled trades and the significant extremities of the price distortions in the market following these trades. The Absolute Reversal metric measures the magnitude of the reversal disregarding direction and illustrates a similar finding.

The Overnight Reversal metric does not take into account the direction of the initial wash trade; therefore we focus on the results of the Absolute Overnight Reversal metric. The average magnitude of overnight reversal (Absolute Overnight Reversal) is 1.57% with a large standard deviation of 3.81%. The minimum and maximum extremes of overnight reversal in the sample are 370% and 75.88%, respectively. The results reveal that overnight reversals exhibit larger extreme returns than trading hour reversals. However, this may be the result of the larger time frame overnight and the arrival of market relevant news during the closing hours. Nonetheless, the results provide evidence of return reversals following wash trades to the closing price auction and even after market close to the following trading day open.

Table 3-9 Reversal Statistics – By Before/After Market Cancellation

This table reports the statistics for Reversal and Overnight Reversal for the sample of trade cancellations categorized into those cancellations that take place before and after market close. ‘Number of 5-minute intervals’ specifies the number of 5 minutes intervals from the time of the initial trade to either market close or trade cancellation. ‘Absolute Reversal’ and ‘Absolute Overnight Reversal’ present the statistics for the absolute value of Reversal and Overnight Reversal, respectively.

Time of Trade Cancellation	*Statistic*	*Number of 5-minute Intervals*	*Reversal*	*Absolute Reversal*	*Overnight Reversal*	*Absolute Overnight Reversal*
	MEAN	41	-0.0001	0.0049	-0.0007	0.0144
	p-value	0.00	0.24	0.00	0.00	0.00
BEFORE	*MIN*	3	-0.1705	0.0000	-0.2414	0.0000
Market Close	*MAX*	75	0.2069	0.2069	0.7588	0.7588
n=10,708	*STD*	27	0.0096	0.0082	0.0244	0.0198
	MEAN	40	0.0009	0.0048	0.0012	0.0195
	p-value	0.00	0.00	0.00	0.26	0.00
AFTER Market	*MIN*	3	-0.2231	0.0000	-3.7007	0.0000
Close	*MAX*	75	0.1257	0.2231	0.5390	3.7007
n=3,909	*STD*	23	0.0116	0.0106	0.0691	0.0663

Table 3-10 Reversal Statistics – By Year

This table reports the statistics for Reversal and Overnight Reversal for the trade cancellations split into the different years in our sample ‘Number of 5-minute intervals’ specifies the number of 5 minutes intervals from the time of the initial trade to either market close or trade cancellation. ‘Absolute Reversal’ and ‘Absolute Overnight Reversal’ present the statistics for the absolute value of Reversal and Overnight Reversal, respectively.

Year	*Statistic*	*Number of 5-minute Intervals*	*Reversal*	*Absolute Reversal*	*Overnight Reversal*	*Absolute Overnight Reversal*
	MEAN	40	0.0000	0.0022	-0.0020	0.0063
	p-value	0.00	0.90	0.00	0.00	0.00
	MIN	4	-0.0253	0.0000	-0.1178	0.0000
2006	*MAX*	75	0.0451	0.0451	0.0458	0.1178
n = 497	*STD*	26	0.0046	0.0040	0.0118	0.0102
	MEAN	41	0.0001	0.0032	-0.0018	0.0106
	p-value	0.00	0.24	0.00	0.04	0.00
	MIN	3	-0.1333	0.0000	-3.7007	0.0000
2007	*MAX*	75	0.1097	0.1333	0.5337	3.7007
n=4,565	*STD*	26	0.0068	0.0060	0.0583	0.0573
	MEAN	44	0.0001	0.0066	0.0031	0.0210
	p-value	0.00	0.64	0.00	0.00	0.00
	MIN	4	-0.2231	0.0000	-0.2600	0.0000
2008	*MAX*	75	0.2069	0.2231	0.5390	0.5390
n=5,487	*STD*	26	0.0130	0.0112	0.0335	0.0262
	MEAN	36	0.0003	0.0048	-0.0026	0.0155
2009	*p-value*	0.00	0.03	0.00	0.00	0.00

	MIN	3	-0.1705	0.0000	-0.1892	0.0000
	MAX	75	0.0757	0.1705	0.7588	0.7588
n=4,068	*STD*	26	0.0095	0.0082	0.0274	0.0227

The analysis is also broken down into wash trades that are cancelled before market close and after market close. The results are presented in Table 3-9. Apart from the observation that after market cancellations outnumber before market cancellations, the results presented in the table are very much similar for both before and after market cancelations and are in line with the results of the entire sample presented in Table 3-8.

The sample is also further broken down by the year of the trade in Table 3-10. Again, the results are consistent for reversals and overnight reversals across the 4 years and in line with the results of the entire sample.

Finally, the results are broken down into ten size deciles based on the market value of the stock during the trading year. The results are presented in Table 3-11. Although most of the results are quite consistent across the size deciles, there is evidence of an increasing magnitude of return reversals following wash trades as the market value of a stock decreases. Absolute Reversal increases from 0.07% and statistically insignificant in size decile 1 to 0.45% and significant in size decile 3 and a high of 0.87% in size decile 7. This finding is not replicated in overnight return reversals. The increasing magnitude of return reversals in smaller size stocks is in line with the findings of Mei et al. (2004) and Gallagher et al. (2009).

Table 3-11 Reversal Statistics – By Size Decile

This table reports the statistics for Reversal and Overnight Reversal for the sample of trade cancellations categorized into size deciles. The ten size deciles are based on market value of the stock during the trading year. 'Number of 5-minute intervals' specifies the number of 5 minutes intervals from the time of the initial trade to either market close or trade cancellation. 'Absolute Reversal' and 'Absolute Overnight Reversal' present the statistics for the absolute value of Reversal and Overnight Reversal, respectively.

Company Size Decile	*Statistic*	*Number of 5-minute Intervals*	*Reversal*	*Absolute Reversal*	*Overnight Reversal*	*Absolute Overnight Reversal*
	MEAN	40.5862	-0.0007	0.0007	0.0227	0.0593
	p-value	0.00	0.33	0.33	0.33	0.01
	MIN	4.0000	-0.0196	0.0000	-0.1398	0.0000
1	*MAX*	74.0000	0.0000	0.0196	0.3655	0.3655
n=29	*STD*	21.9342	0.0036	0.0036	0.1033	0.0868
	MEAN	43.0000	0.0013	0.0070	-0.1617	0.2082
	p-value	0.00	0.75	0.07	0.35	0.23
	MIN	4.0000	-0.0499	0.0000	-3.7007	0.0000
2	*MAX*	75.0000	0.0741	0.0741	0.2513	3.7007
n=24	*STD*	23.3387	0.0196	0.0182	0.7938	0.7823
	MEAN	45.1591	-0.0036	0.0045	-0.0064	0.0364
	p-value	0.00	0.08	0.03	0.45	0.00
	MIN	5.0000	-0.0568	0.0000	-0.1252	0.0000
3	*MAX*	75.0000	0.0135	0.0568	0.1625	0.1625
n=44	*STD*	25.7871	0.0133	0.0130	0.0525	0.0379

	MEAN	45.4038	-0.0010	0.0043	0.0113	0.0545
	p-value	0.00	0.61	0.02	0.47	0.00
	MIN	4.0000	-0.0670	0.0000	-0.1967	0.0000
4	*MAX*	75.0000	0.0502	0.0670	0.5390	0.5390
n=52	*STD*	23.8782	0.0135	0.0128	0.1045	0.0895
	MEAN	41.7200	0.0012	0.0084	-0.0059	0.0341
	p-value	0.00	0.70	0.00	0.49	0.00
	MIN	5.0000	-0.0741	0.0000	-0.1823	0.0000
5	*MAX*	74.0000	0.0743	0.0743	0.1398	0.1823
n=50	*STD*	22.5389	0.0218	0.0201	0.0565	0.0451
	MEAN	46.6842	0.0034	0.0057	0.0037	0.0284
	p-value	0.00	0.11	0.01	0.46	0.00
	MIN	4.0000	-0.0339	0.0000	-0.1823	0.0000
6	*MAX*	75.0000	0.2069	0.2069	0.1823	0.1823
n=114	*STD*	21.0319	0.0225	0.0220	0.0499	0.0411
	MEAN	41.9670	0.0004	0.0087	-0.0074	0.0282
	p-value	0.00	0.82	0.00	0.04	0.00
	MIN	4.0000	-0.1096	0.0000	-0.1892	0.0000
7	*MAX*	75.0000	0.1257	0.1257	0.2559	0.2559
n=182	*STD*	24.3762	0.0219	0.0201	0.0468	0.0380
8	*MEAN*	42.9321	0.0000	0.0068	-0.0047	0.0225

	p-value	0.00	0.95	0.00	0.02	0.00
	MIN	4.0000	-0.1120	0.0000	-0.1892	0.0000
	MAX	75.0000	0.0665	0.1120	0.1878	0.1892
n=368	*STD*	24.1877	0.0146	0.0129	0.0373	0.0301
	MEAN	41.6136	-0.0002	0.0065	-0.0016	0.0162
	p-value	0.00	0.64	0.00	0.01	0.00
	MIN	4.0000	-0.2231	0.0000	-0.2013	0.0000
9	*MAX*	75.0000	0.1097	0.2231	0.2025	0.2025
n=1,752	*STD*	26.6713	0.0140	0.0124	0.0266	0.0211
	MEAN	39.8440	0.0002	0.0045	0.0005	0.0144
	p-value	0.00	0.06	0.00	0.03	0.00
	MIN	3.0000	-0.1597	0.0000	-0.2600	0.0000
10	*MAX*	75.0000	0.0815	0.1597	0.5337	0.5337
n=9,638	*STD*	25.9705	0.0084	0.0070	0.0238	0.0189

Overall, the results document evidence of return reversals following potential wash trades that are subsequently cancelled. It is well documented in literature that return reversals are characteristic of distorted or manipulated prices (Vila, 1989; Allen and Gale, 1992; Allen and Gorton, 1992; Jarrow, 1992; Benabou and Laroque, 1992; Gerard and Nanda, 1993; Bagnoli and Lipman, 1996; Van Bommel, 2003; Chakraborty and Yilmaz, 2004a, 2004b; Aggarwal and Wu, 2006; and Allen et al., 2006). However, there are limitations to the study that restrict the scope of the conclusions regarding possible cancelled wash trades.

Crossings, in which the same broker is on both sides of the trade, are used as a proxy for wash trades. This is an imperfect proxy as it is increasingly common for brokers to 'internalise' trades and cross the trades of clients themselves. Crossings do not necessarily imply that the same party is behind both sides of the trade. The subsequent cancellation of the crossings may be an indicator that the trade was in fact a wash trade if it were specified in the cancel request. However, the trade reversal codes do not reveal such information. If an original trade was subsequently discovered to be a 'wash trade' and a cancel request was submitted, it would be recorded under the 'Other' category. In addition, the return reversal metric is also influenced by any new information that may be revealed to the market from the time of the trade to the end of the trading day or the opening of the next trading day. This study fails to account or correct for this shortcoming. Further, considering only approximately 2.8% of the total cancelled crossings data during the sample period is utilised, the conclusions that can be drawn from this study are limited. All that can be inferred from the data is that a very small minority of possible cancelled 'wash trades' exhibit manipulative return reversal patterns consistent with market manipulation.

3.7 Trade Cancellations and Return, Volume, and Volatility

This section examines the impact of cancelled crossings on return, volume, and volatility prior to, following, and during the trades. In response to the restricted nature of the sample of cancelled crossings in the previous section, this analysis utilizes a methodology that permits the retention of a majority of the observations. Similar to the previous study crossings are used as a proxy for 'wash trades'. Following the methodology of Aggarwal and Wu (2006), the extent to which the alleged 'wash trades' are associated with return, volume, and volatility patterns indicative of trade based manipulation is empirically tested.

3.7.1 Data and Sample

The data are obtained from an internal database from the ASX. The sample consists of trade-by-trade data for all stocks listed on the exchange and the subsequent trade cancellations. The data on trade cancellations contain a record describing each transaction, including the ASX Code, Sales Slip Number, Buyer and Seller Broker ID, Trade Reversal Code, Trade Volume, Trade Price, Trade Value, Trade Condition Codes, the initial Trade Date and Time, and the Reversal Date and Time. The sample period extends from October 30, 2006 to October 23, 2009. The sample is restricted to normal trading hours for equities markets (10:00 a.m. - 4:12 p.m.). The internal data are combined with order book data sourced from Reuters Data Scope Tick History provided by Securities Industry Research Centre of Asia-Pacific (SIRCA). The data provide the prices of the best bid and ask quotes time stamped to the nearest millisecond. To calculate stock betas in the following section, the ASX All Ordinaries Index values, daily stock prices, and monthly market value for each stock are sourced from Datastream. Daily and monthly Treasury Notes yields are sourced from the Reserve Bank of Australia website.

The analysis is limited to 'crossings' which means all cancelled trades where the Buyer and Seller Broker ID do not match up are eliminated. In the data set there are 516,467 unique trade cancellations in the specified time period, of which 510,807 are crossings. The crossings are grouped into packages where they occur within 1 hour of the previous crossing within the same stock on the same trading day. This leads to a sample of 67,206 crossing packages.

Table 3-12 Crossing Package Characteristics

This table reports the descriptive statistics for the Trade Cancellation packages.

Statistic	*Number of Trades in Package*	*Average Package Price*	*Package Total Manipulation Time*	*Package Total Volume*	*Package Total Traded Value*
N	67,206				
MEAN	4	$12	0:26:07	47,355	$262,987
MIN	1	$0	0:00:00	1	$0
MAX	305	$197	6:10:53	50,000,000	$455,671,844
STD	10	$18	1:01:04	443,874	$2,623,600

There are on average 4 consecutive crossings in a cancelled crossings package with the minimum being 1 crossing and the maximum being 305 consecutive crossings. The average trade price for these cancelled crossing packages is $12, but ranges from $0.002 to $197. The average manipulation period per package is 26 minutes and 7 seconds, with the longest one-day manipulation period during our sample lasting for over 6 hours. The shortest manipulation period is that of just one trade and therefore is zero or momentary. The total volume traded per package during the manipulation period is 47,355 shares. However, the volume traded can range from 1 share to 50 million shares. Similarly, the total value traded per package during the manipulation period is $262,987 and can vary from $0.05 to over $455 million. The characteristics of the cancelled crossing packages illustrate that the whole cross-section of different stocks, trading sizes, and manipulation periods in the sample are captured.

3.7.2 Research Design

This section empirically tests the extent to which the alleged 'wash trades' are associated with return, volume, and volatility patterns indicative of trade based manipulation. Specifically the impact of the crossings on Return, Volume, and Volatility are examined for the:

- Manipulation period is the interval between the *first trade* and the *last trade* in the package.
- Pre-manipulation period is the 1-hour interval prior to the *first trade* in the package.
- Post-manipulation period is the 1-hour interval following the *last trade* in the package.

Table 3-13 Crossing Package Summary Statistics

This table reports the Return, Volume, and Volatility summary statistics for the Trade Cancellation packages during the Manipulation, Pre-Manipulation, and Post-Manipulation periods. Manipulation period is the interval between the first trade and the last trade in the package. Pre-manipulation period is the 1-hour interval prior to the first trade in the package. Post-manipulation period is the 1hour interval following the last trade in the package.

	Mean	*Standard Deviation*	*Skewness*	*Kurtosis*
		Manipulation Period, n=35480		
Return	0.0001	0.0127	11.67	641.21
Volume	1,330,590	5,779,333	52.20	4607.64
Volatility	0.0157	0.0423	59.03	5043.70
		Pre-Manipulation Period, n=67206		
Return	0.0003	0.0161	7.71	370.76
Volume	767,687	5,692,119	186.44	42709.79
Volatility	0.0176	0.0334	84.49	12994.84
		Post-Manipulation Period, n=67206		
Return	-0.0002	0.0123	2.77	207.10
Volume	830,860	4,121,234	142.89	29333.38
Volatility	0.0162	0.0295	72.24	9717.98

Table 3-13 summarises return, volume, and volatility for the cancelled crossing packages during the three periods. It is observed that average returns are highest during the pre-manipulation period, followed by the manipulation period, and post-manipulation period. Average volume traded during the manipulation period is double that of pre- and post-manipulation periods. Finally, volatility is lowest during the manipulation period and greatest in the pre-manipulation period. The results regarding volume are consistent with wash trades and the creation of a false sense of activity in the stock.

Aggarwal and Wu (2006) posit that illiquidity in a stock implies a higher likelihood of it being manipulated. They argue that one key element to a successful manipulation is to move the price effectively and that it would be difficult for a manipulator to be able to move a large-capitalization and highly liquid stock through trade-based manipulation by any significant amount without incurring huge costs and taking on enormous risk. Further, trade based manipulation is likely to result in higher liquidity during and following the manipulative trading in order to create a false sense of activity in the security and entice uninformed traders to trade. To examine this issue, trading volume is used as a measure of liquidity over the 'manipulation', 'pre-manipulation', and 'post-manipulation' periods.

For each 'manipulated' stock, the trading volume for a benchmark is also calculated.[19] For the benchmark, the manipulated stock is matched to an equally weighted portfolio of 10 stocks. These stocks must be in the same size decile of all ASX listed stocks as that of the manipulated stock, and they are the closest in estimated betas to that of the manipulated stock. The average trading volume for the portfolio is calculated as the benchmark. Trading volume is then cross-sectionally regressed on a constant and a dummy variable for

[19] 'Manipulated stock' for the purpose of this study refers to the stock in which there were crossed trades that were subsequently cancelled.

‘manipulation’. The dummy variable equals one for the manipulated stock and equals zero for the benchmark. The sample period is 30 October 2006 to 23 October 2009.

$$Trading\ Volume = \alpha_0 + \alpha_1 \times I\{manipulated\} + \varepsilon$$

(3-6)

There are a total 67,206 manipulated stock packages for which trading data is available. With the matched sample from the benchmark, there are a total of 134,412 observations in the regressions.

In addition, of interest is how the ‘manipulated’ stocks perform relative to other stocks during the manipulation period. Since most trade based manipulation involves enticing other uninformed traders to trade and thereby profiting off the change in price, it is expected to observe abnormal returns during and especially following instances of manipulation. This section also examines whether manipulators prefer stocks that have underperformed or outperformed their market benchmarks.

Returns over the manipulation period, as well as over the pre- and post-manipulation periods are calculated. Similar to trading volume, returns for the corresponding period for a benchmark are also calculated. The benchmark is an equally weighted portfolio of 10 stocks matched on size and beta. The interval return is cross-sectionally regressed on a constant and a dummy for manipulation. The dummy variable equals one for the manipulated stocks and equals zero for the benchmark.

$$Return = \alpha_0 + \alpha_1 \times I\{manipulated\} + \varepsilon$$

(3-7)

Next the volatility of manipulated stocks is examined. The analysis is similar to that on returns above, except now the logarithm of the interval high price divided by the interval low price[20] is used as the dependent variable in the regression:

$$Volatility = \alpha_0 + \alpha_1 \times I\{manipulated\} + \varepsilon \tag{3-8}$$

In computing the benchmarks' volatilities, the 'Hi-Lo' volatility measure is averaged for the 10 benchmark stocks in the portfolio.

3.7.3 Results

Panel A of Table 3-14 reports the regression results for trading volume. For the pre-manipulation period, manipulation period, and the post-manipulation period, the results show that the coefficient for 'manipulation' is positive and significant in all three intervals. Further, the results indicate that that there is positive abnormal volume prior to the manipulation, in the 'pre-manipulation' period and following the trades in the 'post-manipulation' period. However, the most interesting result is the finding that abnormal volume during the 'manipulation' period is twice that of the abnormal volume during the 'pre-manipulation' period. This finding is consistent with manipulative 'wash trades' which create a false and misleading sense of activity in securities thereby enticing uninformed traders to trade. This finding is further reinforced by the discovery that abnormal volume continues following the 'manipulation' period into the 'post-manipulation' period, indicating that uninformed traders may have been influenced to trade in the security following the crossed trades.

[20] Volatility is measured as *log(High/Low)* price during the interval.

Panel B of Table 3-14 reports the regression results for returns. The results illustrate that there are significant abnormal returns for the manipulated stocks prior to the trading in the 'pre-manipulation' period of 0.034% for the one-hour interval. Further, significant abnormal returns continue into the manipulation period of 0.016%. As for the post-manipulation period we find no significant abnormal returns. These results are somewhat consistent with trade-based manipulation that is designed to lead to abnormal returns, but perplexing in the finding that there are higher abnormal returns prior to the manipulation. An explanation may be that we cannot account for whether the 'manipulators' were trying increase or decrease the price of the stocks through their wash trades. This would definitely have some bearing on the findings.

Panel C of Table 3-14 presents the results for volatility. For all three periods, volatility is higher for manipulated stocks, and the coefficients are statistically significant. This indicates that manipulation is more likely to happen in volatile stocks, and manipulated stocks often experience dramatic price movements during the manipulation period.

Overall, these results suggest that prior to the manipulation, the manipulated stocks generate higher returns, higher volumes, and tend to be more volatile than their benchmarks. During the manipulation period, manipulated stocks exhibit higher returns, higher liquidity, and higher volatility, consistent with Mei et al. (2004). Volatility and volume remain higher for manipulated stocks in the post manipulation period. These results are consistent with most models of successful trade-based manipulation such as Allen and Gale (1992).

Table 3-14 Liquidity, Return, and Volatility of Manipulated Stocks

This table reports the results of the regression analysis. For each 'manipulated' stock, we also compute the return, volume, and volatility for a benchmark. For the benchmark, we match the manipulated stock to an equally weighted portfolio of 10 stocks. These stocks must be in the same size decile of all ASX listed stocks as that of the manipulated stock, and they are the closest in estimated betas to that of the manipulated stock. We compute the average return, volume, and volatility for the portfolio as the benchmark and then cross-sectionally regress the return, volume, and volatility on a constant and a dummy for 'manipulation'. The dummy variable equals one for the manipulated stock and equals zero for the benchmark. The sample period is 30 October 2006 to 23 October 2009.

