Algorithmic Trading and Market Access Arrangements

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Executive Summary

Background

In July 2009, having observed sustained growth in algorithmic trading, the Australian Securities Exchange (ASX) initiated a review of algorithmic trading and market access arrangements in Australia ('the ASX Review')[1]. The ASX Review was aimed at determining the impact of algorithmic trading in Australia, assessing the future growth of algorithmic trading, and identifying ways to meet demand from customers for alternative access arrangements to ASX's market without undermining market integrity. While ASX has been active in facilitating what has become a global phenomenon of algorithmic trading since 2006, and remains committed to developing liquidity through algorithmic trading and enhanced market access, it is mindful of ensuring that its ongoing development does not have a negative impact on market integrity or quality. ASX also notes that other jurisdictions in North America and Europe have since commenced similar reviews of the impact of algorithmic trading.

The Australian Securities and Investments Commission's (ASIC) Market Assessment Report of ASX for calendar year 2008, released in September 2009, also referred to the ASX Review. ASIC recommended that certain issues be covered, including the adequacy of ASX operating rules. This report has been prepared to convey to ASIC the findings of ASX's Review as well as identify initiatives that ASX should implement in its capacity as a licensed market operator.

Subsequent to the objective setting and commencement of the ASX Review, the Australian Government announced the transfer of certain supervisory responsibilities from ASX to ASIC, scheduled to be completed in the third quarter of 2010.[2] The transfer of these responsibilities means that some (but by no means all) of the recommendations in the ASX Review are now provided for consideration by ASIC as the prospective whole-of-market supervisor, rather than for ASX as a market operator.

This paper is also being released more widely to help develop a broader understanding of the issues raised by algorithmic trading both for today and in the future, as well as to begin to address a number of concerns from some retail investors about algorithmic trading.

Introduction

What is algorithmic trading?

While trading has occurred electronically for many years, it has been in the past five years that equity markets globally have undergone the most profound technological change. Advances in technology have dramatically altered the way in which orders are executed. Rather than orders being entered into the market manually by broker operators, there has been an increasing trend towards orders being generated by computer algorithms seeking to minimise market impact costs for clients and to capture proprietary trading opportunities.

There is no commonly agreed definition of algorithmic trading. It describes a very broad range of trading activities utilising computer technology. For the purposes of the ASX Review, algorithmic trading is defined as *computer generated trading activity whose parameters[3] are determined by strict adherence to a predetermined set of rules aimed at delivering specific execution outcomes*.

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[1] http://www.asx.com.au/about/pdf/mr_280909_asx_response_asic_group_activities_report09.pdf
[2] Relevant excerpts from the Government's announcement read: "The Government has decided to provide for the Australian Securities and Investments Commission (ASIC) to perform supervision of real-time trading on all of Australia's domestic licensed markets. This change will mean that ASIC will now be responsible for both supervision and enforcement of the laws against misconduct on Australia's financial markets… The changes will mean that ASIC will become responsible for supervising trading activities by broker participants which take place on a licensed financial market, while individual markets – such as the Australian Securities Exchange (ASX) - will retain responsibility for supervising the entities listed on them." The full text of the Minister's announcement is available at:
http://minscl.treasurer.gov.au/DisplayDocs.aspx?doc=pressreleases/2009/013.htm&pageID=003&min=ceba&Year=2009&DocType=0
[3] For example: volume, price, security, market, type, timing of execution, news event.

The emergence of algorithmic trading has resulted in a substantial increase in the speed of trade execution and the number of transactions executed on a daily basis, and a significant reduction in the average value of each trade. Technological advances have also driven the demand for new access arrangements (such as direct market access (DMA) and co-location facilities) as both brokers and end-users seek to improve their speed of trade execution.

Impacts of Algorithmic Trading

ASX has played an active role in facilitating algorithmic trading through the ongoing investment in technology capacity, changes to its fee structures, and the introduction of co-location services. In doing so, ASX acknowledges the positive effect that algorithmic trading can have on liquidity - to the benefit of both ASX and the broader market.

ASX anticipates that algorithmic trading in Australia will increase more rapidly in the coming years. This will be fuelled by further technological advances and the ongoing sophistication of a diverse range of investors. In particular, algorithmic trading will, in all likelihood, significantly increase if the Government grants licences to alternative market operators to trade ASX listed securities. This is because sophisticated algorithmic traders, not yet active in the Australian market, will seek to take advantage of new arbitrage opportunities that would become available as a result of liquidity fragmentation across different trading platforms.

Indeed, new market operator aspirants have indicated their intention to bring these new 'liquidity providers' to Australia. This is an example of how regulation can enable or even create trading opportunities that were previously not possible or profitable – and it generates implications for brokers and for less sophisticated investors in terms of trading costs and trading/investment decisions. It also has profound implications for supervisors and market operators in terms of seeking to preserve market and operational integrity, and it raises some important public policy issues about balancing the interests of short-term traders with those of long-term investors.

A significant proportion of algorithmic trading (both buy and sell side) is conducted for market impact minimisation, arbitrage, asset allocation, and many other traditional trading strategies. However, a small number of trading algorithms in use internationally employ strategies that, if they became widely used in Australia, would raise questions about their impact on the supervision of the local equity market and on non-algorithmic market users (particularly retail investors). The ASX Review noted that regulators in other jurisdictions, where the evolution of algorithmic trading is more advanced than in Australia, are only just beginning to understand and address the emerging issues that these algorithms raise.

When considering these complex issues, it is important to avoid simplistic characterisations. Algorithmic trading is not inherently harmful to market integrity or quality – in fact algorithmic trading plays an important role in developing liquidity. Equally, algorithmic trading is not, by definition, inherently good for market quality and integrity. Significant order flow generated by an algorithm should not be considered as synonymous with 'liquidity', and therefore desirable regardless of its impact. Rather, the growth in algorithmic activity has generated new issues which to date have not been evident in Australia, but for which the Australian regulatory framework and whole-of-market supervisory infrastructure needs to be equipped.

The experience overseas and lessons for Australia

The regulatory framework is a key determinant of likely future trends in algorithmic trading and a key protector of market integrity and quality. The Australian Government has previously indicated that it may move toward a market structure with multiple platforms trading the same securities. It is therefore appropriate to look overseas to jurisdictions where multiple platforms trading the same securities already operate, to help inform how changes to Australia's equity market microstructure are likely to affect the growth of algorithmic trading, to examine what issues this would raise, and to avoid some of the pitfalls encountered elsewhere. In doing this, it is also important to acknowledge the differences between the

Australian market and other jurisdictions - for example, the absence of the practice of 'flash orders[4]' on the ASX cash equity market and the relatively small scale of the Australian market.

In North America and Europe, the impact of algorithmic trading, as well as the impact of liquidity fragmentation across competing market operator environments, has raised complex supervisory issues. In the past month, the US Securities and Exchange Commission (SEC) has published a consultation paper as part of its review of US equity market microstructure and, specifically, of the impact of high frequency trading (a subset of algorithmic trading described later in this paper).

The SEC's review attempts to reconcile the role of the market as a means of facilitating efficient capital formation and risk transfer, with the arguably unforseen increase in high frequency trading volumes that have flowed from regulatory changes designed to facilitate competition between trading venues. The SEC review also notes that markets are not ends unto themselves - rather, they are the means for investors to save for the future, and to allocate those savings efficiently among companies that put that capital to work in the economy.

The SEC review underlines the importance of Government decision-making on equity market micro-structure reform. Such reform must ensure that public policy settings balance the interests of short-term traders and long-term investors, and are not compromised in the short-term pursuit of 'liquidity' or by creating an inadvertent bias towards a subset of algorithmic market users.

In Australia, macro or whole-of-market impacts from any market microstructure reform need to be examined as part of the Government's consideration of whether to grant licences to alternative market operators to facilitate trading in ASX listed securities. In the event that licences are granted, the Government must give careful consideration to the appropriate legislation and regulation (through the creation of comprehensive rules common to each market operator) in order to preserve market quality and integrity, and to ensure that change is in the broad public interest, not only in the interests of promoting competition between market operators.

The importance of these issues and the prospect of exponential growth in algorithmic trading in Australia, makes the content and publication of the ASX Review timely.

What the ASX Review does

Firstly, the ASX Review assesses the impact that algorithmic trading and changes to access arrangements have already had on ASX's markets. While ASX has for some time invested in significant enhancements to its technology infrastructure, functionality, rules framework, pricing and supervisory processes to both accommodate algorithmic trading and to manage its impact on the market, the ASX Review identifies areas where ASX can (and will) further improve the operation of its cash equity market.

Secondly, drawing on the experiences of markets in North America and Europe, the ASX Review looks forward and anticipates the issues that are likely to arise as the growth of algorithmic trading accelerates in Australia. ASX is currently responsible for both operating the market and for supervising broker conduct in relation to the market. In the third quarter of 2010, ASIC is scheduled to take over responsibility for certain market monitoring and broker supervision functions, and for all investigation and enforcement activity. As well as making recommendations for actions to be taken by ASX to further improve the operation of its markets, the ASX Review also makes recommendations for consideration by ASIC. These recommendations are made to ASIC, for the most part, as a practical consequence of the transfer of supervisory responsibilities from ASX to ASIC.

Importantly, the substance of several of the recommendations results from the findings of the ASX Review regarding the effect of a multi-market operator environment on algorithmic trading. ASX makes these recommendations in the interests of ensuring that effective whole-of-market supervision is maintained and confidence in the integrity and quality of Australia's exchange-traded markets is preserved.

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[4] The disclosure of an unexecuted order by an exchange to algorithmic traders to provide an opportunity to trade prior to fulfilling the exchange's obligation to route the order to an alternative platform displaying a better price.

On 28 January 2010 the Government announced its intention to strengthen ASIC's powers in relation to insider trading and market manipulation. Ensuring that ASIC has the appropriate surveillance tools and capabilities is an important step in enabling ASIC to effectively use those strengthened powers. ASX believes that supervisory effectiveness would be improved further by a comprehensive review of the market manipulation provisions within the Corporations Act to ensure that these are adequately drafted to capture contemporary forms of trading and to provide for a more granular definition of market manipulation.

Scope

The scope of the ASX Review has been extensive, and has involved:

1. Identifying the generic types of algorithms that are currently employed and the algorithmic products currently offered by brokers;

2. Estimating current and future trading volumes executed through these algorithms;

3. Identifying potential supervisory and operational issues;

4. Identifying initiatives to enhance the operational environment (over and above improvements to ASX systems, rules and processes already underway);

5. Identifying changes to the ASX rule framework to more efficiently facilitate user access (including introducing 'Sponsored Access' for ASX);

6. Identifying potential regulation, rule, procedure and functional improvements to the control features available to ASX for the cash equity market, recognising the changes which are anticipated to be made to ASX's role from the third quarter 2010;

7. Identifying potential rule, procedure and functional improvements to the control features available for participants to manage their clients; and

8. Making recommendations for the whole-of-market supervisory infrastructure to enhance the supervisory environment post the scheduled transfer of certain market supervisory responsibilities in the third quarter 2010.

The specific issues which ASIC asked ASX to consider were:

1. The adequacy and consistency of ASX group's operating rules and procedures, in setting minimum risk and operational requirements for participants in enabling direct market access to clients;

2. Whether the operating rules set suitable standards of accountability by participants for the trading activities of their direct market access clients;

3. Whether retail investors are adequately informed about the nature of the direct market access services and the characterisation of the securities and investments that they acquire via this service; and

4. Developments in international best practice standards for the provision of direct market access services and the supervision of algorithmic trading.

All findings and recommendations contained within the ASX Review reflect ASX's understanding of developments in international best practice adapted for the Australian market context.

Methodology

In conducting this Review, ASX formed an internal project team with representation from across the organisation, including Market Operations, Regulatory and Public Policy, ASX Markets Supervision (ASXMS) and Business Development. The team focused on delivering the scope of the Review by a three-stage process:

1. Desktop research and reviews of academic and industry literature, complemented by a mix of internal workshops, conference attendance, and some external meetings with ASX Participants;

2. Face to face meetings with supervisory bodies (Finra[5], NYSE Regulation, IIROC[6], FSA), exchanges and electronic crossing networks (NYSE, Nasdaq, BATS, DirectEdge, TMX, LSE), market users and technology providers in North America and Europe to learn from their experiences; and

3. Research commissioned from SIRCA, an independent research body, to look at the effects of algorithmic trading on ASX equity market quality from 2006 to 2009.

A summary of the findings of the ASX Review are included below, and are dealt with in more detail in the body of this document.

Summary of the ASX Review Findings - Backward-Looking

The ASX Review found that, to date, there have been no significant supervisory issues raised by algorithmic trading on the ASX cash equity market. While there has been an increase in customer complaints to ASX about 'unusual' patterns of behaviour attributable to algorithmic trading, ASXMS investigations of these complaints have not identified any instances of market manipulation directly related to algorithmic trading. That said, the ASX Review found that orders entered by algorithms can create dynamic price movement not previously observed by investors that can (from an historical interpretation perspective) appear to be prima facie evidence of manipulation.

In order to better understand the effect of algorithms, it is necessary to understand what algorithms are seeking to achieve. *Execution algorithms* were developed to minimise the market impact of large orders and therefore reduce the costs of trading. The most common of these is VWAP – an algorithm designed to achieve, or better, the volume weighted average price of a security over a day. VWAP reportedly remains the most commonly used execution algorithm for buy-side traders in the Asian region.

Situational algorithms have evolved more recently and are more sophisticated algorithms, which seek to profit from changes in data, information and events. In contrast to an execution algorithm that is used to execute a pre-existing order in the most efficient manner, a situational algorithm will create orders from a computer-generated algorithmic strategy as well as execute the orders as efficiently as possible. Generally speaking, execution algorithms are used by investors[7], while situational algorithms are used by traders.

The ASX Review concluded that education of stakeholders, investors and issuers is needed to develop a broader understanding of both execution and situational algorithmic trading and to address some of the misconceptions (and hence prejudices) about their purpose and uses. In anticipation of the inevitable rise in complaints that will occur as algorithmic trading increases and as the price discovery process becomes more complex and dynamic, it is important to understand execution and situational algorithms when attempting to identify potential integrity issues or their impact on market quality.

Empirical research undertaken by SIRCA (attached under Appendix 1) concluded that there has been an increase in algorithmic trading over the past three years, but, importantly, that algorithmic trading has not led to significant changes in the quality of ASX's markets. Market metrics such as bid-ask spreads have not significantly changed, nor has a correlation been found between the long-term trend in liquidity and volatility, and the increasing use of algorithms.

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[5] Market supervisor for Nasdaq and other US trading platforms.
[6] Canada's cross-market supervisor.
[7] Albeit many investors do not use algorithms at all.

Having said this, the research does show that market depth[8] improved significantly towards the end of the global financial crisis, increasing by around 250% between March and September 2009. This may be as a result of the lifting of the regulatory short selling ban put in place in the aftermath of the collapse of Lehman Brothers in September 2008, the general recovery in market confidence, as well as the increased use of the ASX co-location facility by algorithmic traders. It also coincided with a significant increase in the number of orders generated on ASX. However, the reasons for the change are not as important as the fact that these significant increases in market depth and order proliferation do not appear to have translated into significantly greater turnover (as seen in the following table).

While the ASX Review draws no firm conclusions as to why this has occurred, it does raise questions as to whether definitions of 'liquidity' need to be re-examined – particularly since orders in the market may only appear for very short periods of time (consistent with the trading strategies of some algorithmic traders). 'Liquidity' and 'order proliferation' should not be used inter-changeably, as the relationship between them is poorly understood.

Considering that increased use of 'dark pools[9]' in Australia has occurred over the same period as increased market depth and order proliferation in the central market, this provides some prima facie evidence that the additional orders contributing to increased market depth are either not accessible or attractive to those that have directed order flow to 'dark pools'. ASX intends to commission further research from SIRCA to identify appropriate methodologies to define and analyse 'liquidity'. The identification of genuine liquidity providers (distinct from order proliferators) is a key objective of ASX to ensure fee structures and incentives are set appropriately. For policy makers, distinguishing between liquidity and order proliferation is important when considering the benefits and costs of facilitating the trading of securities on multiple platforms.[10]

Operationally, the ASX Review noted that there has been a significant change in a number of metrics as shown in the table below, with value traded reflecting the impact of the GFC:

ASX Cash Equity Market Trade Metrics:

	2007	2008	2009
Value Traded (billion)	$1,576.4	$1,393.5	$1,153.6
Number of Trades (million)[11]	68.2	106.3	115.8
Number of Order Book Changes (million)	333.9	562.7	826.7
Average Trade Size	$23,092	$13,108	$9,961
Number of Errors[12]	24	20	12
Number of Crossing Trades Cancelled[13]	126,854	195,677	338,951

Most notably, there has been a significant increase in trading activity (in terms of orders and trades) as well as a reduction in the average trade size. These are all prima facie evidence of an increase in the use of algorithmic trading in Australia[14]. Also notable is the fact that the number of errors over the same period has declined. However, there has been a significant increase in trade cancellations, as a result of an

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[8] The $ value of unexecuted (or 'resting') buy and sell orders in the order book
[9] Broadly speaking, a dark pool is a non-public, non-transparent venue for executing orders away from the central market.
[10] The SEC discusses the use of market quality metrics in its recent Concept Release on Equity Market Structure, requesting comment on whether new measures of market quality are needed to reflect changes in market microstructure. See: http://www.sec.gov/rules/concept/2010/34-61358.pdf page 35.
[11] Includes billable and non-billable trades.
[12] A trade that is executed sufficiently away from the market price that ASX in consultation with the Dispute Governors Committee, determines that the trade will be cancelled. The error can be identified by ASX, the Participant or a third party, and ASX does not seek counterparty approval for the cancellation.
[13] Many of these cancelled trades may have been subsequently reported at corrected prices or volumes.
[14] Algorithmic trading is not specifically identifiable through ASX trade data as it is transmitted to ASX through generic interfaces in the ASX trading platform that may comprise a mix of manual and algorithmic order flow.

increase in the number of wash trades[15], and this is consistent with the increased use of algorithms. Trade cancellations impact on the accuracy of VWAP and TWAP[16] calculations if trades are cancelled after the average price has been calculated. The ASX Review identified a range of measures that ASX should implement to reduce the instances of trade cancellations.

In addition, the ASX Review identified improvements to ASX processes for granting and removing access to the market. These changes would reduce risks to market integrity in the instance of a malfunctioning algorithm by improving the speed that ASX can remove access to the market for such an algorithm.

Furthermore, the ASX Review acknowledges the demand from brokers to provide their clients with enhanced DMA services, and that ASX must develop the appropriate operational and risk management mechanisms before providing those services, as well as ensuring that brokers have appropriate controls in place to manage client access.

While the issue of capacity[17] management has been a key ASX focus for several years, the ASX Review did not identify any new requirements to add to the ongoing program of technology enhancements to ASX infrastructure currently underway to meet the anticipated growth in algorithmic trading, as well as the expected increase in the number of orders and trades generated on ASX markets.

