A Tale of Two Consequences

Intended and Unintended Outcomes of the Japan TOPIX Tick Size Changes

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1 Abstract

We look at the effect of the tick size changes on the TOPIX 100 index names made by the Tokyo Stock Exchange on Jan-14-2014 and Jul-22-2014. The intended consequence of the change is price improvement and shorter time to execution. We look at security level metrics that include the spread, trading volume, number of trades and the size of trades to establish whether this goal is accomplished. An unintended effect might be the reduction in execution sizes, which would then mean that institutions with large orders would have greater difficulty in sourcing liquidity. We look at a sample of real orders to see if the execution costs have gone up across the orders since the implementation of this change.

We study the mechanisms that affect how securities are traded on an exchange, before delving into the specifics of the TSE tick size events. Some of the topics we explore are: The Venue Menu and How to Increase Revenue; To Automate or Not to Automate; Microstructure under the Microscope; The Price of Connections to High (and Faraway) Places; Speed Thrills but Kills; Pick a Size for the Perfect Tick; TSE Tick Size Experiments, Then and Now; Sergey Bubka and the Regulators; Bird's Eye View; Deep Dive; Possibilities for a Deeper Dive; Does Tick Size Matter? Tick Size Does Matter!

2 The Venue Menu and How to Increase Revenue

The more that shoppers shop, the more shops there will be and the more the shops will try to woo the shoppers. Similar has been the effect of increasing financialization across the globe. Greater levels of trading, by both retail and institutional investors, have resulted in more exchanges springing up and offering more products that can be traded. The longer the menu of venues, more the competition among them, and this naturally requires attempts at trying to attract and retain customers, by a venue to increase its revenue. If people are willing to pay (or bid) more than what is asked (or offered), then perhaps, we would not have specialized venues to trade, a small price to pay for, let us just say, peace on Earth. Forgetting about Utopia - but keeping in mind that conceivably, the Bid-Offer spread can be a barometer to a civilization's

progress, till it becomes irrelevant, indicating that a society has transcended beyond mere material matters of accumulating and allocating wealth - a brief and worthy digression would be to look at how exchanges have evolved and what factors drive the future development of trading venues.

An exchange, as the word implies, is the process during which people give and take things of similar value. At a place where this transfer happens, also an exchange, shares or holdings can be liquidated and hence the primary mission of an exchange is to provide liquidity. For the rest of the discussion, we ignore the exchange of OTC (Over The Counter) securities, which are traded wherever, whenever and however one can trade them; but we leave the reader with the analogy that if Exchange Trading is similar to collecting tolls on a road; OTC Trading is like highway robbery.

As with most historical matters, there is no agreement on when and where the first stock exchange was started. There seems to be some consensus that the first exchanges were started to finance East India companies that provided investment for merchants that sailed on the high seas to conduct business with various countries in Asia. In addition to raising capital, these trading arenas, offered a means for the transfer and sharing of risk. The effect of this simple movement of securities between owners, ripples across, gets magnified and affects the entire economy. See, (Michie 2001), for an excellent exposition on the questions exchanges faced centuries ago and how they are similar to the issues that are cropping up today, with a focus on the London Stock Exchange (LSE). Conceptually, the trading venues of today, still perform the same duties, since all of finance, through time, has involved three simple outcomes – "Buy, Sell or Hold". The complications are mainly to get to these results.

2.1 To Automate or Not To Automate

Alongside the progression of exclusive trading locations, a parallel development has been the increased use of automation and technology in the buying and selling of securities. This has removed the traditional concept of a brick and mortar building where specialists or jobbers (the market makers on the NYSE - New York Stock Exchange - and LSE) acted as the counter-parties for brokers, who were undertaking orders on behalf of the end investors. Since the advent of the National Association of Securities Dealers Automated Quotations (NASDAQ), the first electronic stock market, many more electronic trading networks have proliferated and virtual trading has been adopted even by the remaining physical exchanges to a great degree.

There is no dearth of evidence that the rules of trading affect the profitability of various trading strategies. Venkataraman (2001) compares securities on the NYSE (floor-based trading structure with human intermediaries, specialists and floor brokers) and the Paris Bourse (automated limit order trading structure). He finds that execution costs might be higher on automated venues even after controlling for differences in adverse selection, relative tick size and economic attributes. A trade occurs when an aggressive trader submits a market order and demands liquidity, hence the rules on a venue are designed to attract demanders of liquidity, and nudge liquidity providers to display their orders. Displaying limit orders involves risks. First,

the counter-parties could be better informed and liquidity providers could get picked off. Hence, they would like the trading system to allow them to trade selectively with counter-parties of their choice. Second, they risk being front-run by other traders with an increase in the market impact of their orders. Hence, large traders want to hide their orders and expose them only to traders who are most likely to trade with them. This means fully automated exchanges, which anecdotally seems to be the way ahead, need to take special care to formulate rules to help liquidity providers better control the risks of order exposure.

2.2 Microstructure under the Microscope

Market microstructure is the investigation of the process and protocols that govern the exchange of assets with the objective of reducing frictions that can impede the transfer. In financial markets, where there is an abundance of recorded information, this translates to the study of the dynamic relationships between observed variables, such as price, volume and spread, and hidden constituents, such as transaction costs and volatility, that hold sway over the efficient functioning of the system. Madhavan (2000) provides a comprehensive survey of the theoretical and experimental literature relating to: price formation, the dynamic process by which prices come to impound information; market structure and design, the relation between price formation and trading rules; and transparency, the ability of market participants to observe information about the trading process.

Differences in microstructure, such as tick size, spread, trade depth and clustering of prices (clustering is the tendency for prices to fall on a subset of available prices), could be due to differences in market structure such as whether a given market is a dealer market or an auction market. Auction markets are order driven, where buy orders seek the lowest available prices and sell orders seek the highest available prices. This process is called the price discovery process because it reveals the prices that best match buyers to sellers. Dealer markets are quote-driven because prices are set only by dealer quotes in the market. Huang and Stoll (2001) study securities on the LSE and American Depository Receipts (ADRs) on the NYSE. The key feature differentiating the two market structures is the treatment of public limit orders. In an auction market, limit orders are displayed and may trade against incoming market orders. In a dealer market, limit orders are held by each dealer, are not displayed, and can only be traded against the dealer's quote. Spreads could be higher in dealer markets since they are set by dealers. A minimum tick is necessary in an auction market to encourage liquidity provision by limit orders and by dealers. Without a minimum tick (or a minimum trade size), a limit order can cheaply step ahead of another limit order or a dealer quote. If there is no minimum tick, it is easy to avoid time priority. Dealer markets do not require time priority across dealers and they have less need for a minimum tick. However, each dealer quotes in depth even in the absence of a tick rule because he wishes to maintain a reputation for liquidity or because dealer markets set standards as to depth. Quote clustering is highly correlated with spreads and with the stock characteristics that determine spreads. If a market has higher spreads it has greater clustering. Trade clustering is lesser relative to quote clustering in dealer markets indicating that negotiations with dealers can be successful even though negotiation for better

prices by customers takes place off the screen whereas negotiation in an auction market takes place on the screen via limit order placement. In auction markets, limit orders break up quote clustering as they seek to gain priority and trades cluster to a similar degree as quotes. Higher spreads are accompanied by greater depth. Trade sizes are larger consistent with the large depth, but the difference in trade size is not as great as the difference in depths.

While a number of variables can be observed on an exchange, the primary lever available for adjustment is the spread. (Roll 1984 and Stoll 1989) connect stock price changes to the bid-offer spread. The spread is determined due to order processing costs, adverse information or inventory holdings costs. A key distinction to be aware of is between the quoted spread and the realized spread. The quoted spread is the difference between the ask price quoted by a dealer and the bid price quoted by a dealer at a point in time. The realized bid-ask spread is the average difference between the price at which a dealer sells at one point in time and the price at which a dealer buys at an earlier point in time. The quoted spread is related to characteristics of securities such as the volume of trading, the stock price, the number of market makers, the volatility, and other factors. If the spread reflects only order processing costs, the bid and the offer always straddle the true price. The dealer covers costs by buying at the bid and selling at the offer (on average). Sequences of purchases at the bid price are ultimately offset by sequences of sales at the ask price. In this case, the realized spread and quoted spread are the same. An implication of both the inventory cost model and the adverse information cost model is that the realized spread earned by a dealer is less than the spread quoted by the dealer (empirical studies show this to be the case; references mentioned earlier in the paragraph have more details). Under the inventory cost model, this is because the dealer lowers both bid and ask prices after a dealer purchase in order to induce dealer sales and inhibit additional dealer purchases and raises both bid and ask prices after a sale in order to induce dealer purchases and inhibit dealer sales. The net effect of bid and ask price changes are such that future transactions that will equilibrate inventory. New prices are set such that the dealer is indifferent between a transaction at the bid price and a transaction at the ask price. Under the adverse information cost model, bid and ask prices are changed in a similar way to reflect the information conveyed by transactions. After a sale to the dealer, bid and ask prices are lowered because a transaction conveys information that the expected equilibrium price of the security is lower. Transactions convey information under the assumption that some traders are better informed than others.