	Manipulation Period	*Pre-manipulation Period*	*Post-Manipulation Period*
		A. Volume	
Intercept	503,836	355,002	391,158
(t-statistic)	21.62	22.62	34.1
(P-value)	0.00	0.00	0.00
Manipulation	826,755	412,685	439,702
(t-statistic)	25.08	18.6	27.11
(P-value)	0.00	0.00	0.00
R squared	0.88%	0.26%	0.54%
		B. Return	
Intercept	-0.000014	-0.000081	-0.000102
(t-statistic)	-0.27	-1.76	-2.9
(P-value)	0.79	0.08	0.00
Manipulation	0.000155	0.000339	-0.000071
(t-statistic)	2.14	5.23	-1.43
(P-value)	0.03	0.00	0.15
R squared	0.01%	0.02%	0.00%

		C. Volatility	
Intercept	0.0131	0.0133	0.0129
(t-statistic)	78.55	139.89	149.27
(P-value)	0.00	0.00	0.00
Manipulation	0.0026	0.0043	0.0033
(t-statistic)	11.1	31.54	27.13
(P-value)	0.00	0.00	0.00
R squared	0.17%	0.73%	0.54%

3.8 Summary

This essay initiates the first comprehensive investigation of trade cancellations to understand their magnitude and impact on market integrity. The investigation finds that trade cancellations as a proportion of total traded value on the ASX almost doubled from 0.69% to 1.16% between 2006 and 2009. These trades can lead to distorted prices among other market wide statistics. Further, there is evidence to suggest that some of these trades are in violation of exchange trading rules and possibly manipulative in nature. This essay draws from theoretical and empirical research on market manipulation and applies it to the case of trade cancellations.

The results reveal a proliferation in the number of trades that are subsequently cancelled on the ASX year on year and a resulting significant impact on the daily reported VWAP figures within stocks on certain days. These results are also more pronounced in the smallest listed stocks on the ASX and are of a greater concern. Findings also document evidence of return reversals following potential wash trades that are subsequently cancelled. Examination of the impact of trade cancellations also reveals that during the initial trades (prior to being cancelled), stocks exhibit higher returns, higher liquidity, and higher volatility, consistent with Mei et al. (2004). Volatility and volume also remain higher following the trades. These results are consistent with most models of successful trade-based manipulation such as Allen and Gale (1992).

Chapter 4: The Impact of Large Off-Market Option Trades: Evidence from the Australian Options Market

4.1 Introduction

Off-market trading allows traders to access unexpressed liquidity provided by off-market participants that is unavailable on the centralised limit order book. It thereby provides large traders with a platform to search for liquidity and negotiate a trade with minimal market impact. A great deal of academic literature focuses on the economics of off-market trading in equity markets. However, the impact of off-market trading in derivatives markets is yet to be investigated. This is largely due to unavailability of the data required for this line of research. The objective of this essay is to bridge this gap in the literature by using a unique data set provided by the Australian Options Market (AOM). Specifically, this essay (i) reports the change in bid and ask quotes on the options and underlying equity market around the off-market option trades, (ii) measures the price impact of off-market option trades on the underlying equities market, and (iii) examines cumulative abnormal returns on the underlying stocks in the days surrounding the large off-market option trades.

Prior empirical studies examine the role of off-market trading in liquidity provision for larger traders in the equities market, also referred to as block trading. The literature suggests that off-market trading lowers execution costs for large traders by reducing adverse selection costs as off-market broker-dealers can screen out informed traders and tap into unexpressed liquidity (Booth et al. 2002; and Bessembinder and Venkataraman, 2004). In addition, it is posited that off-market trading improves market quality by supplementing liquidity when on-market liquidity is not sufficient. Although these findings are based on empirical studies examining equities markets, this study aims to test these findings for the Australian Options Market (AOM) and the underlying equities market.

The remainder of this chapter is organised as follows. Section 4.2 describes the literature and develops several testable hypotheses. Section 4.3 provides institutional details. Section 4.4 describes the data and sample. Section 4.5 sets out the research design. Section 4.6 presents the empirical results. Section 4.7 summarises the chapter.

4.2 Literature Review

This section reviews the literature related to the issues examined in this study. This section is organised in a manner so as to highlight the areas of the existing literature upon which this study builds. In turn, based on the literature reviewed, a number of testable hypotheses are developed. This section is structured as follows. Section 4.2.1 reviews the literature on upstairs trading (or off- market trading)[21]. Section 4.2.2 examines the literature on the impact of informed options trading on the options and underlying equity market. Section 4.2.3 provides a review of the literature on large trades and price impact. Section 4.2.4 uses the literature reviewed to develop testable hypotheses that are tested subsequently in this study.

4.2.1 Upstairs Trading

Theoretical literature on upstairs trading focuses on two pertinent issues to large traders: order exposure and the information content of trades. The revelation of an imminent large order arriving on market may move prices adversely against the large trader if other market

[21] Upstairs trading and off-market trading are used interchangeably in this dissertation.

participants decide to front run or simply infer information about the future price movement of the security. A large limit order, in particular, offers a free trading option to other market participants and is susceptible to adverse selection risk if market conditions change. Grossman (1992) posits that the trading preferences of many large investors are not expressed publicly and that the upstairs brokers act as a repository of information on the unexpressed trading interests of large investors. Therefore, considering all trading interest are not reflected in the limit order book, a large market order submitted on the downstairs market will simply ‘walk’ the book, bypassing uncommitted liquidity, and thus increasing execution costs and price impact. In contrast, Grossman (1992) devises a model in which upstairs broker-dealers have access to the information on unexpressed liquidity off-market. This allows a large order negotiated on the upstairs market to tap the pool of unexpressed liquidity through an upstairs broker, while minimizing the degree to which the customer’s order is exposed.

The second line of literature on upstairs trading focuses on the role of upstairs brokers in certifying trades’ information content. Easley and O’Hara (1987) establish that liquidity providers will require greater compensation to execute larger orders in response to the finding that informed traders with private information prefer to trade larger quantities. As a result large uninformed utilitarian traders are incentivized to identify themselves as uninformed to upstairs brokers. Seppi (1990) provide descriptions of the mechanisms by which an upstairs broker attempts to distinguish between informed and uninformed traders. The Seppi (1990) model allows upstairs broker-dealers to screen out informed traders in a repeated game setting. This leads to a separating equilibrium where only uninformed (or liquidity-motivated) investors trade upstairs, thereby reducing the adverse selection costs to large upstairs liquidity providers.

Both the Seppi (1990) and Grossman (1992) models predict that upstairs markets facilitate block transactions at lower costs compared to downstairs markets. Another implication of the findings is that upstairs trading may not contribute to price discovery. That is, upstairs broker-dealers attract the large uninformed order flow from the downstairs market.

Prior empirical work has focused mainly on the Seppi (1990) prediction regarding the informational role of the block broker. Keim and Madhavan (1996) study block transactions that are facilitated upstairs and examine the price changes around the transactions. They find evidence that upstairs (both seller- and buyer-initiated) trades have permanent price impact. Their results also reveal that price changes occur prior to upstairs trades, which they interpret as suggesting the leakage of information about upstairs trades during the facilitation process. However, their findings cannot be generalised to all upstairs trading as their data are sourced from one particular investment firm.

Madhavan and Cheng (1997) compare the execution costs of block trades executed in the upstairs market to those executed in the downstairs market for the stocks comprising the Dow Jones Industrial Average (DJIA) trading on the NYSE. They find that the downstairs market plays a dominant role in facilitating block trades on the New York Stock Exchange (NYSE) and that execution costs for block trades in both markets are comparable. Although their analysis of the price impact of large trades is in contrast to the Seppi (1990) proposition that upstairs broker-dealers are able to screen out informed traders, they note the similarities in the negotiation between floor traders and specialists on the NYSE and the negotiation process in the upstairs market.

Smith et al. (2001) and Booth et al. (2002), study upstairs trading in the Toronto Stock Exchange (TSE) and the Helsinki Stock Exchange (HSE), respectively. In both markets the downstairs market is electronic. The studies find that upstairs brokers are able to lower adverse selection costs by effectively discerning informed trading. Their findings support the Seppi (1990) model in which upstairs brokers are able to certify trades' information content. They also provide support for the Grossman (1992) model in that their findings show that upstairs trading is more likely to be preferred when the downstairs market is less liquid. Furthermore, Booth et al. (2002) show that upstairs trades have lower permanent price impact than the downstairs trades. In contrast, the temporary price effects of block trades are larger in the upstairs market, implying that upstairs broker-dealers require a greater reward for liquidity provision. Consistent with the Seppi (1990) prediction, their evidence reveals that upstairs order flow is less informative than the downstairs counterpart.

Bessembinder and Venkataraman (2004) analyze upstairs trading on the Paris Bourse, which more accurately resembles the market structure modelled in both Seppi (1990) and Grossman (1992). The Paris Bourse is an electronic limit order book without designated market makers and has an upstairs market. Similar to Smith et al. (2001) and Booth et al. (2002) and consistent with the Seppi (1990) model they find that block traders incur smaller adverse selection costs in the upstairs market. Furthermore, they directly investigate the Grossman (1992) prediction by reconstructing the downstairs limit order book and estimating the execution costs that upstairs block traders would incur if they were to execute their trades in the downstairs market. Their results indicate that execution costs are lower in the upstairs market for both buy and sell orders but not as a result of unexpressed liquidity in the downstairs but more as a result of the ability of upstairs brokers in certifying trades' information content, consistent with Seppi (1990).

In conclusion, the empirical literature provides overwhelming support for the Seppi (1990) model that predicts that upstairs broker-dealers are able to screen out information-motivated orders. To a weaker extent, the literature also supports the Grossman (1992) model that predicts that upstairs broker-dealers reduce execution costs by exploiting their access to unexpressed liquidity. The exception to the literature is the Madhavan and Cheng (1997) study of upstairs block trades on the NYSE with results in contrast to Seppi (1990). However, their findings can be attributed to the fact that the upstairs negotiation mechanism modelled in Seppi (1990) is embedded in the NYSE downstairs market, offsetting the benefits of upstairs trading. Chakravarty (2001) offers support, arguing that NYSE specialists and floor brokers can sometimes deduce the identity of trade initiators, thereby lowering the risk of adverse selection. Furthermore, the NYSE specialist, being positioned at the centre of a trading crowd on the exchange floor, has information on the hidden liquidity on the floor and unexpressed liquidity upstairs thereby offering support for the Grossman (1992) model.

4.2.2 The Impact of Informed Options Trading on Liquidity in Options and Underlying Equities Markets

Demsetz (1968) explains that the bid-ask spread partly compensates market makers for the operating costs incurred in providing immediacy (also referred to as order processing costs) in securities markets. In theoretical microstructure literature, information-based models are concerned with adverse selection costs faced by dealers in the presence of information asymmetry (e.g. Bagehot, 1971; Copeland and Galai, 1983; Kyle, 1985; Glosten and Milgrom, 1985; Easley and O‟ Hara, 1987; Madhavan, 1992; and Foster and Viswanathan, 1994). The key implication is that bid-ask spreads are wider for volatile securities.

Literature that investigates the extent of information-motivated trading in options markets include Manaster and Rendleman (1982), Anthony (1988), Stephan and Whaley (1990), Sheikh and Ronn (1994), Easley, O" Hara, and Srinivas (1998), Chan et al. (2002), and Charkravarty et al. (2004). However, in this study we are not so much interested in the extent of informed trading but more in how informed trading impacts on both the options and underlying market.

Early empirical studies generally suggest that adverse selection is not a considerable determinant of the bid-ask spread in options markets. Vijh (1990) is one of the first to examine the relationship between information asymmetry and option bid-ask spreads. Similar to our study he examines both stock and option price changes around large option trades on the Chicago Board Options Exchange (CBOE). He posits that the implicit leverage of options relative to equities attracts both informed and noise traders. His results reveal insignificant price effects on options surrounding the large option trades and that the adverse selection component of the bid-ask spread is negligible. Together, the results suggest that the large CBOE option trades are uninformed and utilitarian in nature. Neal (1992) expands on the work of Vijh (1990) by examining 26 AMEX options and 15 CBOE options using the Glosten and Harris (1988) spread decomposition method to estimate the adverse selection component. He finds the adverse selection component of the spreads around the trades to be statistically insignificant. Extending the results of Vijh (1990) and Neal (1992), Lee and Yi (2001) investigate the extent of information-motivated trading on the CBOE by partitioning trades into different trade sizes. Consistent with Vijh (1990), they find that the adverse selection component is lower in the options market than the stock market for large trades after controlling for leverage. They obtain the opposite results for small trades.

In related literature looking at how option market makers may hedge away their adverse selection risk, Cho and Engle (1999) proposed a new theory called "derivative hedge theory". The theory stipulates that bid-ask spreads in the option market are determined by both option activity and activity in the underlying stock. If market makers in derivative markets are able to perfectly hedge away their position with an underlying security, then spreads in the option market will only be determined by spreads in the underlying market. The implication is that the presence of informed trading in options will not affect bid-ask spreads in the options market. Examining S&P 100 index options, the authors find that option market spreads are positively related to spreads in the underlying market, supporting their derivative hedge theory. Furthermore, the authors propose that the market maker is only able to imperfectly hedge his position in the underlying securities market.

Building on Cho and Engle (1999), Kaul, Nimalendran and Zhang (2004) contend that the derivative hedge theory of Cho and Engle (1999) only accounted for the initial hedging cost but neglected rebalancing costs. By calculating and accounting for rebalancing costs, Kaul, Nimalendran and Zhang (2004) find that a large proportion of the bid-ask spread is attributable to inventory management costs; 50% attributable to setting up a delta neutral position and 6.93% associated with discrete rebalancing.

Utilising the Cho and Engle (1999) model, Landsiedl (2005) consider additional factors such as underlying asset and cross option market characteristics on the Austrian option exchange. He finds that hedging costs on the Austrian option exchange represent only part of the variability of the bid and ask spread. Furthermore, delta hedging and order processing costs are significantly and positively related to bid-ask spreads. Information asymmetry however is not a significant factor in the Austrian option market.

Bartram et al. (2008) study the impact of adverse selection on option bid-ask spreads by comparing two markets with different levels of information asymmetry. The study examines the EuRex, a traditional derivatives exchange, with EuWax, which specializes in bank-issued options. It is proposed that the level of adverse selection is lower on the EuWax as a result of market makers knowing the identity of the investors with whom they trade. By assessing similar option contracts across both markets they find that bid-ask spreads on the EuWax are tighter (4.2%) than on the EuRex (8.8%).

4.2.3 Large Trades and Price Impact

Kraus and Stoll (1972) were the first to examine the determinants of the price impact of large trades. They explain that there are three possible factors that lead to price impact. First, price concessions are often required to find block trade counterparties (i.e. find liquidity), and thus the impact of the search for liquidity could lead to price impact. Second, inelastic supply and demand curves, in that stocks are not perfect substitutes for each other, lead to price concessions and thus price impact. Thirdly, the possible information conveyed by large orders can result in a price adjustment and thus new equilibrium prices. Finally, they regress the value of block trades on price impact, and find that the size of trades is positively related to the level of price impact.

Typically, large block trades demand more liquidity than is available at the current best quotes. As a result, if the block trade was to be fully executed against the expressed liquidity available on the market, the block trade would 'walk' through the limit order book, and in doing so, force the stock price to move in the direction of the trade (Aitken et al., 1993).[22] Madhavan and Cheng (1997) show that when a block trade is shopped in the upstairs market, information can leak to other market participants prior to the execution of the block trade. This information leakage is known as the leakage effect in price impact literature.

The temporary effect of price impact is a measure of the market frictional price reaction following the execution of a block trade. The temporary effect measures the liquidity component of price impact, as it occurs as a result of large trades executing at prices away from the equilibrium price. The frictional price reaction arises in large trades because usually there is no readily available counterparty that can assume the opposite side of a large block purchase (sale) at the best available ask (bid) quote (Kraus and Stoll, 1972). The temporary effect can also be considered as compensation to liquidity providers (i.e. counterparties) given it is necessary for large block buyers (sellers) to offer a price premium (discount) in order to attract counterparties to participate.

The temporary effects calculated in previous studies following large block trades on equity markets show considerable variation. Several studies, including Holthausen, Leftwich and Mayers (1987) find a positive temporary effect is associated with both block purchases and block sales. Gemmill (1996) finds that the temporary effect is negative following block purchases and positive following block sales.

Post-trade benchmarks represent the equilibrium price after the temporary effects of the trade has dissipated (usually following a price reversal following the block trade). The most

[22] This 'cutting' through the limit order book occurs in limit order markets like the ASX.

common benchmark for the post trade impact is the closing price on the day of the trade, although benchmarks both closer to, and further from the trade, are also used.

The permanent effect captures the overall impact of the block trade on the stock price. It is argued that since most large block trades are executed by institutions, and institutions are more likely to be informed (Easley and O'Hara, 1987), the equilibrium stock price following a block purchase is expected to increase, and decrease following a block sale. The pre- and post- trade benchmarks are often the opening and closing stock prices on the day of the block trade (Beebower and Priest, 1980). Several studies also use benchmarks closer to, or further away from, the block trade. Kraus and Stoll (1972), for example, calculate the permanent effect as the return from the closing price on the previous day to the closing price on the day of the block trade.

4.2.4 Hypothesis Development

A great deal of academic literature has focused on the economics of off-market trading in equity markets. However, the impact of off-market trading in derivatives markets is yet to be investigated. This is largely due to unavailability of the data required for this line of research. This study investigates the impact of large off-market option trades on both the options and underlying equity market.

Theoretical literature on upstairs trading focuses on two pertinent issues to large traders: order exposure and the information content of trades. The Seppi (1990) model predicts that upstairs broker-dealers are able to screen out information-motivated orders. While the Grossman (1992) model predicts that upstairs broker-dealers reduce execution costs by exploiting their access to unexpressed liquidity. The empirical literature (Smith et al., 2001; Booth et al., 2002; and Bessembinder and Venkataraman, 2004) provides overwhelming support for the Seppi (1990) model and some support for the Grossman (1992) model. The exception to the literature includes Madhavan and Cheng (1997). However, their findings can be attributed to the fact that the upstairs negotiation mechanism modelled in Seppi (1990) is embedded in the NYSE downstairs market, offsetting the benefits of upstairs trading.

Although there is no direct literature on the effects of large off-market options trades on the options market, this study draws on the literature on upstairs trading to form the hypotheses. The above literature leads to the following hypothesis to be tested in the study.

Hypothesis$_{4,1}$: Large off-market option trades transact at prices equal to or better than the standing quotes on the options market.

Cho and Engle (1999) proposed a new theory called "derivative hedge theory" that stipulates that bid-ask spreads in the option market are determined by both option activity and activity in the underlying stock. It is posited that if market makers in derivative markets are able to perfectly hedge away their position with an underlying security, then spreads in the option market will only be determined by spreads in the underlying market. The implication is that the presence of informed trading in options will not affect bid-ask spreads in the options market. Therefore, this study tests the impact of large off-market option trades on the underlying equities market. The following hypothesis is tested:

$\text{Hypothesis}_{4,2}$: Large off-market option trades have no impact on the liquidity of the underlying equity market.

Kraus and Stoll (1972) identify three determinants of price impact for large trades. These include the price concessions in order to find liquidity (leakage effect), price concessions to counterparties for taking on the opposing side to a large trade (temporary effect), and finally the possible information conveyed by large orders which can result in a price adjustment and thus new equilibrium prices (permanent effect).

Madhavan and Cheng (1997) find evidence of a leakage effect when a block trade is shopped in the upstairs market. Several studies, including Holthausen et al. (1987) find a positive temporary effect is associated with both block purchases and block sales. Gemmill (1996) finds that the temporary effect is negative following block purchases and positive following block sales. Easley and O'Hara (198) also posit that since most large block trades are executed by institutions, and institutions are more likely to be informed the equilibrium stock price following a block purchase is expected to increase, and decrease following a block sale (permanent effect).

In empirical literature on upstairs trading, Keim and Madhavan (1996) find evidence that upstairs (both seller- and buyer-initiated) trades have permanent price impact. Their results also reveal that price changes occur prior to upstairs trades, which they interpret as a leakage of information about the upstairs trade during the facilitation process. However, their sample only looks at the trades of one particular firm. Booth et al. (2002) show that upstairs trades have lower permanent price impact than the downstairs trades. In contrast, the temporary price effects of block trades are larger in the upstairs market. The above discussion suggests that the price impact of large off-market options trades on the options market is an open question, which leads to the following hypothesis.

Hypothesis$_{4,3}$: Large off-market option trades have no price impact on the underlying equity market.

4.3 Institutional Details

The Australian Options Market (AOM) provides a trading platform that uses a centralised limit order book with designated market makers. The Integrated Trading System (ITS), a screen-based trading system, facilitates trading options on the AOM.[23] The AOM offers options on a range of underlying assets such as equities, fixed income instruments, and commodities. Of these instruments, equity options are the most actively traded. Equity options are American options, and are classified according to a set of exercise prices and

[23] The Australian Options Market (AOM) is one of the trading platforms provided by the Australian Securities Exchange (ASX).

expiry dates predetermined by the AOM. There are two sub-trading platforms on the AOM; the centralised limit order book (CLOB) and the off-market facility.

The Australian Options Market (AOM) centralised limit order book (CLOB) is an order-driven market where market orders execute against standing limit orders based on price-time priority. Mandated market makers further supplement liquidity. The mandated market makers are each assigned two or more stocks in which they must meet ASX's minimum volume and maximum spread requirements. The market makers are incentivised to meet certain benchmark quoting requirements under contractual arrangements with the ASX. Market makers can choose to make a market on a continuous basis, in response to quote requests, or both. Market makers who choose to make a market on a continuous basis are obligated to provide orders continuously for a certain percentage of time, in a set of 18 options per underlying security. The set of 18 options encompasses three calls and three puts in any three of the following 6 expiry cycles. Market makers who choose to make a market only in response to quote requests are monitored on their provision of quotes for a certain percentage of time for all options up to nine months to maturity. A stock can have more than one market maker in competition with one another. Although there may be multiple market makers in a class (representing each underlying security), there is no guarantee that all options series will have prices displayed as market makers are not required to provide quotes in all options, or at all times. Normal trading hours for the AOM are from 10:00 a.m. to 4:20 p.m.