Summary of the ASX Review Findings - Forward-looking

The ASX Review found that the Australian equity market has not yet experienced algorithmic trading activity on anything like the scale (or of the type) that is prevalent on overseas markets.

Situational algorithms are far more prevalent in North America and Europe because of the existence of multiple trading platforms for the same listed securities. These markets are particularly attractive to high frequency trading (HFT), a sub-set of situational algorithmic trading. HFT lacks a commonly agreed definition (primarily because the collective term for HFT describes an increasingly diverse set of algorithms). However it loosely refers to trading strategies that generate significant order flow and trades, with positions typically closed out before the end of the day. HFT is highly dependent on low execution latency[18] to be successful.

The attraction of HFT algorithms to these markets is primarily due to the fragmentation of liquidity. Fragmentation of liquidity generates new arbitrage trading opportunities that are not present in a single market environment such as Australia. Because the arbitrage opportunity often manifests itself for a very short period of time (typically a brief pricing anomaly between trading platforms), HFT algorithms generate significant numbers of orders and seek to liquidate their exposure as quickly as possible. As a result, positions are typically held for a matter of seconds or even a fraction of one second. This type of 'liquidity provider' has not been present in Australia due to the absence of liquidity fragmentation in the consolidated order book operated by ASX.

Other types of HFT also raise questions for ASX as a market operator and for ASIC as whole-of-market supervisor. For example, some so-called 'momentum' algorithms have the potential to distort price discovery for a security. Within a multi-market operator environment, where liquidity has been fragmented and where maker-taker pricing encourages algorithms to 'chase' one another to receive incentives, the risk of price distortion increases significantly. This behaviour could impact on long-term investors' immediate costs of trading, and also the accurate measurement of value of funds invested, through distortions in unit pricing at reporting dates. The ASX Review concurred with ASIC's view that the need for the use of controls (such as 'circuit breakers'[19]) as a mechanism to limit the risk of significant price distortion should be assessed, noting that circuit breakers may themselves also introduce their own unintended risks or consequences. The ASX Review also recommends that ASIC should consider what constitutes market manipulation in these circumstances.

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[15] The execution of a buy order against a sell order for the same beneficial owner.
[16] Time Weighted Average Price.
[17] The ability to process orders, disseminate prices and execute, clear and settle trades in a timely manner.
[18] The time it takes to execute an order and receive confirmation on a trading platform.
[19] A circuit breaker is an automatic trading halt designed to address issues of disorderly trading. The concept can apply to whole-of-market halts (typically imposed to manage systemic risk) or to individual security halts (typically imposed to reduce volatility and promote orderly price discovery by allowing time for both sides of the order book to replenish).

Aware of the need to ensure that market quality and integrity are not compromised and, in particular, that retail investors are not disadvantaged, policy makers in North America and Europe have created 'common rules' in an attempt to ensure investors are fairly treated when trade execution becomes a complex process of searching for liquidity across multiple trading platforms. While entirely appropriate as an objective, in some instances this has led to the unintended consequence of creating advantages for algorithmic traders as brokers and market operators seek to ensure compliance with the best execution obligations contained within those 'common rules'.

In the North American and European markets, HFT algorithms compete with one another to take advantage of these opportunities, and a 'multiplier effect' is created which drives massive order proliferation. This is further fuelled by the maker-taker pricing models present in those markets that incentivise HFT algorithms to post large quantities of small orders in order to receive revenue incentives.

A way of measuring order proliferation is to measure the ratio between orders posted on a market and trades generated as a result. The ratio of orders to trades is important, as it is a key indicator of the data management, systems, and network challenges for end-users, brokers, exchanges and supervisors/regulators. *ASX currently exhibits a relatively low order/trade ratio of approximately 7:1 and is indicative of relatively low levels of HFT activity. Averages in the North American and European markets are in the region of 100:1 (with peaks of 250:1), and demonstrate the extent of order proliferation resulting from HFT explained above.*

There is no doubt that advances in technology will continue to drive growth in the proportion of trades executed by algorithms within the Australian equity market under the existing market microstructure framework. However, the ASX Review found that there is a strong likelihood that any Australian market microstructure reforms similar to those in North America or Europe will facilitate significant additional algorithmic trading (particularly HFT) and will result in exponential growth in the number of orders generated.

For brokers and other infrastructure providers this creates new capacity challenges, and the ASX Review has identified a need to review the business continuity processes of these stakeholders.

For the whole-of-market market supervisor, the prospect of a substantial increase in order traffic and the potential for new forms of market manipulation (known as micro-manipulation[20]) across multiple trading platforms will not only drive the need for new whole-of-market supervisory core competencies and data management technologies, but also new whole-of-market surveillance tools and processes to maintain overall market integrity that have been not necessary to adopt by ASX operating a single trading platform.

To achieve this, if new licences are granted ASIC will need to impose new requirements on market operators and brokers in relation to order and trade information. Experiences in other jurisdictions show limited success in being able to conduct adequate whole-of-market supervision due to functional limitations in (or a complete absence of) the necessary tools and data. Finra and IIROC have recently identified the increasing fragmentation of the market and quotation of securities in multiple jurisdictions as the reason why it is harder to detect and investigate manipulative trading.[21] Market operators themselves cannot effectively undertake these functions as potential micro-manipulation activity occurs across multiple platforms.

While it is not directly attributable to algorithmic trading, the ASX Review also found that growth in algorithmic trading and consequential order proliferation exacerbates the supervisory challenges in monitoring, enforcement and other types of supervisory issues in a multiple market operator environment. These include monitoring Participant access, managing trading halts, maintaining accurate audit trails and identifying individual trader activity inter-platform.

Summary of Intended Actions and Recommendations

As a result of the ASX Review, there is work to be undertaken by ASX in its capacity as trading platform operator and by ASIC as the whole-of-market supervisor.

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[20] The manipulation of the bid or offer through entering, amending and deleting orders.
[21] "Globalism gives cover to bad guys", Australian Financial Review, Friday 29 January 2010, pg. 50.

ASXMS will continue to cooperate with ASIC and offer its general supervisory expertise, including supervision of algorithmic trading, in the lead-up to the transfer of certain supervisory responsibilities in the third quarter of 2010. However, it is recognised that as a whole-of-market supervisor, ASIC will face new and different challenges, not previously experienced by any Australian market supervisor. The review has attempted to anticipate some of these challenges, and proposed ways to address them, as described below.

Intended actions for ASX in relation to algorithmic trading:

- Modify the existing ASX cash equity market trade cancellation policy to substantially shorten the window within which a trade can be cancelled, as well as introduce trade cancellation fees to discourage deliberate execution and subsequent trade cancellation activity;

- In conjunction with ASIC, reiterate the requirement for brokers to have in place appropriate measures to prevent wash trades;

- Review the procedures governing removal of market access for brokers, with a view to identifying ways to streamline the decision-making process, including the introduction of an automated process for preventing electronic access to the market in the event of a malfunctioning algorithm that has the potential to impact on market integrity;

- Encourage brokers to review their procedures for removing client access to the market to ensure that these are adequate and work in practise;

- Commission further SIRCA research to examine the relationship between 'liquidity' and order proliferation;

- Review the need for security-specific circuit breakers in the event of additional trading platforms commencing trading, or in the event that momentum trading results in trade error[22] on the ASX cash equity market;

- Enhance the ASX DMA offering subject to the development of appropriate pre-order filters and other controls such as drop copies of order flow;

- Ensure Clearing and Settlement Participants review their capacity and business continuity planning regarding the future growth in the number of trades that will need to be processed;

- Continue the strategic focus on capacity management and investment in trading infrastructure capacity upgrades to meet capacity headroom and order execution latency reduction targets; and

- Contribute to raising retail investor, listed entity and other stakeholder awareness of algorithmic trading, including the strategies commonly used, supervision issues raised and how these are managed. The public release of this paper is the first step in this process.

Recommendations for consideration by ASIC:

- Impose a requirement on brokers and clients that all algorithms are appropriately tested before being connected to a trading platform to ensure that the algorithm operates as intended and does not interfere with market integrity;

- Prohibit market operators from enabling brokers to offer unfiltered market access[23] to their clients;

- Consider what process it will use to coordinate real-time removal of access for a specific client (or algorithm) from market venues, and whether there will be circumstances in which ASIC will itself request or require removal;

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[22] Defined as a trade that is executed sufficiently away from the market price that ASX in consultation with the Dispute Governors Committee, determines that the trade will be cancelled. The error can be identified by ASX, the Participant or a third party, and ASX does not seek counterparty approval for the cancellation.
[23] The connection of a client directly to the market without appropriate pre-order controls.

- Ensure brokers (particularly smaller brokers) review their business continuity planning in anticipation of significant increases in order traffic;

- Provide detailed guidance on how order record requirements are to be satisfied by algorithmic traders to enable ASIC to effectively conduct its investigation and enforcement functions;

- Implement sophisticated post-order and post-trade pattern recognition analysis systems and staff competencies to detect manipulation (including micro-manipulation) across trading platforms. This will necessitate the capacity to detect potential manipulative activity through the analysis of orders, not just trades;

- Analyse the benefits, and conduct public consultation in respect of, a new requirement for brokers to attach a unique client ID to each order submitted to a licensed market or crossed internally as a tool to significantly improve ASIC's capacity as whole-of-market supervisor to detect insider trading and market manipulation;

- Introduce rules which require a Participant to have in place an adequate IT infrastructure governance framework, including a comprehensive IT security policy;

- To further assist whole-of-market analysis, impose a requirement on market operators to ensure audit trails across market operators have synchronised timestamps to enable accurate post-trade analysis;

- Consider working with ASX to educate the retail sector, listed entities and other stakeholders on the anticipated impact of multiple venues trading the same securities, including how this is likely to facilitate new trading behaviour from algorithmic traders (particularly HFTs);

- Consider taking a proactive role in articulating, as have equivalent overseas regulators, what is considered to be acceptable and unacceptable algorithmic trading practices (with particular focus on momentum algorithms); and

- Ensure that the market manipulation provisions of the Corporations Act are adequately drafted to capture contemporary forms of trading and provide a more granular definition of market manipulation.

Conclusion

The ASX Review has identified that, while algorithmic trading has increased on the ASX cash equity market in the past three years, this has not raised major supervisory, operational or technology capacity issues for ASX. The SIRCA review concluded that algorithmic trading has not had a harmful impact on the ASX market. These findings suggest that algorithmic trading is no more or less likely than other trading styles to trigger incidents requiring an operational or supervisory response, and that the growth in retail trader complaints to ASX about algorithmic trading has not raised systemic supervisory issues. All suspicious trading patterns are thoroughly investigated by ASXMS and referred to ASX's Disciplinary Tribunal as appropriate.

ASX is generally supportive of developing and facilitating algorithmic trading in Australia – albeit mindful of the findings of the ASX Review about issues associated with a subset of algorithms. However, some important ASX actions have been identified to further improve the operation of the market, to educate investors, and to facilitate new DMA services. ASX has commenced the implementation of those initiatives.

Looking forward, the ASX Review has identified more significant implications of algorithmic trading in the event that multiple markets for the same securities become operational. Understanding the distinctions between execution and situational algorithms, between liquidity and order proliferation, as well as comprehensively reviewing their effects are important considerations for the Government when assessing the public policy benefits and risks of any regulatory reform of equity market microstructure.   The findings of the SEC review of US equity market micro-structure should further assist the development of that understanding.

Fragmented markets, common rules that can be 'gamed' by a small subset of algorithms, and maker-taker pricing models have brought significant order proliferation to North American and European equity markets.   While not inherently problematic from a market integrity perspective, this creates the need for new supervisory techniques to identify potential market manipulation across trading platforms. Regulators in those jurisdictions are only now beginning to address the inter-relationship between market micro-structure, the growth in algorithmic trading, and the potential impact on market quality and integrity.

Noting the particular impacts that will result if the Government licences multiple market operators to facilitate trading in ASX-listed securities, the ASX Review has made recommendations for consideration by ASIC regarding investment in new competencies and technologies, as well as for the imposition of new obligations on market operators, brokers and clients to enable ASIC to address some of the significant challenges that have yet to be satisfactorily dealt with in the US and Europe.

ASX is committed in its role as a market operator to develop long-term sustainable liquidity, working with participants to facilitate algorithmic trading, and working with ASIC in its new role as whole-of-market supervisor to ensure that market integrity and quality are maintained in Australia.

Paper Structure

The first part of this paper sets out the findings of the backward-looking component of ASX's Review. The second part of this paper sets out the forward-looking findings and recommendations. A high level overview of key sections of the paper is set out below.

Part One – Backward-Looking

- Section one introduces and defines some commonly used terms, such as algorithmic trading and high frequency trading (HFT).

- Section two outlines current ASX practices:
    - Market access arrangements;
    - Information about algorithms currently being used on ASX;
    - Metrics on trade / order / error rates; and
    - Background on supervision function and referrals.

- Section three summarises SIRCA research into algorithmic trading and its impact on ASX market quality. The research is attached at Appendix 1.

- Section four looks overseas and describes key elements of overseas regulatory regimes which have facilitated HFT, including regulations permitting competing trading platforms and trade execution obligations.

Part Two – Forward-Looking

- Drawing on overseas experiences, section five considers several predictions for the future of algorithmic trading. It considers the level of public awareness of algorithmic trading in Australia and suggests measures to raise the general level of awareness as a means of maintaining investor confidence in the integrity of Australia's markets.

- Section six considers the operational challenges posed by algorithmic trading, including managing aberrant trading and increased incidents of wash trades. Recommendations include introducing a kill switch and enhanced DMA and ASX-controlled pre-order filters to minimise erroneous trading.

- Section seven considers the supervisory issues associated with algorithmic trading. It outlines some of the potential manipulative techniques associated with HFT ('micro-manipulation') and recommends that ASIC put in place sophisticated post-trade pattern analysis tools, which potentially combined with client ID, will greatly improve ASIC's ability to detect whole-of market misconduct.

PART ONE: BACKWARD-LOOKING FINDINGS

1. Terminology

This section introduces some commonly used terms: algorithmic trading, high frequency trading (HFT), capacity, co-location, and latency. Definitions of algorithmic trading and HFT are still evolving, reflecting continual development in market practices. Execution algorithms are used by long-term holders to invest in securities; situational algorithms are used by HFTs with a much shorter time horizon.
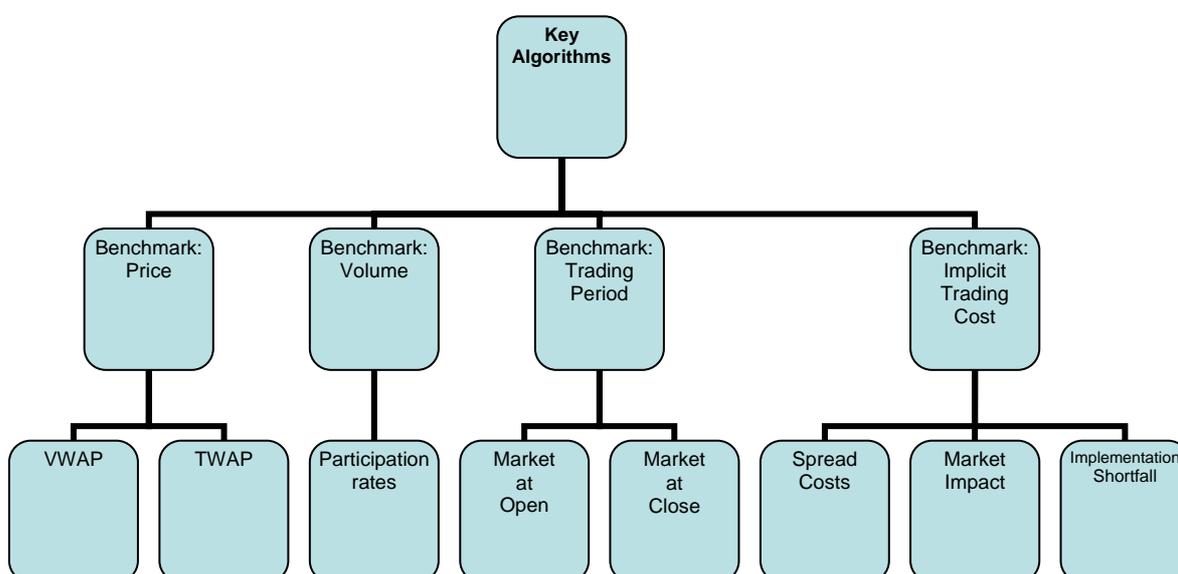
Algorithmic Trading

There is no commonly agreed definition of 'algorithmic trading'. It is a very broad concept which encompasses a number of trading strategies. For the purposes of this Review, ASX has adopted the following definition:

Algorithmic trading is electronic trading activity whose parameters are determined by strict adherence to a predetermined set of rules aimed at delivering specific execution outcomes. These parameters may include volume, price, instrument, market, type, timing, news etc.

Benchmark execution algorithms (also referred to as structured algorithms) were developed by the sell-side brokers. They were concerned with minimising market impact for brokers' buy-side clients. Examples of these algorithms include those programmed to achieve or better the volume weighted average price of a security over a day ('VWAP') or a given time period ('TWAP'). The concept of VWAP was developed in 1988, initially as a means to measure the market impact cost of a trade (i.e. by comparing the price of the trade executed to the VWAP).[24] Subsequently, brokers adopted strategies to predict and replicate VWAP. It is now reportedly the most commonly used algorithm for buy-side traders in the Asian region.[25]

The diagram below illustrates a range of execution algorithms:[26]

Execution algorithmic trading models were designed to minimise potential losses, rather than to trade at a profit.[27] Subsequently, new types of algorithms have been developed, whose aim is to trade at a profit. One label for these is 'situational algorithms'. Situational algorithms have typically been developed for the buy-side by third party vendors, and by the sell-side for their clients and their own use. Situational

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[24] Berkowitz, S. A., Logue, D. E., and Noser, E. A. J., (1988) The total cost of transactions on the NYSE. *The Journal of Finance*, 43(1), 97-112.