2.3 The Price of Connections to High (and Faraway) Places

Technology coupled with globalization is causing financial markets to be linked. While the global financial connection is mostly implicit at this stage, explicit links across exchanges are being added (See Kashyap 2015b on the Hong Kong Shanghai Connect). Caldarelli, Marsili, and Zhang (1997) show that even a simple model of an exchange, operating as a completely closed system with no external influences, where the participants

trade with the sole purpose of increasing their capital after observing the price history, can produce rich and complex fluctuations in prices. In our numerical explorations, we return to this premise and restrict our observations to measurements that can be directly gathered on an exchange. Structuring the study in this way abstracts away from the subjective decision regarding what external variables can influence a system. This benchmark scenario, which is a simplified platform to glean illuminative lessons, differs from a realistic setting with regards to the changes in demand from an exchange participant, which can be influenced by external factors as observed by the participant himself or from the order flow he receives from investors that are not exchange members, who could be acting due to other extraneous forces. Karolyi and Stulz (1996) explore factors that affect cross-country stock return correlations using dollar-denominated returns of U.S. and Japanese shares trading in the U.S. They find that U.S. macroeconomic announcements, shocks to the Yen/Dollar foreign exchange rate and Treasury bill returns, and industry effects have no measurable influence on U.S. and Japanese return correlations or the co-movements between U.S. and Japanese share returns. However, large shocks to broad-based market indices (Nikkei Stock Average and Standard and Poor's 500 Stock Index) positively impact both the magnitude and persistence of the return correlations. Possibly, movements in prices are the biggest contributors to further price movements.

Adding technology enabled buying and selling, which can support more trades, to the ability to buy and sell in distant lands, accelerates the transfer of securities, causing prices to be displaced back and forth from any equilibrium (rather pseudo equilibrium) which causes more transactions to happen affecting the entire cycle of investment management (Kashyap 2014a). Advocates of setting daily limits on how much the price of a security can change over the course of a trading day believe that such measures can decrease stock price volatility, counter overreaction, and do not interfere with trading activity. Daily price limit critics claim that price limits cause higher volatility levels on subsequent days (volatility spillover hypothesis), prevent prices from efficiently reaching their equilibrium level (delayed price discovery hypothesis), and interfere with trading due to limitations imposed by price limits (trading interference hypothesis). Kim and Rhee (1997) study the effect of daily price limits on the Tokyo Stock Exchange (TSE) and despite small sample size issues find evidence supporting all three hypotheses, suggesting that price limits may be ineffective.

This constant jumping of prices and the associated transfer of capital gives rise to a highly specialized work force that seeks to plug every source of inefficiency and profit from it (Kashyap 2015a). As funds flow from the benefactor to the beneficiary, chunks of it are taken by players along the financial food chain. The touch point during this transfer of capital, the exchange, has to seen as reducing any potential losses. But intermediaries and their actions can possibly aid the overall process of liquidation, making it quicker and efficient; it also brings more trading volumes, a main source of income for the exchanges. There is also an indirect channel as more participants and more volume begets lower spreads, which lowers execution costs, which induces more volume, which then generates more profits. Easley and O'Hara (2010) demonstrate the

potential benefits to exchanges, investors and firms from reducing ambiguity over how markets work or asset prices are formed. Uncertainty can cause some traders to be overly influenced by "worst case" outcomes, even when these outcomes have little objective possibility of occurring. This, in turn, can cause such naive investors to opt not to participate in markets, a result detrimental to both markets and the economy alike. Microstructure features (which in their study refers to listing thresholds; monitoring to ensure fair and non-manipulative trading; and operational oversight of clearing and settlement to insure that a trader who buys stock actually receives it and that one who sells stock actually delivers it) can be used to reduce this ambiguity, and thereby induce greater participation in markets. A side effect of excess liquidity might be investor passivity and fragmentation of stockholdings (Bhide 1993), since investors can exit stocks they don't like easily and their holdings are not big enough to be a voice for better corporate governance.

2.4 Speed Thrills but Kills

The technical arms race will give rise to a situation where participants focus their efforts on trading faster once certain kinds of new information is received since being first would mean the difference between profits and losses (or perhaps, just the difference between profits and lesser profits, which can sometimes seem equally worse in an atmosphere where milliseconds matter). Ye, Yao & Gai (2012) confirm the old adage, speed thrills but kills. They find evidence that increasing the speed of trading from the microsecond level to the nanosecond level, lead to dramatic increases in message flow. The increases in message flow are due largely to increases in order cancellations without any real increases to actual trading volume. Spread does not decrease following increase in speed; market efficiency, in terms of price formation, does not improve; market depth decreases and short-term volatility increases, probably as a consequence of more cancellations. A fight for speed increases high-frequency order cancellation but not real high-frequency order execution. Increased cancellation generates more noise to the message flow. Low-frequency traders then subsidize high-frequency traders because only executed trades are charged a fee. The exchanges continually make costly system enhancements to accommodate higher message flow, but these enhancements facilitate further order cancellations, not increases in trading volume. Investment in high frequency trading with sub-millisecond accuracy may provide a private benefit to traders without consummate social benefit; therefore, there may be an over-investment in speed.

The point that warrants further consideration is whether High Frequency Trading (HFT) is leading to benefits by either directly providing additional liquidity or indirectly via the spawning of numerous technological innovations in computer networking hardware, software or other items used to facilitate HFT, which can then be beneficial to other sectors. An example that concerns high speeds is from the car racing industry, which comes up with innovations that produce faster and safer cars. Many of these innovations slip into the mainstream automobile industry over time. Completely restricting any endeavor is not ideal since it hard to know where the next life changing idea might spring up; but regulating the dangerous or unfavorable ones is

prudent. Learning further from this example, we do not see race-cars cruising down our town streets (though, not something to rule out entirely in the not too distant future); they hustle around in an exclusive arena, indicating that perhaps we need a similar mandate for the HFT industry.

2.5 Pick a Size for the Perfect Tick

From a theoretical point of view (Harris 1994), the tick size is the lower bound of the bid-ask spread. We can then expect that a reduction in the tick size would decrease the quoted spread. Nevertheless, the reduction in the spread could also decrease order exposure because liquidity provision is less profitable and more risky. As a consequence, the quoted depth could also decline. Goldstein and Kavajecz (2000) and Lipson and Jones (2001) explore the effects of the tick size reduction on the NYSE and find that while decrease in tick sizes might improve the liquidity for small size orders, institutional traders were worse off because they had to bear an increase in trading costs following the decline in depth throughout the entire order book. Bessembinder (2003) reports evidence regarding trade execution costs and market quality after the 2001 decimilization on NYSE and NASDAQ, which includes narrower average quoted, effective, and realized bid-ask spreads on both markets, lower volatility on both markets, and the absence of systematic reversals of quote changes on either market, indicating that market quality has indeed been improved, while admitting that a complete assessment of the impact of decimalization on market quality will also require access to proprietary data on institutional trading programs, in order to assess whether trading costs for large institutions have also declined.