Off-market trading allows more flexibility than the CLOB since the strict price/time priority rules do not apply to off-market transactions. For a special size crossing (SPXT) or off-market option trade to take place, the crossing must have a premium greater than the threshold special size crossing for that category.[24] During the sample period the contract size threshold for off-market trading was $500,000 for Category 1 option classes, and $250,000 for Category 2 option classes.[25] Note that option classes are classified into two groups (Category 1 and Category 2) based on the liquidity of the underlying stocks, at the discretion of the ASX; Category 1 option classes are more liquid than Category 2 option classes. Special crossings must be reported on the trading day on which they are transacted between 9:00 a.m. and 6:00 p.m.

4.4 Data and Sample

The data are obtained from an internal database from the AOM. The sample consists of trade-by-trade data for all equity options listed on the exchange. The data contain a record describing each transaction, including the option series, the underlying stock, date, time (to the nearest millisecond), price, volume, and a condition code specifying whether each trade was executed on the CLOB (Centralised Limit Order Book), or off-market as a special crossing (SPXT). The focus of this study is off-market special crossings (SPXT) and only non-combination trades are considered, as the direction of combination trades cannot be determined using the quote rule. The sample period extends from January 1, 2007 to August 31, 2007. The sample is restricted to normal trading hours for the AOM (10:00 a.m. - 4:20 p.m.).

[24] The threshold special size crossings in Category 1 stocks underlying ETOs is $500,000 worth of premium. The threshold for special size crossings in Category 2 & Category 3 stocks underlying ETOs is $250,000 worth of premium. The threshold for special size LEPO crossings is $1,000,000 worth of premium.
[25] Off-market trading refers to Special Crossing (SP) defined in ASX Market Procedure 22.3.

The internal AOM data are combined with order book data sourced from Reuters Data Scope Tick History provided by Securities Industry Research Centre of Asia-Pacific (SIRCA).[26] The data provide the prices of the best bid and ask quotes time stamped to the nearest millisecond. The quote rule is utilised to determine the direction of each trade. In a study on the direction of option trades, Savickas and Wilson (2003) finds the quote rule, where trades are determined as buyer- or seller-initiated according to whether the trade price is above or below the midpoint, to be the most accurate in determining trade direction.

Table 4-1 reports the mean price, contract size, strike price, the average value of contracts traded, average time to maturity, and moneyness. The sample consists of a total of 524 transactions, of which 276 are call options, and 248 are put options. The moneyness ratio is calculated as the stock price divided by the exercise price for call options and the exercise price divided by the stock price for put options, as performed in Chakravarty et al. (2004). Options are considered At-the-Money (ATM) if the ratio lies between 0.98 and 1.02. If the ratio is below 0.98 it is considered Out-of-the-Money (OTM) and if above 1.02 it is considered to be In-the-Money (ITM), as defined in Engstrom (2002). Time to maturity is calculated as the difference between the trade date of the option and the expiry date. Each trade is further broken down into contract size categories. Small contract size trades are those in which only 1-4 contracts are traded, Medium contract size trades are those in which 5-99 contracts are traded, and Large contract size trades are those in which 100+ contracts are traded.

Summary statistics are partitioned by both Call and Put options and whether the off-market trades were buy or sell trades. The results show that Call sell trades have an average contract

[26] The Reuters intra-day data are cross-checked with the data internally sourced from the AOM.

size almost 3-times larger than the remaining categories. Similarly, the average traded value of Call sell trades is more than 5-times larger than the remaining categories. As expected, the majority of the trades in our sample consist of large contract size trades.

Table 4-1 Descriptive Statistics

This table provides descriptive statistics of the sample in the study. Option Type specifies the type of option, whether a Call or Put option. Trade direction specifies whether the trades were buyer (Buy) or seller (Sell) initiated. Number of Trades is the size of that sub-category sample. Average Price is the mean trade price of all trades in that sub-category. Average Contract Size species the mean amount of contracts transacted in each sub-category. Average Strike Price is the mean Strike Price of all option contract trades in the sub-category. Average Traded Value is the mean total value traded in each trade in the sub-category. Average Time to Maturity specifies the mean number of days until expiry for each contract traded in the sub-category. OTM (Out of the Money), ATM (At the Money), and ITM (In the Money), specifies the relationship between the current underlying price of the options contracts and their strike price. Options are considered At-the-Money (ATM) if the ratio lies between 0.98 and 1.02. If the ratio is below 0.98 it is considered Out-of-the-Money (OTM) and if above 1.02 it is considered to be In-the-Money (ITM). Small Contract Size trades are those in which only 1-4 contracts are traded, Medium Contract Size trades are those in which 5-99 contracts are traded, and Large Contract Size trades are those in which 100+ contracts are traded.

Option Type	*Trade Direction*	*Number of Trades*	*Average Price*	*Average Contract Size*	*Average Strike Price*	*Average Traded Value*	*Average Time To Maturity (Days)*	*OTM*	*ATM*	*ITM*	*Small Contract Size*	*Medium Contract Size*	*Large Contract Size*
CALL	*BUY*	151	$4.50	523	$40.94	$914,396	156	1	31	119	1	13	137
	SELL	125	$5.88	1,426	$39.21	$5,161,830	137	4	30	91		15	110
PUT	*BUY*	158	$3.20	419	$56.66	$791,131	185	13	6	139		7	151
	SELL	90	$3.70	465	$58.05	$757,128	165	6	5	79		3	87

4.5 Research Design

4.5.1 Execution Costs and Liquidity available to off-market option trades

This section determines immediate execution costs and the liquidity available to off-market option trades. This analysis investigates whether off-market option trades are perceived to be informed and thereby experience higher execution costs as a by-product of their size. The analysis examines the 'off-market premium' and bid-ask spreads in 5-minute and 1-hour intervals surrounding the trades both in the option market and the underlying stock market.

The off-market premium is defined as the difference between the actual execution price and the market quote at the time of order entry. In a study of exchange-traded equity options in the US, Wei and Zheng (2010) find the dollar bid-ask spread to be an increasing function of the option price. Consequently, the proportional off-market premium is also calculated.

$$Off-market\ Premium = \begin{cases} [Price - Standing\ Ask\ Price]\ If\ Buy\ Trade \\ [Standing\ Bid\ Price - Price]\ If\ Sell\ Trade \end{cases} \tag{4-1}$$

$$Proportional\ Off-market\ Premium = \begin{cases} [Price - Standing\ Ask\ Price/Standing\ Ask\ Price]\ If\ Buy\ Trade \\ [Standing\ Bid\ Price - Price/Standing\ Bid\ Price]\ If\ Sell\ Trade \end{cases} \tag{4-2}$$

The proportional bid-ask spread is also calculated to examine the average round-trip transaction costs surrounding the time of the off-market option trades. The average transaction costs to the investor are usually considered as one-half of the proportional spread.

$$Proportional\ Spread = (Standing\ Ask - Standing\ Bid)/Midpoint \tag{4-3}$$

The proportional Ask (Bid) statistic calculated below for Buy (Sell) trades provide an idea of how much the Ask (Bid) moves from the time of the trade.

$$Proportional\ Ask = (Standing\ Ask - Midpoint_{t=0})/Midpoint_{t=0}\ \ if\ Buy\ Trade \tag{4-4}$$

$$Proportional\ Bid = (Midpoint_{t=0} - Standing\ Bid)/Midpoint_{t=0}\ \ if\ Sell\ Trade \tag{4-5}$$

4.5.2 Price and Information effects of off-market option trades

This section examines the impact of off-market option trades on prices. The analysis specifically tests the role of any information leakage on the price, the permanent change in the price following the trade, and any temporary changes in the price as a result of the trade execution. Studies in market microstructure such as Kraus and Stoll (1972) and Huang and Stoll (1996) have long defined permanent changes in price as either liquidity costs or price impact, and temporary changes in price as informational effects or realized spreads. Figure

4-1 from Bessembinder and Venkataraman (2004) illustrates the price effects of a block buy order.

Figure 4-1 Liquidity and Information Effects of a Block Buy

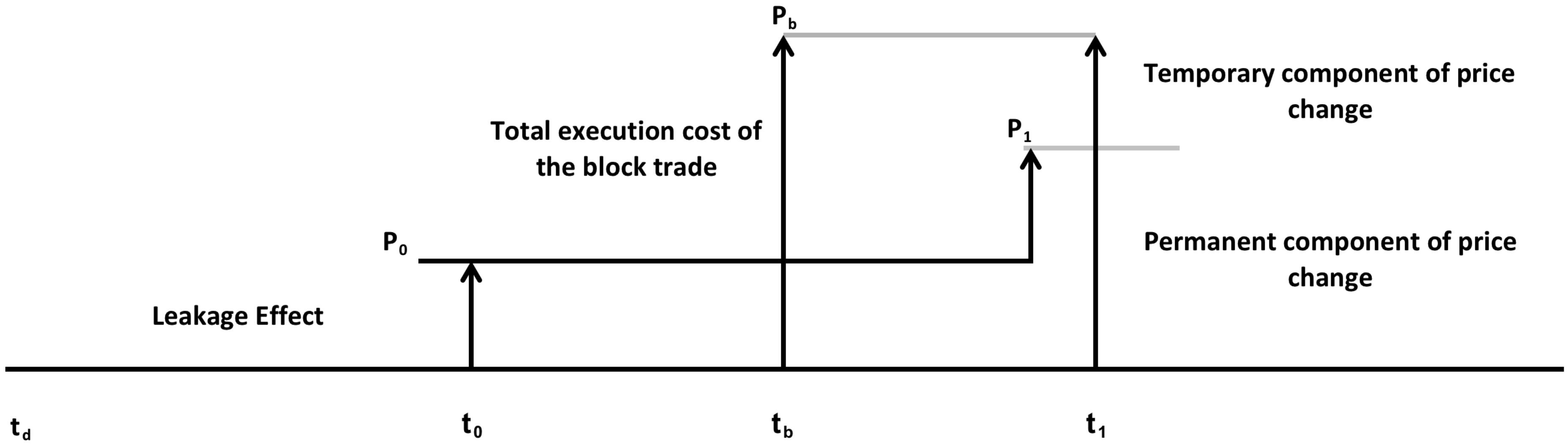


Fig. 4-1 Liquidity and information effects of a block buy. The facilitation process is initiated at time=t_d in the upstairs market. The leakage of information of the block size could move the security value in the downstairs market. The security value just before the block trade (time=t_0) is P_0. The block of size=Q is executed in the upstairs market at (time=t_b) at price=P_b. The liquidity effect of the block results in a price reversal and moves prices to P_1. Temporary component of price change $\tau(Q)$: $\ln(P_b) - \ln(P_1)$. Post-trade impact $\pi(Q)$: $\ln(P_1) - \ln(P_0)$. Leakage effect L(Q): $\ln(P_0) - \ln(P_d)$. Permanent component of price change P(Q): $\ln(P_1) - \ln(P_d)$. Total execution cost of the block trade T(Q): $\ln(P_b) - \ln(P_d)$.

Following Bessembinder and Venkataraman (2004), the temporary component, $\tau(Q)$, represents compensation to liquidity providers (i.e., counterparties) and can be measured by the price reversal after the block trade:

$$\tau(Q) = \ln(P_b) - \ln(P_1),$$

where P_b is the block trade price and P_1 is a measure of post-trade value.[27] The permanent component, $P(Q)$, can be divided into post-trade impact and pre-trade leakage. The post-trade impact, $\pi(Q)$, represents the change in the market's perception of a security's value after the announcement of the block trade:

$$\pi(Q) = \ln(P_1) - \ln(P_0),$$

where P_0 is the pre-trade value of the security, proxied by the last quote midpoint before the announcement of the block trade. The leakage effect $L(Q)$ represents price movements in the downstairs market while the block is being facilitated (or shopped) in the upstairs market:

$$L(Q) = \ln(P_0) - \ln(P_d),$$

where P_d is the security value when the upstairs broker initiates the search process.[28] All measures are expected to be positive for a block buy and negative for a block sell. We adjust each measure for overall market movements by subtracting the Adjusted All Ordinaries Share Index's market return from the stock's return.

4.5.3 Price Behaviour surrounding off-market option trades

[27] Similar to Bessembinder and Venkataraman (2004) we also examine the sensitivity of results to four different proxies for P_1: (1) the midpoint of the first quote reported 30 minutes after the trade, (2) the midpoint of the first quote reported after 12:00 noon the next trading day, (3) the midpoint of the closing quotes on the next trading day, and (4) the midpoint of the closing quote on the third trading day after the trade. The empirical results are similar across all four measures. We only report results obtained while using the midpoint of the closing quotes on the next trading day.

[28] Again, similar to Bessembinder and Venkataraman (2004) we consider three proxies for P_d: (1) the midpoint of the quotes 30 minutes before the trade, (2) the midpoint of the closing quotes the day before the block trade (t_{-1}), and (3) the midpoint of the closing quotes three days before the block trade. We report results using (2).

This section provides a summary of the behaviour of share prices around the announcement of the large off-market option trades. This analysis assesses whether there are common share price traits leading up to the large off-market option trades, and whether there are similar share prices patterns following the large off-market option trades.

Following Bozcuk and Lasfer (2005), the analysis utilizes the market model (Brown and Warner, 1985) with parameters (α and β) calculated over the estimation period [-90, -31] to compute the abnormal returns over the event period -30 to +30 days, where day 0 is the date of the trade. The company share prices adjusted for capital changes and dividends are used to calculate the log of security i's returns (R_i), the Adjusted All Ordinaries Share Index, which covers over 2,000 quoted Australian companies to compute the market return (R_m).

4.6 Results

4.6.1 Execution Costs and Liquidity available to off-market option trades

Figure 4-2 Off-market Option Premium Histogram - All Off-market Option Trades

This figure shows a histogram of the dollar value of the off-market option premium for the entire sample of off-market option trades. The Off-market Option Premium is equal to Price - Standing Ask Price for Buy Trades and Standing Bid Price - Price for Sell Trades.

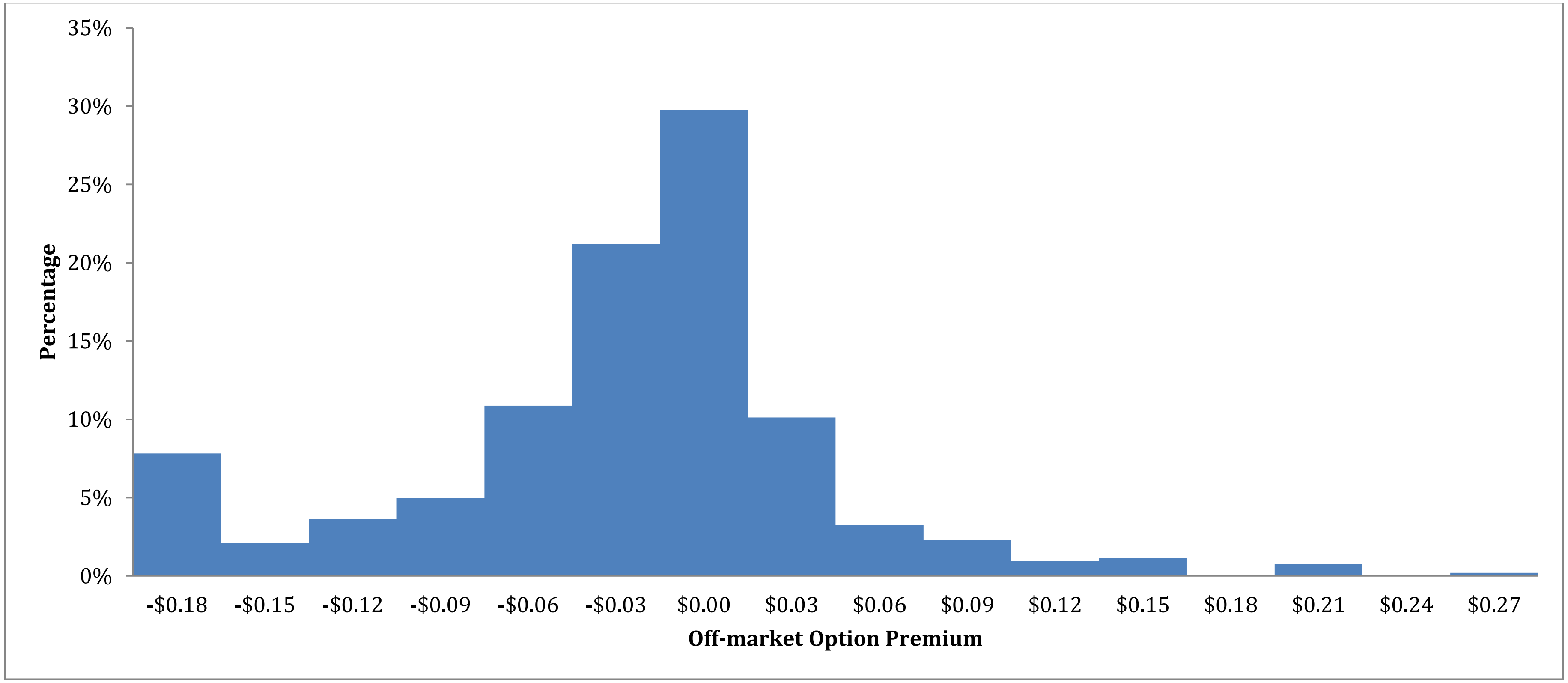


Figure 4-3 Proportional Off-market Option Premium Histogram - All Off-market Option Trades

This figure shows a histogram of the percentage value of the Proportional Off-market Option Premium for the entire sample of off-market option trades. The Proportional Off-market Option Premium is equal to (Price - Standing Ask Price)/Standing Ask Price for Buy Trades and (Standing Bid Price - Price)/Standing Bid Price for Sell Trades.

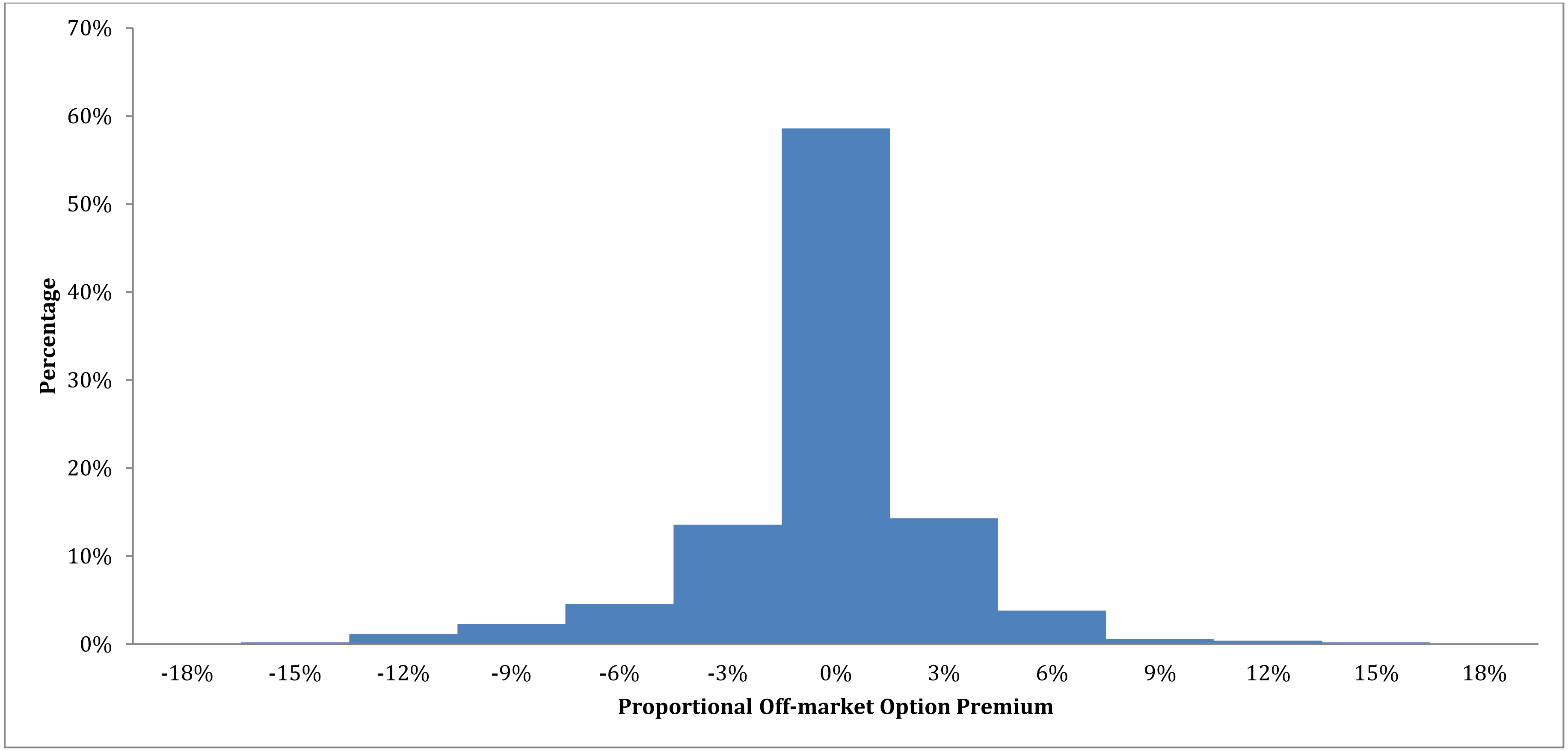


Table 4-2 Mean Off-Market Option Premiums

This table provides the mean of the off-market option premiums for all off-market option trades within the sample. The sample includes 524 off-market option trades.