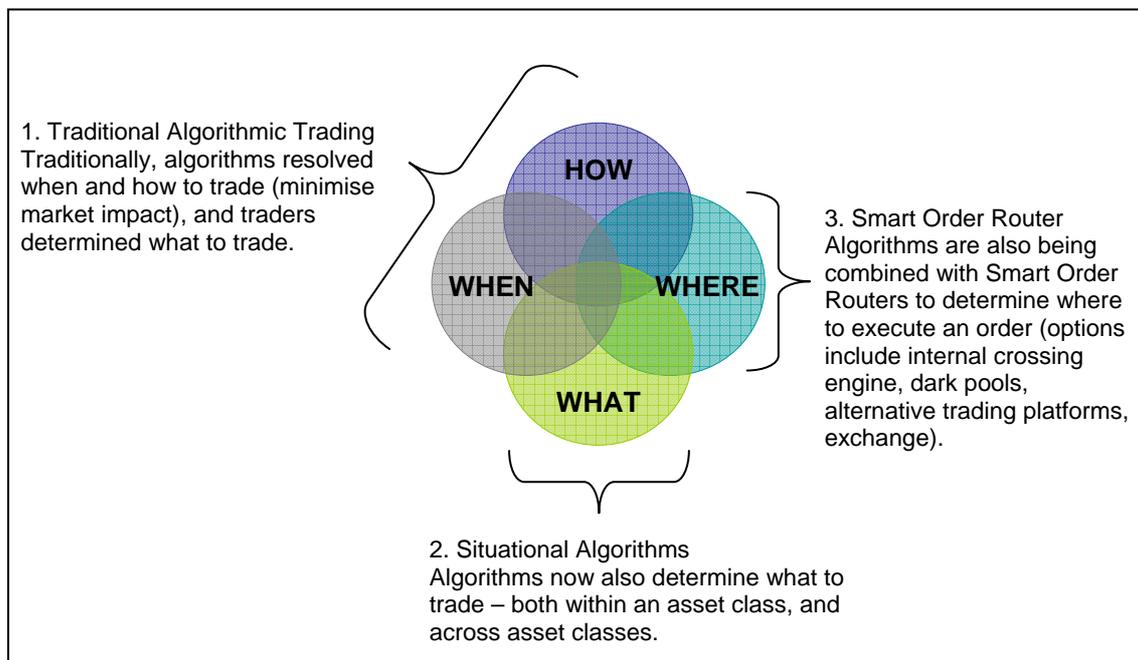[25] The Trade, 2009 Algorithmic Trading Survey.

[26] Gomber, "Meet the Algo Traders" Presentation delivered October 17 2006.

[27] Gsell, M., Is Algorithmic Trading distinctively different? Assessing its behaviour in comparison to informed, momentum and noise traders. Discussion paper 15/2/2006, available at: http://ssrn.com/abstract=1142738

algorithms are more sophisticated algorithms which seek to utilise data, information and events (e.g. to identify and act upon arbitrage opportunities).

In practice, both buy and sell side users employ a range of algorithms, depending on their trading objectives.

Increasingly, there is blurring distinction between algorithms and other execution services, such as smart order routers, which determine where an order should be executed. See illustration below.

1. Traditional Algorithmic Trading
Traditionally, algorithms resolved when and how to trade (minimise market impact), and traders determined what to trade.

3. Smart Order Router
Algorithms are also being combined with Smart Order Routers to determine where to execute an order (options include internal crossing engine, dark pools, alternative trading platforms, exchange).

2. Situational Algorithms
Algorithms now also determine what to trade – both within an asset class, and across asset classes.

Key drivers of algorithmic trading include technological advances – such as the introduction of electronic central limit order books to replace trading floors, and development of the FIX protocol; regulatory changes that allow trading of a security to occur on multiple trading platforms (e.g. US Reg NMS; MiFID) and associated order handling rules; and, investor efforts to minimise the costs of trading, including demand for anonymity and block trading.

High Frequency Trading (HFT)

High frequency trading ('HFT') is a loosely used term to describe a sub-set of algorithmic trading. It is still sufficiently new that academics and market users have not yet agreed on its definition, or how to classify the various trading strategies that comprise HFT.

The SEC has described the characteristics of HFT as follows:

> Other characteristics often attributed to proprietary firms engaged in HFT are: (1) the use of extraordinarily high-speed and sophisticated computer programs for generating, routing, and executing orders; (2) use of co-location services and individual data feeds offered by exchanges and others to minimize network and other types of latencies; (3) very short time-frames for establishing and liquidating positions; (4) the submission of numerous orders that are cancelled shortly after submission; and (5) ending the trading day in as close to a flat position as possible (that is, not carrying significant, unhedged positions over-night).[28]

HFT is defined by American research company TABB as "fully automated trading strategies that seek to benefit from market liquidity imbalances or other short-term pricing inefficiencies." It was defined at a recent US HFT conference as being "systematic, quant-based models, with holding periods ranging from a fraction of a second to less than one day".[29] It is clear from these descriptions that HFT is a very different concept to long-term investing.

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[28] http://www.sec.gov/rules/concept/2010/34-61358.pdf page 45.
[29] Capital Markets Consortium, High Frequency Trading: Market Structure, Technology & Regulation, 9 December 2009, New York.

Categorisation of the trading strategies which are used by HFTs often includes strategies such as market making (liquidity provision), statistical arbitrage, momentum trading (event trading) and liquidity detection.[30]

Electronic market making and liquidity provision is where traders profit from small spreads, entering and exiting positions in milliseconds / microseconds. Firms trade enormous volumes to be profitable. This strategy favours more actively traded securities where the trader can enter and exit a position quickly.

Statistical arbitrage is where traders search for inefficiencies in pricing which they can exploit e.g. they may simultaneously trade two securities at prices that appear to be outside the normal pricing relationship. This requires extremely fast data feeds and little to no latency between receiving market data, sending orders, receiving confirmation of acceptance, execution and/or order cancellation.

Momentum trading, also referred to as swing trading, typically involves anticipating short-term market trends based on trade history and profiting from that volatility. See further section 7.4

Liquidity detection is an umbrella term for trading strategies that involve sending small orders to look for where large undisclosed orders might be resting, on the assumption that when a small order is filled quickly there is likely to be a large order behind it. See further section 7.4.

Drivers of HFT include the following:[31]

- Competition between multiple trading platform operators;
- Maker-taker pricing or other financial incentives for liquidity provision;
- Electronically traded, low latency trading environments (encapsulating platform, co-location and data delivery);
- Liquid, actively traded instruments;
- Regulatory 'trade through' protection for limit orders; and,
- Small minimum price increments (tick size).

The list of drivers, above, suggests that regulatory reform which results in new trading platforms (potentially coupled with maker-taker pricing) is likely to lead to increased HFT activity in Australia. Some of the known consequences of this new HFT trading activity for market operations and supervision, such as new trading techniques and increased numbers of orders submitted but not executed, are considered further in part two of this paper.

Capacity

Capacity refers to the amount of data that can be simultaneously electronically sent or received. It is a necessary prerequisite for many algorithmic traders that a trading system can reliably sustain large volumes of data. For example, electronic market makers constantly check market prices and adjust their quotes accordingly. Statistical arbitrageurs are constantly looking for mis-pricing opportunities. At a very simplistic level, both strategies require the ability to send and receive large amounts of data simultaneously, in the form of requesting and receiving current bids/offers, sending their own bid/offer and then receiving confirmation that the trading engine has received their order – and any subsequent amendment or cancellation of that order.

One of the findings of this review is that brokers and ASIC must take into account regulatory reforms likely to accelerate HFT volumes when planning their future IT and operational capacity needs.

The issue of capacity management has been a key ASX focus for several years. The ASX Review did not identify any new requirements to add to the ongoing program of technology enhancements to ASX infrastructure currently underway to meet the anticipated growth in algorithmic trading, as well as the expected increase in the number of orders and trades generated on ASX markets.

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[30] Aldridge, I., High-Frequency Trading: A Practical Guide to Algorithmic Strategies and Trading Systems, John Wiley and Sons, 2009; Rosenblatt Securities, Trading Talk: Market Structure Analysis & Trading Strategy: An in-depth look at High-Frequency Trading", September 30, 2009. Capital Markets Consortium, High Frequency Trading: Market Structure, Technology & Regulation, 9 December 2009, New York.
[31] Rosenblatt Securities, Trading Talk: Market Structure Analysis & Trading Strategy: An in-depth look at High-Frequency Trading", September 30, 2009.

Co-Location

Co-location is the practice of locating broker or client trading software and hardware in close proximity to the trading platform's trading engine. The aim is to minimise propagation and transmission latency. Exchanges and third party providers charge a fee for offering co-location. ASX offers co-location to its equity and options trading platform. This service commenced in late 2008. ASX is currently in the process of upgrading and expanding its co-location facility.

Latency

Latency refers to the amount of time taken to electronically send or receive information. HFTs rely on very low latency (i.e. very quick data transmission) for their trading strategies. References to trading in microseconds or milliseconds are references to latency.

Key Conclusions:

Advances in technology have dramatically changed the way in which orders are executed, with a trend towards orders being entered by algorithms seeking to minimise market impact costs and capture trading opportunities.

The speed of trade execution has increased, and the mix of long-term investors and short-term trades has altered, as new trading techniques labelled 'HFT' have gained popularity.

2. Current ASX Practices

This section sets out background to ASX's current market access arrangements, and information on algorithms being used on ASX, metrics relevant to capacity planning, and supervisory activities conducted to date.

2.1 Access

Broker and client access requirements and objectives have evolved over time, with the most recent requirements being a need for minimal latency in market data and order messaging to support execution and situational algorithms. A constant requirement has been the focus by both ASX and its Participants, on risk management and operational integration.

Until 1990, ASX operated an open out-cry trading floor where orders were shouted to the market and trades were executed face to face. In this environment clients either telephoned or faxed their orders to their broker. The accuracy and timeliness of available prices and executed trades was limited by the requirement to manually collate and distribute the data. Market data was available to large clients via independent vendors while retail users would practically rely on the following morning's newspaper.

In the trading floor environment, client orders required multiple points of handling that proved expensive, prone to error, required significant delays in execution and was not easily scalable to increased trading activity. Direct access to the market was afforded exclusively to Exchange Members, who as a result of their proximity achieved a significant informational advantage.

Between 1987 and 1990, ASX transformed its trading environment from a physical to an electronic market with the implementation of SEATS (Stock Exchange Automated Trading System). SEATS resulted in the replacement of floor trading with an electronic trading application. ASX provided the trading terminal, known as the SEATS Trader Workstation, directly and exclusively to Members. The creation of electronic pre and post trade data dramatically increased the performance, granularity and accuracy of ASX market data. Further, electronic market data provided the basis for the low cost internet distributed market data utilised heavily by retail users today.

In 1997, ASX responded to further Participant demand and introduced a technical Open Interface (SEATS 97) and a supporting Market Rule framework to allow Participants to offer Direct Market Access (DMA) to their clients.

The technical open architecture created the capability for Participants to utilise Order Management Systems (OMS) (proprietary or purchased) other than the SEATS Trader Workstation. OMS facilitated the integration of Participant's order handling, risk-management, and ultimately clearing and settlement operations associated with their activity on ASX. This innovation reduced costs and operational errors, allowed Participants to actively and automatically monitor risk, and provided the technical foundation for the distribution of DMA to clients.

ASX Market Access Rules

The introduction of the Automated Order Processing (AOP) rules in 1997 provided the framework, in conjunction with the technical capability, for Participants to offer DMA to their clients.[32]

Clients had increasingly demanded additional control over their order flow and Participants responded with the provision of DMA services. The Market Rule framework supported the placing of trading terminals in the offices of clients. This achieved the client objectives of increased order control and reduced costs, with the Participant requirements for risk control and operational integration. These services were extended to a full range of clients, and formed the basis of the internet trading capability that retail users are now so familiar with.

The Market Rules detail that Participants are responsible for ensuring that all orders that are presented to ASX have been appropriately filtered. The Open Interface facilitates Participants either creating or purchasing (from a third party) appropriate controls for the pre-release validation of orders.

AOP (or DMA) is a broader concept than algorithmic trading. To illustrate the distinction, consider online broker systems. These require AOP certification because their business model permits clients to enter orders which are transmitted to the trading platform without being re-keyed by an authorised broker staff member. In place of the manual order entry process, ASX requires a Participant to have adequate filters in place to detect trades that may breach the law or the trading rules. Online brokers therefore offer DMA, but their clients are not generally engaged in algorithmic trading. In fact, the majority of their clients are retail investors who manually input orders into their computer.[33] Participants or clients who are using algorithms to trade will also (currently) use DMA because it is the fastest way to connect to the trading platform. ASX is in the process of considering alternative ways for these traders to connect to the trading platform – see part two.

ASX does not require Participants to nominate in advance whether they will be algorithmic trading themselves or whether their clients will be algorithmic trading. In many instances, a Participant may not know whether its clients are engaged in algorithmic trading – in the same way that they are unlikely to know whether an investor's order flow is premised on technical or fundamental analysis. ASX does not require Participants to identify specific algorithms that are in use. However, ASX can obtain this information if necessary, either directly or indirectly. ASXMS can ask a Participant for details of trading to assist in investigation and enforcement activity. Additionally, ASX or ASXMS can determine with a reasonable degree of certainty via analysis of trade data, which orders are generated by an algorithm (see further below).

As at December 2009, 60 of 85 (70%) ASX Market Participants had AOP certification. This compares with 37 of 87 Participants in 2006 (42%).

All SFE Participants access the market using an Automated Order Electronic Interface (AOEI). There are currently 32 Trading Participants (with several additional applications being processed at the time of the Review). SFE Participants can choose to offer DMA access to their clients, whose orders are then routed to the trading platform via the Participant's AOEI.

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[32] Participants using DMA require AOP certification pursuant to the Operating Rules before they commence DMA trading.
[33] However, retail investors who use automated stop-loss facilities provided by on-line brokers are using a simple form of algorithmic trading.

ASX and SFE Participants are not obliged to inform ASX if client access is being offered, however the Participant must ensure that clients possess the required skills, knowledge and financial status to use the systems in accordance with the Operating Rules.

2.2 Algorithms in Use

Algorithmic trading is not specifically identified as such by brokers entering trades into the ASX trading platform. Accordingly, the ASX Review drew on estimates of algorithmic trading activity provided by brokers. Those estimates are in line with the results of third party surveys of market users, such as conducted by industry publications. Major ASX Participants estimate their levels of algorithmic trading at 30-40% of total volumes traded, with HFT comprising around 10% of that figure.

This compares with US markets, where estimates of HFT activity in NYSE securities ranges from 65 – 75% volumes traded. TABB Group estimates around 40% trading activity on London Stock Exchange is HFT. As noted earlier, ASX's low order : trade ratio suggests that the new forms of HFT which dominate trading overseas have not yet migrated to Australia, adding support to an estimate of around 10% volumes being HFT.

A wide range of algorithms are used by brokers and their clients. Many algorithms operating in the Australian market are developed initially in the US (where algorithmic trading is more widespread) and are subsequently tailored to the requirements of the Australian (and other) markets. Many of the same global investment banks which dominate the US market in terms of broker volumes are also responsible for a large percentage of ASX trading volumes.
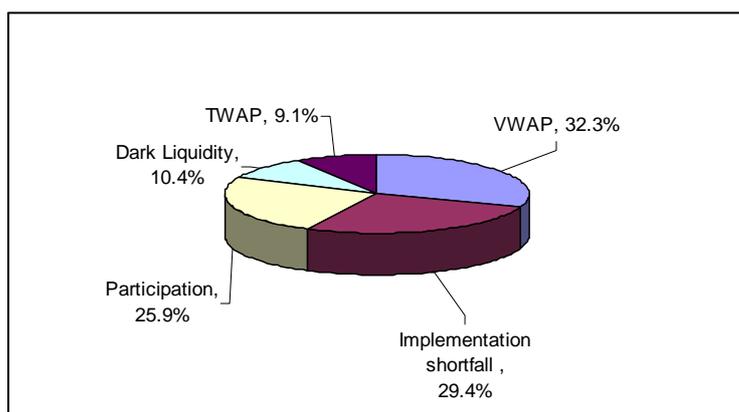
Execution Algorithms

The majority of algorithmic trading on ASX currently takes the form of execution algorithms, which are considered in more detail below.

The Trade, an industry publication, conducted an algorithmic trading survey of buy-side market users in early 2009. According to that publication,fund managers are increasing their use of algorithmic trading. A recent survey of 150 traders in 20 countries showed that more than 25% traders now use algorithms for more than 40% of their order flow, up from 9% the previous year. 45% traders surveyed expected usage to increase in the next 12 months.[34]

According to the Trade survey, the types of algorithms used across Asia can be segmented into the following execution algorithm types:[35]

Chart 1: Asian Buy-Side Types of Algorithms Used

The following is a summary of some common execution algorithmic strategies.[36]

- VWAP- Attempts to minimise tracking error while maximising performance versus the Volume Weighted Average Price traded in the market;'

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[34] The Trade News, March 2009.
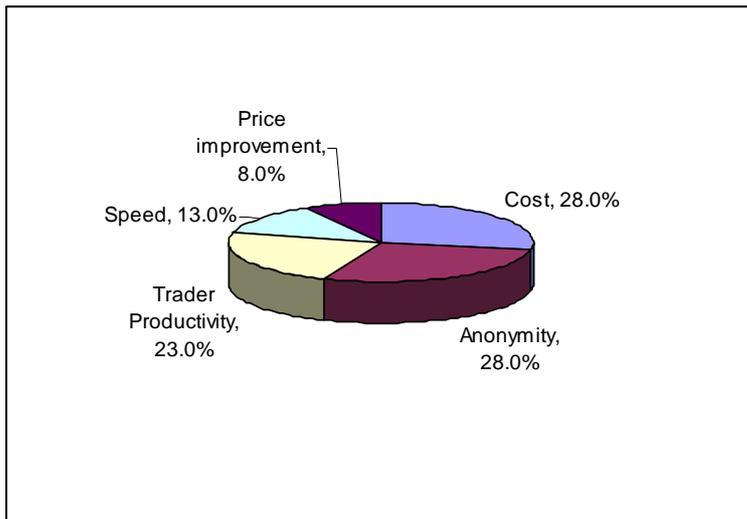[35] The Trade Asia, Issue 4, Q1-Q2 2009, p. 26- 29.
[36] This information is sourced from a presentation to the Intermarket Surveillance Group (ISG) in October 2009.

- TWAP- Aims to match the Time Weighted Average Price. Similar to simple time slicing, but aims to minimise spread and impact costs;

- Implementation Shortfall – Aims to minimise the difference between the price when the decision to trade was taken, and the average execution price; and,

- Participate: Also known as Inline, Follow, With Volume. Aims to be a user-specified fraction of the volume traded in the market.

As noted earlier, retail investor use of algorithmic trading is generally limited to automated stop-loss facilities, a service offered by on-line brokers.

The Trade survey also asked buy-side users why they use algorithms. The two main reasons given were anonymity and cost.