Bourghelle and Declerck (2004) look at the consequences of a change in the tick size at the Paris Bourse, where there was a both a decrease and increase in tick size on different groups of securities and hence offered an opportunity to simultaneously explore the issues involved. Decreased tick sizes induced a decrease in depth at the quotes. However, in contrast with results obtained for US markets, (reflecting differences in market design between European and US exchanges), this change neither generated a change in the bid-ask spread nor a reduction in liquidity provision for large trades. Limit order submission inside the best quotes (on the best quotes) increases significantly, and investors use more hidden quantity orders to reduce exposure. Stocks that experienced an increase in the tick size did not have altered spreads, but it increased the depth at the best quotes, showing evidence of a larger display of liquidity. Limit order submission inside the best quotes significantly decreases, and investors use fewer hidden quantity orders. By increasing the per-share rent, a larger relative tick makes liquidity supply more profitable and probably attracts new limit order traders in the market. To attract liquidity demanders, designers of trading systems have to stimulate investors to fully display their orders. A relatively coarse pricing grid does not always result in excessively large spreads, but enhances quoted depth, encourages liquidity providers to expose their trading interest and stimulate investors to quote the competitive spread.

Ahn, Cao and Choe (1998) examine the impact of decimalization in Canada and find a significant reduction

in the spread and quotation depth on the Toronto Stock Exchange (ToSE) and a significant reduction in the spread on NASDAQ for ToSE stocks indicating that NASDAQ dealers might not operate as efficiently as perfect competition warrants and could quote narrower spreads without any rule change on the NASDAQ. However, the decimalization does not affect the spread on the NYSE and American Stock Exchange (AMEX) for ToSE cross-listed stocks. The most important finding is that despite an economically significant reduction in the spread on the ToSE, orders for the cross-listed stocks do not migrate from U.S. markets to the ToSE. This result contrasts with the ToSE's objective to attract order flows from the U.S. markets and to increase the market share of the ToSE in cross-listed stocks. The savings in transaction costs on the ToSE are not sufficient to offset the benefits of trading (which include the ease of trading and superior execution of blocks) on the NYSE and AMEX. The practice of payments for order flow has existed between Canadian brokers and U.S. dealers for years. Given the restriction that a Canadian broker cannot accept payments for the purchased order from a Canadian dealer but can accept payments from a U.S. dealer, there is little incentive to direct the order to the TSE for execution, even though the TSE offers lower trading costs. Chung and Van Ness (2001) look at the intraday effect on spreads due to the Order Handling Rules (OHR, which included quote depth and tick size reductions) implemented on the NASDAQ in 1997. They find that the tick-size reduction led to a significant decline in spreads with the magnitude of the decline being largest (smallest) during the last (first) hour of trading and to a significant decrease in quoted depths with the magnitude of the decline being smallest during the first hour of trading. Bessembinder (1999) finds that executions costs on the NASDAQ remain higher compared to the NYSE even after the OHR was put in place, though the cross-market differential has decreased steadily over time. Some explanations for the difference could be that: one, NASDAQ securities have different economics characteristics (such as greater return volatility or smaller investor base); two, NASDAQ's quote driven dealer structure could be less efficient than the order drive NYSE structure; three, or the NASDAQ facilitates a form of collusion that can keep spreads higher. A point worth noting is the preferencing arragements whereby orders are routed by brokers to dealer based on preexisting agreements rather than to the market maker displaying the best quote might have been responsible for a lack of competition on the NASDAQ. Bessembinder (2000) examines changes in trade execution costs and market quality for a set of NASDAQ listed firms whose tick size changed as their share prices passed through \$10. Though there was apparently no written rule, the convention on Nasdaq during 1995 was to use tick sizes of 1/8 dollar for bid quotations at or above \$10 per share and 1/32 dollar for bid quotations below \$10 per share. The empirical results indicate that spreads decreased and there was no evidence of a reduction in liquidity.

Bollen and Busse (2006) measure changes in mutual fund trading costs following two reductions in the tick size of U.S. equity markets: the switch from eighths to sixteenths and the subsequent switch to decimals. They estimate trading costs by comparing a mutual fund's daily returns to the daily returns of a synthetic

benchmark portfolio that matches the fund's holdings but has zero trading costs by construction. Smaller tick sizes lower depth, thereby penalizing institutional investors. Large institutional orders are sensitive to market depth for at least two reasons. First, filling a large order may take several days and multiple transactions; hence a large order likely suffers price concessions as market depth is consumed. Second, information leakage may move prices adversely as the institutional investor attempts to fill the order. Investors who trade small quantities of individual equities benefit from the tighter spreads following the switch to decimal pricing, and are largely unaffected by any decline in depth.

These results underscore the view that market structure has a significant effect on trading costs and hence the design of optimal trade and quote dissemination protocols coupled with proper regulatory oversight of the investment process are essential for investor welfare and market quality. Of all the weapons in the regulatory arsenal, it seems, changes that can influence the price formation process without directly setting price levels, hold the greatest power. One takeaway from these studies is that regulators may be well advised to avoid reducing tick size if they want to attract liquidity providers, and if order exposure is profitable for a market.

2.6 TSE Tick Size Experiments, Then and Now

The TSE has tried its hand earlier at tick size changes when it introduced a change in its minimum tick sizes on April 13, 1998. The TSE is one of the largest limit order markets using a tick size that is a step function of share price. The reduction in tick size therefore depends on price ranges. Ahn, Cai, Chan and Hamao (2007) investigate the liquidity and market quality of the stocks affected by this change. They find that the quoted spread and the effective spread declined significantly. Reductions in spread are greater for firms with greater tick size reductions, greater trading activity, and higher monopoly rent proportion in the bid-ask spread component. There is an increase in the quote revision (relative to the number of trades), suggesting there is more price competition among limit order traders in providing liquidity. Although investors are more aggressive in posting quotes, there is no definite evidence of an increase in trading volume reflecting a decrease in depth provided to the market.

The current change has a three phase implementation over a period of close to two years.

- Phase 1 was a pilot phase that went live from 14th January 2014. It covered stocks from TOPIX 100 index and reduced tick sizes only for stocks with quote price above ĕ3000. Due to the high concentration of stocks with lower market price in TOPIX, this pilot phase had an impact on only 39 stocks. For simplicity, we consider the affected securities based on the prices as of the ex-date.

- Phase 2 commenced on 22nd July 2014 over the same universe of stocks, i.e. TOPIX 100. It introduced decimal yen tick sizes for stocks trading below ĕ5000. This phase had an impact on 80 stocks. For simplicity, we consider the affected securities based on the prices as of the ex-date.

- Phase 3, expected in September 2015, will be based on the tick structure of Phase 2. However, TSE will announce the final tick sizes and list of target stocks after evaluating the impact of previous 2 phases.

Price				Tick Size		
				TOPIX100 Constituents		Other Issues
				Phase I (2014/1/14～)	Phase II (2014/7/22～)	
		Up to	1,000 yen	1 yen	**0.1 yen**	1 yen
More than	1,000 yen	"	3,000 yen	1 yen	**0.5 yen**	1 yen
"	3,000 yen	"	5,000 yen	**1 yen**	**0.5 yen**	5 yen
"	5,000 yen	"	10,000 yen	**1 yen**	1 yen	10 yen
"	10,000 yen	"	30,000 yen	**5 yen**	5 yen	10 yen
"	30,000 yen	"	50,000 yen	**5 yen**	5 yen	50 yen
"	50,000 yen	"	100,000 yen	**10 yen**	10 yen	100 yen
"	100,000 yen	"	300,000 yen	**50 yen**	50 yen	100 yen
"	300,000 yen	"	500,000 yen	**50 yen**	50 yen	500 yen
"	500,000 yen	"	1,000,000 yen	**100 yen**	100 yen	1,000 yen
"	1,000,000 yen	"	3,000,000 yen	**500 yen**	500 yen	1,000 yen
"	3,000,000 yen	"	5,000,000 yen	**500 yen**	500 yen	5,000 yen
"	5,000,000 yen	"	10,000,000 yen	**1,000 yen**	1,000 yen	10,000 yen
"	10,000,000 yen	"	30,000,000 yen	**5,000 yen**	5,000 yen	10,000 yen
"	30,000,000 yen	"	50,000,000 yen	**5,000 yen**	5,000 yen	50,000 yen
"	50,000,000 yen			**10,000 yen**	10,000 yen	100,000 yen

Figure 1: Tick Size Change Schedule

2.7 Sergey Bubka and the Regulators

Any attempt at regulatory change is best exemplified by the story of Sergey Bubka [(Endnote 2)], the Russian pole vault jumper, who broke the world record 35 times. Attempts at regulatory change can be compared to taking the bar higher. In this case, the intended effect of the change is price improvement and shorter time to execution. We look at security level metrics that include the spread, trading volume, number of trades and the size of trades to establish whether this goal is accomplished. Despite all the uncertainty (Kashyap 2014b), we can be certain of one thing, that certain market participants will find some way over the intended consequences, prompting another round of rule revisions, or raising the bar, if you will. In this circumstance, an unintended effect caused by the reactions of participants to the new rules, might be the reduction in execution sizes, which would then mean that institutions with bigger orders would have greater difficulty in sourcing liquidity. We look at a sample of real orders to see if the executions costs have gone up across larger orders since the implementation of this change. So far, we have talked about the unknowns (or unintended

consequences) that we know about (or can anticipate). What about the unknowns that we don't know about (or cannot even imagine). The only thing, we know about these unknown unknowns are that, there must be a lot of them, hence the need for us to be eternally vigilant, compelling all attempts at risk management to make sure that the unexpected, even if it does happen, is contained in the harm it can cause, while being cognizant that this is easier said than done; a topic best saved for another time.