	Mean	*p-value*
Off-market Option Premium	-0.0435	<.0001
Proportional Off-market Option Premium	-0.0159	<.0001

Figure 4-2 reports the off-market premium for all trades within the sample in histogram format; 38% of all trades centre around an off-market premium of $0.00 with the majority of trades reporting a negative dollar off-market premium. Similarly, Figure 4-3 reports the proportional off-market premium. Again, the results find that the majority (64%) of trades centre on a proportional off-market premium of 0% with an equal amount of trades above and below. Table 4-2 presents the mean off-market option premiums. The findings support the fact that large off-market options trades receive price improvement in the order of 1.59% from the standing market quotes at the time of the trade. Together, the results imply that the majority of off-market option trades do not pay an off-market premium and in contrast receive price improvement.

Figure 4-4 Off-market Option Premium Histogram - Call Option Trades

This figure shows a histogram of the dollar value of the off-market option premium for all Call off-market option trades. The Off-market Option Premium is equal to Price - Standing Ask Price for Buy Trades and Standing Bid Price - Price for Sell Trades.

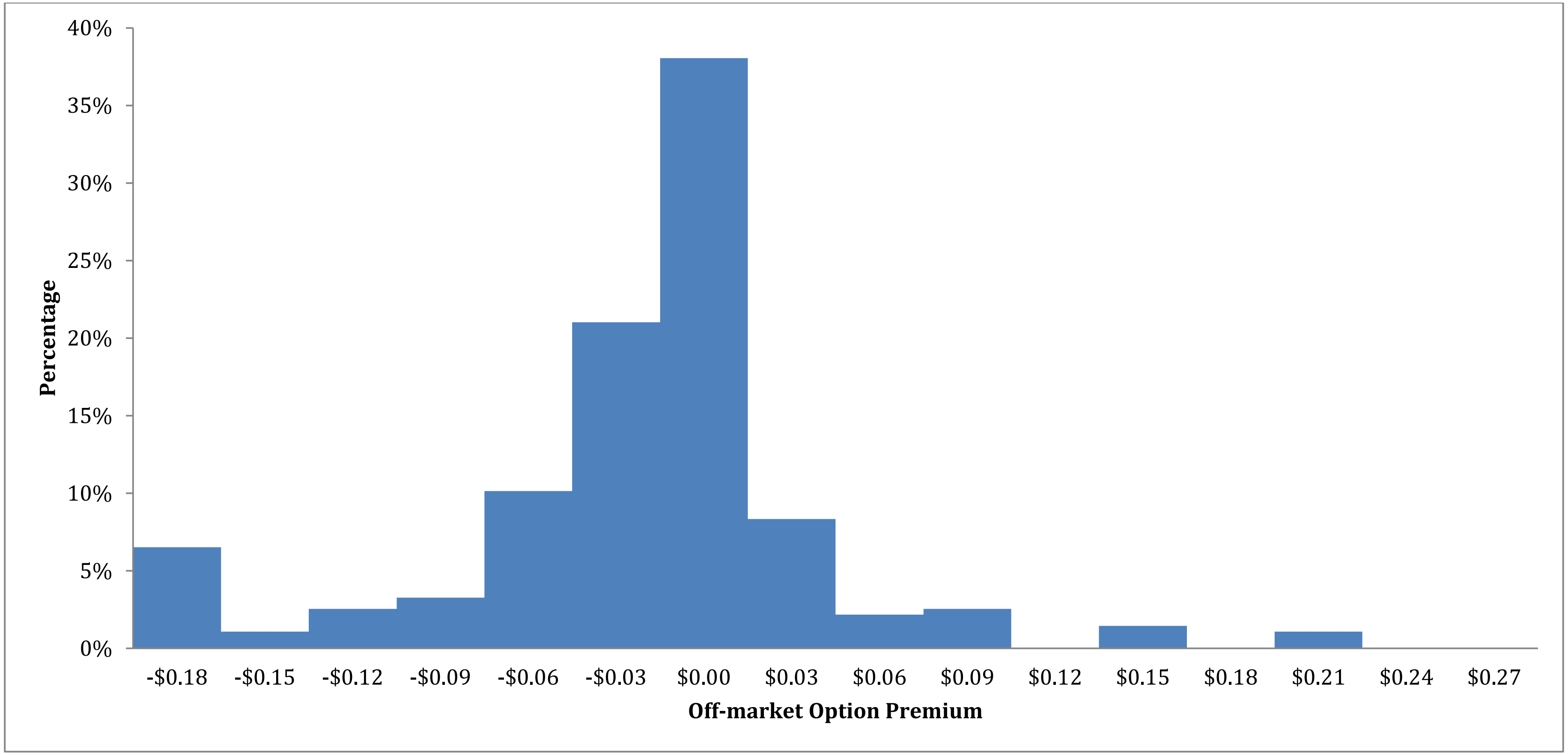


Figure 4-5 Proportional Off-market Option Premium Histogram - Call Option Trades

This figure shows a histogram of the percentage value of the Proportional Off-market Option Premium for all Call off-market option trades. The Proportional Off-market Option Premium is equal to (Price - Standing Ask Price)/Standing Ask Price for Buy Trades and (Standing Bid Price - Price)/Standing Bid Price for Sell Trades.

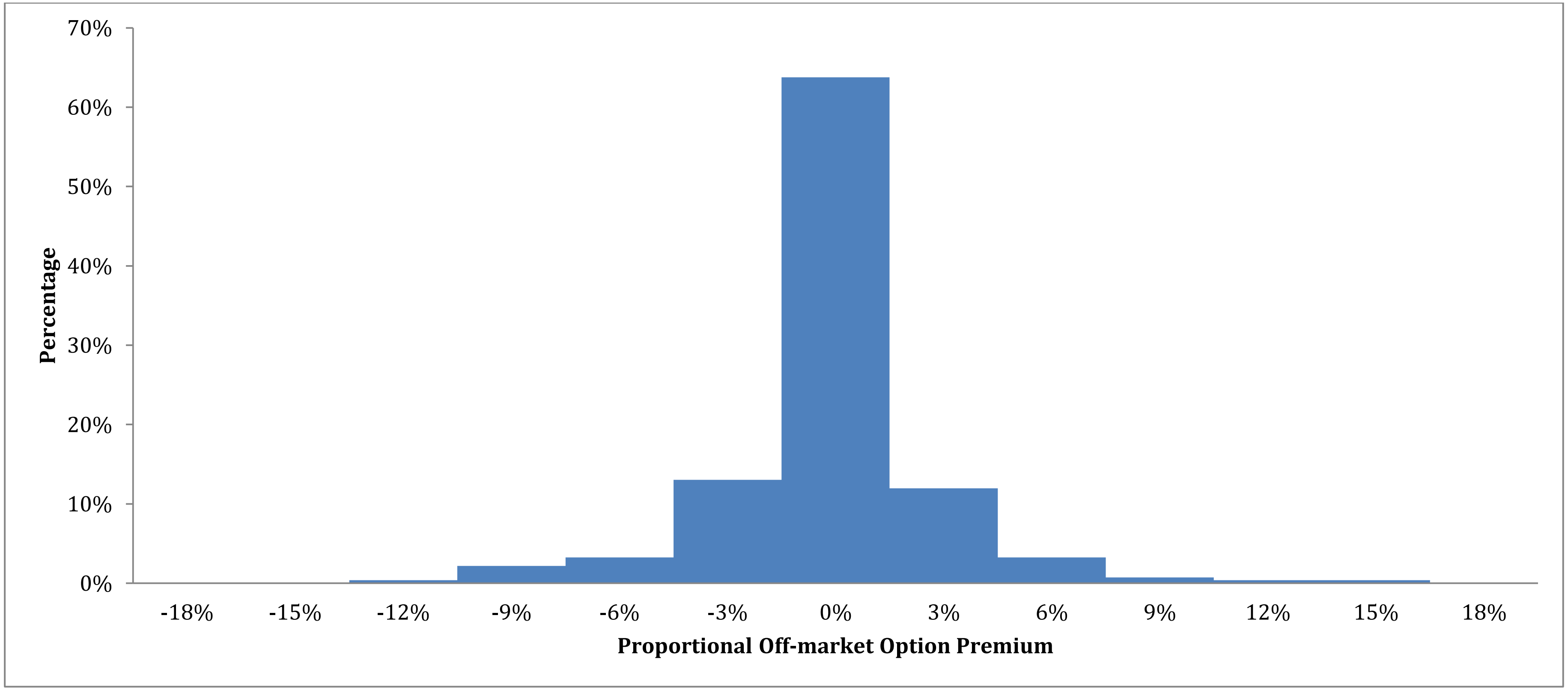


Figure 4-4 reports the off-market premium for only the call option trades. Similar to the findings on the entire sample, the results show that the majority (38%) of call option trades centre around an off-market option premium of $0.00 with 21% of trades at an off-market premium of -$0.03. Figure 4-5 further reinforces the same findings on proportional off-market premium for call option trades as for the entire sample with over 64% of trades centred on 0%.

Figure 4-6 Off-market Option Premium Histogram - Put Option Trades

This figure shows a histogram of the dollar value of the off-market option premium for all Put off-market option trades. The Off-market Option Premium is equal to Price - Standing Ask Price for Buy Trades and Standing Bid Price - Price for Sell Trades.

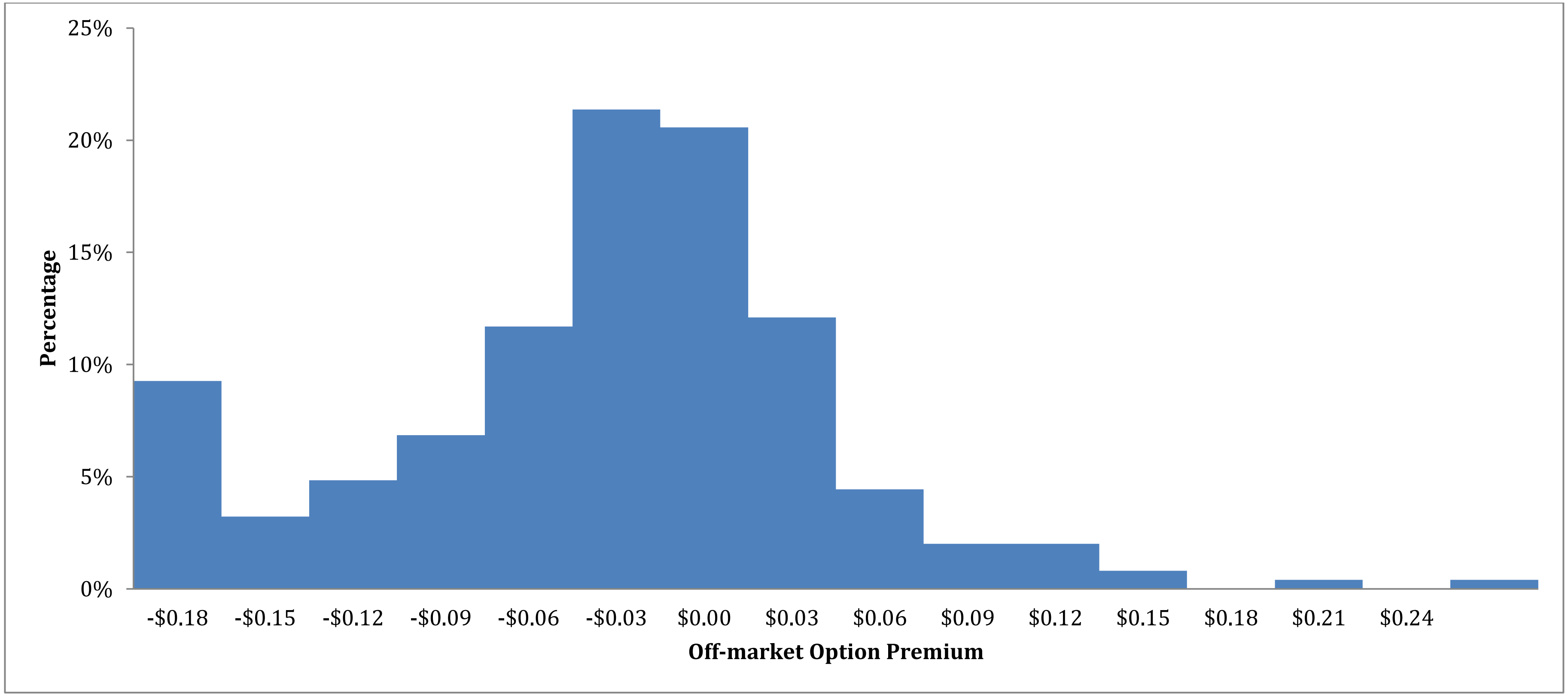


Figure 4-7 Proportional Off-market Option Premium Histogram - Put Option Trades

This figure shows a histogram of the percentage value of the Proportional Off-market Option Premium for all Put off-market option trades. The Proportional Off-market Option Premium is equal to (Price - Standing Ask Price)/Standing Ask Price for Buy Trades and (Standing Bid Price - Price)/Standing Bid Price for Sell Trades.

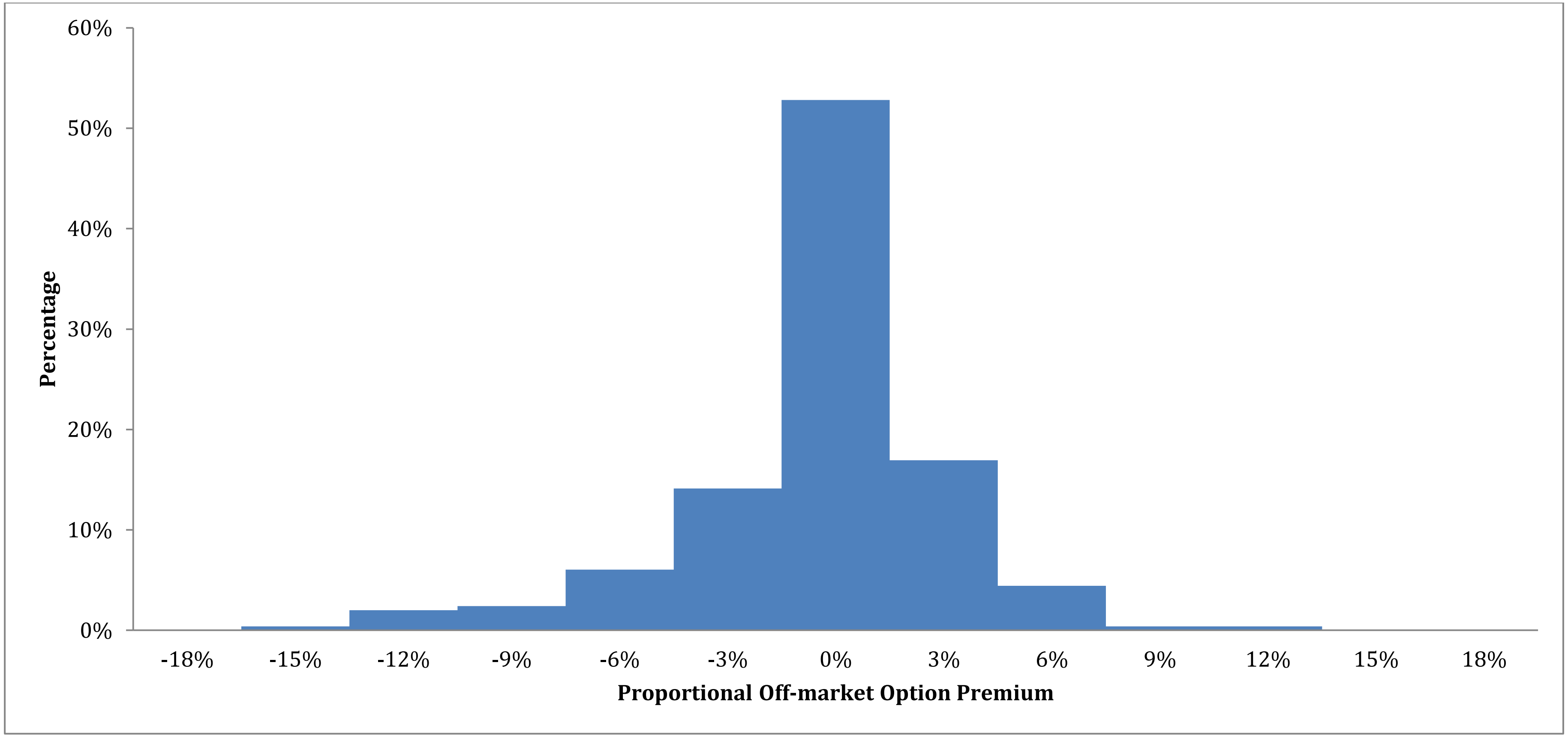


Table 4-3 Mean Off-market Option Premiums – By Call/Put

This table provides the mean of the off-market option premiums for off-market Call and Put option trades within the sample. The sample includes 276 off-market Call option trades, and 248 off-market Put option trades.

	Option Type	*Mean*	*p-value*
Off-market Option Premium	*Call*	-0.0306	0.0078
	Put	-0.0578	<.0001
Proportional Off-market Option Premium	*Call*	-0.0132	<.0001
	Put	-0.0189	<.0001

Figure 4-6 reports the off-market premium findings for off-market put option trades. The results find that almost an equal amount (21%) of trades centre around off-market premiums of either -$0.03 and $0.00. In Figure 4-7 the results show that similar to off-market call option trades, off-market put option trades also centre around 0% proportional off-market premium. Table 4-3 presents the mean off-market option premiums for both Call and Put options. The findings reveal that all off-market option premiums are significant and negative.

The results surrounding off-market premiums are consistent across both the entire sample and when categorised into call or put option trades. The findings imply that, on average, off-market option traders do not face higher execution costs and, in the contrary, find price improvement beyond what is available on the Centralised Limit Order Book (CLOB). These findings lend support to the Grossman (1992) model that predicts that upstairs brokers are able to reduce execution costs by tapping into unexpressed liquidity.

Figure 4-8 Options Market Proportional Spreads - 5 Minute Interval

This figure shows a graph of the Proportional Spread on the Options market in the 5-minute intervals prior to and following the off-market option trades. The Proportional Spread is equal to (Standing Ask - Standing Bid)/Midpoint.

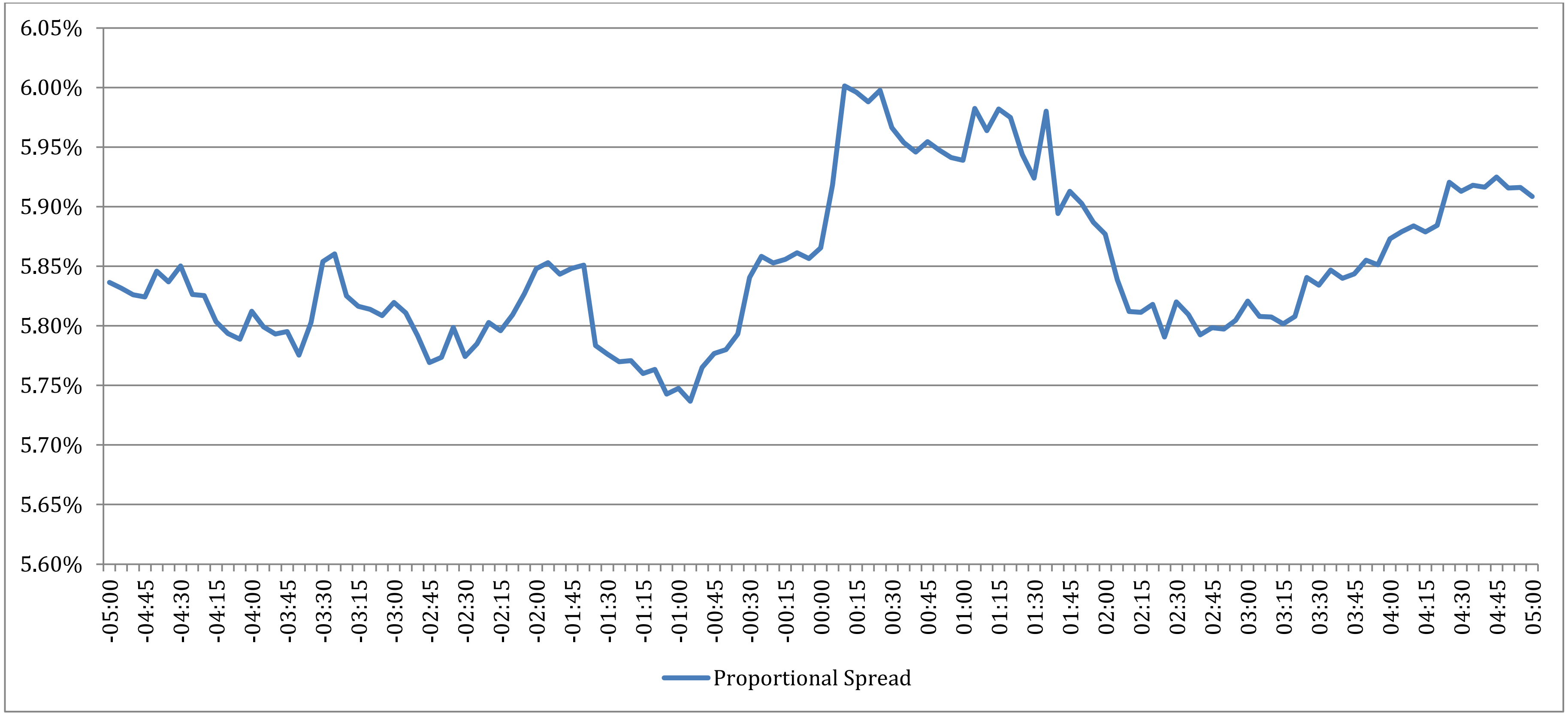


Table 4-4 Options Market Proportional Spreads - 1 Minute Intervals

This table presents the mean proportional spreads on the options market at 1-minute intervals in the 5 minutes prior to and following the off-market trades. The sample includes 524 off-market option trades. Time 00:00 represents the time of trade.

Time (mm:ss)	*Mean*	*p-value*
-05:00	0.0584	<.0001
-04:00	0.0581	<.0001
-03:00	0.0582	<.0001
-02:00	0.0585	<.0001
-01:00	0.0575	<.0001
00:00	0.0587	<.0001
01:00	0.0594	<.0001
02:00	0.0588	<.0001
03:00	0.0582	<.0001
04:00	0.0587	<.0001
05:00	0.0591	<.0001

Figure 4-9 Options Market Proportional Spreads - 1 Hour Interval

This figure shows a graph of the Proportional Spread on the Options market in the 1-hour intervals prior to and following the off-market option trades. The Proportional Spread is equal to (Standing Ask - Standing Bid)/Midpoint.