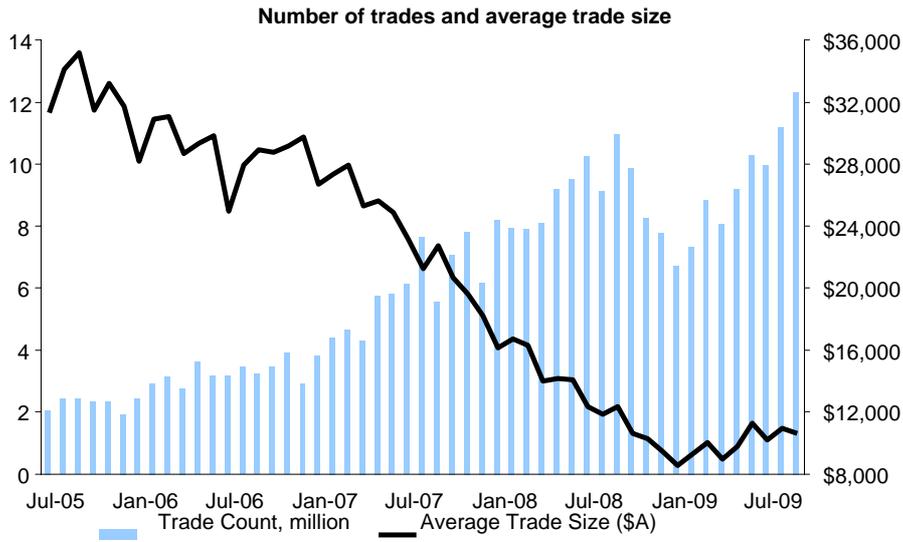*Chart 2: Asian Buy-Side Reasons for Using Algorithms*

2.3 Trading Volumes

For some time, ASX and other markets globally have experienced the same trend: a larger number of trades being executed, and decreasing trade size. This trend is largely attributed to the increased use of algorithms.
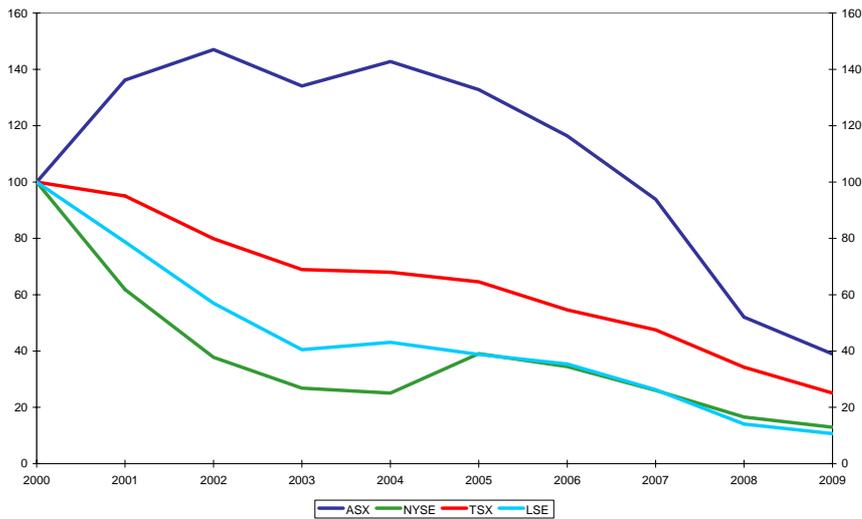
As illustrated below, the average trade size on ASX today is less than one-third of the average trade size in 2005, while the number of trades executed has increased by a factor of about 6 (Chart 3).

Chart 3: Number of Trades and Average Trade Size (ASX)

Number of trades and average trade size

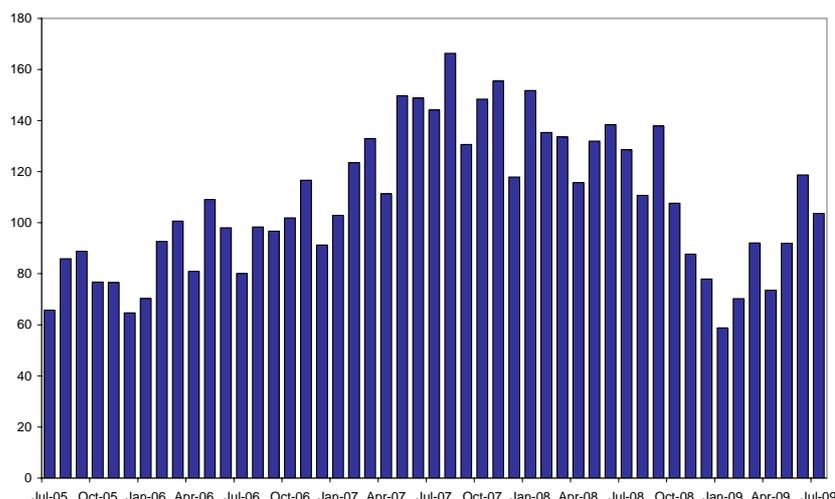Trade Count, million   Average Trade Size ($A)

ASX's average trade size followed the same downward trend as other leading markets over the years from 2000 - 2009 (Chart 4).

Chart 4: Average Trade Size (comparison of % decline, indexed from January 2000)

ASX   NYSE   TSX   LSE

The average value of ASX securities traded has trended upwards over time, although recently declined during the period of the GFC, as set out below (Chart 5).

Chart 5: Average Daily Turnover (A$ billion)

2.4 Metrics

ASX is a fully electronic market and processed a total of 1.3 billion order book changes in the final quarter of 2009, from 1424 Open Interface connections, distributed across 78 Participants.

Of the 1.3 billion order book changes processed in Q409 ASX were required to intervene and cancel resulting trades on 2 occasions (for a total of 41 trades); this represented a market impact error rate of 0.00000003%. In addition the 2 errors were the result of order entry by a Participant representative, in contrast to order entry resulting from DMA models.

ASX has experienced, and anticipates further, substantial growth in the quantity of orders and trades that it is required to process and distribute. The ASX trading platform, ITS, has performed with 100% availability since its introduction in October 2006 while achieving performance statistics that are leading in the region and globally competitive. ASX continues to monitor and invest in the performance, capacity and availability of its trading platform.

A finding of the ASX Review is that algorithmic trading has not contributed to any increase in trading errors – in fact, instances of trade error have fallen over time, as algorithmic trading volumes have increased.

The following table sets out key metrics taken into account in the ASX Review:

ASX Cash Equity Market Trade Metrics:

	2007	2008	2009
Value Traded (billion)	$1,576.4	$1,393.5	$1,153.6
Number of Trades (million)[37]	68.2	106.3	115.8
Number of Order Book Changes (million)	333.9	562.7	826.7
Average Trade Size	$23,092	$13,108	$9,961
Number of Errors[38]	24	20	12

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[37] Includes billable and non-billable trades.

	2007	2008	2009
Number of Crossing Trades Cancelled	126,854	195,677	338,951

2.5 Supervision

Market supervision, including real time surveillance of trading, is currently undertaken by ASX Market Supervision (ASXMS). Any abnormal trading detected by ASX's operational areas, and all complaints received from the general public which they believe relate to abnormal trading activity, are investigated by ASXMS staff. A dedicated market surveillance function within ASXMS is tasked with identifying possible market misconduct, such as breaches of continuous disclosure requirements, insider trading, front running and market manipulation. The Government has previously announced that certain supervisory functions, including monitoring of insider trading, front running and market manipulation, will be conducted by ASIC from the third quarter 2010.

Currently, ASXMS uses SMARTS and IRESS to conduct real-time and post-trade market monitoring. The two main market integrity concerns most commonly levelled at algorithmic trading relate to market manipulation and front-running (insider trading). Pre-trade controls, specifically separation of order flows, can be (and currently are) used by Participants to mitigate the risk of front-running. Increasingly, however, the ability to pre-empt and detect front-running is becoming increasingly reliant on understanding of technology infrastructure design and implementation. A combination of pre-order filters and post-trade analysis is used to prevent, and detect market manipulation and front-running.

The level of interest in algorithmic trading in Australia is arguably disproportionate to the supervision issues it has posed to date. ASXMS Surveillance has made 160 manipulation-related referrals to ASIC since 2006, none of which relate to algorithmic trading. More recently, however, the number of complaints from members of the public received by ASX in relation to algorithmic trading has increased - from 17 in Q1 2009 to 30 in Q3 2009. Meanwhile, the overall number of complaints declined in this time, perhaps reflecting improved market conditions.

The majority of complaints to ASX about algorithmic trading relate to observations of 'unusual' trading which may be manipulative. To date, ASXMS analysis of trading referred to in complaints related to algorithmic trading has not identified market manipulation. The majority of complaints appear to be triggered by trading activity generated by VWAP algorithms, often in illiquid securities. Because these algorithms place orders regularly over the day, for small parcels of shares (often less than 10 shares), other market users may form the impression that these trades are being conducted to manipulate the price of the security or for some other improper purpose. VWAP algorithms can often cause small price movements either up or down. The vast majority of VWAP algorithm complaints received relate to price falls rather than price rises.

Part two of this paper contains recommendations aimed at improving retail investor understanding of algorithmic trading (thereby increasing confidence in the integrity of the market), and to help to establish ASIC in its new role with enhanced abilities to detect possible market misconduct and investigate complaints of manipulation. Those forward-looking recommendations are premised on a trading environment which has continued to evolve, probably as a result of regulatory change, and which is characterised by far greater HFT volumes than is currently the case.

Intended Actions and Recommendation 1: Current ASX Practice
ASX will continue its strategic focus on capacity management and investment in trading infrastructure capacity upgrades to meet its capacity headroom and order execution latency reduction targets.

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[38] A trade that is executed sufficiently away from the market price that ASX in consultation with the Dispute Governors Committee, determines that the trade will be cancelled. The error can be identified by ASX, the Participant or a third party, and ASX does not seek counterparty approval for the cancellation.

3.   SIRCA Research: Impact of Algorithms on Market Quality

Research conducted for ASX by SIRCA demonstrates that there has been an increase in algorithmic trading. However, there does not appear to be a strong correlation between the key quality indicators such as the long term trend in liquidity or volatility and the increasing use of algorithms.

There are very few academic studies which address algorithmic trading, and only recently are papers emerging that assess the broader effects of algorithmic trading on overall market quality. One such recent study of NYSE stocks concluded "algorithmic trading lowers the costs of trading and increases the informativeness of quotes and prices."[39]

ASX commissioned SIRCA to analyse ASX market data from October 2006 to October 2009, with a view to understanding what impact, if any, algorithmic trading has had on key indicators of market quality (bid-ask spread, volatility, depth). The date range was chosen because ASX introduced a number of market enhancements in 2006 which were driven by, or supportive of algorithmic trading. These enhancements included reform of trading fees from trade volume to value, replacement of the old trading (SEATS) with ITS to improve capacity; and the introduction of FIX protocol. SIRCA's report is at Appendix 1.

SIRCA's research does not show any evidence that algorithmic or high frequency trading has led to significant or obvious changes in the quality of ASX markets.

Having said this, the research does show that market depth[40] improved significantly towards the end of the global financial crisis. This may be as a result of the lifting of the regulatory short selling ban put in place in the aftermath of the collapse of Lehman Brothers in September 2008, the general recovery in market confidence, as well as the increased use of the ASX co-location facility by algorithmic traders. It also coincided with a significant increase in the number of orders generated on ASX. However, the reasons for the change are not as important as the fact that these significant increases in market depth and order proliferation do not appear to have translated into significantly greater turnover (as seen in the table below).

While the ASX Review draws no firm conclusions as to why this has occurred, it does raise questions as to whether definitions of 'liquidity' need to be re-examined – particularly since orders in the market may only appear for very short periods of time (consistent with the trading strategies of some algorithmic traders). 'Liquidity' and 'order proliferation' should not be used inter-changeably, as the relationship between them is poorly understood. When considering that increased use of 'dark pools[41]' in Australia has occurred over the same period as increased market depth and order proliferation in the central market, this provides some prima facie evidence that the additional orders contributing to increased market depth are either not accessible or attractive to those that have directed order flow to 'dark pools'.

ASX intends to commission further research from SIRCA to identify appropriate methodologies to define and analyse 'liquidity'. The identification of genuine liquidity providers (distinct from order proliferators) is a key objective of ASX to ensure fee structures and incentives are set appropriately. For policy makers,

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[39] Hendershott, T., Jones, CM., Menkveld, A. J., "Does Algorithmic Trading Improve Liquidity?" available at http://ssrn.com/abstract=1100635
[40] The $ value of unexecuted (or 'resting') buy and sell orders in the order book
[41] Broadly speaking, a dark pool is a non-public, non-transparent venue for executing orders away from the central maker.

distinguishing between liquidity and order proliferation is important when considering the benefits and costs of facilitating the trading of securities on multiple platforms.

<u>Key Conclusions:</u>

Empirical research by SIRCA has concluded that there has been an increase in algorithmic trading over the past three years.

Metrics used to measure the health of the market do not provide a factual basis for a concern that algorithmic trading has negatively affected the quality of ASX's markets.

4. Overseas Comparison

This section outlines key elements of overseas regulatory regimes which have facilitated HFT, such as regulations permitting competing trading platforms and the introduction of trade execution obligations. These markets are valuable case studies of the effects of regulatory change, as currently being contemplated by the Australian Government.

The ASX Review has benefited from the experiences of overseas exchanges and market participants. In particular, trend analysis of potential growth in the Australian market has benefited from reference to the US and Canadian markets where HFT is more widespread than it is in Australia. Similarly, with respect to the challenges of investigating and enforcing market misconduct, the ASX Review benefited from the experience of overseas regulators, especially in their use of post-trade analysis tools to detect patterns of manipulative behaviour.

Importantly, however, it is recognised that there are significant differences between the Australian market (in its current form) and overseas markets. A number of key areas of difference (market structure and scale, market access, pricing, and flash orders) are briefly outlined below. Owing to these differences, it is necessary to analyse the drivers of potential issues or misconduct before determining whether overseas experiences can be translated to the Australian environment. It is also noted that the overseas environment is continually evolving. This is evidenced by the SEC's recent concept paper inviting comment on the US market structure and SEC proposals to address specific negative consequences of the market structure for trading US equity securities.[42]

Market Structure and Scale

US, Canadian and European market regulations all facilitate trading of securities on multiple trading platforms. In the US, there are approximately 100 such platforms. Canada has a much smaller number of trading platforms (7); whereas Europe is somewhere in the middle with around 50 equity trading venues (exchanges and MTFs) as at September 2009. The Australian equity market – while generally considered to punch above its weight internationally, e.g. in terms of capital raised – is simply not on the same scale as major European and US markets. The impact of algorithmic trading and liquidity fragmentation in a smaller market such as Australia, has the potential to be greater than in a larger market with deeper liquidity.

In some instances it is difficult to distinguish the operational and supervisory challenges that arise from market structure, with those associated with algorithmic trading. For instance, there has been a clear increase in the order: trade ratio on most overseas trading platforms. This ratio measures how many orders are submitted to a trading platform, for every trade that is executed. Traditionally, the order: trade ratio for an exchange has been as low as 3:1. In recent years, however, this number has increased on overseas platforms, to peak as high as 250:1; with 80:1 and 100:1 being averages on two North American exchanges. ASX currently has an equity order: trade ratio of around 7:1 – double what it was several years ago, and this is expected to continue to grow, coupled with ongoing increases in trades executed.

Increases in the order: trade ratio pose operational and supervisory capacity issues, and result in additional costs for supervisors, brokers and clients. Essentially this is because there is a much larger quantity of data to manage. At worst, an overload of data could result in trading platform breakdown, as

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[42] Available at: http://www.sec.gov/rules/concept/2010/34-61358.pdf

occurred on one Asian exchange in recent years. In a supervisory context, the large increase in orders that are subsequently amended or cancelled rather than executed means that new forms of market surveillance are required to detect 'micro-manipulation' – i.e. manipulation of the bid/offer through entering, amending and deleting orders. Supervisor, client and broker infrastructure and telecom costs increase because they must be able to handle, store and manage larger volumes of data.

The driver of this change in order: trade ratio is not clear. The differences between ASX's ratio and those of overseas trading platforms suggests that market microstructure plays a significant role in influencing the ratio. New trade execution rules, the introduction of additional trading venues, competitive pricing structures and competition for posting the best bid/offer at a given time to attract liquidity potentially all contribute to the higher order: trade ratios.

Market Access

ASX's market access requirements will continue to evolve to meet Participant and client needs. However, it is important that ASX's proposed new models are distinguished from a common form of market access in North America, unfiltered access, also colloquially referred to as 'naked access'. Unfiltered access is the practice of allowing clients to enter trades directly into a trading platform without any form of control, pre-vetting or filtering by the market Participant. Clients are sponsored by a Participant of a trading platform, but their order flow, which is usually generated by algorithms, does not pass through any IT infrastructure controlled by the broker. Instead, the client effectively connects directly to the trading platform. It is estimated that unfiltered access accounts for around 38% equity volumes in the US. The SEC recently proposed to impose a number of minimum controls around client access, effectively prohibiting unfiltered access.[43] The US Securities and Exchange Commission's (SEC's) concerns with the practice include increased risk of trading error, possible increased systemic risk, and 'fair access' considerations, because unfiltered access clients can achieve lower latency and gain an advantage over other traders who are required to use pre-trade order filters.

ASX currently requires all Participants offering direct market access (DMA) to have in place adequate pre-trade controls (including filters) which are intended to detect and prevent erroneous, and some forms of manipulative, orders from being entered. Going forward, as set out in part two, ASX intends to offer a form of DMA access where ASX or a third party provides minimum filters to prevent some clearly erroneous trades from occurring and to provide Participants with the capability to manage client credit limits.

It is assumed, on the basis of the SEC's approach, that ASIC would not permit any Australian trading platform to provide unfiltered access, and if necessary would introduce rules which bring Australia into line with any new US rules to this effect.

Pricing

Overseas markets exhibit a range of pricing models, including maker-taker pricing, and different fee rebates and incentive schemes designed to attract liquidity (i.e. order flow) to the trading platform.

Maker-taker pricing (also known in Canada as 'provider-seeker' pricing) has its origins in the US equities market in the late 1990s. New trading platforms (ECNs) initially charged fees for both passive (liquidity provider) and aggressive (liquidity taker) trades, with a lower fee for passive. Competition among trading platforms eventually led to the current system where rebates are paid to liquidity providers, while takers of liquidity are charged a fee.[44]

By the early 2000s, with multiple, competing, US trading platforms adopting this pricing structure, the size of the passive rebate quickly grew – offset by the fee charged for aggressive orders. The SEC was concerned that the cost to the liquidity-seeking side of the trade would be prohibitive, to the detriment of overall market efficiency. In 2003 the SEC introduced rules capping the maximum charge for taking liquidity.[45] The provisions are now in Reg NMS Rule 610C.[46]

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[43] See further: http://www.sec.gov/news/press/2010/2010-7.htm
[44] http://www.thetradenews.com/2237
[45] BMO Capital Markets Quantitative Execution Services, *The Impact of High Frequency Trading on the Canadian Market*, July 22, 2009.

A number of alleged manipulative or unfair trading practices, including variations on trading for volume, are premised on the specific fee models of overseas trading platforms, and do not necessarily translate to the current Australian environment. However, Australian policy makers should be alert to these issues when seeking to identify genuine opportunities to develop liquidity and should consult as necessary before implementing any market microstructure reforms. See further, section 8, on market manipulation.

Flash Orders

In 2009, debate in the US centred on 'flash orders', which the SEC subsequently proposed to ban.[47] ASX does not offer flash orders and could not in the current environment. The flash order issue in the US is a product of a market with multiple trading venues, a strict trade through rule (i.e. an obligation on exchanges to divert an order to a different trading venue if there is a better price available elsewhere), and a legacy exception to the regulatory obligation on exchanges to publicly display their best bid/offer. These conditions are not replicated in Australia.