3 Bird's Eye View

Before doing an in-depth study over a large sample of data, we perform a cursory check around the days surrounding the two ex-dates to see if we can spot any hints of change. We did three groups of high level comparisons to ensure that the observations are not restricted to the altered dynamics of trading on any single day. The key metrics we used in this analysis are the average spread, measured in yen per share and the average execution size measured in number of shares. We adjust the price and spread according to the split ratio for securities that had stock splits during the time period of our data sample (Figure 4).

1. We compared the metrics on the day of the change to the metrics on the immediately previous trading day; i.e. between Jan 14th and Jan 10th for the first phase of the change; and between Jul 22nd and Jul 18th for the second phase of the change (Jan 13th and Jul 21st were public holidays in Japan).

2. We compared the metrics one and two days after the change for the first phase and second phase respectively with the metrics exactly a week before this day; i.e. between Jan 15th and Jan 8th; and Jul 24th and Jul 17th.

3. We compared the metrics between the earliest date in this limited sample and the last day we have observed after the change; i.e. between Jan 16th and Jan 6th for the first phase of the change; and between Jul 28th and Jul 14th for the second phase of the change.

3.1 Bird's Eye View Results

As expected, after the change to decrease the tick size on the TOPIX 100 index names on Jul 22 2104 and Jan 14 2104, the average spreads have decreased consistently, across the names that had prices in the range which would be affected by the new rules. On the days immediately following the change, the spreads are down for almost all the securities affected by the change. This also fits in with the fact that the minimum tick size after the change is 0.1 yen across some of the names. Another observation due to this change is probably the unexpected change in the average execution size on these names. While this change is not as significant and consistent as the spread changes, the initial results do indicate a trend towards decreased execution sizes.

For the first phase, the average spreads have decreased across 100%, 100% and 100% of the affected names over the three sets of comparisons that we did (It is across 63%, 72% and 84% over the full set of names and the change is across 96% of the names when we consider only the names where the spread was on average

in excess of 1 yen earlier) and for the second phase the spreads have decreased across 100%, 100% and 96% of the affected names over the three sets of comparisons (It is across 100%, 90% and 86% of the full set of names and the magnitude of the change is considerably smaller as compared to the change that was done in Jan 2014).

For the first phase, the average execution size has decreased across 100%, 95% and 95% of the affected names over the three sets of comparisons that we did (It is across 89%, 70% and 65% over the full set of names and there seems to be no threshold over which the decreased size is entirely consistent, we need additional observations for this metric) and for the second phase the average execution size has decreased across 93%, 88% and 79% of the affected names over the three sets of comparisons (It is across 81%, 77% and 72% of the full set of names). The summary of the results (Figures 2 and 3) and the details (Figures 5 to 8) across individual securities are given in section 8, Appendix - I.

4 Deep Dive

A fly through of the data across the two ex-dates reveals that a detailed analysis would indeed be a worthy endeavor. As part of this deep dive, first, we perform stationarity checks on prices, spreads, trade sizes and volumes and also consider whether these variables have become more volatile since the changes. We supplement these with statistical tests and evaluate properties that can establish trends regarding whether the variables are either increasing or decreasing, after the two event dates. While this is interesting information, a question of paramount importance is, "what is the effect of these changes on the trading costs across different size orders"? For this we consider trading costs on a sample of close to 250,000 real orders starting six months before the first event and ending six months after the second event. Before we tackle the crucial conundrum of trading costs, we review some basics regarding the measurement of transaction costs.

4.1 Methodological Fundamentals

The unique aspect of our approach to trading costs is a method of splitting the overall move of the security price during the duration of an order into two components (Collins and Fabozzi 1991; Treynor 1994; Yegerman and Gillula 2014). One component gives the costs of trading that arise from the decision process that went into executing that particular order, as captured by the price moves caused by the executions that comprise that order. The other component gives the costs of trading that arise due to the decision process of all the other market participants during the time this particular order was being filled. This second component is inferred, since it is not possible to calculate it directly (at least with the present state of technology and publicly accessible data) and it is the difference between the overall trading costs and the first component, which is the trading cost of that order alone. The first and the second component arise due to competing forces, one from the actions of a particular participant and the other from the actions of everyone else that would be looking to fulfill similar objectives. Naturally, it follows that each particular

participant can only influence to a greater degree the cost that arises from his actions as compared to the actions of others, over which he has lesser influence, but an understanding of the second component, can help him plan and alter his actions, to counter any adversity that might arise from the latter. Any good trader would do this intuitively as an optimization process, that would minimize costs over two variables direct impact and timing, the output of which recommends either slowing down or speeding up his executions. With this measure, traders now actually have a quantitative indicator to fine tune their decision process. When we decompose the costs, it would be helpful to try and understand how the two sub costs could vary as a proportion of the total. The volatility in these two components, which would arise from different sources (market conditions), would require different responses and hence would affect the optimization problem mentioned above invoking different sorts of handling and based on the situation, traders would know which cost would be the more unpredictable one and hence focus their efforts on minimizing the costs arising from that component. Another popular way to decompose trading costs is into temporary and permanent impact [See Almgren and Chriss (2001); Almgren (2003); and Almgren, Thum, Hauptmann and Li (2005)]. While the theory behind this approach is extremely elegant and considers both linear and nonlinear functions of the variables for estimating the impact, a practical way to compute it requires measuring the price a certain interval after the order. This interval is ambiguous and could lead to lower accuracy while using this measure.

We now introduce some terminology used throughout the discussion.

1. Total Slippage - The overall price move on the security during the order duration. This is also a proxy for the implementation shortfall (Perold 1988; and Treynor 1981). It is worth mentioning that there are many similar metrics used by various practitioners and this concept gets used in situations for which it is not the best suited (Yegerman and Gillula 2014). While the usefulness of the Implementation Shortfall, or slippage, as a measure to understand the price shortfalls that can arise between constructing a portfolio and while implementing it, is not to be debated, slippage need to be supplemented with more granular metrics when used in situations where the effectiveness of algorithms or the availability of liquidity need to be gauged.

2. Market Impact (MI) - The price moves caused by the executions that comprise the order under consideration. In short, the MI is a proxy for the impact on the price from the liquidity demands of an order. This metric is generally negative or zero since in most cases, the best impact we can have is usually no impact.

3. Market Timing - The price moves that happen due to the combined effect of all the other market participants during the order duration.

4. Market Impact Estimate (MIE) - This is the estimate of the Market Impact, explained in point two

above, based on recent market conditions. The MIE calculation is the result of a simulation which considers the number of executions required to fill an order and the price moves encountered while filling this order, depending on the market microstructure as captured by the trading volume and the price probability distribution, over the past few days. See Kashyap 2015b for a dynamic programming approach to minimize the Market Impact under various formulations of the law of motion of prices. This simulation can be controlled with certain parameters that dictate the liquidity demanded on the order, the style of trading, order duration, market conditions as reflected by start of trading and end of trading times. In short, the MIE is an estimated proxy for the impact on the price from the liquidity demands of an order. Such an approach holds the philosophical viewpoint that making smaller predictions and considering their combined effect would result in lesser variance as opposed to making a large prediction; estimations done over a day as compared to estimations over a month, say. A geometrical intuition would be that fitting more lines (or curves) over a set of points would reduce the overall error as compared to fitting lesser number of lines (or curves) over the same set of points. When combining the results of predictions, of course, we have to be mindful of the errors of errors, which can get compounded and lead the results astray, and hence, empirical tests need to be done to verify the suitability of such a technique for the particular situation.