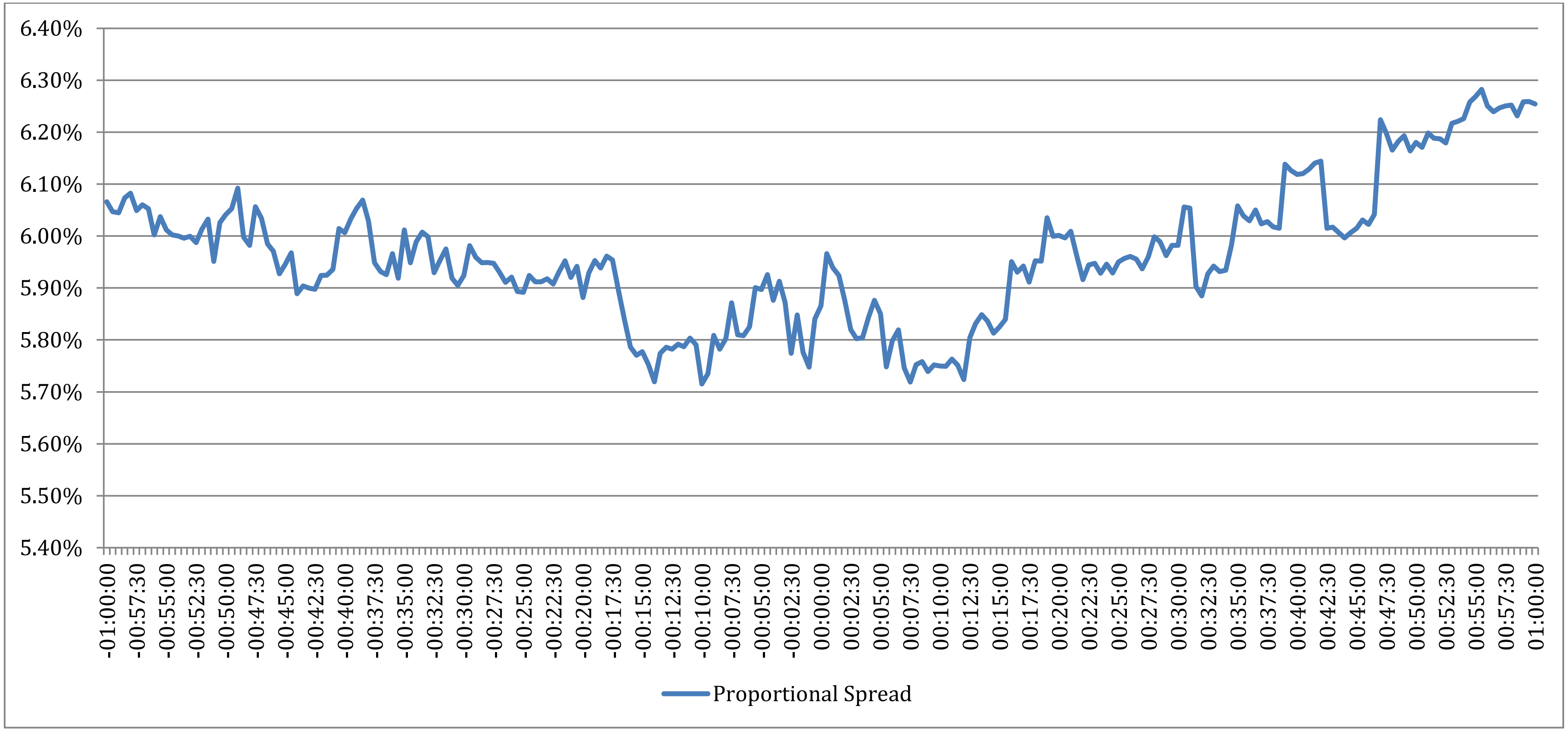


Table 4-5 Options Market Proportional Spreads - 10 Minute Intervals

This table presents the mean proportional spreads on the options market at 10-minute intervals in the 1-hour prior to and following the off-market trades. The sample includes 524 off-market option trades. Time 00:00 represents the time of trade.

Time (hh:mm:ss)	*Mean*	*p-value*
-01:00:00	0.0607	<.0001
-00:50:00	0.0604	<.0001
-00:40:00	0.0601	<.0001
-00:30:00	0.0592	<.0001
-00:20:00	0.0588	<.0001
-00:10:00	0.0572	<.0001
00:00:00	0.0587	<.0001
00:10:00	0.0575	<.0001
00:20:00	0.0600	<.0001
00:30:00	0.0598	<.0001
00:40:00	0.0612	<.0001
00:50:00	0.0618	<.0001
01:00:00	0.0625	<.0001

Figure 4-8 and Figure 4-9 report the changes in option proportional spreads in 5-minute and 1-hour intervals, respectively, around the entire sample of off-market option trades. Although it seems that proportional spreads increase from the time of the trade to 1 minute after in Figure 4-8, Figure 4-9 renders this finding insignificant when viewing the changes in proportional spreads in 1 hour intervals around the trades. Further, the graphs highlight the transient volatility of the proportional spreads, and there is no evidence of significant patterns prior to or following the off-market trades. Table 4-4 and Table 4-5 present the proportional spread at 1-minute and 10-minute intervals, respectively, and reveal no significant spread patterns.

Figure 4-10 Underlying Equity Market Proportional Spreads - 5 Minute Interval

This figure shows a graph of the Proportional Spread on the Underlying Equity market in the 5-minute intervals prior to and following the off-market option trades. The Proportional Spread is equal to (Standing Ask - Standing Bid)/Midpoint.

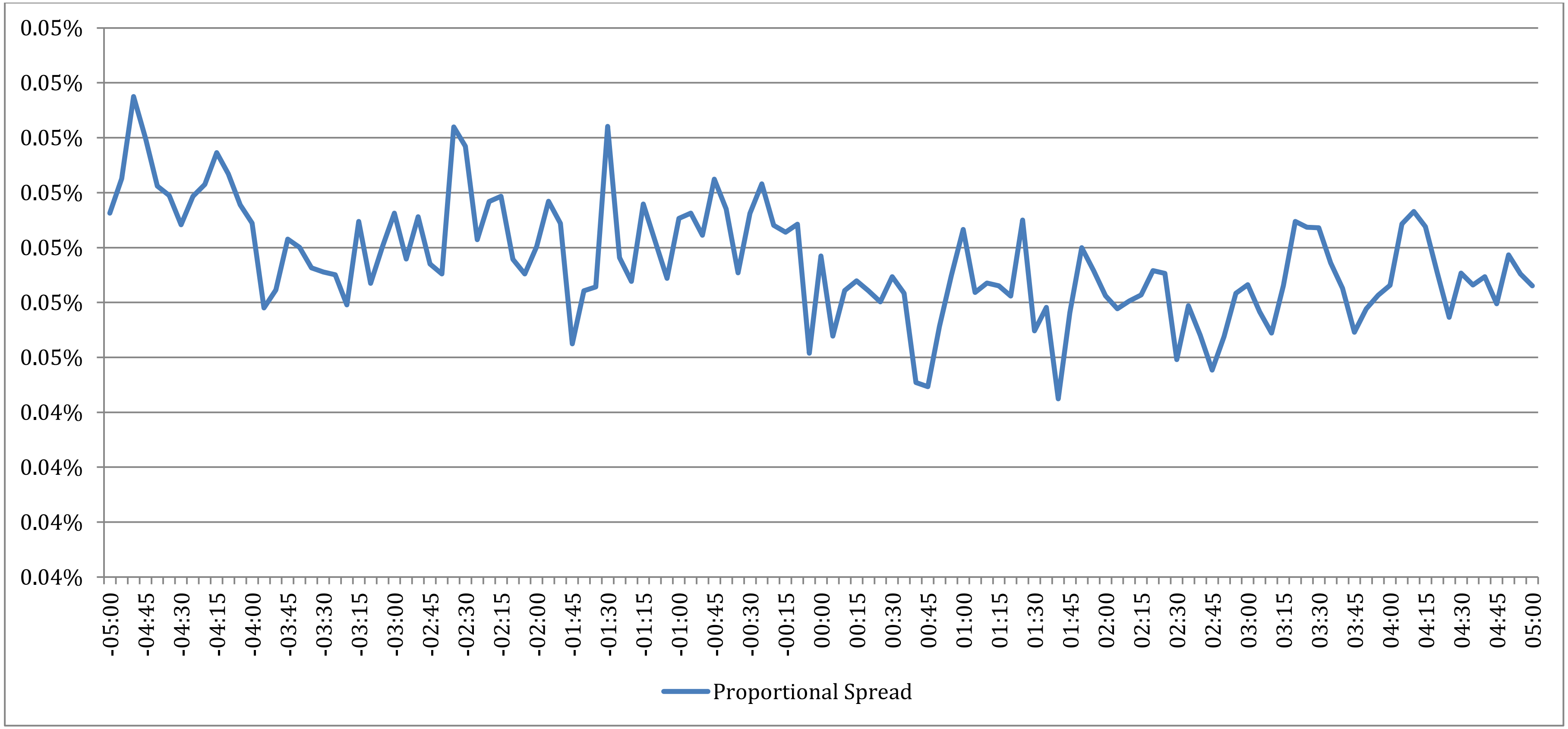


Table 4-6 Underlying Equity Market Proportional Spreads - 1 Minute Intervals

This table presents the mean proportional spreads on the underlying equity market at 1-minute intervals in the 5 minutes prior to and following the off-market trades. The sample includes 524 off-market option trades. Time 00:00 represents the time of trade.

Time (mm:ss)	*Mean*	*p-value*
-05:00	0.00048	<.0001
-04:00	0.00047	<.0001
-03:00	0.00048	<.0001
-02:00	0.00047	<.0001
-01:00	0.00048	<.0001
00:00	0.00047	<.0001
01:00	0.00047	<.0001
02:00	0.00046	<.0001
03:00	0.00046	<.0001
04:00	0.00046	<.0001
05:00	0.00046	<.0001

Figure 4-11 Underlying Equity Market Proportional Spreads -1 Hour Interval

This figure shows a graph of the Proportional Spread on the Underlying Equity market in the 1-hour intervals prior to and following the off-market option trades. The Proportional Spread is equal to (Standing Ask - Standing Bid)/Midpoint.

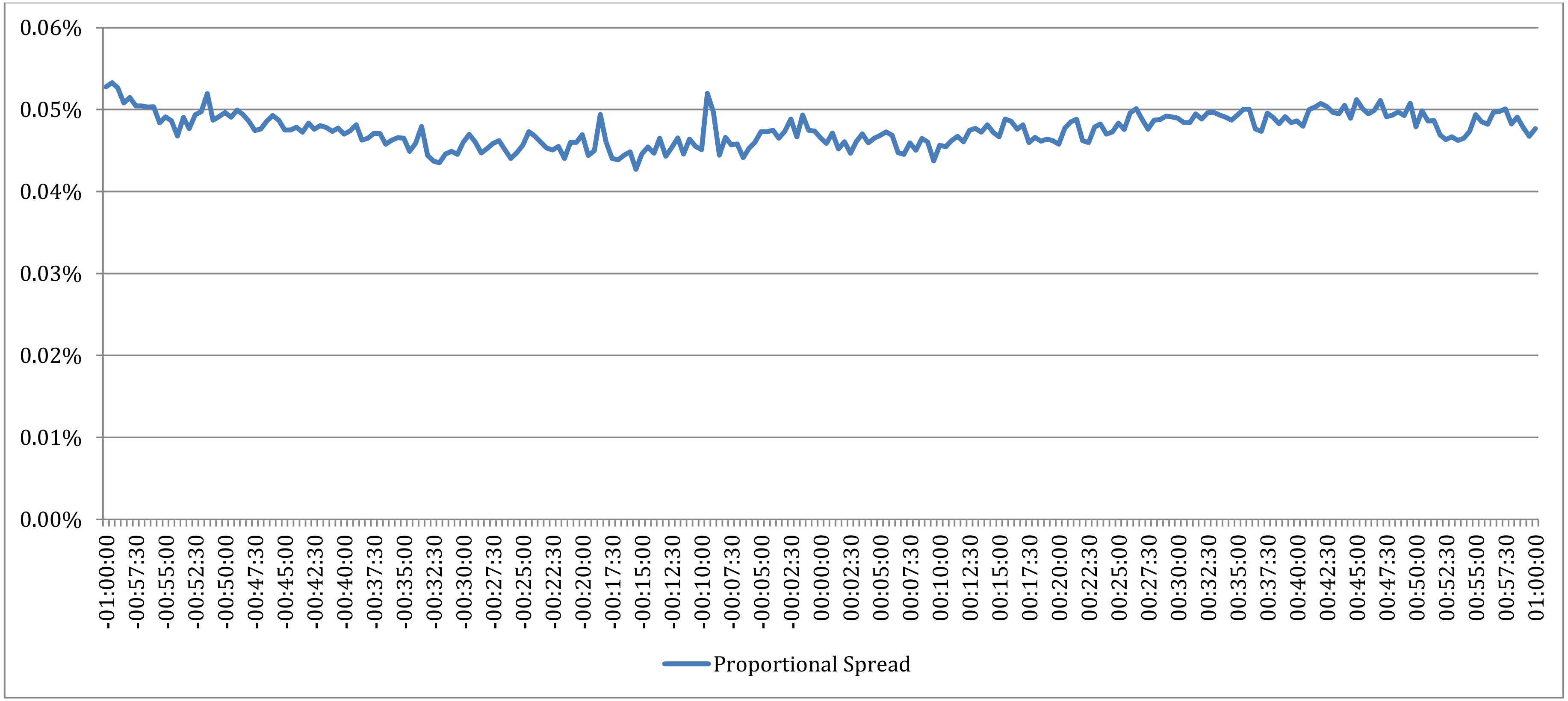


Table 4-7 Underlying Equity Market Proportional Spreads - 10 Minute Intervals

This table presents the mean proportional spreads on the options market at 10-minute intervals in the 1-hour prior to and following the off-market trades. The sample includes 524 off-market option trades. Time 00:00 represents the time of trade.

Time (hh:mm:ss)	*Mean*	*p-value*
-01:00:00	0.00053	<.0001
-00:50:00	0.00050	<.0001
-00:40:00	0.00047	<.0001
-00:30:00	0.00046	<.0001
-00:20:00	0.00047	<.0001
-00:10:00	0.00045	<.0001
00:00:00	0.00047	<.0001
00:10:00	0.00046	<.0001
00:20:00	0.00046	<.0001
00:30:00	0.00049	<.0001
00:40:00	0.00049	<.0001
00:50:00	0.00048	<.0001
01:00:00	0.00048	<.0001

Figure 4-10 and Figure 4-11 present the underlying equity market proportional spreads in 5-minute and 1-hour intervals, respectively, around the entire sample of off-market option trades. Similar to the options market, the results find no significant patterns in proportional spreads in both 5-minute or 1-hour intervals prior to and following the off-market option trades. Further, Table 4-6 and Table 4-7 reveal no significant spread patterns in the 1-minute and 10-minute intervals, respectively, around the trades. These results imply that off-market option trades have no significant impact on the underlying equities market. This finding is contrary to the Cho and Engle (1999) "derivative hedge theory" model whereby option market makers actively hedge their positions in the underlying stock.

Figure 4-12 Options Market Proportional Ask- Call Buys -1 Hour Interval

This figure shows a graph of the Proportional Ask on the Options market in the 1-hour intervals prior to and following the off-market Call option Buy trades. The Proportional Ask is equal to (Standing Ask - $Midpoint_{t=0}$)/$Midpoint_{t=0}$ for a Buy Trade.

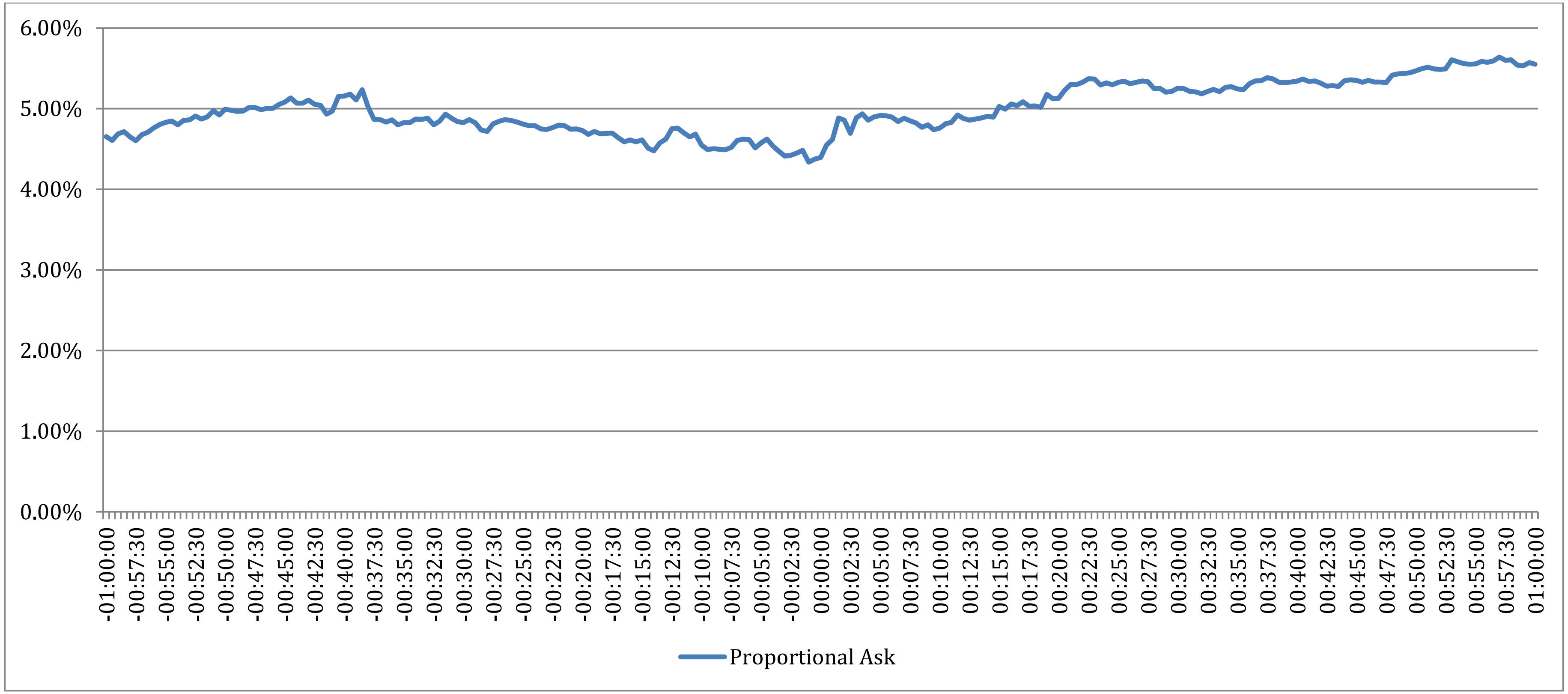


Table 4-8 Options Market Proportional Ask- Call Buys -10 Minute Intervals

This table presents the mean Proportional Ask on the Options market in the 1-hour intervals prior to and following the off-market Call option Buy trades. The Proportional Ask is equal to (Standing Ask - $Midpoint_{t=0}$)/$Midpoint_{t=0}$ for a Buy Trade. The sample includes 151 off-market Call option buy trades. Time 00:00 represents the time of trade.

Time (hh:mm:ss)	*Mean Proportional Ask*	*p-value*
-01:00:00	0.04653	<.0001
-00:50:00	0.04991	<.0001
-00:40:00	0.05155	<.0001
-00:30:00	0.04827	<.0001
-00:20:00	0.04727	<.0001
-00:10:00	0.04549	<.0001
00:00:00	0.04394	<.0001
00:10:00	0.04757	<.0001
00:20:00	0.05130	<.0001
00:30:00	0.05253	<.0001
00:40:00	0.05340	<.0001
00:50:00	0.05469	<.0001
01:00:00	0.05550	<.0001

Figure 4-13 Options Market Proportional Bid - Call Sells -1 Hour Interval

This figure shows a graph of the Proportional Bid on the Options market in the 1-hour intervals prior to and following the off-market Call option Sell trades. The Proportional Bid is equal to ($Midpoint_{t=0}$ - Standing Bid)/$Midpoint_{t=0}$ for a Sell Trade.