The SEC describes the process of a flash order as follows: a buy or sell order is submitted to an exchange (e.g. Nasdaq); the exchange determines it has no willing buyer/seller at the best quoted price. Before seeking out a seller/buyer in a competing exchange, the order is flashed to HFTs (who pay to gain access to flash orders) for ~0.03 seconds. This may elicit a willing counterparty that did not want to display their price. If so, then the order will trade at the best price. If not, the order is then routed to other markets to be executed at the best available price.

The SEC has expressed the following concerns with this practice: "The flashing of order information could lead to a two-tiered market in which the public does not have access, through the consolidated quotation data streams, to information about the best available prices for U.S.-listed securities that is available to some market participants through proprietary data feeds."

Because flash orders are not offered by ASX, they are not considered in the Review.

Key Conclusions:

One of the reasons that ASX has not experienced the types of HFT that are prevalent in other markets, or the issues associated with those practices, is due to the differences between the regulatory environment in Australia and overseas.

Fragmented markets, maker-taker pricing and common rules that can be 'gamed' by algorithms have contributed to order proliferation and associated supervisory issues on overseas markets.

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[46] The Rule says a trading centre can charge (or allow to be charged) no more than $0.003 per share for accessing its protected quotations.
[47] http://www.sec.gov/rules/proposed/2009/34-60684fr.pdf

PART TWO: FORWARD-LOOKING FINDINGS

5. Overview of Future Trends

This section considers the likely future position of algorithmic trading in Australia. A key recommendation stemming from this section is that the Australian government examine the likely impact of any market micro-structure changes on the market, and market users' readiness to deal with those changes, before instigating reform.

5.1 Macro-Trends: Regulatory Environment

The volumes of algorithmic trading undertaken in Australia, and the mix of different algorithms used (including whether by long-term investors or short-term traders) will be primarily driven by the regulatory environment. For example, the introduction of additional trading venues, and the accompanying design of 'best execution' or 'trade through' rules in Australia may have a significant impact on algorithmic and HFT practices.

The extent to which Australia follows North American or European market trends will hinge on the extent to which the Government adopts a North American (Reg-NMS) or European (MiFID) style market structure. Prior to considering either approach, the Government should address key public policy issues of the type raised by the SEC in its recent concept release - including how to ensure that the interests of long-term investors are not sacrificed in the course of facilitating shorter-term trading activity, and how to ensure effective whole-of market supervision.

In announcing its review, the SEC noted that markets are not ends unto themselves - rather, they are the means for investors to save for the future, and to allocate those savings efficiently among companies that put that capital to work in the economy.[48]The SEC's review attempts to reconcile the role of the market as a means of facilitating efficient capital and risk transfer, with the ability of particular users of the markets to shape market structure. The Australian Government should be similarly transparent in its analysis of market microstructure changes, to ensure that these are in the public interest before any change program is commenced. Before any meaningful debate on the current and future structure and performance of the Australian equity market can occur, the Government needs to engage with listed entities, who are key stakeholders, but whose integral role in the capital market framework could easily be overlooked if reforms being considered are narrowly and wrongly characterised as 'trading'-oriented.

As discussed in more detail later in this section, licensing of any new trading platform that targeted HFT would have operational and supervisory implications for all trading platforms. Some of the transaction level impacts would include massive increases in data capacity requirements, new processes to coordinate the use of 'kill switches'[49], and the need for a new ability to construct accurate audit trails of order flow for post-trade analysis aimed at detecting new forms of micro-manipulation. Brokers would also be affected, as they would need to increase their own IT and operational capacity and implement new risk management and control procedures to ensure they fulfil their regulatory obligations to their clients. Feedback from North American brokers who have experienced regulatory reform suggests that in the absence of appropriate education and consultation from Government and regulators, it can take many years for any change to be even partially successfully implemented.

Public Awareness

Algorithmic trading is not a new phenomenon, but it has attracted considerable mainstream media and retail investor attention in the past 12-18 months. One reason for this attention may be the politicisation of HFT in the US, (at a time when many practices of Wall Street firms are being questioned in the wake of the GFC), and international press coverage of the SEC's investigation of flash trading.

In Australia, where there is a single trading platform for ASX-listed securities, algorithmic trading (including HFT) appears to be primarily used to execute the same trading strategies and techniques that have

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[48] Commissioner Luis A. Aguilar, "Assuring Securities Markets that are Fair, Transparent and Efficient", *U.S. Securities and Exchange Commission,* Open Meeting, Washington, D.C., January 13, 2010
[49] A kill switch is the ability of an exchange or Participant to instantly stop trading activity by a specific client and to purge open orders.

previously been used – albeit in a much shorter time frame. One attraction of traditional algorithmic trading for fund managers and brokers is that it dramatically lowers the cost of trade execution.

What appears to have occurred overseas is that the ability to trade large quantities of shares very quickly, combined with other market developments such as the market structure and pricing policies referred to above, has led to new trading techniques that are designed to profit from the changing market microstructure environment, and the ability to identify and execute based on opportunities that previously could not be identified. While these new trading techniques (primarily taking the form of different types of liquidity detection) are not necessarily manipulative, they have attracted the attention of overseas regulators who are currently reviewing their impact on market quality and integrity.

Based on overseas experience and comments from the Australian Government about future changes to market structure in Australia, it is considered likely that there will continue to be a rapid evolution of equity market microstructure fuelled by increases in HFT. These changes will continue to be observable by retail investors, and will continue to raise supervisory challenges which the market regulator must be ready to address.

As a consequence of the rapid development of algorithmic trading (including HFT), there has been a growing divergence between contemporary market and trading practice and retail investor expectations of market behaviour. If the Australian Government facilitates multiple trading venues, this divergence could be expected to increase, unless there is a commensurate increase in investor education. If the gap gets too wide, retail investor confidence in Australia's markets may be adversely impacted.

Intended Actions and Recommendation 1: Market Education

1.1 ASX proposes to take steps to raise listed entity, retail investor and other stakeholder awareness of algorithmic trading – including techniques commonly used, the supervision issues raised, and how these are managed. The public release of this paper is the first step in this process. ASX's aim is to de-mystify algorithmic trading and to maintain confidence in the integrity of Australia's security markets notwithstanding the observable changes in the way that trades are executed.

1.2 It is recommended that ASIC also undertakes to educate the retail sector, listed entities and other stakeholders with a focus on the anticipated impact of multiple venues trading the same securities, including how this is likely to facilitate new trading behaviour from HFTs.

1.3 It is recommended that ASIC take a proactive role in articulating, as have overseas regulators, what is considered to be acceptable and unacceptable algorithmic trading practices.

1.4 ASX intends to engage with Clearing and Settlement Participants to ensure they review their business continuity planning regarding the future growth in the number of trades that will need to be processed.

1.5 It is recommended that ASIC ensure brokers (particularly smaller brokers) review their business continuity planning in anticipation of significant increases in order traffic.

5.2 Micro-Trends: Algorithm Development

There have been a range of predictions for the future of mainstream algorithmic trading and HFT globally. Some of these include:

- Programme algorithms which manage a portfolio of orders;

- Widespread use of execution algorithms and integration of these with smart order routers;

- Cross-asset class algorithms (trading groups of multi-asset class instruments, perhaps in different currencies);

- Algorithms which incorporate machine readable news information into their decision making;

- Transaction cost algorithms – essentially an algorithm that determines which are the best order-level algorithms to use based on transaction costs.

- Offerings of algorithms to retail investors.

With the exception of the final point, these products already exist and in some instances are well developed in overseas markets, but do not yet appear to be wide-spread in Australia.

Analysis of algorithms' performance during the global financial crisis has led to predictions of greater customisation to meet the needs of individual buy-side trading desks and the ability for end-users to exert their own control over how a particular algorithm works.[50] It is also suggested that brokers will offer models and features which are less reliant on historical data-models, and which use decision-making and are more intelligent regarding current and predictive market conditions.

In the short-term, US analysts expect to see continued increases in algorithmic trading of non-equity securities – futures, options and foreign exchange in the first instance. Arguably, the Australian equities market has room for substantial further growth of HFT – possibly doubling current levels of activity before reaching the percentages of volume traded by HFTs in the US. The potential introduction of additional trading venues in Australia is likely to be a significant factor in attracting additional HFT activity. As noted in the introduction, the maker-taker fee model has also contributed to HFT growth.

Key Conclusions:

Regulators in the US and Europe, where algorithmic trading is far more advanced that Australia, are only now beginning to come to grips with the inter-relationship between market microstructure, the growth in algorithmic trading, and the potential impact on market quality and integrity.

There is a strong likelihood that any Australian microstructure reforms similar to those in North America or Europe will facilitate significant additional algorithmic trading, particularly HFT.

There is already evidence of a growing divergence between contemporary market and trading practice, and retail investor expectations of market behaviour. This divergence could be expected to increase, adversely impacting on retail investor confidence in Australia's markets. A combination of ASX education, Government consultation and public policy consideration is needed to address this issue.

6. Operational Issues and Recommendations

This section considers the operational challenges posed by algorithmic trading, including managing potentially aberrant trading and responding to increased incidents of wash trades. It sets out recommendations to minimise the chance of an algorithm interfering with the orderly operation of the market, and measures to enhance ASX's market access regime, including the introduction of new pre-order filters.

6.1 Risks and Controls

In conjunction with changes to trading practices, risk management and controls have also evolved. An advantage of the automated trading environment is the capacity to use sophisticated pre-order electronic filters to minimise the risk of trading error.

The Review considered a range of potential risks arising from algorithmic trading. These were grouped according to four broad risk categories: credit, trading, market quality and market integrity. The Review focused on identifying characteristics of algorithmic trading and HFT which may exacerbate existing risks or give rise to entirely new forms of risk. Overseas markets have experienced some issues that have not been experienced by ASX. Relevant risks were then matched with appropriate controls. Where the control does not currently exist but should be introduced, or does exist but could be improved, a recommendation is made to that effect.

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[50] http://www.journalofcreditrisk.com/public/showPage.html?page=870069

The table below sets out some of the different risks and accompanying controls that were considered by the ASX Review.

Risk	Control
Credit Risk (brokers and clearing participants); arises because brokers and clearing participants are financially responsible for the trades of their clients	Collateral; pre-order filters; real-time copies of order flow and trades; credit limits; margining
Trading Risk (brokers); arises because brokers are responsible for ensuring compliance with market rules and the law	Contractual arrangements; pre-order filters; real-time copies of order flow and trades; removal of market access
Market Quality Risk (liquidity, volatility, market impact costs, etc)	Rules framework; Regulatory framework; 'kill switch'; trading halts/circuit breakers
Market Integrity Risk; could arise due to occurances of, or perception of, fraud, manipulation, insider trading, etc	Rules framework; Regulatory framework

6.2 Enhanced Direct Market Access Arrangements

Proposed ASX Enhanced DMA Model

Clients of Participants are demanding to minimise the market data and order latency associated with the current DMA model. ASX is committed to innovation in the supported market access models, while continuing to enhance the risk management options and standards of Participants.

The ASX Review considered ways in which ASX could facilitate technical capabilities and the accompanying rule framework to extend its range of DMA models to meet the evolving needs of clients and Participants, including potentially offering sponsored access.

The aim of introducing an enhanced DMA model is to achieve the objectives of both clients and Participants by removing unnecessary latency, while maintaining and enhancing the order, risk management and market access capability of Participants.

ASX's current DMA model requires all client orders to be routed to the exchange via the Participant's infrastructure. This adds latency to order flow, and contributes to concerns about the potential for front-running to occur. ASX has reviewed overseas market access arrangements to see how these issues have been overcome. The ASX Review concluded that unfiltered direct access should not be permitted, because although it reduced latency and segregates order flows, it may increase the risk of trading error or other undesirable risk management outcomes. Unfiltered direct access is prohibited by the operating rules, and should remain prohibited, both on ASX and any other trading platform.

The ASX Review favoured a DMA model where a client is able to manage its own connection to the exchange, but is required to direct its order-flow through either an ASX-provided or a third-party provided risk management system (commonly referred to as sponsored access). The Participant would retain control over certain filters, such as in relation to credit limits, and would receive real-time information on client orders and trades processed by ASX ('drop copy'). Both ASX and the Participant would maintain the ability to instantly and electronically remove a client's access to the trading platform.

> **Intended Actions and Recommendation 2: Market Access Arrangements**
>
> 2.1 ASX will ensure that any amendments to its DMA model, including those to facilitate sponsored access, are accompanied by appropriate pre-order controls.
>
> 2.2 ASX will introduce an automated means of removing access to the market ('kill switch') that is independent of existing Participant infrastructure.
>
> 2.3 ASX will review mechanisms to enhance its capability to independently validate orders based on price characteristics prior to accepting orders onto its order books.
>
> 2.4 It is recommended that ASIC prohibit market operators from enabling brokers to offer unfiltered access[51] to their clients.

Further technical information about ASX's current and proposed DMA models is at Appendix 2.

6.3 Algorithm Testing

One of the most effective means of preventing operational or supervisory issues that may arise from the use of algorithms is to make sure the algorithm works as intended. Participants have a strong incentive to ensure that their algorithms and those of its clients work correctly, as they could incur significant financial loss through trading error, manipulative activity, or malfunction. As noted earlier, a Participant is responsible under the operating rules for client orders submitted to ASX. However, the review concluded that this self-interest should be backed up by a regulatory requirement to ensure that adequate testing has taken place, providing ASIC (as the whole-of market supervisor) with a tool that should help to prevent potential market disruption and also the means to pursue remedies if testing was not adequate and a disruption occurred as a result.

The current rule framework contains a number of relevant ongoing requirements but falls short of an explicit rule that requires testing. SFE Operating Rule 2.2.13 sets out the prudent risk management obligations for SFE full participants. This includes obligations in relation to client connections and prior to connecting a client – e.g. ensuring that any order and any order system complies with the operating rules. Section 13.3 of the ASX Market Rules similarly sets out requirements for AOP, including an obligation to ensure that the AOP does not interfere with the efficiency and integrity of the market or the proper functioning of the trading platform.

Practices on overseas exchanges vary, but typically include a combination of information gathering about any algorithm being connected to the exchange, and testing requirements. For example, a member asking for a new port may be required to complete a connectivity questionnaire. Where a broker is sponsoring client access via a co-location facility, the broker may be required to provide the exchange with a list of names from their clients, showing who is allowed to access the technology.

A recently released finding of the NYSE Hearing Board highlights the issue of testing of algorithmic trading programs. A firm was found to breach NYSE rules in failing to "adequately supervise development, deployment and operation of proprietary algorithm, including failure to implement procedures to monitor certain modifications made to algorithm."[52] An "unforseen programming issue" stemming from revisions to a proprietary algorithm led to aberrant trading activity (see further below) which disrupted trading in 975 securities and led to late closing of trading.

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[51] The connection of a client directly to the market without appropriate pre-order controls.
[52] Hearing Board Decision 09-NYSE-24, November 27 2009, available at: http://www.nyse.com/pdfs/09-NYSE-24.pdf

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Intended Actions and Recommendation 3: Pre-trading algorithmic testing

3.1 Recent examples from overseas suggest that it will be appropriate to have in place a requirement relating to testing and controls, extending to both broker and client algorithms. Recognising that the Government's proposed rule making powers for ASIC will extend to both brokers and clients, it is recommended that ASIC impose a rule to ensure that all algorithms are appropriately tested before being connected to a trading platform to ensure that the algorithm operates as intended and does not interfere with market integrity.

6.4 Trading Aberrations

One of the often-cited concerns with non-human trading is that an aberrant algorithm could disrupt an orderly market. These concerns generally stem from the 1987 stock market crash, and have two iterations. The first is the risk of a 'feedback loop' whereby an algorithm does not receive or correctly interpret messages from the trading engine, resulting in a flood of orders and potentially unwanted trades or network capacity issues. The second iteration is the 'domino' scenario, where an algorithm submits orders into the market, which in turn triggers other algorithms to submit orders, and these feed off each other, ultimately moving prices away from their perceived value.

Feedback Loop: The NYSE Regulationulatory action referred to above is an example of an algorithm not operating as intended, and creating a feedback loop. The algorithm in question sent hundreds of thousands of 'cancel/replace' messages for orders that could not be located on the trading system, creating a high amount of message traffic which interfered with the operation of the market. The trading platform responded to those messages with 'reject-unmatched cancel' messages. However, the algorithm was not programmed to properly respond to the 'reject-unmatched cancel' message and therefore continued to repeatedly re-send the cancel/replace requests. The firm was unaware of the malfunction until advised by NYSE Regulation.

Domino Scenario: The domino scenario has already been experienced by ASX over the past decade, usually as a result of retail investor use of online broker stop loss facilities.[53] In some circumstances, particularly where investors have nominated the same sale price (often a round-figure amount such as $3.00 or $3.50), a trade can trigger one stop loss which in turn results in a sell order moving the price down, which triggers others stop losses, leading to a rapid sell-down in that security. Depending on the quantity of sell orders, the depth of the market, and the liquidity of the security at that point in time, some stop loss sales may occur well below the stop loss price nominated by the investor. The domino scenario is not confined to stop-loss orders. In a recent US example of the domino effect, the price of a US-listed biotech as sold down from $24 to $7.50 in just over one minute, before trading was halted. The price subsequently rebounded to previous levels later that day.

Dealing with Trade Aberrations

ASX employs a combination of measures designed to ensure that any application that connects and communicates with the trading platform does so appropriately. Measures include minimum operating rule standards, the AOP certification process described above, and qualification testing.[54] ASX also has a trade cancellation policy designed to deal with instances of erroneous trading, such as those occurring as a result of human error, a feedback loop or domino effect. Under the policy, trades which are deemed to be erroneous may be cancelled. In respect of the cash equities market, this process is based upon advice from external market practitioners in the form of the Dispute Governors Committee.[55]

In addition to post-trade issue resolution, real time controls also exist. ASX has the ability to stop client trading activity by removing their access to the market. As stated above, it is recommended that ASX's

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[53] A stop loss is a basic type of algorithm, where a triggering event (e.g. a trade at a nominated price) results in an order to sell securities.
[54] Qualification testing ensures that any application which will connect directly to the exchange's trading engine is able to send and receive messages correctly. This testing is not a substitute for brokers' own application testing, but is a pre-requisite for connecting an application to the exchange.
[55] http://www.asx.com.au/products/shares/how/trade_cancellation_policy.htm

ability to remove access to the market be streamlined with the implementation of a kill switch that could be used by ASX or a Participant (in respect of a client). Pre-order filters can also be used by Participants and their clients to detect problems before orders are submitted to the trading platform.