5. All these variables are measured in basis points to facilitate ease of comparison and aggregation across different groups. It is possible to measure these in cents per share and also in dollar value or other currency terms.

6. The following equations, expressed in pseudo mathematical terms to facilitate easier understanding, govern the relationships between the variables mentioned above.

4.2 Technical Aside

Total Slippage = Market Impact + Market Timing

{Total Price Slippage = Your Price Impact + Price Impact From Everyone Else (Price Drift)}

Market Impact Estimate = Market Impact Prediction = f (Execution Size, Liquidity Demand)

Execution Size = g(Execution Parameters, Market Conditions)

Liquidity Demand = h(Execution Parameters, Market Conditions)

Execution Parameters <->vector comprising (Order Size, Security, Side, Trading Style, Timing Decisions)

Market Conditions <-> vector comprising (Price Movement, Volume Changes, Information Set)

Here, f, g, h are functions. We could impose concavity conditions on these functions, but arguably, similar results are obtained by assuming no such restrictions and fitting linear or non-linear regression coefficients,

which could be non-concave or even discontinuous allowing for jumps in prices and volumes. The specific functional forms used could vary across different groups of securities or even across individual securities or even across different time periods for the same security. The crucial aspect of any such estimation is the comparison with the costs on real orders, as outlined earlier. Simpler models are generally more helpful in interpreting the results and for updating the model parameters. Hamilton [1994] and Gujarati [1995] are classic texts on econometrics methods and time series analysis that accentuate the need for parsimonious models.

The Auxiliary Information Set could be anything under our Sun or even from under other heavenly objects. A useful variable to include would be the blood pressure and heart rate time series of a representative group of security traders.

4.3 Implementation Shortfall Refresher

As a brush up, the total slippage or implementation shortfall is derived below with the understanding that we need to use the Expectation operator when we are working with estimates or future prices. (Kissell 2006) provides more details including the formula where the portfolio may be partly executed. The list of symbols we use are,

- $\bar{S}$, the total number of shares that need to be traded.
- T, the total duration of trading.
- N, the number of trading intervals.
- $\tau = T/N$, the length of each trading interval. We assume the time intervals are of the same duration, but this can be relaxed quite easily. In continuous time, this becomes, $N \to \infty, \tau \to 0$.
- The time then becomes divided into discrete intervals, $t_k = k\tau,\ k = 0, ..., N$.
- For simplicity, let time be measured in unit intervals giving, $t = 1, 2, ..., T$.
- S_t, the number of shares acquired in period t at price P_t.
- P_0 can be any reference price or benchmark used to measure the slippage. It is generally taken to be the arrival price or the price at which the portfolio manager would like to complete the purchase of the portfolio.
- Any trading trajectory, would look to formulate an optimal list of total pending shares, $W_1, ..., W_{T+1}$. Here, W_t is the number of units that we still need to trade at time t. This would mean, $W_1 = \bar{S}$ and $W_{T+1} = 0$ implies that $\bar{S}$ must be executed by period T. Clearly, $\bar{S} = \sum_{j=1}^{T} S_j$. This can equivalently be

represented by the list of executions completed, $S_1, ..., S_T$. Here, $W_t = W_{t-1} - S_{t-1}$ or $S_{t-1} = W_{t-1} - W_t$ is the number of units traded between times $t-1$ and t. W_t and S_t are related as below.

$$W_t = \bar{S} - \sum_{j=1}^{t-1} S_j = \sum_{j=t}^{T} S_j \qquad , t = 1, ..., T.$$

Using the above notation,

$$\text{Paper Return} = \bar{S}P_T - \bar{S}P_0$$

$$\text{Real Portfolio Return} = \bar{S}P_T - \left(\sum_{t=1}^{T} S_t P_t \right)$$

$$\begin{aligned} \text{Implementation Shortfall} &= \text{Paper Return} - \text{Real Portfolio Return} \\ &= \left(\sum_{t=1}^{T} S_t P_t \right) - \bar{S}P_0 \end{aligned}$$

The innovation we introduce would incorporate our earlier discussion about breaking the total impact or slippage, Implementation Shortfall, into the part from the participants own decision process, Market Impact, and the part from the decision process of all other participants, Market Timing. This Market Impact, would capture the actions of the participant, since at each stage the penalty a participant incurs should only be the price jump caused by their own trade and that is what any participant can hope to minimize. A subtle point is that the Market Impact portion need only be added up when new price levels are established. If the price moves down and moves back up (after having gone up once earlier and having been already counted in the Impact), we need not consider the later moves in the Market Impact (and hence implicitly left out from the Market Timing as well). This alternate measure would only account for the net move in the prices but would not show the full extent of aggressiveness and the push and pull between market participants and hence is not considered here, though it can be useful to know and can be easily incorporated while running simulations. Our measure of the Market Impact, for a buy order, then becomes,

$$\text{Market Impact} = \sum_{t=1}^{T} \left\{ \max \left[(P_t - P_{t-1}), 0 \right] S_t \right\}$$

The Market Timing is then given by,

$$\begin{aligned} \text{Market Timing} &= \text{Implementation Shortfall} - \text{Market Impact} \\ &= \left(\sum_{t=1}^{T} S_t P_t \right) - \bar{S}P_0 - \sum_{t=1}^{T} \left\{ \max \left[(P_t - P_{t-1}), 0 \right] S_t \right\} \end{aligned}$$

4.4 Deep Dive Results

We perform many levels of comparisons and tests to gauge the impact of the changes. Our information set for the deeper dive consists of two datasets. One is the daily close price, average spread, total volume and total number of trades across each of the 100 securities starting from July-01-2013 to Dec-10-2014. The other dataset comprises orders on these securities for the same time period. This information set contains all the standard order level information like number of shares, value, number of executions taken to fill the order and also includes Market Impact, Timing and the Total Slippage. All the variables can be measured based on observations done on an exchange, since our study is structured as a self contained closed system, except for the inclusion of the FX rate, which is required to construct notional buckets in USD and helps relate to a broader audience and to facilitate inferences to be drawn easily. All the results are depicted using summary tables and graphical elements in section 9, Appendix - II.

We first calculate the Equal Weighted, Volume Weighted and Trade Weighted Spread, Prices, the ratio of the Spread and Price and the Trade Size. We use the average spread, the close price, the total daily volume and the total number of daily trades at the security level. The fall in the spread, both the average spread and the ratio of the spread by the price, and the trade size around the two event days is easily seen in the time series graph (Figures 9, 10 and 11). The trend in the trade size is better inferred when we smooth it using a ten day moving average filter, being conscious of the fact there will be a lag before we observe the values going down. We supplement all the individual variables with the 90 day moving volatility of each of the time series. The volatilities of the spread moves upward around the two event days, but we cannot conclude that a new higher volatility level is established. When we consider the price volatility (Figure 10), it is not clearly evident that volatility has trended upwards. This is also not clearly established from the volatility time series at the security level, hence we do not report the security level volatilities. Both the raw values and filtered values for the volumes and the number of trades, do not show any discernible trend (Figure 12). A point to bear in mind is that these events would have a greater effect on intraday volatility and this is something to be checked for in later studies. Greater volatility results in more efforts at managing a more uncertain environment. In addition to affecting the Market Impact numbers, this would be reflected in the Market Timing as well and hence in the overall Slippage numbers.

We perform standard stationary tests on price, volume, spread and other variables at the individual security level. We employ the Augmented Dickey-Fuller (ADF) Test, the KPSS test and Phillips-Perron (PP) test. The null hypothesis for the ADF and PP test is that there is a unit root against the alternate that the series is explosive or stationary. The KPSS null hypothesis is that the series is level or trend stationary against the alternate that there is a unit root. It is easily apparent that total daily volume, daily average spread, average volume, ratio of spread by price and the number trades are stationary. Prices, Inverse of the Price and USD/JPY FX rates are not. We repeat these tests across the below six samples that we create

from the overall dataset. We see that the first difference of the non stationary variables results in a stationary time series. We report the count of securities with a p-value less than 0.05 in Figure 20. In all our regressions, we include the first difference of the variables which are non stationary.