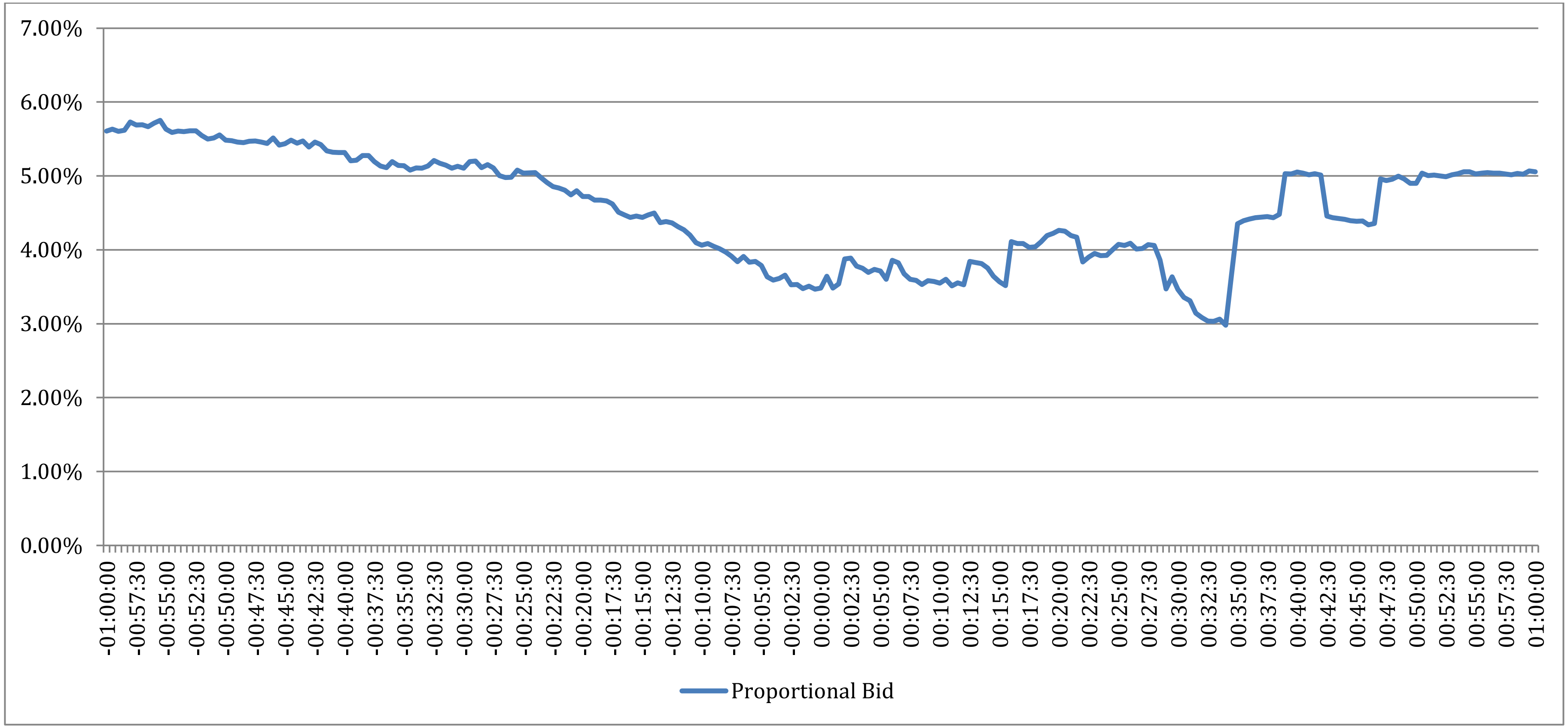


Table 4-9 Options Market Proportional Bid- Call Sells -10 Minute Intervals

This table presents the mean Proportional Bid on the Options market in the 1-hour intervals prior to and following the off-market Call option Sell trades. The Proportional Bid is equal to ($Midpoint_{t=0}$ - Standing Bid)/$Midpoint_{t=0}$ for a Sell Trade. The sample includes 125 off-market Call option sell trades. Time 00:00 represents the time of trade.

Time (hh:mm:ss)	*Mean Proportional Bid*	*p-value*
-01:00:00	0.056	<.0001
-00:50:00	0.055	<.0001
-00:40:00	0.053	<.0001
-00:30:00	0.051	<.0001
-00:20:00	0.047	<.0001
-00:10:00	0.041	<.0001
00:00:00	0.035	<.0001
00:10:00	0.036	<.0001
00:20:00	0.043	<.0001
00:30:00	0.035	<.0001
00:40:00	0.051	<.0001
00:50:00	0.049	<.0001
01:00:00	0.051	<.0001

The proportional bid/ask statistic measures how much the ask moves from the prevailing midpoint at the time of a call option buy trade, and how much the bid moves from the prevailing midpoint from the time of the call option sell trade. Figure 4-12 shows the changes in the proportional ask 1-hour before and after off-market call option buy trades, while Figure 4-13 shows the changes in the proportional bid 1-hour before and after the off-market call option sell trades. In both cases there is no evidence of significant patterns regarding the relevant proportional ask or bid. Table 4-8 and 4-9 present the mean proportional ask/bid at 10-minute intervals for call option buy and sell trades, respectively. Similar to the graphs, they show no evidence of significant price patterns.

Figure 4-14 Options Market Proportional Ask - Put Buys - 1 Hour Interval

This figure shows a graph of the Proportional Ask on the Options market in the 1-hour intervals prior to and following the off-market Put option Buy trades. The Proportional Ask is equal to (Standing Ask - $Midpoint_{t=0}$)/$Midpoint_{t=0}$ for a Buy Trade.

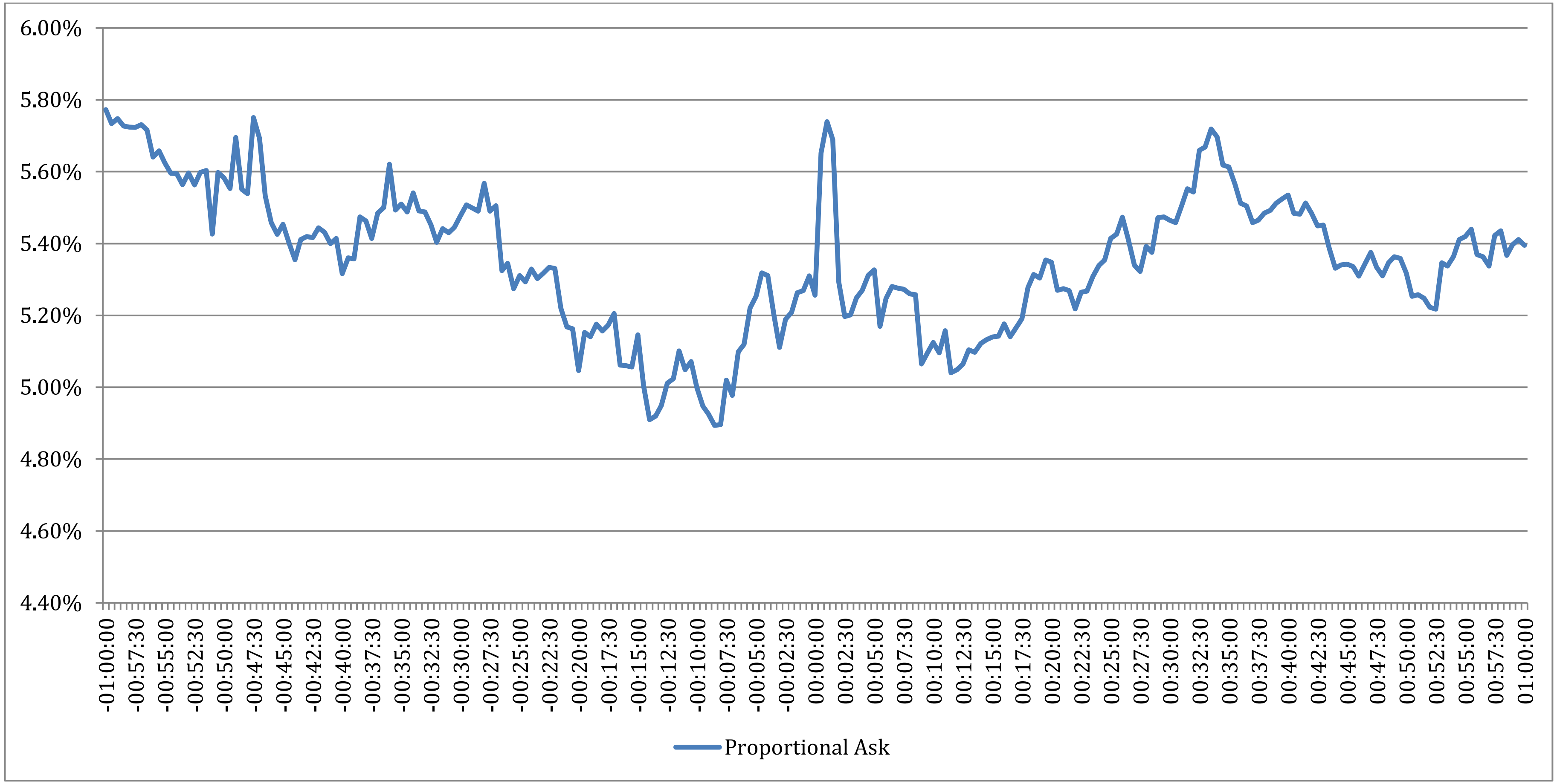


Table 4-10 Options Market Proportional Ask- Put Buys -10 Minute Intervals

This table presents the mean Proportional Ask on the Options market in the 1-hour intervals prior to and following the off-market Put option Buy trades. The Proportional Ask is equal to (Standing Ask - $Midpoint_{t=0}$)/$Midpoint_{t=0}$ for a Buy Trade. The sample includes 158 off-market Put option buy trades. Time 00:00 represents the time of trade.

Time (hh:mm:ss)	*Mean Proportional Ask*	*p-value*
-01:00:00	0.058	<.0001
-00:50:00	0.056	<.0001
-00:40:00	0.053	<.0001
-00:30:00	0.055	<.0001
-00:20:00	0.050	<.0001
-00:10:00	0.050	<.0001
00:00:00	0.053	<.0001
00:10:00	0.051	<.0001
00:20:00	0.053	<.0001
00:30:00	0.055	<.0001
00:40:00	0.055	<.0001
00:50:00	0.053	<.0001
01:00:00	0.054	<.0001

Figure 4-15 Options Market Proportional Bid - Put Sells - 1 Hour Interval

This figure shows a graph of the Proportional Bid on the Options market in the 1-hour intervals prior to and following the off-market Put option Sell trades. The Proportional Bid is equal to (Midpoint$_{t=0}$ - Standing Bid)/Midpoint$_{t=0}$ for a Sell Trade.

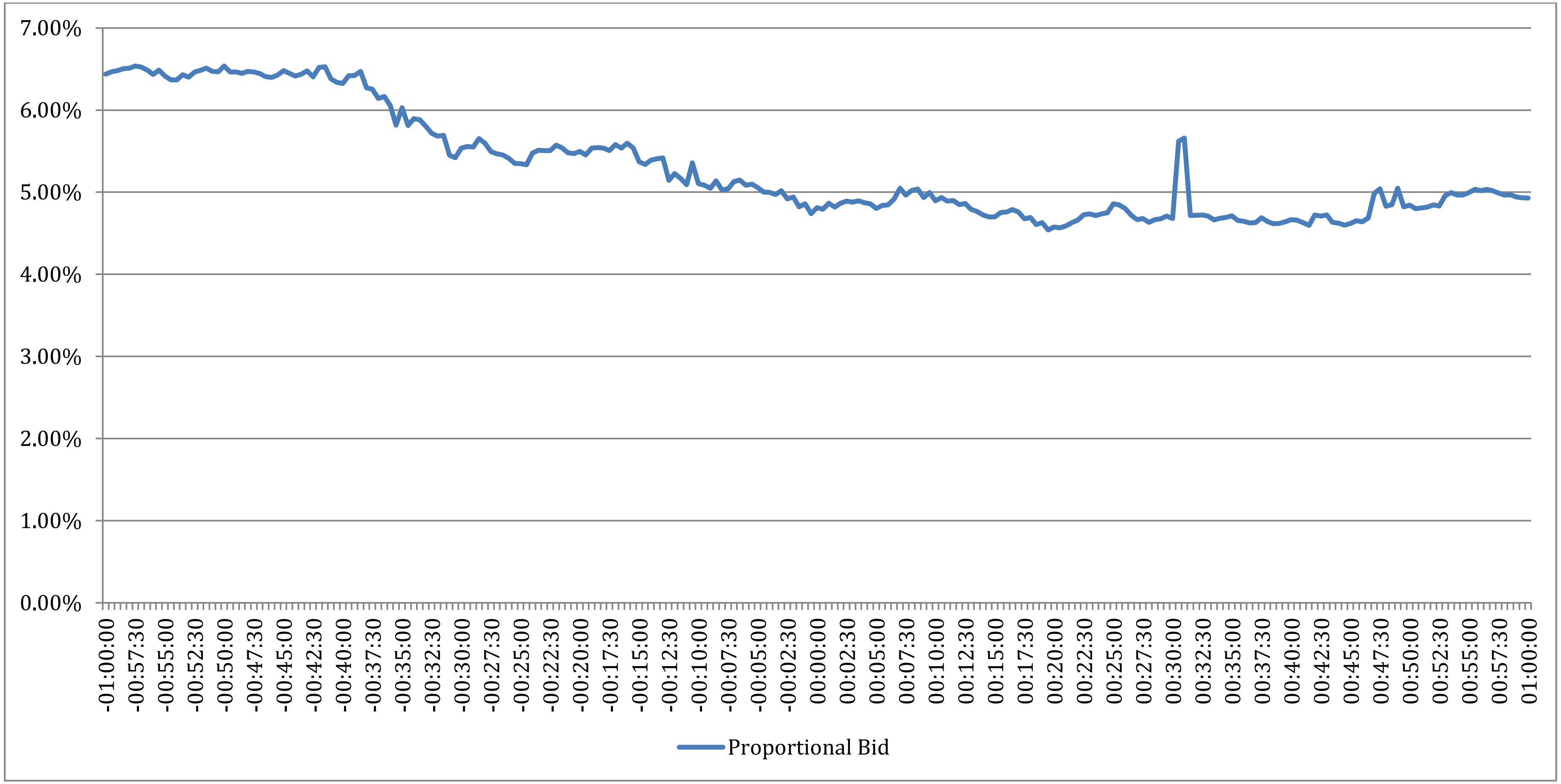


Table 4-11 Options Market Proportional Bid- Put Sells -10 Minute Intervals

This table presents the mean Proportional Bid on the Options market in the 1-hour intervals prior to and following the off-market Put option Sell trades. The Proportional Bid is equal to ($Midpoint_{t=0}$ - Standing Bid)/$Midpoint_{t=0}$ for a Sell Trade. The sample includes 90 off-market Put option sell trades. Time 00:00 represents the time of trade.

Time (hh:mm:ss)	*Mean Proportional Bid*	*p-value*
-01:00:00	0.064	<.0001
-00:50:00	0.065	<.0001
-00:40:00	0.063	<.0001
-00:30:00	0.055	<.0001
-00:20:00	0.055	<.0001
-00:10:00	0.051	<.0001
00:00:00	0.048	<.0001
00:10:00	0.049	<.0001
00:20:00	0.046	<.0001
00:30:00	0.047	<.0001
00:40:00	0.047	<.0001
00:50:00	0.048	<.0001
01:00:00	0.049	<.0001

Figure 4-14 shows the changes in the proportional ask 1-hour before and after off-market Put option buy trades. The results show a short spike in the proportional ask in the minutes following the off-market put purchases, however in the context of the 1-hour interval following the trade this spike is insignificant. Figure 4-15 shows the changes in the proportional bid 1-hour before and after off-market put option sell trades, again, in which there are no significant patterns. Table 4-10 and Table 4-11 confirm these findings.

Figure 4-16 Options Market Proportional Ask - Call Buys - 1 Hour Interval

This figure shows a graph of the Proportional Ask on the Underlying Equity market in the 1-hour intervals prior to and following the off-market Call option Buy trades. The Proportional Ask is equal to (Standing Ask - $Midpoint_{t=0}$)/$Midpoint_{t=0}$ for a Buy Trade. The proportional ask is examined because it is posited (according to the derivative hedge theory) that in the case of an informed call option purchase, market makers would protect themselves against a rise in the underlying equity and therefore would hedge themselves against the exposure by buying at the ask price in the underlying.

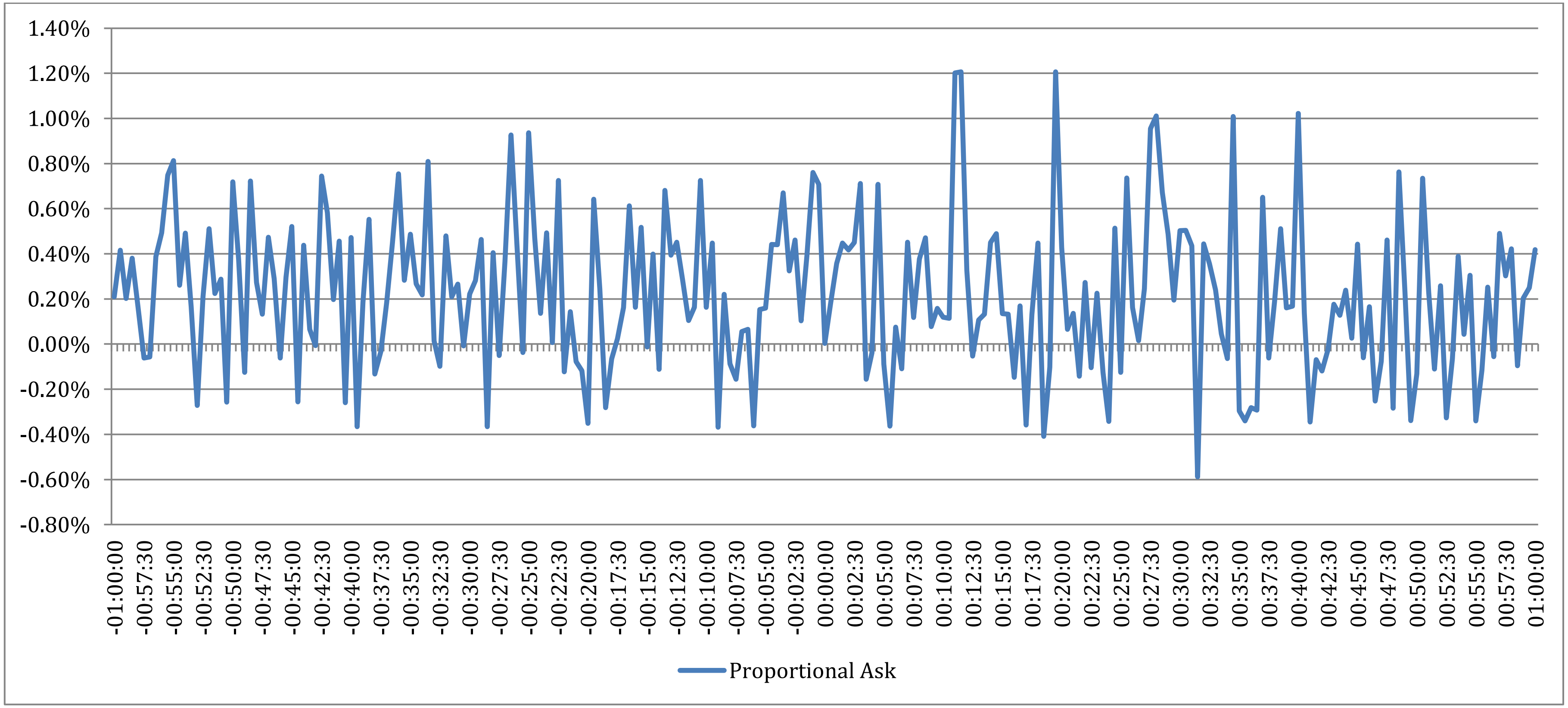


Table 4-12 Underlying Equity Market Proportional Ask- Call Buys -10 Minute Intervals

This table presents the mean Proportional Ask on the underlying Equity market in the 1-hour intervals prior to and following the off-market Call option Buy trades. The Proportional Ask is equal to (Standing Ask - $Midpoint_{t=0}$)/$Midpoint_{t=0}$ for a Buy Trade. The sample includes 151 off-market Call option buy trades. Time 00:00 represents the time of trade. The proportional ask is examined because it is posited (according to the derivative hedge theory) that in the case of an informed call option purchase, market makers would protect themselves against a rise in the underlying equity and therefore would hedge themselves against the exposure by buying at the ask price in the underlying.

Time (hh:mm:ss)	*Mean Proportional Ask*	*p-value*
-01:00:00	0.002	0.706
-00:50:00	0.007	0.154
-00:40:00	0.005	0.357
-00:30:00	0.002	0.609
-00:20:00	-0.004	0.223
-00:10:00	0.002	0.681
00:00:00	0.000	0.996
00:10:00	0.001	0.807
00:20:00	0.004	0.312
00:30:00	0.005	0.324
00:40:00	0.010	0.080
00:50:00	-0.001	0.648
01:00:00	0.004	0.216

Figure 4-17 Options Market Proportional Bid - Call Sells - 1 Hour Interval

This figure shows a graph of the Proportional Bid on the Underlying Equity market in the 1-hour intervals prior to and following the off-market Call option Sell trades. The Proportional Bid is equal to ($Midpoint_{t=0}$ - Standing Bid)/$Midpoint_{t=0}$ for a Sell Trade. The proportional bid is examined because it is posited (according to the derivative hedge theory) that in the case of an informed call option sale, market makers would protect themselves against a fall in the underlying equity and therefore would hedge themselves against the exposure by selling at the bid price in the underlying.