The ASX Review concurred with ASIC's view that the need for the use of controls (such as 'circuit breakers'[56]) as a mechanism to limit the risk of significant price distortion should be assessed. The benefit of a circuit breaker is that it can be used to temporarily halt trading – or to revert to an intra-day auction before normal trading resumes. However, circuit breakers may introduce unintended risks or consequences. For example, it may be difficult in practice (and in real time) to distinguish between unwanted price distortion caused by a domino scenario, and genuine price movement in response to news or information. In any multi-platform market, it may be difficult to effectively coordinate circuit breakers across all trading venues. If coordination was not achieved, the intended outcome of using the circuit breaker may be undermined, as the aberrant trading activity could conceivably immediately shift to another trading venue if trading was halted on ASX alone.

Intended Actions and Recommendation 4: Trade Aberration

4.1 ASX will review the need for security-specific circuit breakers in the event of additional trading platforms commencing trading, or in the event that algorithmic trading results in trade errors[57] on the ASX cash equity market.

4.2 ASX will review its procedures governing removal of market access, with a view to identifying ways to streamline the current decision-making process (noting that ASX intends to introduce a streamlined 'kill switch' in the future) .

4.3 ASX will encourage brokers to review their own procedures and make sure that these work in practice.

4.4 It is recommended that ASIC consider in what circumstances (if any) it might ask a broker to use a kill switch in the event that use of an algorithm may result in a breach of the Corporations Act or ASIC rules. ASIC should also consider how the use of a kill switch would be coordinated if there were multiple trading platforms.

6.5 Trade Cancellations / Wash Trades

The proportion of ASX 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.[58] 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).[59] These circumstances suggest that the reason for the increase in trade cancellation is that the trades being cancelled are 'wash trades', which may be technically in breach of ASX rules and the law.[60] Cancelling the trade does not have any effect on the breach of the law (i.e. the Corporations Act breach has occurred, notwithstanding the subsequent cancellation), but quickly responding to the breach may be viewed as a mitigating factor in any action taken by ASIC or by ASX under its rules.

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[56] A circuit breaker is an automatic trading halt designed to address issues of disorderly trading. The concept can apply to whole-of-market halts (typically imposed to manage systemic risk) or to individual security halts (typically imposed to reduce volatility and promote orderly price discovery by allowing time for both sides of the order book to replenish).
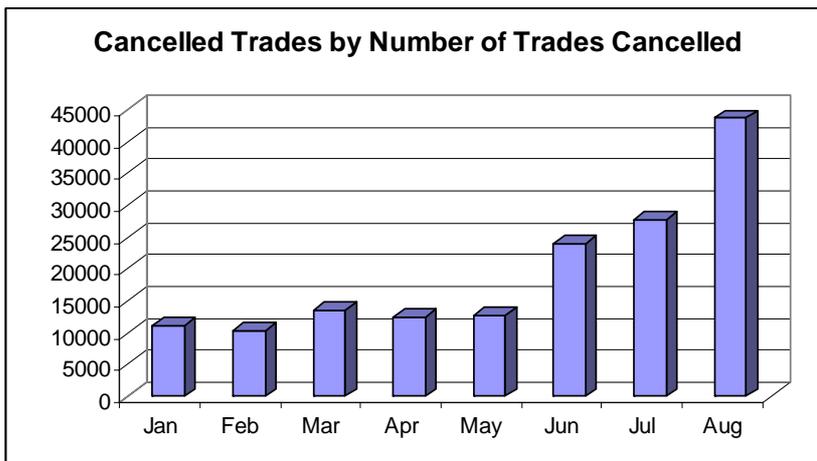
[57] Defined as a trade that is executed sufficiently away from the market price that ASX in consultation with the Dispute Governors Committee determines that the trade will be cancelled. The error can be identified by the ASX, the Participant or a third party, and ASX does not seek counterparty approval for the cancellation.

[58] Many of these cancelled trades may have been subsequently reported at corrected prices or volumes.

[59] Crossing trades can be unilaterally cancelled by Participants without involvement by ASX. Because ASX operates an anonymous market, as a practical matter, a non-crossing trade cannot be cancelled without involvement by ASX because the counterparties to the trade do not know each others' identity.

[60] The Corporations Act says that a wash trade is deemed to create a false and misleading appearance of active trading in a security. Wash trades are prohibited by section 1041B of the Act. Wash trades may also be indicative of market manipulation under ASX Market Rule 13.4.1(a) and SFE Operating Rule 3.1.6.

Chart 12: Cancelled Trades by Number of Trades Cancelled

Cancelled Trades by Number of Trades 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. Where trade cancellation occurs after the close of trading or on T+1, for example it could also affect intra-day TWAP strategies and the calculation of daily VWAPs, impacting other market users.

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. Overseas exchanges commented to ASX that they have also noticed increased numbers of wash trades.

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."*

The ASX Review considered some separate but related issues:

- What can be done to prevent wash trades occurring?; and,
- What can be done to deter Participants from executing then cancelling crossings;**or**
- What can be done to ensure that 'accidental' wash trades or crossings are cancelled in a more timely manner?

Intended Actions and Recommendation 5: Trade Cancellation / Wash Trade

Prevention

5.1 The rule requirement that all brokers offering AOP or AOEI implement measures such as filters or algorithmic programming enhancements to prevent wash trades should be reiterated. The transfer of certain supervision responsibilities to ASIC and the creation of new ASIC rules should provide an opportunity for the importance of these rules to be highlighted.

Cancellation

5.2 ASX will undertake further work to align ASX and SFE approaches to dealing with cancellation of crossed trades, based on the current SFE approach.

5.3 Additionally, and where possible, ASX and SFE trade cancellation policies will be aligned with US and UK practice regarding time limits for notifying the exchange of the trade error and effecting cancellation where permitted according to the Error Resolution Policy. This would mean, for example, that equity trades could no longer be cancelled on T+1.

5.4 ASX will review its fees for trade cancellation (there currently are no fees for cancelling trades on ASX but there are for cancelling trades on SFE) and for trades which are subsequently cancelled (these currently do not incur a fee on ASX, but do incur a fee on SFE).

5.5 It is recommended that ASIC release guidance to the market on the application of the Corporations Act and any ASIC manipulation rules to wash trades. Specifically, ASIC may wish to provide greater clarity around how it will assess whether wash trades are 'accidental' (e.g what measures (volume?) are relevant) for the purposes of law and rule enforcement.

5.6 It is recommended that ASIC provide clarity to market operators about the circumstances in which systematic wash trades constitute a 'significant' contravention for the purposes of the Corporations Act requirement that market operators notify ASIC of certain breaches of the law.

Key Conclusions:

Increased automation of orders has been accompanied by automated pre-order controls which have reduced the risk of trade error.

The ASX Review identified improvements to ASX's market access arrangements, and to procedures to removing access to the market in real time.

The Review identified a range of measures for ASX to implement to reduce the instances of trade cancellations. The Review also identified mandatory algorithm testing as a measure which could further reduce the likelihood of aberrant algorithmic trading.

7. Supervision Issues and Recommendations

This section considers the supervisory issues associated with algorithmic trading. It outlines some of the potential manipulative techniques that may be associated with HFT ('micro-manipulation') and recommends measures which ASIC could adopt in its new role as whole-of-market supervisor: sophisticated post-trade pattern analysis tools and client ID requirements to aid detection of whole-of market misconduct.

Supervision of ASX's markets is currently undertaken by ASXMS. It has responsibility for both market surveillance and monitoring broker conduct in relation to the market. In August 2009, the Federal Government announced that some of ASXMS's responsibilities would be transferred to ASIC in 2010. While not relevant to the essence of the recommendations below, it is assumed that instead of being implemented by ASXMS, these recommendations will be considered by ASIC in the course of the transfer of market supervision.

The Review took into account referrals to ASIC and publicly available enforcement decisions as at 15 January 2010.

7.1 Scope of Operating Rules

ASIC asked ASX to consider whether the operating rules set suitable standards of accountability by participants for the trading activities of its DMA clients. The Review considered ASX's Market Rules and SFE Operating Rules, MPC meeting notes for June and December 2008, and legal advice regarding the breadth of SFE Operating Rule 2.2.14. It is concluded that the rules do set suitable standards of

accountability for brokers for the trading activities of their DMA clients. Both ASX and SFE rules hold a Participant accountable for all trading activity undertaken through the Participant (ASX: 13.1; SFE: 2.2.13). Note that this accountability is not tantamount to some form of strict liability for any rule breaches, such as market manipulation. Using ASX rules as an example, a Participant is appropriately held accountable only for manipulative client trading if the Participant is aware, or ought reasonably suspect, that the person placing the order indents to create a false or misleading appearance of active trading.

The Review considered whether ASX should extend a Participant's obligation further – for instance making the Participant responsible for conduct of a client *before* an order to trade is given to a Participant (either manually or entered into their system). It was concluded that this change would not be feasible or justifiable. This is because the activities of the client are outside ASX's jurisdiction. ASX notes that ASIC rules will not have this same jurisdictional limitation, meaning that ASIC will have the capacity to consider a wider range of regulatory responses than was available to ASX.

7.2 Client ID

Market operators and supervisors do not currently require algorithmic or high frequency traders to register or identify themselves (to regulators) as such. The Review concluded that ASX in its capacity as market operator should not require identification of algorithmic trading in the form of real-time tagging of orders, as this information is not needed for ASX to operate its trading platform.

Market supervisors can determine whether trading activity is algorithmic by asking a Participant for client order details, after the fact. This can make detection of misconduct difficult, because the supervisor is missing a key piece of information – the identity of the client – which could distinguish apparently legitimate trading from market misconduct.

In the US, broker-dealers have a unique ID to each different trading platform. Regulators have to reconstruct trading with a list of the different IDs before they have an accurate whole-of-market order record. This is even before the regulator is in a position to request client details from the relevant broker(s).This was described to ASX by brokers and market supervisors as a messy process. It is an issue not currently experienced in Australia, where there is a single trading platform and a single broker ID. However, it may become an issue if additional venues commence trading ASX-listed securities.

With this backdrop, and a degree of political interest in the issue, the SEC is currently considering whether it will require registration of HFTs. On 3 December 2009, SEC Commissioner Schapiro responded to correspondence from US Senator Kaufman that she intends to "implement the Commission's 'large trader' reporting authority, so the Commission has better baseline information about high frequency traders and their trading activity." David Shillman, associate director of the SEC's Division of Trading and Markets, said the SEC can use its authority under Section 13(h) of the Securities Exchange Act to force large trading firms, including hedge funds and proprietary trading shops that are not broker-dealers, to file a form with the SEC and use an identification number when they trade. That would allow the SEC to gather information about their executions and help determine what impact, if any, they may be having on the marketplace.[61]

The ASX Review initially considered whether the whole-of-market supervisor should require algorithmic traders to be identified as such ('client ID'). The client ID could arguably take one of several forms: real-time tagging of each order with a flag that indicates it was generated by an algorithm; or registration of algorithmic traders and connection via designated IT (pre-order). The ID would not be publicly available – it would be solely intended to assist market supervisors.

In considering whether to recommend the introduction of real time flags, the Review focused on what the information would be used for, and whether the benefits of this use would outweigh the compliance costs that clients and brokers would incur.

One of the North American regulators commented to ASX that it would be very helpful to be able to accurately identify algorithmic trading so that this trading activity could be *excluded* from some post-trade analysis. It was considered that analysis for some types of market misconduct would be better conducted

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[61] http://www.tradersmagazine.com/news/sec-hft-large-trader-reporting-system-104565-1.html?zkPrintable=true

without the large volume of trading activity ('noise') generated by algorithms. As noted above, to date this is not considered to be a problem for ASXMS, but may become an issue for the whole-of market supervisor in the future, if order volumes dramatically increase as anticipated.

The Review's focus subsequently expanded to consider whether the whole-of-market supervisor should require all orders to carry a client ID. To be meaningful in helping to detect misconduct, the client ID would have to be the same, irrespective of which broker or which trading platform a client used to execute their orders. It was considered that this information would provide the supervisor with a powerful new tool to detect insider trading, manipulation, and front-running irrespective of the method of execution, the broker or the trading platform.

The Review noted the implications of this change for brokers and trading platforms, including the IT changes that may be required to capture and convey the client ID. It was also considered that there may be privacy concerns which should be considered, and balanced with the potential benefits of the changes proposed.

Intended Actions and Recommendation 6: Client ID

6.1 It is recommended that ASIC analyse the benefits, and conduct public consultation in respect of, a new requirement for brokers to attach a unique client ID to each order submitted to a licensed market or crossed internally as a tool to significantly improve ASIC's capacity as whole-of-market supervisor to detect insider trading and market manipulation

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7.3 Market Manipulation

The Review considered whether algorithmic trading could lead to increased or new instances of market manipulation, or make manipulation harder to detect. In the course of the Review, ASX also discussed market surveillance techniques with overseas regulators.

Several market supervisors indicated that the split between real time and post trade analysis is roughly 5%:95%. This strong emphasis on post-trade surveillance activity is necessary due to the large volumes of data that need to be integrated before sophisticated pattern analysis software can scan the data for indications of misconduct. These pattern-recognition tools are generally developed in-house. A number of regulators which use third-party provided surveillance systems noted that they use a combination of third party-provided tools and in-house tools.

While it is not directly attributable to algorithmic trading, the ASX Review found that growth in algorithmic trading and consequential order proliferation exacerbates the supervisory challenges in monitoring, enforcement and other types of supervisory issues in a multiple market operator environment. These include monitoring Participant access, managing trading halts, maintaining accurate audit trails and identifying individual trader activity inter-platform. Finra and IIROC have recently identified the increasing fragmentation of the market and quotation of securities in multiple jurisdictions as the reason why it is harder to detect and investigate manipulative trading.[62]

Macro-manipulation

Macro-manipulation is used to refer to traditional share price manipulation. There are various manipulative techniques – including 'pump and dump' (placing buy orders to increase the price of a security and attract other traders, before selling at the inflated price), 'pooling' and 'churning' (variations on wash trades, where pre-arranged trades give the appearance of additional liquidity in a security), and 'ramping' (spreading incorrect information to increase a share price).

One concern in relation to share price manipulation relates to momentum algorithms, which in certain circumstances could distort price discovery for a security. Within a multi-market operator environment, where liquidity has been fragmented and where maker-taker pricing encourages algorithms to 'chase' one another to receive incentives, the risk of price distortion increases significantly. As a market operator, ASX

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[62] "Globalism gives cover to bad guys", Australian Financial Review, Friday 29 January 2010, pg. 50.

will continue to assess the need for the use of controls (such as 'circuit breakers'[63]) in the event that significant price distortion is seen to occur.

Micro-Manipulation

The term 'micro-manipulation' was used by one regulator in discussions with ASX about trading activity (i.e. entering, amending, cancelling orders) designed to move or influence the bid/offer. This is a form of manipulation which is arguably more likely to be exacerbated by HFT due to the speed and intelligence with which HFTs can operate.

It is problematic to distinguish between trading activity that is manipulative, and trading activity that is evidence of competition for the smartest, fastest, most profitable algorithm. Public debate in the US has focused to a large degree on whether certain types of HFT activity are manipulative. The SEC has sought comment on a range of trading strategies in its January 2010 concept release. In the Australian context, any new rules about market manipulation will presumably be generated by ASIC; while any new laws are the responsibility of the Federal Government. As a consequence of the transfer of market supervision from ASX to ASIC, decisions as to what trading constitutes market misconduct will be made solely by ASIC in the future.

Trading platforms create a detailed record of the history of each order entered into the platform, capturing and time-stamping events including order entry, amendment, execution (partial or full) and deletion. This information can be analysed in the context of the broader market – e.g. the best bid and ask, or order book depth at a given point in time. A number of academic studies have examined this data, and concluded that specific patterns can be identified - for example in relation to cancelled orders' lifetimes, providing evidence of the trading strategy behind the algorithmic orders.[64] Increasingly, this approach is being used by regulators globally, to detect patterns of activity that may indicate potential manipulation.

Some specific types of micro-manipulation are considered below.

Layering

Layering (also known as 'spoofing') has been described by the FSA as activity when a client submits multiple orders at different prices on one side of the order book slightly away from the best bid/offer; the client then submits an order to the other side of the order book (which reflects the client's true intention to trade); and following the execution of the latter order, rapidly removes the multiple initial orders from the book.[65]

The entry of multiple non-bona fide orders on one side of the book is intended to create pressure such that an order on the opposite side of the order book receives favorable execution. Layering has been used by clients in an attempt to deceive HFTs which are executing strategies such as momentum trading, which predict share price direction based upon historical patterns and depth of market available at varying price levels.

Layering poses concerns to regulators because it interferes with genuine price discovery and creates false market information.

As with other forms of manipulation, layering creates a pattern of order entries and deletions that can be detected by market supervisors. Other tools such as monitoring order/trade ratios can also be used to identify suspicious trading activity. The FSA has stated "DMA providers should ensure that they have appropriate systems and controls in place to identify and prevent layering and spoofing. Where these systems and controls are not deemed sufficient, we may also consider supervisory or enforcement action against the DMA provider."

ASXMS has referred 'layering' matters to ASIC in the past (but these were not in relation to algorithmic trading).

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[63] A circuit breaker is an automatic trading halt designed to address issues of disorderly trading. The concept can apply to whole-of-market halts (typically imposed to manage systemic risk) or to individual security halts (typically imposed to reduce volatility and promote orderly price discovery by allowing time for both sides of the order book to replenish).

[64] Prix, J., OLoistl, O., Huetl, M., "Algorithmic Trading Patterns in Xetra Orders", *The European Journal of Finance*, Vol. 134, No. 8, 717-739, December 2007

[65] FSA Market Watch, Issue No. 33, August 2009, http://www.fsa.gov.uk/pubs/newsletters/mw_newsletter33.pdf

Locked Market Passive Rebate Arbitrage

An example of a new trading strategy that has emerged overseas and attracted the label 'predatory' is a form of arbitrage designed to ensure that the HFT receives a rebate for providing liquidity to a retail or institutional investor. This strategy is the result of market microstructure changes which make certain types of trading profitable for high frequency traders, where previously this was not the case.

The strategy has been labelled 'Locked Market Passive Rebate Arbitrage' by Canadian broker BMO Capital Markets. As the name suggests, the strategy is made possible by a combination of North America's trade through protection rules and maker-taking pricing.

Trade through protection is an overseas regulatory obligation imposed on trading platforms. It prohibits them from executing a trade if there is a better price available on another trading platform (unless the client has opted-out of protection). Instead, the platform must route the order away to the better price. A locked market occurs where two orders which would otherwise match (e.g. $9 bid and $9 offer), appear simultaneously on different trading platforms, so there is no clear obligation on either platform to route their order away to be filled. There is currently no equivalent rule or maker-taker fee regime in Australia.

BMO Capital Markets described Locked Market Passive Rebate Arbitrage as follows:

"As more participants crowd out passive flow and lock markets to take advantage of the passive rebates it will become much more difficult for liquidity seeking investors to trade on the passive side of the market. This forces them to cross spreads and pay aggressive trading fees resulting in significantly higher trading costs for retail and institutional clients alike. Any uptick in market locking strategies will also cause greater confusion for investors looking at the quote, ultimately harming confidence in the Canadian markets. These strategies are designed to benefit the arbitrageur at the expense of other market participants."[66]

The Review did not consider this issue in detail because it does not fall within the project scope of considering current issues in Australia. Going forward, if the Australian Government contemplates market microstructure reform, it will need to precede any changes with consideration of the public policy issues that arise in the context of multiple markets, trade execution obligations, and fee models.