1. Sample Full , SF: The entire dataset, from Jul-01-2013 to Dec-10-2014.
2. Sample One, S1: The start of the dataset to the first event, from Jul-01-2013 to Jan-10-2014.
3. Sample Two, S2: The first event to the second event, from Jan-14-2014 to Jul-18-2014.
4. Sample Three, S3: The second event to the end of the dataset, from Jul-22-2014 to Dec-10-2014.
5. Sample Four, S4: From the start of the dataset to the second event, from Jul-01-2013 to Jul-18-2014.
6. Sample Five, S5: From the first event to the end of dataset, from Jan-15-2014 to Dec-10-2014.

Next, we fit a trend line with a non-zero intercept across each of the variables at the security level and count the number of securities that show an increasing trend (Figure 21). This is also equivalent to checking a deterministic time trend in the variables. It is clearly seen from this that spreads have come down and the average volume has decreased consistently across most of the names around the two events. To clarify an apparent divergence, the counts for the third sample show a high number for increased spread, but this sample includes only days after the second event and the fall in spreads have occurred before the start of this sample. There is a jump in the spread around Oct-31-2014 (also the volume, number of trades and notational) which causes the spread trend lines to have increased slope in the last sample period, overcoming the effect of the earlier decrease on Jul-22-2014. Barring this outlier, which was caused by a sudden surge in prices, possibly attributable to the Bank of Japan unexpectedly adding stimulus by targeting a $726 billion USD annual expansion in the central bank's monetary base and the $1.2 trillion USD Government Pension Investment Fund announcing plans to more than double its target allocation to Japanese stocks to 25 percent of assets, (See End Notes 3 and 4) the results are consistent and as expected. We run two sets of regressions one up-to the last date, Dec-10-2014 and the other until Oct-30-2104, allowing us to judge the results after removing the effects of this abnormal jump.

The volume and number of trades trend is inconclusive just by looking at the slope of the time trend. Hence to assess this further, we run some regressions across each of the six samples. We run three sets of regressions. In the first, the volume is the dependent variable. Spread and Number of Trades are the key independent variables. In the second, we exclude the number of trades. The third regression is similar to the second except that we set the number of trades as the dependent variable. Here, the ratio of the spread by price and the inverse of the price act as control variables. We also include the USD/JPY as an additional control variable. All the variables except the FX rate are significant. The correlation matrix is in Figure 22. It is clearly seen from the regression coefficients (Figure 23) that the volume and number of trades increase

when spreads fall. We get similar results when we take the lag of the independent variables by one day and by one week.

Saving the best for last, we look at trading costs. We run separate regressions with all three of our cost metrics described earlier, Market Impact, Market Timing and Total Slippage as the independent variables. We find that, the results are similar across all three proxies of the trading cost, but the adjusted R-Squared is higher with the Market Impact. The real cost associated with a trader's effort in seeking liquidity is given by the Market Impact, hence we report and discuss only those results. We need to interpret the results keeping in mind that trading costs are notoriously difficult to predict, and models relating costs to other variables come with a high level of variance. We include a whole smattering of variables as the independent variables, including usual suspects such as spread, spread by price, inverse price, FX Rates, order notional, number of executions, moving 90 day volatilities of price, spread, volume, number of trades and the FX rate. The correlation matrix is in Figure 24. As additional control variables, we include the liquidity demanded by the order as a percentage of the total daily volume bucketed into five categories and the USD notional bucketed into four categories. We repeat the regressions for two different sets of categorizations of the Notional buckets (Figure 13). With such a setup, the orders in the smallest notional bucket, 0-1MM (million) USD, become the benchmark against which we measure the trading costs in the other buckets. The costs are on a decreasing trend from the beginning of our sample (Figures 14, 15 and 16). Hence, later studies should try to include explanatory variables to account for this phenomenon. We do not run these regression with a time lag since we are primarily interested in the contemporaneous relationship between changes in the variables, but lag effects are not to be ruled out and can be pursued later.

As primary evidence of increased trading costs, we see from the regression results (Figure 25) that the coefficients are more negative in the 10MM+ notional buckets in the sample periods after either of the two changes have happened, indicating that the costs in this bucket are higher relative to the other buckets. For example, in the S2, S3 and S5 samples, the 10MM+ bucket coefficients are higher by 5%, 2% and 0% as compared to the 5-10MM bucket coefficients which are lower by 13%, 30% and 19% respectively. We can observe this effect in the graph of the Market Impact by notional buckets over time. In the other set of regressions with 25MM+ notional size categorization, for the S2, S3 and S5 samples, the 10-25MM bucket coefficients are higher by 9%, 5% and 11% as compared to the 1-10MM buckets coefficients which are lower by 29%, 7% and 14% respectively. The sample size is much smaller for the the 25MM+ bucket than the 10MM+ buckets and hence the results are not as reliable, but we include it for completeness. Including interaction effects between the liquidity demand and notional buckets or excluding the notional buckets does not improve or change the results significantly.

As secondary evidence of increased costs, we present daily 90-day moving volatilities on all three of trading costs metrics in Figures 17, 18 and 19. The higher volatility in finding liquidity is seen in the Market Impact

volatilities which has risen consistently since the changes. We need to keep in mind that the metric we are using is a moving 90 day volatility hence the actual effects of the change start to show up after a few days time. Also, the values near the start of the sample are not yet fully incorporating many days of data and hence need to be overlooked. The Market Timing and Total Slippage can vary from positive to negative numbers, hence to calculate the corresponding volatilities we cannot use continuous compounding and instead we use a 5 day moving average and the percentage difference between successive values. Because these values can fluctuate more widely than the Market Impact, the consistent increasing volatility pattern is not easily inferred for these two variables. Further explorations using intraday data are required to establish whether higher volatility levels have been reached and could be one possible explanation for higher trading costs.

In short, we have decreased spreads, decreased trading size, increased number of trades, increased volume and increased trading costs for larger orders. The implications of this and to whom the immediate benefits will accrue should be fairly obvious. Buying and selling smaller sizes more frequently can be less expensive, but buying (or selling) and holding (after holding) larger chunks of securities for longer periods of time might have become more costly. The aftereffects of the change are not exactly a win-win situation for everyone, there seem to be some winners and some losers.

5 Possibilities for a Deeper Dive

A key metric that would be useful to understand the effects of the change would be the intraday volatilities of the prices and execution sizes. Volatility is proportional to trading costs, hence, measuring intraday volatility before and after the change could provide some answers to why costs have increased. When price volatility and execution size volatility increase, a trader faces a more uncertain environment. He has to factor in his decisions the possibility of the price and liquidity slipping away from him which results in higher overall costs or uncertainty about costs, which is also costly. This happens through greater swings in the Market Impact; in addition, greater movements in the Market Timing will cause higher overall Slippage numbers. Intraday data will allow the depth posted at the quotes to be analyzed and this could explain the reduction in the execution sizes and the increased difficulty in sourcing large orders. It would be interesting to trace the number of cancelled orders, quotes, the additional messages being relayed, changes to instructions and other forms of noise, and the technology infrastructure being deployed to accommodate any additional processing burdens, both by the exchange and (if possible to estimate) across other participants. Another intended effect was to reduce the time to execution which can be measured using tick by tick data. Again, it is worth pondering the reasons why filling an order in 10 milliseconds or 50 milliseconds would make such a difference to the loftier goal of providing a secondary market for the transfer of firm ownership and risk. For the deep dive, we have not considered the results by the securities affected during each event, since the results seem

to hold strongly across the entire set. Checking this extra box might show other potentially interesting or unexpected outcomes. The sudden spread increase and surrounding market events on Oct-31-2014 are worthy of a closer inspection. This study has been performed as a completely closed system. To further this avenue of approach, having external control variables could help account for some of the cyclical or structural variations in the variables and establish the trends strongly. This is particularly important for the trading costs which are on a decreasing trend from the beginning of our sample and including explanatory variables could explain this phenomenon. We have not included moving trading cost volatilities in any of our regressions, but these could be useful control variables since these change at a slower pace compared to the actual variable and pick up long term trends.