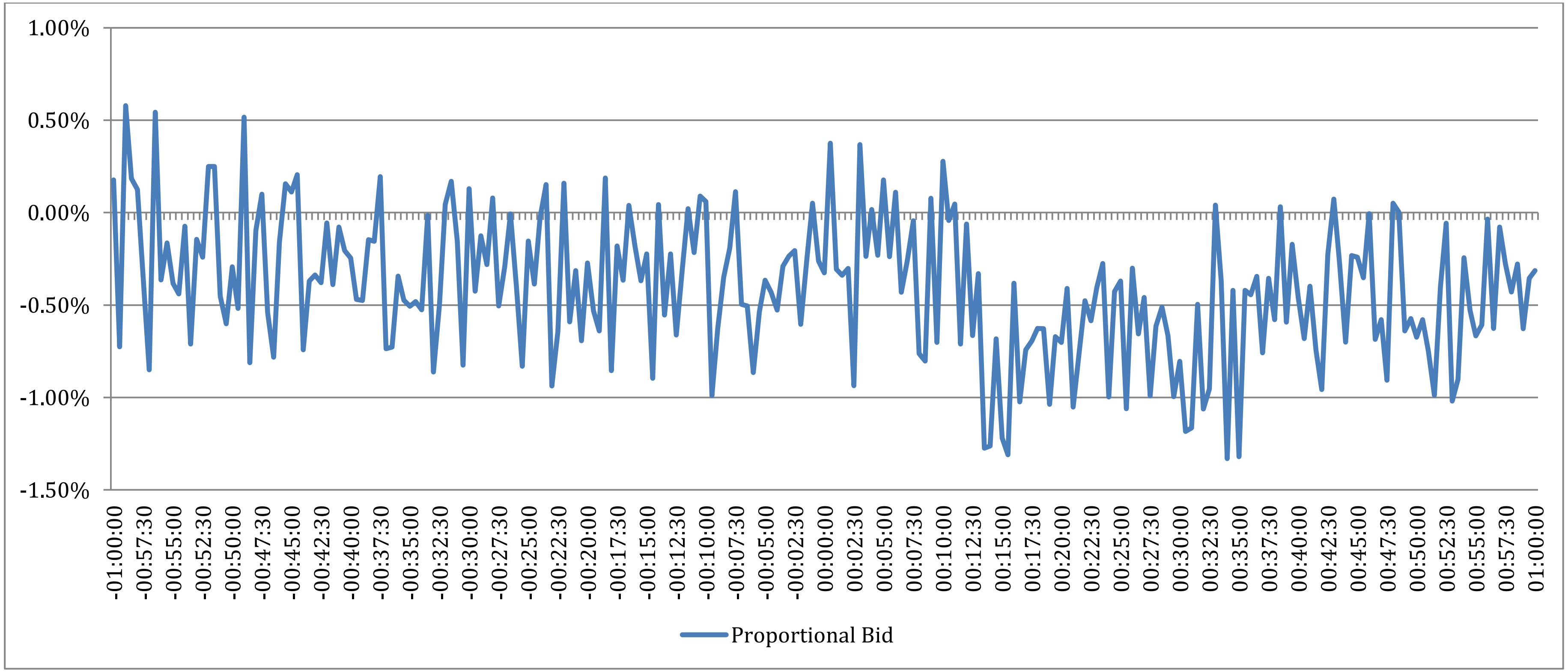


Table 4-13 Underlying Equity Market Proportional Bid- Call Sells -10 Minute Intervals

This table presents the mean Proportional Bid on the underlying Equity market in the 1-hour intervals prior to and following the off-market Call option Sell trades. The Proportional Bid is equal to ($Midpoint_{t=0}$ - Standing Bid)/$Midpoint_{t=0}$ for a Sell Trade. The sample includes 125 off-market Call option sell trades. Time 00:00 represents the time of trade. The proportional bid is examined because it is posited (according to the derivative hedge theory) that in the case of an informed call option sale, market makers would protect themselves against a fall in the underlying equity and therefore would hedge themselves against the exposure by selling at the bid price in the underlying.

Time (hh:mm:ss)	*Mean Proportional Bid*	*p-value*
-01:00:00	0.002	0.692
-00:50:00	-0.003	0.503
-00:40:00	-0.002	0.677
-00:30:00	0.001	0.772
-00:20:00	-0.003	0.514
-00:10:00	0.001	0.893
00:00:00	-0.003	0.489
00:10:00	0.003	0.303
00:20:00	-0.007	0.266
00:30:00	-0.008	0.198
00:40:00	-0.005	0.271
00:50:00	-0.007	0.113
01:00:00	-0.003	0.532

The underlying equities market is examined because options and equity markets must move together in the absence of arbitrage. Further, this analysis investigates the Cho and Engle (1999) "derivative hedge theory" by directly surveying the options and underlying equities markets around large off-market option trades. Figure 4-16 presents the results for the proportional ask in the underlying equities around call option purchases. The proportional ask is examined because it is posited (according to the derivative hedge theory) that in the case of an informed call option purchase, market makers would protect themselves against a rise in the underlying equity and therefore would hedge themselves against the exposure by buying at the ask price in the underlying, and vice versa for call option sells. Figure 4-16 shows no evidence of price patterns in the underlying equities prior to and following the off-market call option purchases. Table 4-12 presents the results of the mean proportional ask at 10-minute intervals around the off-market call option buy trades and show no significant price changes. Similarly, Figure 4-17 presents the results for the proportional bid in the underlying equities around call option sales. Again, it reveals similar results and no apparent price patterns. Table 4-13 presents the results of the mean proportional bid at 10-minute intervals around the off-market call option sell trades, and show no significant price changes. Together these results suggest that there is no evidence of option market makers hedging their exposure to large off-market call option trades in the underlying equities in the 1-hour prior to and following the trades.

Figure 4-18 Options Market Proportional Bid - Put Buys - 1 Hour Interval

This figure shows a graph of the Proportional Bid on the Underlying Equity market in the 1-hour intervals prior to and following the off-market Put option Buy trades. The Proportional Bid is equal to (Midpoint$_{t=0}$ - Standing Bid)/Midpoint$_{t=0}$ for a Buy Trade. The proportional bid is examined because it is posited (according to the derivative hedge theory) that in the case of an informed put option purchase, market makers would protect themselves against a fall in the underlying equity and therefore would hedge themselves against the exposure by selling at the bid price in the underlying.

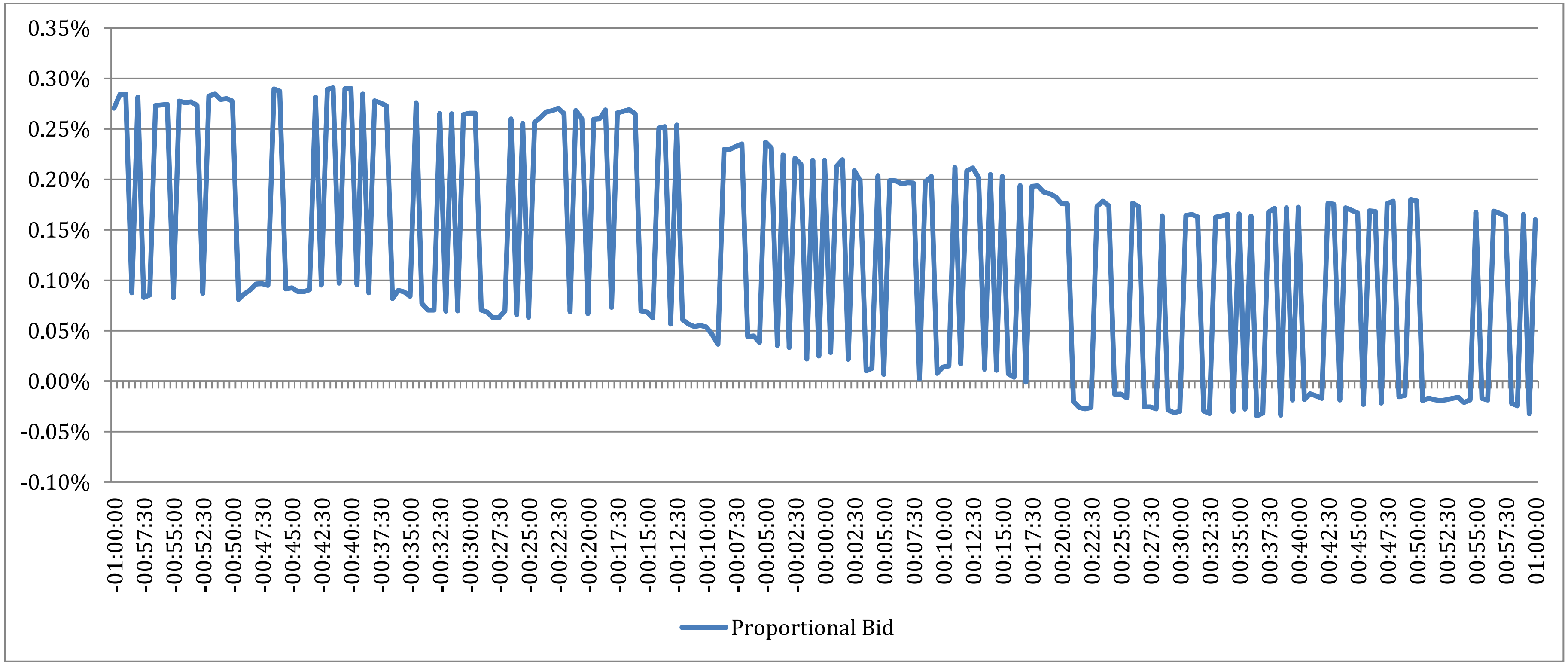


Table 4-14 Underlying Equity Market Proportional Bid- Put Buys -10 Minute Intervals

This table presents the mean Proportional Bid on the underlying Equity market in the 1-hour intervals prior to and following the off-market Put option Buy trades. The Proportional Bid is equal to ($Midpoint_{t=0}$ - Standing Bid)/$Midpoint_{t=0}$ for a Buy Trade. The sample includes 158 off-market Put option buy trades. Time 00:00 represents the time of trade. The proportional bid is examined because it is posited (according to the derivative hedge theory) that in the case of an informed put option purchase, market makers would protect themselves against a fall in the underlying equity and therefore would hedge themselves against the exposure by selling at the bid price in the underlying.

Time (hh:mm:ss)	*Mean Proportional Bid*	*p-value*
-01:00:00	0.003	0.174
-00:50:00	0.003	0.162
-00:40:00	0.003	0.142
-00:30:00	0.003	0.176
-00:20:00	0.001	0.010
-00:10:00	0.001	0.002
00:00:00	0.002	0.260
00:10:00	0.000	0.425
00:20:00	0.002	0.366
00:30:00	0.000	0.312
00:40:00	0.002	0.378
00:50:00	0.002	0.361
01:00:00	0.002	0.415

Figure 4-19 Options Market Proportional Ask - Put Sells - 1 Hour Interval

This figure shows a graph of the Proportional Ask on the Underlying Equity market in the 1-hour intervals prior to and following the off-market Put option Sell trades. The Proportional Ask is equal to (Standing Ask - $Midpoint_{t=0}$)/$Midpoint_{t=0}$ for a Sell Trade. The proportional ask is examined because it is posited (according to the derivative hedge theory) that in the case of an informed put option sell, market makers would protect themselves against a rise in the underlying equity and therefore would hedge themselves against the exposure by buying at the ask price in the underlying.

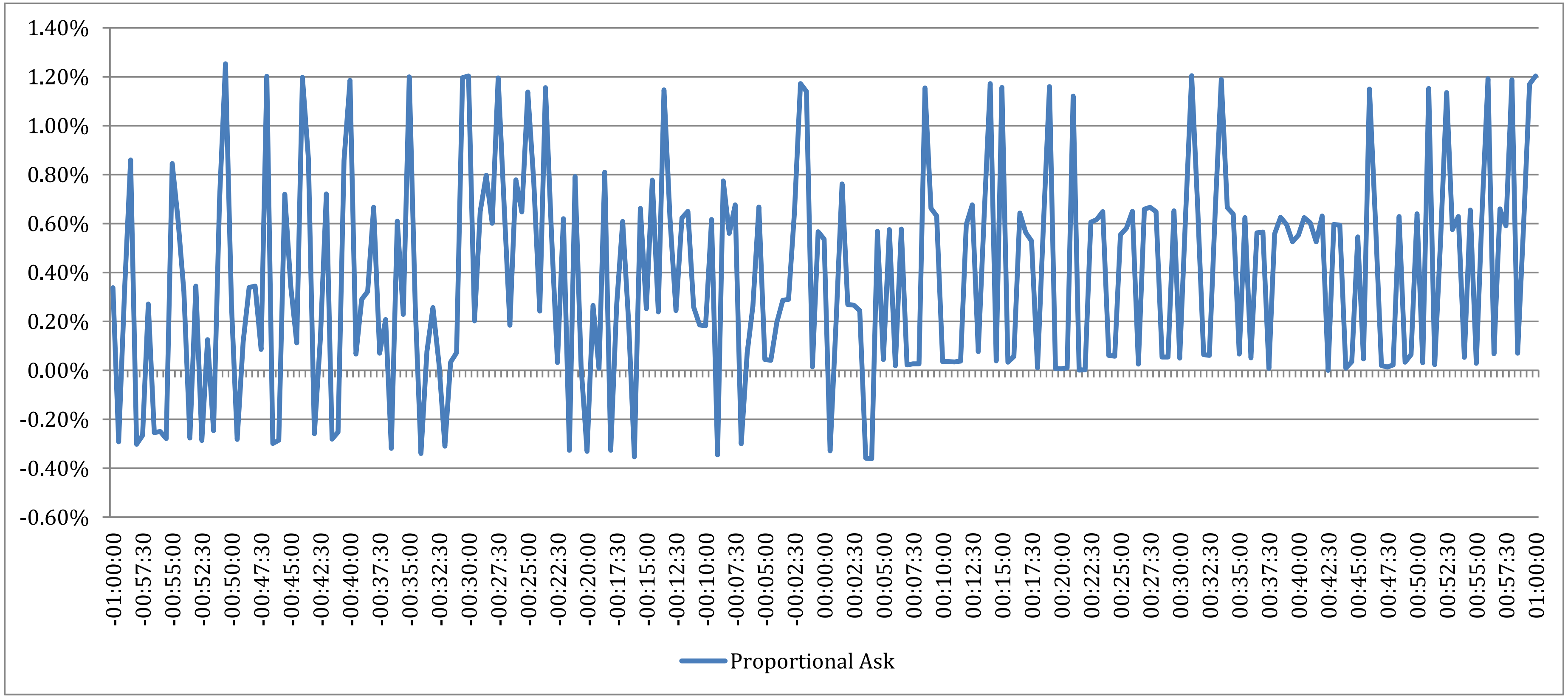


Table 4-15 Underlying Equity Market Proportional Ask- Put Sells -10 Minute Intervals

This table presents the mean Proportional Ask on the underlying Equity market in the 1-hour intervals prior to and following the off-market Put option Sell trades. The Proportional Ask is equal to (Standing Ask - $Midpoint_{t=0}$)/$Midpoint_{t=0}$ for a Sell Trade. The sample includes 90 off-market Put option sell trades. Time 00:00 represents the time of trade. The proportional ask is examined because it is posited (according to the derivative hedge theory) that in the case of an informed put option sell, market makers would protect themselves against a rise in the underlying equity and therefore would hedge themselves against the exposure by buying at the ask price in the underlying.

Time (hh:mm:ss)	*Mean Proportional Ask*	*p-value*
-01:00:00	0.003	0.646
-00:50:00	0.003	0.681
-00:40:00	0.012	0.144
-00:30:00	0.012	0.137
-00:20:00	-0.003	0.386
-00:10:00	0.002	0.781
00:00:00	0.005	0.314
00:10:00	0.000	0.358
00:20:00	0.000	0.880
00:30:00	0.000	0.372
00:40:00	0.006	0.301
00:50:00	0.006	0.283
01:00:00	0.012	0.132

Figure 4-18 presents the results for the proportional bid in the underlying equities around put option purchases. The proportional bid is examined because it is posited (according to the derivative hedge theory) that in the case of an informed put option purchase, market makers would protect themselves against a fall in the underlying equity and therefore would hedge themselves against the exposure by selling at the bid price in the underlying, and vice versa for put option sells. Figure 4-18 shows no evidence of price patterns in the underlying equities prior to and following the off-market put option purchases. Similarly, Figure 4-19 presents the results for the proportional ask in the underlying equities around put option sales. Again, it reveals similar results and no apparent price patterns. Table 4-14 and Table

4-15 present the proportional bid/ask at 10-minute intervals for off-market put option buys and sells, respectively. The results show no evidence of significant price patterns around the trades. Together, the results suggest that there is no evidence of option market makers hedging their exposure to large off-market put option trades in the underlying equities in the 1-hour prior to and following the trades.[29]

4.6.2 Price and Information effects of off-market option trades

Table 4-16 presents several execution cost measures for seller- and buyer- initiated off-market option trades. Across all categories there is no evidence of leakage effects or post-trade effects. The results, however, show that both Call buys and sells lead to a statistically significant positive temporary component of price change, which represents the compensation to liquidity providers.

[29] We also examine proportional bid/ask in both the options and underlying equities markets for 5-minute intervals when the data is split into call/put sells and buys and find similar empirical results.

Table 4-16 Intraday Price and Information effects of off-market option trades

This table reports the components of price effects in the Underlying Equity market for seller- and buyer-initiated off-market Call and Put option trades during the sample period. All price effects are adjusted for market movements in the Adjusted All Ordinaries Share Index. The adjustment is made by subtracting the relevant market index return from the stock's return. The trades are classified into buy and sell trades using the Lee and Ready (1991) algorithm.

Contract	*Trade Direction*	*n*	*Statistic*	*Leakage Effect = ln(P0) - ln(Pd)* *P(0) = md before trade* *P(d) = md -1Day close*	*Post-Trade Effect = ln(P1) - ln(P0)* *P(0) = md before trade* *P(1) = md +1Day close*	*Temporary Effect = ln(Pb) - ln(P1)* *Pb = block trade price* *P(1) = md +1Day close*
CALL	*BUY*	*151*	*Mean*	0.0021	-0.0014	0.0146
			P-Value	0.73	0.77	0.02
	SELL	*125*	*Mean*	-0.0015	0.0025	0.0108
			P-Value	0.78	0.45	0.05
PUT	*BUY*	*158*	*Mean*	0.0000	-0.0007	0.0007
			P-Value	0.98	0.79	0.78
	SELL	*90*	*Mean*	0.0052	0.0071	0.0023
			P-Value	0.29	0.41	0.67

To summarize, off-market option trades present no evidence of a leakage effect which is the price movements that occur in the CLOB as a result of the large options trade being shopped around and negotiated among numerous counterparties off-market. This finding is in contrast to Keim and Madhavan (1996). However, as previously noted, the findings of Keim and Madhavan (1996) cannot be generalised as their study was based on the trades of one particular firm. Further, the results also reveal that off-market option trades have no significant post trade impact, which represents the change in market value of a security following the trades. These results suggests that off-market options trades are largely perceived to be uninformed by the market. The results also suggest that off-market call option trades require compensation to liquidity providers in the form of a higher price than the equilibrium price. Put option trades experience no significant temporary price change following the trades. The results regarding off-market call option trades are consistent with Booth et al. (2002), Kraus and Stoll (1972), and Holthausen et al. (1987).

Table 4-17 Long Horizon Return Behaviour surrounding off-market option trades

This table reports the cumulative abnormal returns in the Underlying Equity market in the 30 days surrounding the off-market option trades. The sample includes all off-market option trades in our sample, categorized in to Puts and Calls and Buys and Sells. The abnormal returns are grouped into Pre-event (CAR-2,-30), Post-event (CAR+2,+30), and Event (CAR-1,+1) periods. Returns are calculated using the OLS market model. Day 0 is the announcement day of the trade. N reports the sample size per category, Mean reports the average cumulative return during the period, and p-value reports the significance level.

Contract	*Trade Direction*	*Event Period*	*N*	*Mean*	*p-value*
CALL	*BUY*	*CAR-2,-30*	151	0.0382	0.33
		CAR-1,+1	151	0.0129	0.03
		CAR+2,+30	151	0.0412	0.19
	SELL	*CAR-2,-30*	125	0.0559	0.11
		CAR-1,+1	125	0.0099	0.06
		CAR+2,+30	125	0.0194	0.45
PUT	*BUY*	*CAR-2,-30*	158	-0.0135	0.49
		CAR-1,+1	158	0.0009	0.74
		CAR+2,+30	158	-0.0069	0.73
	SELL	*CAR-2,-30*	90	-0.0336	0.36
		CAR-1,+1	90	-0.0001	0.99
		CAR+2,+30	90	0.0075	0.86

4.6.3 Price Behaviour surrounding off-market option trades

Table 4-17 provides a summary of the behaviour of the underlying share prices around off-market option trades split into call and put option buy and sell trades. The results indicate that on the event dates ($CAR_{-1,+1}$) share prices of both buy and sell trades in call options increase significantly. Off-market call option purchases on average lead to a 1.29% increase in the underlying share price, while off-market call option sales on average lead to a 0.99% increase. There is no evidence of significant underlying share price changes on the event dates of both put option buys and sells. Further, the results show that the pre-event ($CAR_{-2,-30}$) and post-event ($CAR_{+2,+30}$) abnormal returns are not significant across all categories. Overall, these results suggest there are no particular price patterns that lead to large off-market option trades. In addition, the findings do not provide support for the information hypothesis that predicts that the abnormal returns should be positive (negative) on the trade dates and in the post event period following the call option buy and put option sell (call option sell and put options buy) trades.

4.7 Summary

Prior empirical studies examine the role of off-market trading in liquidity provision for larger traders in the equities market, also referred to as block trading. The literature suggests that off-market trading lowers execution costs for large traders by reducing adverse selection costs as off-market broker-dealers can screen out informed traders and tap into unexpressed liquidity (Booth et al., 2002; and Bessembinder and Venkataraman, 2004). In addition, it is posited that off-market trading improves market quality by supplementing liquidity when on-market liquidity is not sufficient. Although these findings are based on empirical studies examining the equities market, this study tests these findings for the Australian Options Market (AOM) and the underlying equities market.

Results reveal that large off-market option trades on average receive price improvement. An analysis of bid and ask quotes indicates that large off-market option trades usually trade within the quoted best bid and ask quotes at the time of the trade across both put and call options, and across a number of characteristics including whether the trade was buyer or seller initiated. Further, analysis of bid-ask quotes around the trades at different time intervals from 5-minutes to 1-hour reveals no significant change before, during, and after the trades take place, both in the options market and the underlying equities market. These results imply that the market, on average, perceives large off-market option trades to be uninformed and therefore mostly utilitarian in nature.

The price impact analysis reveals that all large off-market option trades across all categories have an insignificant impact on the permanent component of price changes. However, an analysis of the components of execution costs uncovers that both off-market call buy and sell trades have a significantly positive impact on the temporary component of price change following the block trade. An examination of share price behaviour and abnormal returns in the days surrounding the off-market option trades finds no evidence of a price run-up leading up to the trades or a price continuation following the trades across all categories. It is noted that on the trade dates the share prices of both off-market call buy and sells increase significantly.

Together, the findings suggest that off-market options are able to tap into unexpressed liquidity in the upstairs market as they usually trade within the best standing bid and ask prices, in support of Grossman (1992). Further, the results lend support to the Seppi (1990) prediction that upstairs trading is also able to reduce execution costs for large traders by reducing adverse selection costs.

Chapter 5: Conclusions

This dissertation investigates market integrity issues in financial markets. The importance of market integrity issues is underscored by the increasing pace of change in financial markets as result of evolving financial instruments, markets, and technological advances. As market integrity concerns fair and informed markets, understanding the impact of novel market structures, financial instruments, trading procedures, and information disclosure practices is relevant to exchanges, investors, regulators, and academics. The literature reviews in Chapter 2, 3, and 4 identify a number of gaps in the existing literature.