Intended Actions and Recommendation 7: Market Manipulation

7.1 It is recommended that ASIC provide detailed guidance to brokers and clients on how order record requirements are to be satisfied by algorithmic traders to enable ASIC to effectively conduct its investigation and enforcement functions.

7.2 It is recommended that ASIC impose a requirement on market operators, brokers and clients to ensure that audit trails across market operators have synchronised timestamps to enable accurate post-trade analysis.

7.3 It is recommended that ASIC, in its capacity as whole-of-market supervisor, develop sophisticated post-order and post-trade pattern recognition analysis tools to detect manipulation. These tools should have the capacity to detect manipulative trading activity that occurs during normal trading hours, and during the opening and closing auction periods. The short-term focus should be on improving current tools which detect micro-manipulation. The tools should be capable of detecting single product and cross-product manipulation (e.g. possible manipulation of the opening price of an equity security as a means of affecting the SPI futures contract).

7.4 It is recommended that ASIC consider taking a proactive role in articulating, as have equivalent overseas regulators, what is considered to be acceptable and unacceptable algorithmic trading practices (with particular focus on possible distortions stemming from the interaction between algorithmic trading and maker-taker pricing models).

7.5 It is recommended that ASIC ensure that the market manipulation provisions are adequately drafted to capture contemporary forms of trading and manipulation.

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[66] BMO Capital Markets Quantitative Execution Services, *The Impact of High Frequency Trading on the Canadian Market*, July 22, 2009

> 7.6 ASXMS will continue to undertake real-time monitoring for the purposes of detecting breaches of continuous disclosure, as potential breaches often require real-time action by ASXMS Issuers.

7.4 Liquidity Detection

Liquidity detection is described by US TABB Group as "perhaps the most controversial and least understood aspect" of HFT.[67] Liquidity detection is an umbrella term for trading strategies that involve sending small orders to look for where large undisclosed orders might be resting, on the assumption that when a small order is filled quickly there is likely to be a large order behind it. Some of the common liquidity detection strategies are:

- Pinging: sending out large numbers of small orders with the intention of getting a fill or to gain information about electronic limit order books;
- Sniper: an Algorithm that tries to detect 'hidden' liquidity by trading in round or odd lots until it completes or reaches an investor's limit price;
- Sniffing: Used to 'sniff' out algorithmic trading and the algorithms being used by sending a small portion of an order waiting to see if someone comes and gets it. Sniffers attempt to outsmart many buy-side algorithmic techniques like iceberging.

TABB Group reports that public debate on HFT often refers to 'front running', when in fact liquidity detection would be a more accurate phrase. A survey it conducted of market participants found that 74% did not regard liquidity detection as a form of front running, because the trader "does not have direct knowledge of an order. It is merely positing its existence by analyzing market data accessible to everyone." The ASX Review reached the same conclusion. A second consideration which supported that conclusion is the ability of algorithm programmers to anticipate and program an algorithm so that it does not respond to liquidity detection techniques. As with a trading floor, some traders will be smarter than their competitors and this may gain them an advantage; but as long as other traders have the potential to alter their own conduct or otherwise respond to their competitors, regulators should not intervene unnecessarily.

7.5 IT Infrastructure, Security and Controls

Generic information on algorithms in use is widely available – e.g. in industry journals, publications and advertising material. However, detailed information about how any given algorithm works is extremely closely guarded. This is because they can be costly to produce, but can become worthless if other traders can predict with any degree of accuracy what the algorithm will do and when.

The Review considered the potential for damage to market integrity resulting from shortcomings with IT infrastructure or IT security which could lead to intentional misuse of algorithms or other sensitive information. This could occur via routine transfer of corporate knowledge as employees shift workplace; through third party providers who customise algorithms for different, competing customers; or from criminal activity. It is conceivable that all of the above could occur. This conduct is of concern to a trading platform because proprietary information could be misused to engage in market misconduct such as market manipulation or front-running, which could damage the integrity of the market.

Commercial considerations and the existing Australian legal framework should act as a disincentive for this conduct, however overseas court cases suggest that misconduct does occur.[68] The US pending criminal action against a former Goldman Sachs employee – has provided insight into the potential for misuse of algorithmic trading software. One scenario of concern to market operators is that a stolen algorithm could be used on a slightly faster connection to the trade platform, to effectively front-run all trading opportunities by deploying the stolen algorithm before the legitimate algorithm has time to react.

The Review considered whether there are any specific measures in relation to theft or misuse of an algorithm that should be implemented by a trading platform or market regulator. It was ultimately considered that the central issue - IT security – is not one that is specific to algorithmic trading. Poor

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[67] TABB Group, US Equity High Frequency Trading: Strategies, Sizing and Market Structure, http://www.tabbgroup.com/PublicationDetail.aspx?PublicationID=505
[68] The legal framework in this context comprises civil law contractual agreements, intellectual property law, criminal law and corporations law.

internal controls can enable misconduct ranging from insider trading and market manipulation to money laundering and fraud, irrespective of whether algorithmic trading is involved. All of these issues are of concern to regulators. The ASX Review concluded that a rule which specifically addressed the issue of IT security and controls would serve several purposes: raise awareness of this issue, provide a hook for internal risk and compliance staff and ASIC to engage with brokers and their clients on the adequacy of their IT security policy and associated practices.

Intended Actions and Recommendation 8: IT Infrastructure, Security and Controls

8.1 It is recommended that ASIC introduce rules which require a Participant to have in place an adequate IT infrastructure governance framework, including a comprehensive IT security policy.

Key Conclusions:

The sophistication of HFT traders, combined with huge increases in order flows from multiple platforms, poses new challenges for market surveillance. Upgraded surveillance systems and sophisticated post-trade pattern analysis tools (e.g. designed by PhDs with the same skills as those programming the algorithmic trading engines) need to be introduced to help meet these challenges.

The scale of the challenge facing regulators should not be underestimated; they face a constant battle to keep pace with market practices and to put in place policies and rules designed to curtail the unintended and unwanted side-effects of market reforms, years after those reforms took effect.

MARKET QUALITY AND THE TREND TOWARDS ALGORITHMIC TRADING

Authors

Professor Alex Frino
Dr Andrew Lepone

Date: 1 February, 2010

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SIRCA

Level 9, 80 Clarence St
Sydney NSW 2000
Tel: +612 9236 9100
Email: sirca@sirca.org.au
Web: www.sirca.org.au

About the Researchers

Professor Alex Frino

Professor Alex Frino is CEO of the Capital Markets Co-Operative Research Centre and Professor of Finance at the University of Sydney. In 1991 he received a Masters Degree in Finance from the University of Cambridge, England and in 1995 a PhD in Finance from the University of Sydney, Australia. Professor Frino specialises in equity and derivatives market microstructure. He has published several articles in leading scholarly journals including the *Journal of Finance*, *Journal of Banking & Finance*, *Journal of Portfolio Management* and *Journal of Futures Markets*.

Dr Andrew Lepone

Dr Andrew Lepone is the Director of the Futures Industry Research Centre and a Senior Lecturer at the University of Sydney where he lectures at both undergraduate and postgraduate levels. Dr Lepone completed his PhD at the University of Sydney in 2007. Dr Lepone has published articles in a number of academic journals including the *Journal of Banking and Finance* and the *Journal of Futures Markets.* Dr Lepone's research focuses on the microstructure of futures and equities markets.

Executive Summary

The purpose of this report is to examine trends in various market quality measures on the ASX over the period of October 2006 to October 2009 and to identify the extent to which algorithmic trading has affected market quality.

Overall, results of the analysis suggest that:

- Trends in trading activity suggest that there has been an increase in algorithmic trading.
- There does not appear to be a correlation between the long term trends in key market quality indicators such as bid-ask spread, quoted depth or volatility and the increasing use of algorithms.   For most of the sample period quoted depth (both at the best quotes and visible in the limit order book) remained stable, but has increased significantly since the start of 2009.   Further analysis is required to identify the cause of this increase.
- Changes in volatility are attributable to security market fluctuations and macro-economic conditions. Price volatility has remained relatively stable throughout the sample period, increasing only during the global financial crisis.

Overall, changes in bid-ask spread, quoted depth and volatilty are predominantly explained by security market fluctuations and macro-economic conditions rather than any particular trends in the composition of trading methods (i.e. increases in algorithmic trading).

1.1 Introduction

In electronic financial markets, algorithmic trading is the use of computer programs for entering trading orders with the computer algorithm deciding on aspects of the orders such as the timing, price and volume. Algorithmic trading may be used as a strategy to pursue investment returns (alpha), a market making system to supply liquidity, or an order execution tool to minimize transaction costs. Academic studies (such as Hendershott et al., 2008)[69] have consistently shown that there has been an increase in algorithmic trading in markets around the world. This report provides some evidence on how algorithmic trading has affected market activity and liquidity on the ASX.

1.2 Study Methodology

To assess the impact of changing patterns of algorithmic trading on market quality, various market quality measures are calculated. The data is sourced from Reuters and contains information on the price and volume of *every* on-market transaction executed, together with prevailing bid and ask quotes. To examine potential changes in the level of algorithmic trading, the average trade size (measured by average number of shares per trade) and trade frequency (measured by average number of trades executed per stock per day) are examined. To examine changes in market quality, the following four measures are calculated:

- Proportional Bid-Ask Spread = (AskQuote – BidQuote) / QuoteMidpoint

- Best Depth = Volume of shares at prevailing bid and ask quotes

- Total Depth = Total volume of shares visible in the limit order book

- Volatility = logarithm (HighPrice / LowPrice)

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[69] Hendershott T., C. M. Jones & A. J. Menkveld (2008) Does Algorithmic Trading Improve Liquidity? Working paper.

1.3 Study Findings

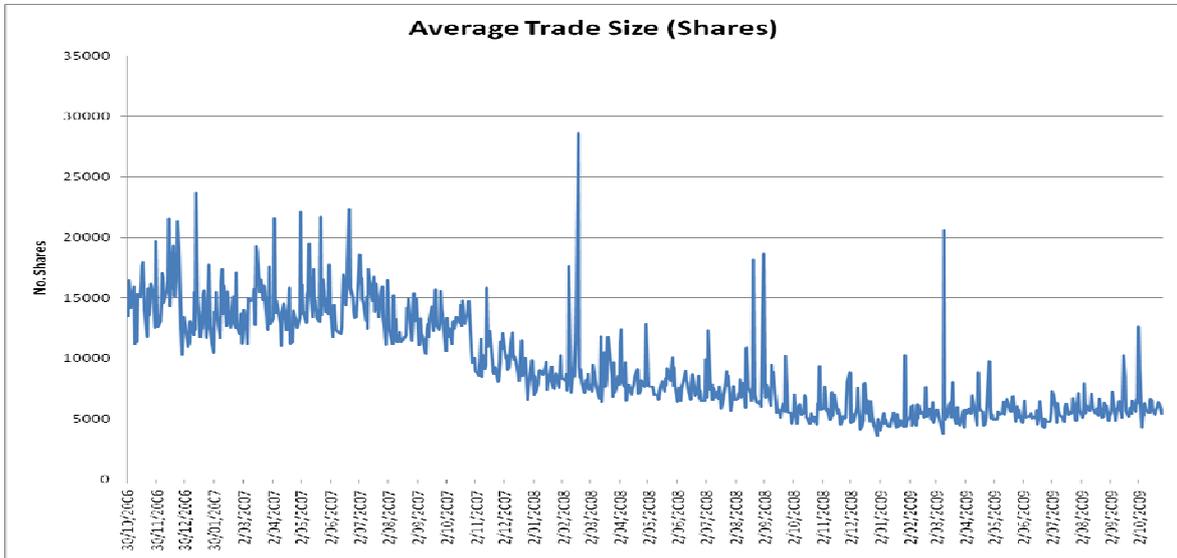## 1.3.1 There is an increase in algorithmic trading[70]
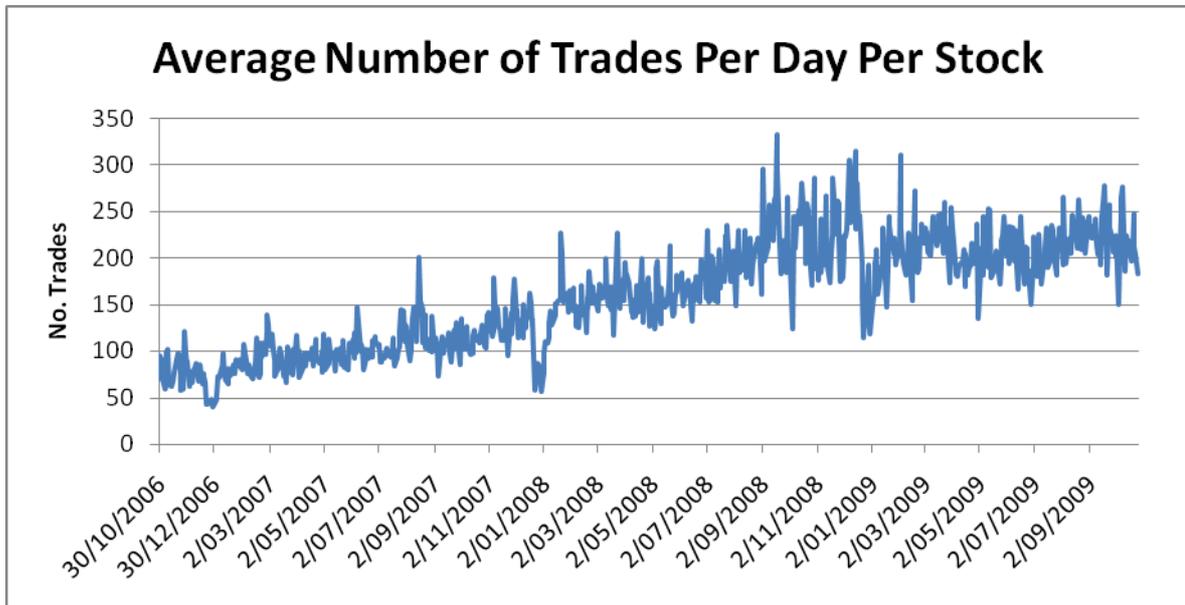
Exhibit 1

Exhibit 2

Exhibit 1 shows how trade size has changed during the sample period. From October 2006 to October 2009, there is a downward trend in the size of trades executed. Exhibit 2 depicts the pattern in trade frequency throughout the sample period. Contrary to the decline in trade size, trade frequency has steadily increased through time. This provides some evidence of an increase in algorithmic trading, because algorithms that seek to create positive alpha, minimise transaction costs and execute block trades generally involve trading with smaller size and

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[70] ASX trade data does not include sufficient data to identify the origin of a trade. Insight into the growth of algorithmic electronic trading can be derived quantitatively, from the changes to trading patterns and qualitatively, from insights gained from ASX Trading Participants. While this study relies on quantitative measures the findings are consistent with qualitative insights gained from ASX Participant feedback.

greater frequency. Therefore these findings are consistent with an increase in algorithmic trading.

1.3.2 There does not appear to be a correlation between the long term trend in bid-ask spread, quoted depth or volatility and the increasing use of algorithms
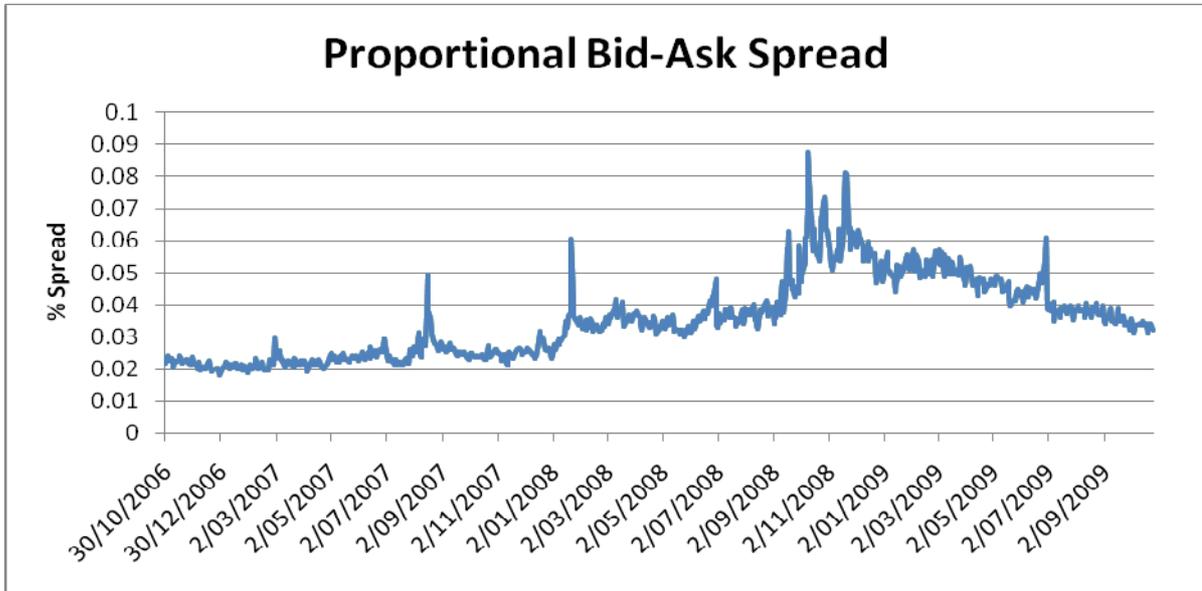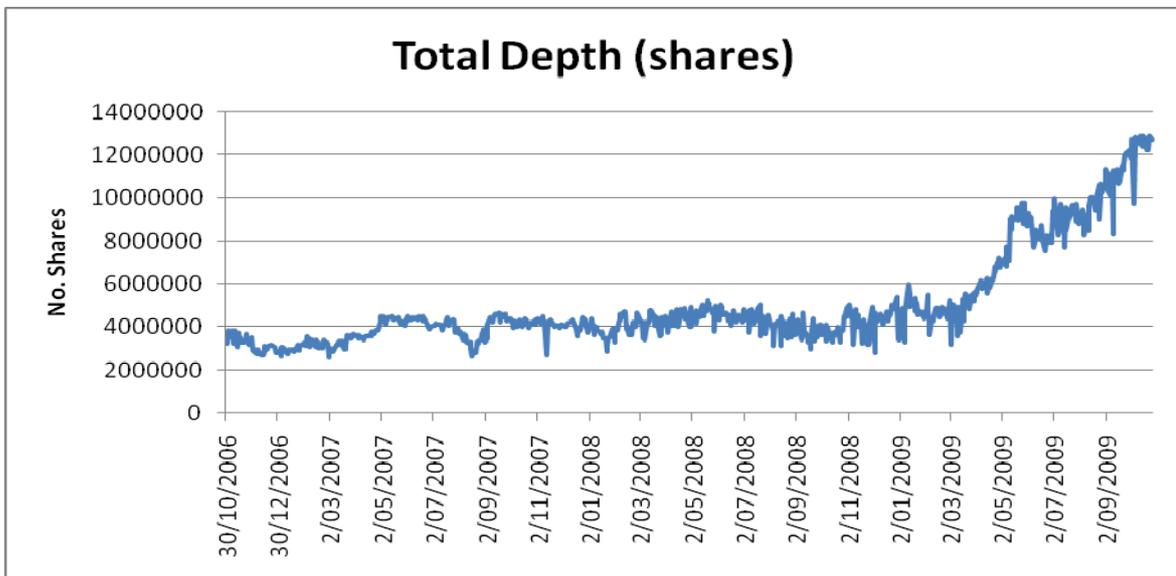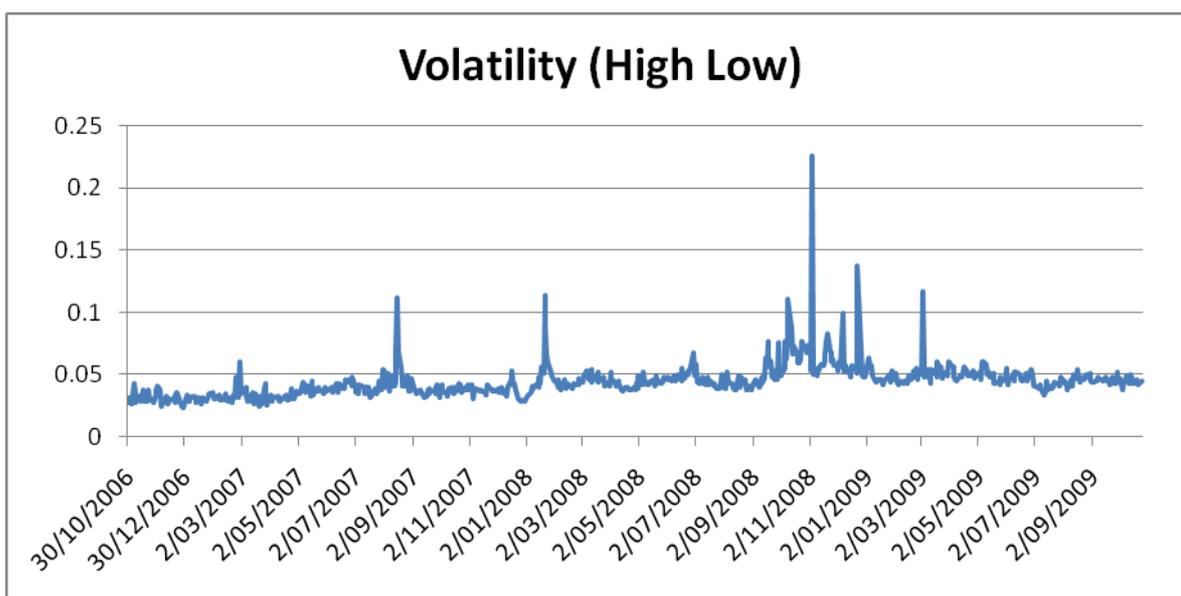
Exhibit 3