6 Does Tick Size Matter? Tick Size Does Matter!

We conclude that one set of changes have happened as anticipated, with the reduction in the average spread size. The unanticipated change is the reduction in the average execution size. We also see that the total volume and the number of trades have increased. The increased volume is not necessarily proving beneficial in adding liquidity to all exchange participants. On one hand, investors who are trading smaller order sizes are likely to experience a decreased cost of trading; on the other hand, large institutional investors trading bigger orders, might require additional efforts to source in the liquidity to fill their trades; with the net effect being that this additional effort might even lead to a slightly increased effective cost of trading. Once the dust from the last set of changes, which are yet to be implemented, settles down, supplementing this study with more intraday indicators will go a long way towards determining conclusively which group of investors will be the ultimate beneficiary. In our attempt to answer the question, "Does Tick Size Matter?", we unequivocally find that, "Tick Size Does Matter". The significant competition between trading mechanisms and venues, highlights the need for future research related to the consequences of tick size on trading costs and the dynamics of liquidity supply.

7 Notes and References

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2. http://en.wikipedia.org/wiki/Sergey_Bubka

3. http://www.bloomberg.com/news/articles/2014-10-31/japan-stocks-rise-on-report-pension-fund-to-boost-shares

4. http://www.bloomberg.com/news/articles/2014-11-05/sell-buy-sell-again-in-27-days-amid-record-topix-swings

5. Ahn, H. J., Cao, C. Q., & Choe, H. (1998). Decimalization and competition among stock markets: Evidence from the Toronto Stock Exchange cross-listed securities. Journal of Financial Markets, 1(1), 51-87.

6. Ahn, H. J., Cai, J., Chan, K., & Hamao, Y. (2007). Tick size change and liquidity provision on the Tokyo Stock Exchange. Journal of the Japanese and International Economies, 21(2), 173-194.

7. Almgren, R., & Chriss, N. (2001). Optimal execution of portfolio transactions. Journal of Risk, 3, 5-40.

8. Almgren, R. F. (2003). Optimal execution with nonlinear impact functions and trading-enhanced risk. Applied mathematical finance, 10(1), 1-18.

9. Almgren, R., Thum, C., Hauptmann, E., & Li, H. (2005). Direct estimation of equity market impact. Risk, 18, 5752.

10. Bessembinder, H. (1999). Trade execution costs on Nasdaq and the NYSE: A post-reform comparison. Journal of Financial and Quantitative Analysis, 34(3).

11. Bessembinder, H. (2000). Tick size, spreads, and liquidity: An analysis of Nasdaq securities trading near ten dollars. Journal of Financial Intermediation, 9(3), 213-239.

12. Bessembinder, H. (2003). Trade execution costs and market quality after decimalization. Journal of Financial and Quantitative Analysis, 38(04), 747-777.

13. Bhide, A. (1993). The hidden costs of stock market liquidity. Journal of financial economics, 34(1), 31-51.

14. Bollen, N. P., & Busse, J. A. (2006). Tick size and institutional trading costs: Evidence from mutual funds. Journal of Financial and Quantitative Analysis, 41(04), 915-937.

15. Bourghelle, D., & Declerck, F. (2004). Why markets should not necessarily reduce the tick size. Journal of banking & finance, 28(2), 373-398.

16. Caldarelli, G., Marsili, M., & Zhang, Y. C. (1997). A prototype model of stock exchange. EPL (Europhysics Letters), 40(5), 479.

17. Chung, K. H., & Van Ness, R. A. (2001). Order handling rules, tick size, and the intraday pattern of bid–ask spreads for Nasdaq stocks. Journal of Financial Markets, 4(2), 143-161.

18. Collins, B. M., & Fabozzi, F. J. (1991). A methodology for measuring transaction costs. Financial Analysts Journal, 47(2), 27-36.

19. Easley, D., & O'Hara, M. (2010). Microstructure and Ambiguity. Journal of Finance, 65(5), 1817-1846.

20. Goldstein, M. A., & Kavajecz, K. A. (2000). Eighths, sixteenths, and market depth: changes in tick size and liquidity provision on the NYSE. Journal of Financial Economics, 56(1), 125-149.

21. Gujarati, D. N. (1995). Basic econometrics, 3rd. International Edition.

22. Hamilton, J. D. (1994). Time series analysis (Vol. 2). Princeton university press.

23. Harris, L. E. (1994). Minimum price variations, discrete bid-ask spreads, and quotation sizes. Review of Financial Studies, 7(1), 149-178.

24. Huang, R. D., & Stoll, H. R. (2001). Tick size, bid-ask spreads, and market structure. Journal of Financial and Quantitative Analysis, 36(04), 503-522.

25. Jones, C. M., & Lipson, M. L. (2001). Sixteenths: direct evidence on institutional execution costs. Journal of Financial Economics, 59(2), 253-278.

26. Michie, R. (2001). The London stock exchange: A history. OUP Catalogue.

27. Karolyi, G. A., & Stulz, R. M. (1996). Why do markets move together? An investigation of USJapan stock return comovements. The Journal of Finance, 51(3), 951-986.

28. Kashyap, R. (2014a). Dynamic Multi-Factor Bid-Offer Adjustment Model. Institutional Investor Journals, Journal of Trading, 9(3), 42-55.

29. Kashyap, R. (2014b). The Circle of Investment. International Journal of Economics and Finance, 6(5), 244-263.

30. Kashyap, R. (2015a). Financial Services, Economic Growth and Well-Being: A Four Pronged Study. Indian Journal of Finance, 9(1), 9-22.

31. Kashyap, R. (2015b). Hong Kong - Shanghai Connect / Hong Kong - Beijing Disconnect (?). Social Science Research Network (SSRN), Working Paper.

32. Kim, K. A., & Rhee, S. (1997). Price limit performance: evidence from the Tokyo Stock Exchange. The Journal of Finance, 52(2), 885-901.

33. Kissell, R. (2006). The expanded implementation shortfall: Understanding transaction cost components. The Journal of Trading, 1(3), 6-16.

34. Madhavan, A. (2000). Market microstructure: A survey. Journal of financial markets, 3(3), 205-258.

35. Perold, A. F. (1988). The implementation shortfall: Paper versus reality. The Journal of Portfolio Management, 14(3), 4-9.

36. Roll, R. (1984). A simple implicit measure of the effective bidask spread in an efficient market. The Journal of Finance, 39(4), 1127-1139.

37. Stoll, H. R. (1989). Inferring the components of the bidask spread: theory and empirical tests. The Journal of Finance, 44(1), 115-134.

38. Treynor, J. L. (1981). What does it take to win the trading game?. Financial Analysts Journal, 37(1), 55-60.

39. Treynor, J. L. (1994). The invisible costs of trading. The Journal of Portfolio Management, 21(1), 71-78.

40. Venkataraman, K. (2001). Automated versus floor trading: An analysis of execution costs on the Paris and New York exchanges. The Journal of Finance, 56(4), 1445-1485.

41. Ye, M., Yao, C., & Gai, J. (2012). The externalities of high frequency trading. SSRN Working Paper: http://papers.ssrn.com/abstract_id=2066839

42. Yegerman, H. & Gillula, A. (2014). The Use and Abuse of Implementation Shortfall. Markit Working Paper.

8 Appendix - I (Bird's Eye View Comparisons)

Percentage showing decreased Spread and Execution Size						
Metric	Spread Comparison			Execution Size Comparison		
Dates	14th and 10th	15th and 8th	16th and 6th	14th and 10th	15th and 8th	16th and 6th
Affected	100%	100%	100%	100%	95%	95%
Full	63%	72%	84%	89%	70%	65%

Figure 2: Bird's Eye View Comparison Summary for Jan 14, 2014

Percentage showing decreased Spread and Execution Size						
Metric	Spread Comparison			Execution Size Comparison		
Dates	22nd and 18th	24th and 17th	28th and 14th	22nd and 18th	24th and 17th	28th and 14th
Affected	100%	100%	96%	93%	88%	79%
Full	100%	90%	86%	81%	77%	72%

Figure 3: Bird's Eye View Comparison Summary for Jul 22, 2014

Ticker	Date-of-Stock-Price-Adjustment	Split Ratio
1605	26-Sep-2013	400/1
4503	27-Mar-2014	5/1
8750	26-Sep-2013	100/1
6594	27-Mar-2014	2/1
8113	26-Sep-2014	3/1
9437	26-Sep-2013	100/1