First, the impact of information disclosure practices and the handling of confidential information are investigated in the European Union Emissions Trading Scheme (EU ETS) market for European Union Allowances (EUA). Prior literature only examines Phase I of the EU ETS. Phase II of the EU ETS warrants examination as Phase I was initiated as a trial phase in which no real carbon emissions abatement occurred. Phase II is the first Kyoto Protocol compliant phase of emissions trading and therefore likely to yield positive emissions abatement. This dissertation adds to the literature by investigating the impact of Phase II European Union emissions trading scheme (EU ETS) national allocation plan (NAP) announcements on carbon markets.

Second, with the proliferation of new technologies such as broker execution engines and high frequency algorithmic trading, the growing trend of cancelling trades that have already executed and been reported have emerged as a developing concern. These trades can lead to distorted prices among other market wide statistics. Further, there is evidence to suggest that some of these trades are in violation of exchange trading rules and possibly manipulative in nature. Thus, this dissertation initiates the first comprehensive investigation of trade cancellations to understand their magnitude and the impact on market integrity. This dissertation draws from theoretical and empirical research on market manipulation and applies it to the case of trade cancellations. Therefore, this dissertation also contributes to the literature on emerging forms of market manipulation.

Finally, although a large amount of theoretical and empirical literature examines block trading or upstairs trading in equity markets, there is a lack of empirical evidence for derivatives markets. Therefore, this dissertation contributes to the literature by examining the impact of large off-market trading in the options market.

Chapter 2 investigates the impact of Phase II EU ETS national allocation plan (NAP) announcements on carbon markets. The analysis is based on the notion that commodity markets are information driven mechanisms that determine equilibrium prices. If markets are active, the information is quickly disseminated among market participants who, upon trading, determine a fair price. Prices can also reflect information that is not publicly announced by a governmental agency but yet successfully forecasted by private agents or leaked by insiders.

Results indicate that Phase II NAP announcements have an effect on both Phase I and II front futures and the sole Phase II futures contracts. That is, Phase II NAP announcements act as new information for the Phase I EU ETS. Phase I verifications announcements, however, only affect the Phase I & II front futures, which is consistent with the information inherent in Phase I verifications, and the no banking of allowances between phases restriction. The results also find evidence of significant returns on the days leading up to both NAP and Verifications information becoming public. Further, there are no significant differences in the volatility of carbon returns before and after NAP and Verifications announcements.

Consistent with the findings of Mansanet-Bataller and Pardo (2007) regarding Phase I NAP announcements, the results demonstrate that there is significant abnormal returns up to 3-days prior to several Phase II NAP-related events, and that there is an absence of volatility effects when the information becomes public. Together, these findings suggest a systematic leakage of information across all types of announcements. Hence, findings in this chapter lend further support to the request made by the European Federation of Energy Traders (EFET, 2006) to the European Commission for carbon price sensitive information that was "*accurate, final and published in such a way as to be available to all market participants at the same time*".

Chapter 3 initiates the first comprehensive investigation of trade cancellations to understand their magnitude and the impact on market integrity. Market manipulation is defined as a deliberate attempt to interfere with the free and fair operation of a market and create artificial, false or misleading appearances with respect to the price of, or market for, a security. The investigation finds that trade cancellations as a proportion of total traded value on the ASX almost doubled from 0.69% to 1.16% between 2006 and 2009. The results suggest that a subset of cancelled trades can be defined as manipulative in nature. There is evidence that trade cancellations, on average, distort market VWAP and exhibit return reversal, volume, and volatility patterns consistent with market manipulation.

The findings also suggest that a substantial quantity of ‘crossed’ trades that are subsequently cancelled on the ASX may actually be illegal ‘wash trades’ intended to manipulate the market. The results on returns, volume, and volatility around the crossings are consistent with the intended effects of manipulative ‘wash trades’. Hence, these findings lend further support to the proposed changes recommended in the ASX REVIEW on *Algorithmic Trading and Market Access Arrangements* published on *8 February 2010.* They include the rule requirement that all brokers implement measures such as filters or algorithmic programming enhancements to prevent wash trades, and the proposed ASX review of fees for trades that are subsequently cancelled.

Following the presentation of certain parts of this investigation to the ASX, the ASX has reviewed their trade cancellations policy (TCP) and implemented the following changes in 2011. They have implemented a ‘qualifying’ cancellation price range in which trades can be can be cancelled without dispute by the ASX, a 10-minute window in which requests for cancellation must be made to the ASX, and the introduction of a cancellation fee schedule. The ASX believes that these changes will provide market users with additional certainty as to when trades will and will not be cancelled, minimise the impact of cancellations on the market by tightening the time-frame in which cancellation requests can be made, and streamline the cancellation process and provide quicker response times to cancellation requests by reducing, to the greatest extent practicable, ASX’s exercise of discretion.

Chapter 4 examines the impact of large off-market option trades on the AOM. Previous literature on block trading on equity markets finds that off-market trading lowers execution costs for large traders by reducing adverse selection costs and improves market quality by tapping into unexpressed liquidity in the upstairs market. Using a proprietary data set provided by the AOM, results show that off-market options are able to tap into unexpressed liquidity in the upstairs market as they usually trade within the best standing bid and ask prices, in support of Grossman (1992). Further, the results lend support to the Seppi (1990) prediction that upstairs trading is also able to reduce execution costs for large traders by reducing adverse selection costs.

The evidence shows that there are no significant changes in bid-ask spreads prior to and following the off-market option trades. Focussing on price impact on the underlying equities market, the findings provide no support for the Cho and Engle (1999) 'derivate hedge theory'. Leakage effects reveal that that there is no evidence of front running or a revision in the equilibrium price of the underlying stock prior to the large off-market option trade. However, following the off-market option trades there is evidence of positive temporary effects and compensation to liquidity providers in the case of call option trades. An examination of returns in the days surrounding the large off-market option trades also reveals no significant price patterns. Overall, the results suggest that the market, on average, perceives off-market option trades to be uninformed and therefore mostly utilitarian in nature.

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Appendix

Table A-1

This table lists all the announcements analysed in Chapter 2, and their corresponding dates.

Letter Date	Registration Date	Point Carbon Date	Point Carbon Time CET	EC Time CET	Event Description	Member States
		17/10/2006	.	.	Draft NAP released, Phase II	Austria
15/01/2007	16/01/2007	15/01/2007	.	.	Notification of NAP, Phase II	Austria
5/03/2007	12/03/2007		.	.	Additional NAP info, Phase II	Austria
21/03/2007	26/03/2007				Additional NAP info, Phase II	Austria
2/04/2007	2/04/2007	2/04/2007	17:30	.	NAP approval, Phase II	Austria
		26/06/2006	.	.	Draft NAP released, Phase II (Walloon region)	Belgium (Walloon)
.	.	27/07/2006	.	.	Draft NAP released, Phase II (Flanders region)	Belgium (Flanders)
29/09/2006	19/10/2006	22/09/2006	16:36	.	Notification of NAP, Phase II	Belgium
13/12/2006	14/12/2006				Additional NAP info, Phase II	Belgium
22/12/2006	5/01/2007				Additional NAP info, Phase II	Belgium
22/12/2006	8/01/2007				Additional NAP info, Phase II	Belgium
16/01/2007	16/01/2007	16/01/2007			NAP approval, Phase II	Belgium
		9/03/2006			Draft NAP released, Phase II & 2007	Bulgaria
.	.	28/04/2006	16:08	.	Draft NAP rejected by parliament, Phase I	Bulgaria
16/04/2007	11/05/2007	30/03/2007	15:09		Notification of NAP, Phase II	Bulgaria
17/08/2007	23/08/2007				Additional NAP info, Phase II	Bulgaria
26/10/2007	26/10/2007	26/10/2007	12:20		NAP approval, Phase I and II	Bulgaria
11/10/2006	13/10/2006	13/10/2006	11:48		Notification of NAP, Phase II	Cyprus
12/12/2006	21/12/2006				Additional NAP info, Phase II	Cyprus
18/12/2006	5/01/2006				Additional NAP info, Phase II	Cyprus
12/01/2007	15/01/2007				Additional NAP info, Phase II	Cyprus
15/01/2007		16/01/2007	14:12		Withdrew original NAP, Phase II	Cyprus
27/02/2007	8/03/2007	26/03/2007	16:16		Notification of revised NAP, Phase II	Cyprus
22/05/2007	25/05/2007				Additional revised NAP info, Phase II	Cyprus
18/07/2007	18/07/2007	18/07/2007	12:54		NAP approval, Phase II	Cyprus
		30/10/2006	14:16		Draft NAP released, Phase II	Czech Republic
8/12/2006	11/12/2006	7/12/2006	11:05		Notification of NAP, Phase II	Czech Republic
16/02/2007	21/02/2007				Additional NAP info, Phase II	Czech Republic
26/03/2007	26/03/2007	26/03/2007	12:35		NAP approval, Phase II	Czech Republic
		22/12/2006	10:54		Draft NAP released, Phase II	Denmark
7/03/2007	8/03/2007	7/03/2007	17:03		Notification of NAP, Phase II	Denmark
2/05/2007	4/05/2007				Additional NAP info, Phase II	Denmark
8/05/2007	11/05/2007				Additional NAP info, Phase II	Denmark
2/07/2007	3/07/2007				Additional NAP info, Phase II	Denmark
31/08/2007	31/08/2007	31/08/2007	12:02		NAP approval, Phase II	Denmark
		9/06/2006	9:31		Draft NAP released, Phase II	Estonia
7/07/2006	12/07/2006	29/06/2006	14:28		Notification of NAP, Phase II	Estonia
7/11/2006	9/11/2006				Additional NAP info, Phase II	Estonia
6/02/2007	15/02/2007	6/02/2007			Additional NAP info, Phase II	Estonia
4/05/2007	4/05/2007	4/05/2007	12:01		NAP approval, Phase II	Estonia
		30/06/2006	16:57		Draft NAP released, Phase II	Finland
		14/09/2006	10:11		Draft NAP Finalised, Phase II	Finland
24/10/2006	26/10/2006	11/10/2006	14:39		Notification of preliminary NAP, Phase II	Finland
25/01/2007	29/01/2007				Additional preliminary NAP info, Phase II	Finland
9/03/2007	12/03/2007				Notification of NAP, Phase II	Finland
21/05/2007	25/05/2007				Additional NAP info, Phase II	Finland
22/05/2007	25/05/2007				Additional NAP info, Phase II	Finland
4/06/2007	4/06/2007	4/06/2007	12:02		NAP approval, Phase II	Finland
		21/06/2006	15:22		Draft NAP released, Phase II	France
28/09/2006	28/09/2006	15/09/2006	15:20		Notification of NAP, Phase II	France
27/10/2006	8/11/2006				Additional NAP info, Phase II	France
28/11/2006		28/11/2006			Withdrew original NAP, Phase II	France
29/12/2006	5/01/2007	12/12/2006	18:35		Notification of revised NAP, Phase II	France
17/01/2007	23/01/2007				Additional NAP info, Phase II	France
13/03/2007					Additional NAP info, Phase II	France
15/03/2007					Additional NAP info, Phase II	France
26/03/2007	26/03/2007	26/03/2007	12:43		NAP approval, Phase II	France

		12/04/2006	11:20		Draft NAP released, Phase II	Germany
		28/06/2006	12:43		Draft NAP released, Phase II	Germany
30/06/2006	4/07/2006	28/06/2006	15:34		Notification of NAP, Phase II	Germany
26/09/2006	28/09/2006				Additional NAP info, Phase II	Germany
		24/11/2006	10:33		NAP ammendment, Phase II	Germany
29/11/2006	29/11/2006	29/11/2006	13:24	12:00:00	NAP approval, Phase II	Germany
21/12/2006					NAP ammendment, Phase II	Germany
26/01/2007	7/02/2007	8/02/2007	17:29		NAP ammendment additional info, Phase II	Germany
14/08/2007	14/08/2007				NAP ammendment additional info, Phase II	Germany
26/10/2007	26/10/2007	26/10/2007	12:18		NAP ammendment approval, Phase II	Germany
		30/06/2006	16:29		Draft NAP released, Phase II	Greece
1/09/2006	5/09/2006	1/09/2006			Notification of NAP, Phase II	Greece
14/11/2006	21/11/2006				Additional NAP info, Phase II	Greece
29/11/2006	29/11/2006	29/11/2006	12:03	12:00:00	NAP approval, Phase II	Greece
		20/10/2006	15:21		Draft NAP released, Phase II	Hungary
23/01/2007	23/01/2007	18/01/2007	11:00		Notification of NAP, Phase II	Hungary
2/04/2007	12/04/2007				Additional NAP info, Phase II	Hungary
16/04/2007	16/04/2007	16/04/2007	12:38		NAP approval, Phase II	Hungary
		12/05/2006	8:54		Draft NAP released, Phase II	Ireland
12/07/2006	14/07/2006				Notification of NAP, Phase II	Ireland
18/09/2006	25/09/2006				Additional NAP info, Phase II	Ireland
27/11/2006					Additional NAP info, Phase II	Ireland
29/11/2006	29/11/2006	29/11/2006	12:04	12:00:00	NAP approval, Phase II	Ireland
21/12/2006					NAP ammendment, Phase II	Ireland
23/04/2007	3/05/2007				NAP ammendment additional info, Phase II	Ireland
13/07/2007	13/07/2007	13/07/2007	17:46		NAP ammendment approval, Phase II	Ireland
		17/07/2006	10:56		Draft NAP released, Phase II	Italy
		17/10/2006	10:30		Draft NAP released, Phase II	Italy
		1/12/2006			Draft NAP released, Phase II	Italy
15/12/2006	21/12/2006	19/12/2006	11:00		Notification of NAP, Phase II	Italy
1/03/2007	2/03/2007				Additional NAP info, Phase II	Italy
23/03/2007	4/04/2007				Additional NAP info, Phase II	Italy
15/05/2007	15/05/2007	15/05/2007	12:01		NAP approval, Phase II	Italy
		12/04/2006	17:52		Draft NAP released, Phase II	Latvia
16/08/2006	1/09/2006	8/08/2006	12:37		Notification of NAP, Phase II	Latvia
8/11/2006	13/11/2006				Additional NAP info, Phase II	Latvia
16/11/2006	21/11/2006				Additional NAP info, Phase II	Latvia
29/11/2006	29/11/2006	29/11/2006	12:09	12:00:00	NAP approval, Phase II	Latvia
29/12/2006		28/12/2006			NAP ammendment, Phase II	Latvia
25/04/2007	27/04/2007				NAP ammendment additional info, Phase II	Latvia
13/07/2007	13/07/2007	13/07/2007	17:46		NAP ammendment approval, Phase II	Latvia
7/07/2006	17/07/2006	7/07/2006	14:06		Notification of NAP, Phase II	Lithuania
12/09/2006	12/09/2006				Additional NAP info, Phase II	Lithuania
22/11/2006	23/11/2006				Notification of revised NAP, Phase II	Lithuania
29/11/2006	29/11/2006	29/11/2006	12:06	12:00:00	NAP approval, Phase II	Lithuania
29/12/2006		29/12/2006			NAP ammendment, Phase II	Lithuania
18/04/2007	23/03/2007	25/04/2007	12:39		NAP ammendment additional info, Phase II	Lithuania
13/07/2007	13/07/2007	13/07/2007	17:46		NAP ammendment approval, Phase II	Lithuania
18/07/2006	2/08/2006	18/07/2006			Notification of NAP, Phase II	Luxembourg
20/10/2006	13/11/2006				Additional NAP info, Phase II	Luxembourg
6/11/2006	21/11/2006				Additional NAP info, Phase II	Luxembourg
29/11/2006	29/11/2006	29/11/2006		12:00:00	NAP approval, Phase II	Luxembourg
28/12/2006					NAP ammendment, Phase II	Luxembourg
23/02/2007	12/03/2007				NAP ammendment additional info, Phase II	Luxembourg
18/06/2007	19/06/2007				NAP ammendment additional info, Phase II	Luxembourg
13/07/2007	13/07/2007	13/07/2007	17:46		NAP ammendment approval, Phase II	Luxembourg
		30/05/2006	11:25		Draft NAP released, Phase II	Malta
27/09/2006	2/10/2006	12/10/2006	10:30		Notification of NAP, Phase II	Malta
23/11/2006	27/11/2006				Additional NAP info, Phase II	Malta
29/11/2006	29/11/2006	29/11/2006	12:10	12:00:00	NAP approval, Phase II	Malta
9/01/2006	23/01/2006	.		.	Additional NAP info, Phase I	Poland
30/06/2006	6/07/2006	27/06/2006		.	Notification of NAP, Phase II	Poland
5/07/2006	5/07/2006	30/06/2006	15:53	14:00:00	NAP approval, Phase I	Poland
29/12/2006	8/01/2007				Additional NAP info, Phase II	Poland
26/03/2007	26/03/2007	26/03/2007	12:27		NAP approval, Phase II	Poland
.	.	23/05/2006	11:11	.	Draft NAP released, Phase II	Poland
.	.	21/06/2006	14:35	.	Draft NAP released, Phase II	Poland

		2/06/2006			Draft NAP released, Phase II	Portugal
30/10/2006	30/10/2006	30/10/2006			Notification of NAP, Phase II	Portugal
8/02/2007	15/02/2007				Additional NAP info, Phase II	Portugal
4/05/2007	16/05/2007	16/05/2007			Additional NAP info, Phase II	Portugal
1/08/2007	6/08/2007				Additional NAP info, Phase II	Portugal
22/10/2007	22/10/2007	22/10/2007	12:04		NAP approval, Phase II	Portugal
		4/09/2006	12:41		Draft NAP released, Phase II	Romania
21/12/2006	4/01/2007	15/11/2006	15:41		Notification of preliminary NAP, 2007 & Phase II	Romania
4/04/2007	3/05/2007				Additional NAP info, 2007 & Phase II	Romania
8/05/2007	6/06/2007				Notification of revised NAP, 2007 & Phase II	Romania
6/08/2007	7/08/2007				Notification of NAP, 2007 & Phase II	Romania
6/08/2007	7/08/2007				Additional NAP info, 2007 & Phase II	Romania
7/09/2007	10/09/2007				Additional NAP info, 2007 & Phase II	Romania
26/10/2007	26/10/2007	26/10/2007	12:21		NAP approval, Phase I and II	Romania
		18/05/2006	12:41		Draft NAP released, Phase II	Slovakia
		6/07/2006	12:54		Draft NAP released, Phase II	Slovakia
18/08/2006	25/08/2006	17/08/2006	13:16		Notification of NAP, Phase II	Slovakia
19/10/2006	25/10/2006				Additional NAP info, Phase II	Slovakia
29/11/2006	29/11/2006	29/11/2006	12:09	12:00:00	NAP approval, Phase II	Slovakia
29/12/2006		3/01/2007	15:34		NAP ammendment, Phase II	Slovakia
16/04/2007					NAP ammendment additional info, Phase II	Slovakia
30/05/2007					NAP ammendment additional info, Phase II	Slovakia
2/08/2007					NAP ammendment additional info, Phase II	Slovakia
10/09/2007	19/09/2007				NAP ammendment additional info, Phase II	Slovakia
7/12/2007	7/12/2007	7/12/2007	12:06		NAP ammendment approval, Phase II	Slovakia
		8/09/2006	12:30		Draft NAP released, Phase II	Slovenia
2/11/2006	7/11/2006	20/10/2006	10:23		Notification of NAP, Phase II	Slovenia
8/01/2007	9/01/2007				Additional NAP info, Phase II	Slovenia
30/01/2007	30/01/2007				Additional NAP info, Phase II	Slovenia
5/02/2007	5/02/2007	5/02/2007	11:57		NAP approval, Phase II	Slovenia
		12/07/2006	12:43		Draft NAP released, Phase II	Spain
30/11/2006	4/12/2006	24/11/2006	16:09		Notification of NAP, Phase II	Spain
1/02/2007	5/02/2007				Additional NAP info, Phase II	Spain
22/02/2007					Additional NAP info, Phase II	Spain
26/02/2007	26/02/2007	26/02/2007	12:10		NAP approval, Phase II	Spain
		8/06/2006	12:28		Draft NAP released, Phase II	Sweden
1/09/2006	13/09/2006	31/08/2006	12:13		Notification of NAP, Phase II	Sweden
29/11/2006	29/11/2006	29/11/2006	12:07	12:00:00	NAP approval, Phase II	Sweden
21/12/2006					NAP ammendment, Phase II	Sweden
20/05/2007	20/06/2007				NAP ammendment additional info, Phase II	Sweden
13/07/2007	13/07/2007	13/07/2007	17:46		NAP ammendment approval, Phase II	Sweden
10/11/2007	17/11/2007				Additional NAP info, Phase II	Sweden
		16/11/2005	12:42		Draft NAP released, Phase II	The Netherlands
		4/09/2006	19:18		Draft NAP released, Phase II	The Netherlands
28/09/2006	29/09/2006	21/09/2006	12:47		Notification of NAP, Phase II	The Netherlands
13/10/2006	17/10/2006				Additional NAP info, Phase II	The Netherlands
19/10/2006	23/10/2006				Additional NAP info, Phase II	The Netherlands
15/12/2006	22/12/2006				Additional NAP info, Phase II	The Netherlands
17/01/2007	17/01/2007	16/01/2007	13:43		NAP approval, Phase II	The Netherlands
		28/03/2006			Draft NAP released, Phase II	United Kingdom
		29/06/2006	14:29		Draft NAP released, Phase II	United Kingdom
28/08/2006	30/08/2006	21/08/2006	15:28		Notification of NAP, Phase II	United Kingdom
3/10/2006	9/10/2006				Additional NAP info, Phase II	United Kingdom
6/11/2006	13/11/2006				Notification of revised NAP, Phase II	United Kingdom
29/11/2006	29/11/2006	29/11/2006	12:02	12:00:00	NAP approval, Phase II	United Kingdom