Exhibit 4

Exhibit 6

Exhibits 3, 4, 5 and 6 describe changes in bid-ask spread, quoted depth and volatility from October 2006 to October 2009. Exhibit 3 shows that the proportional bid-ask spread has remained quite stable up until the beginning of the credit crisis in 2008. Starting from 2008, bid-ask spreads increased dramatically. This is expected, because during the height of the financial crisis, liquidity in global securities markets was severly affected. Both best depth (Exhibit 4) and total depth (Exhibit 5) remained relatively stable until the beginning of 2009, when it started to trend upwards. While this coincided with the decrease in proportional bid-ask spread, indicating an improvement in liquidity as the economy started to recover from the global financial crisis, further analysis is required to identify the full cause of this increase.

Evidence from volatility of share prices shown in Exhibit 6 reveals a similar story. Volatility trended upwards during 2008, spiked at the height of the crisis, and then returned to pre-crisis levels, similar to the patterns exhibited by the bid-ask spread.

Overall, there does not appear to be any systematic correlation of the long term trend in quoted depth or volatility and the increasing use of algorithms. Changes in depth and volatilty are predominantly explained by security market fluctuations and macro-economic conditions rather than any particular trends in the composition of trading methods.

1.3.3 Changes in the volatility of market quality variables are attributable to security market fluctuations and macro-economic conditions
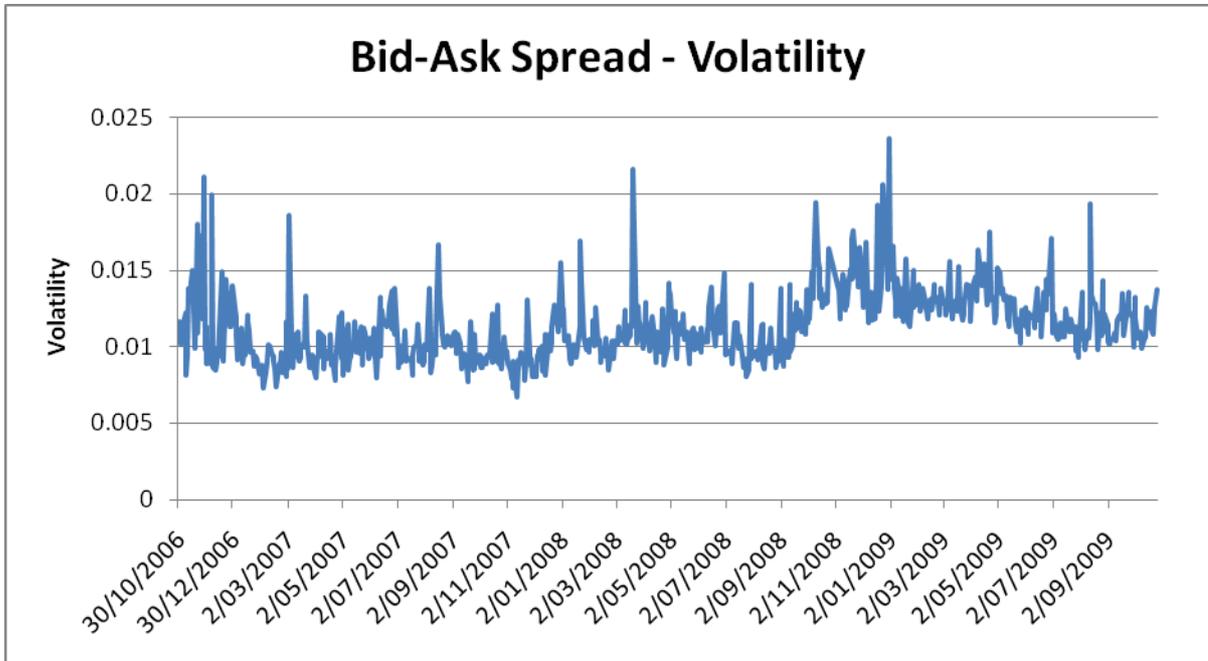
Exhibit 7

Bid-Ask Spread - Volatility

Exhibit 8
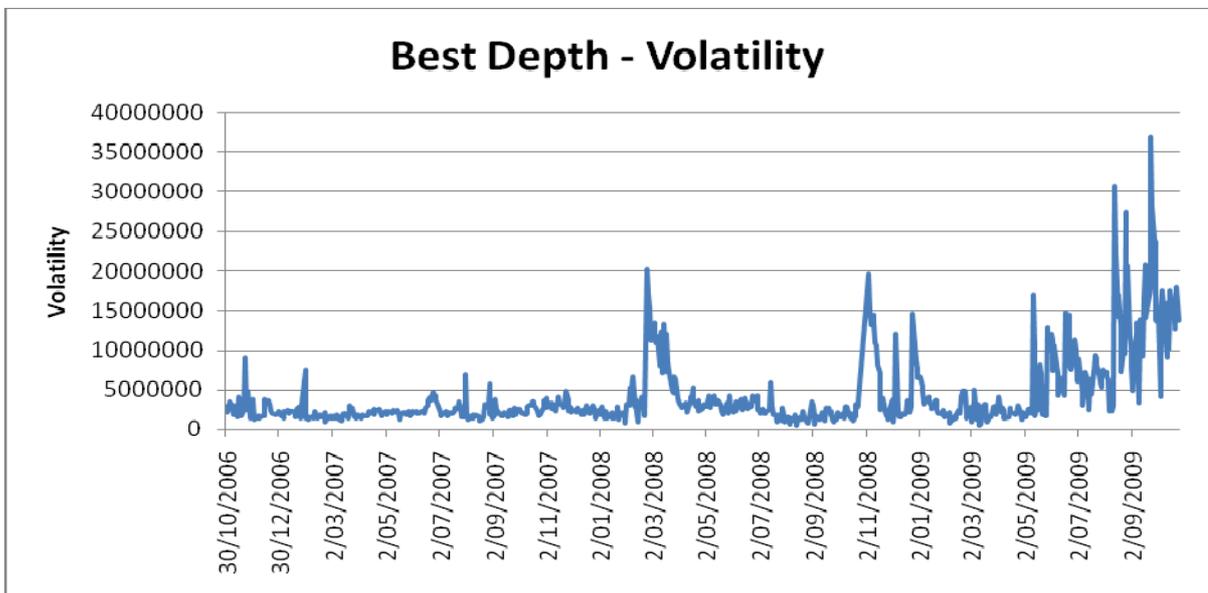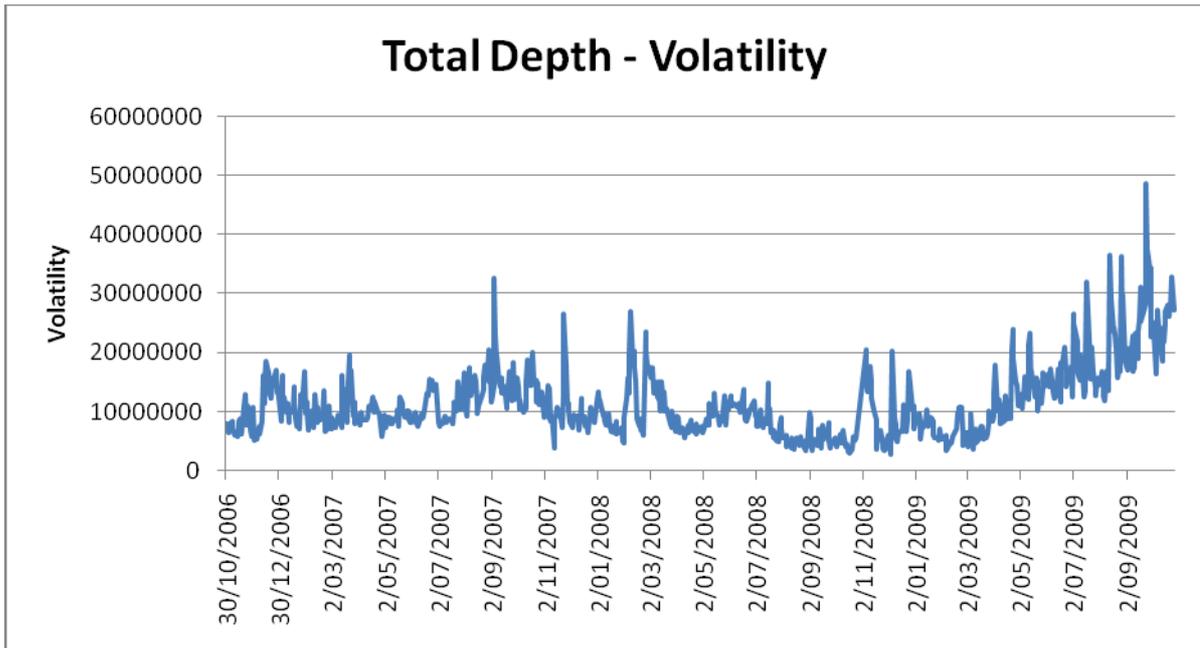

Best Depth - Volatility

Exhibit 9

Further analysis of the market quality measures are presented in Exhibits 7, 8 and 9. The volatilities of the bid-ask spread and quoted depth have remained relatively stable throughout the sample period. Any changes in volatility are strongly correlated to changes in the levels of bid-ask spreads and quoted depth, which we have predominantly attributed to security market fluctuations and macro-economic conditions.

1.4   Conclusion

Overall, this report finds no evidence that any increase in algorithmic trading has led to a deterioration of market quality. Trends and spikes in bid-ask spreads, quoted depth and volatility do not follow any systematic pattern, but are most likely due to security market fluctuations and macroeconomic events.

However, further research is required to better understand the causes of the increase in quoted depth witnessed in 2009 and the relationship between order proliferation and market liquidity.

Appendix 2: Technical Information on ASX Current and Proposed DMA Models

Functional Description of Access Models

The following pages set out technical details of the DMA models currently supported by ASX, and the new enhanced model to be introduced in late 2010. All DMA models support the entry of manual and algorithmic orders by clients.

The differentiators of the supported models are the physical point at which Participant pre-release control is enabled, the scope of the pre-release controls (although all orders are filtered prior to acceptance into ASX Trade) and the control of technical connectivity to the exchange.

1. Direct Market Access – Participant Filtered + OMS (currently available)

The DMA Order Management System (OMS) model combines client order entry and management functionality with Participant-controlled filters in a single system. The client uses the Participant supplied application for entering and tracking orders, and the Participant uses the same system for controlling which orders are sent to the Exchange.

The system may or may not be proprietary to the Participant.

This solution does not support the connection of a client's own algorithmic trading engine, and so is most commonly utilised by clients without a need for low latency or their own OMS, but who have the sophistication to manage their own order execution.

2. Direct Market Access – Participant Filtered (currently available)

This DMA model is similar to the previous model except that the client provides their own OMS, leaving the Participant to only filter the order flow.

This model is utilised by clients with specific needs in terms of order management (e.g. clients using their own algorithmic trading engines), but who are not particularly sensitive to latency.

3. Direct Market Access – Host Filtered (currently unavailable)

The DMA Host Filtered model allows a client to manage its own connection to the exchange but requires it to direct its order flow through a third-party risk management system contracted to the Participant. The third-party provider can proximity-host its infrastructure to further minimise latency.

The Participant has direct control over the pre-submission order and account level filters. The client has no control over the filters maintained by the Participant.

The Participant accesses real-time order and trade information either directly from ASX and / or as a drop-copy from the third-party provider.

The DMA Hosted solution reduces latency by minimising the infrastructure between the client and ASX and allows the client to directly control its own exchange connection for data and order entry.

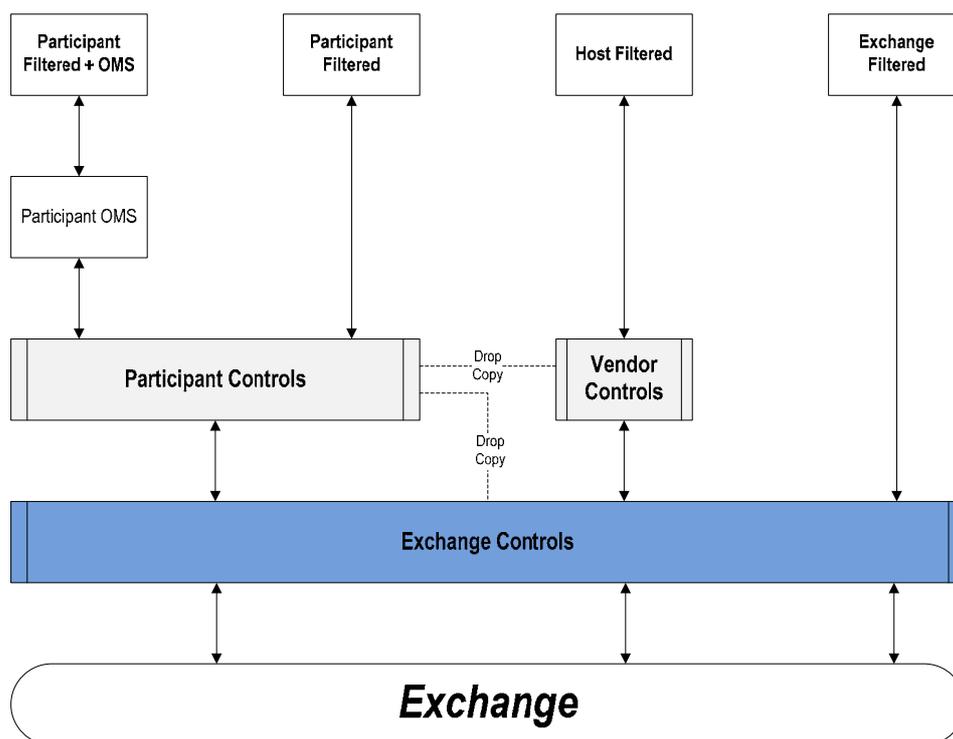This model is aimed at latency-sensitive clients.

4. Direct Market Access – Exchange Filtered (currently unavailable)

The DMA Exchange Filtered model allows a client to manage its own connection to the exchange without the need to route via the Participant's infrastructure or via an external third-party system.

The client order flow will be subject to order and / or account level filters provided by ASX and controlled by the Participant. The Participant will receive real-time information on client orders and trades processed by ASX, and will maintain the ability to instantly and electronically remove a client's access.

This solution is for the most latency sensitive clients while providing the Participant with order, risk-management and access controls consistent with other DMA models.

Diagram 1 – Graphical representation of DMA models

Access Model Filters and Participant Controls

The table below details the scope of controls available to Participants to manage each DMA model. The controls are available through a combination of Exchange and Participant solutions.

DMA Model	Direct control of filters	Pre-release order level filter	Pre-release account level filter	Real-time order and trade disclosure	Real-time access removal
Participant Filtered + OMS	Yes	Yes	Yes	Yes	Yes
Participant Filtered	Yes	Yes	Yes	Yes	Yes
Host Filtered	Yes	Yes	Yes	Yes	Yes
Exchange Filtered[71]	Yes	Yes	Yes	Yes	Yes

Direct control of filters: Determined by whether the Participant has exclusive and continual access to set and amend available pre-release order filters.

Pre-submission order level filters: Filters that assess an order as a discrete unit rather than as part of an account. Filters are designed to prevent errors in price, value and direct compliance such as short selling.

Pre-submission account level filters: Filters that assess an order in the context of account level exposure. Such filters depend on a consolidate account position irrespective or execution venue.

Real-time order disclosure: Determined by whether the Participant has access to real-time information from ASX as to the accepted orders of a DMA client.

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[71] The Exchange Filtered DMA model will not be available until late 2010.

Real-time access removal: Determined by whether the Participant has an ability to electronically and immediately remove a DMA client's trading access and live orders.

Diagram 2 – Location of Filters