Figure 4: Stock Split Ratios During Study Time Period

		Weighted Average Spread								Spread Comparison		
Affected	Ticker	6-Jan-2014	7-Jan-2014	8-Jan-2014	9-Jan-2014	10-Jan-2014	14-Jan-2014	15-Jan-2014	16-Jan-2014	14th and 10th	15th and 8th	16th and 6th
Y	6861	39.72	38.84	40.02	37.51	40.36	27.09	26.57	22.13	1	1	1
Y	9983	37.99	34.74	38.77	36.56	38.67	18.30	12.35	10.64	1	1	1
Y	6273	23.54	20.32	20.50	19.47	16.11	16.05	15.39	14.71	1	1	1
Y	7974	9.23	10.29	10.38	12.39	13.29	8.10	6.53	6.84	1	1	1
Y	6954	8.64	9.58	9.69	9.11	8.34	6.88	5.98	5.26	1	1	1
Y	4661	9.89	9.21	8.93	8.43	8.33	5.91	5.88	5.56	1	1	1
Y	6594	8.01	7.35	7.34	7.28	6.86	5.92	5.63	5.21	1	1	1
Y	9022	7.12	7.01	6.63	6.79	6.77	6.14	5.57	5.14	1	1	1
Y	1878	7.28	6.95	7.25	7.31	6.79	4.44	4.84	5.10	1	1	1
Y	6981	6.80	7.00	6.74	6.90	6.65	4.68	3.30	4.46	1	1	1
Y	8035	6.01	6.25	6.11	5.82	5.91	3.44	1.94	2.28	1	1	1
Y	8830	6.13	5.77	5.68	6.01	4.71	3.00	2.43	2.14	1	1	1
Y	9735	5.70	5.59	5.38	5.26	5.42	3.32	2.46	2.43	1	1	1
Y	9020	5.54	5.39	5.77	5.54	5.59	2.63	2.13	1.81	1	1	1
Y	6367	5.45	5.23	5.18	5.40	5.20	2.94	1.97	1.81	1	1	1
Y	8113	4.82	4.97	5.47	4.88	5.47	2.76	2.26	1.80	1	1	1
Y	4503	4.95	4.92	4.91	5.15	4.37	2.59	1.96	2.14	1	1	1
Y	9984	4.53	5.03	4.75	4.57	4.60	2.29	1.64	1.74	1	1	1
Y	6971	4.78	4.40	3.98	4.47	4.64	2.38	1.67	1.92	1	1	1
Y	1963	4.31	3.85	3.93	4.12	3.96	2.91	2.10	1.98	1	1	1
Y	6902	3.80	4.25	4.16	4.22	4.22	2.71	1.81	1.63	1	1	1
Y	4063	4.15	4.14	3.86	4.17	4.02	2.69	1.84	1.89	1	1	1
Y	9433	4.10	3.98	3.34	3.51	3.67	2.86	2.00	1.65	1	1	1
Y	9432	3.55	3.95	3.66	3.77	3.78	2.51	1.92		1	1	1
Y	4578	4.02	3.29	3.30	3.27	3.42	1.61	1.17	1.31	1	1	1
Y	8316	3.52	3.26	3.12	3.22	3.21	1.98	1.31	1.19	1	1	1
Y	8801	3.16	3.18	2.98	3.05	3.27	1.82	1.55	1.53	1	1	1
Y	9021	3.10	2.95	3.07	3.25	3.04	1.77	1.51	1.41	1	1	1
Y	4523	3.25	2.88	2.66	2.84	2.83	1.68	1.36	1.26	1	1	1
Y	3382	2.64	2.41	2.92	3.00	2.56	1.75	1.30	1.35	1	1	1
Y	5108	2.90	2.79	2.84	2.64	2.52	1.50	1.24	1.17	1	1	1
Y	6988	2.56	2.40	2.45	2.52	2.55	1.87	1.44	1.49	1	1	1
Y	8766	2.58	2.67	2.62	2.47	2.65	1.50	1.24	1.20	1	1	1
Y	4452	2.38	2.42	2.39	2.32	2.53	1.55	1.23	1.24	1	1	1
Y	7203	2.54	2.66	2.28	2.36	2.33	1.46	1.19		1	1	1
Y	4502	2.26	2.16	1.74	2.20	2.44	1.49	1.19	1.17	1	1	1
Y	7267	2.25	2.15	2.08	2.04	2.14	1.22	1.04		1	1	1
Y	2914	1.70	1.72	1.44	1.68	1.89	1.16	0.88	0.86	1	1	1
Y	7751	1.57	1.45	1.47	1.65	1.53	1.13	0.94	0.84	1	1	1
N	8802	3.65	3.43	3.42	2.64	1.42	1.27	1.13	1.15	1	1	1
N	4901	1.09	1.40	1.12	3.62	3.49	1.43	1.16	1.09	1	0	1
N	7270	1.23	1.05	2.52	3.01	3.13	1.38	1.05	0.93	1	1	1
N	7741	1.18	1.26	2.75	1.91	1.64	1.40	1.18	1.08	1	1	1
N	8630	1.29	1.34	1.24	1.25	1.18	1.27	1.14	1.17	0	1	1
N	7269	1.31	1.26	1.06	1.23	1.18	1.09	1.03	1.02	1	1	1
N	8725	1.19	1.06	1.06	1.27	1.09	1.12	1.05	1.10	0	1	1
N	1925	1.13	1.01	1.23	1.16	1.04	1.06	1.07	1.00	0	1	1
N	2502	1.10	1.09	1.11	1.12	1.05	1.04	1.04	1.07	1	1	1
N	4568	0.99	1.00	1.15	1.05	1.02	1.04	0.98	0.98	0	1	1
N	6326	1.07	1.04	1.03	1.09	0.96	0.96	0.91	0.94	1	1	1
N	8750	1.03	1.05	0.90	0.95	0.97	0.97	0.94	0.99	1	0	1
N	2802	1.13	0.94	0.91	1.05	0.94	0.90	0.86	0.93	1	1	1
N	2503	0.93	0.86	0.86	0.85	0.83	0.80	0.84	0.87	1	1	1
N	5411	0.85	0.86	0.80	0.82	0.91	0.88	0.86	0.84	1	0	1
N	9064	0.86	0.83	0.81	0.83	0.82	0.93	0.86	0.86	0	0	0
N	7912	0.93	0.81	0.85	0.94	0.84	0.79	0.79	0.82	1	1	1
N	4911	0.84	0.84	0.83	0.83	0.82	0.87	0.81	0.81	0	1	1
N	5713	0.82	0.80	0.85	0.89	0.79	0.82	0.80	0.77	0	1	1
N	9502	0.79	0.79	0.81	0.82	0.91	0.82	0.78	0.79	1	1	1
N	7731	0.89	0.78	0.78	0.77	0.80	0.84	0.80	0.81	0	0	1
N	1605	0.80	0.74	0.81	0.80	0.75	0.92	0.69	0.84	0	1	0
N	9503	0.85	0.77	0.71	0.82	0.81	0.83	0.76	0.78	0	0	1
N	8795	0.85	0.74	0.79	0.78	0.82	0.83	0.76	0.75	0	1	1
N	6301	0.81	0.77	0.76	0.74	0.75	0.81	0.82	0.81	0	0	0
N	5802	0.80	0.75	0.74	0.69	0.76	0.84	0.83	0.83	0	0	0
N	1928	0.77	0.78	0.73	0.77	0.73	0.75	0.76	0.72	0	0	1
N	8591	0.82	0.76	0.69	0.69	0.77	0.78	0.75	0.70	0	0	1
N	8267	0.72	0.69	0.71	0.71	0.75	0.73	0.69	0.69	1	1	1
N	9437	0.81	0.78	0.81	0.69	0.72	0.77	0.80		0	1	1
N	6503	0.73	0.80	0.76	0.83	0.77	0.75	0.73		1	1	1
N	6758	0.80	0.73	0.72	0.78	0.80	0.78	0.69		1	1	1
N	6752	0.61	0.63	0.60	0.63	0.64	0.67	0.68	0.72	0	0	0
N	3407	0.65	0.62	0.61	0.67	0.66	0.66	0.61	0.64	0	0	1
N	8031	0.62	0.60	0.51	0.57	0.63	0.72	0.67	0.63	0	0	0
N	8053	0.62	0.62	0.58	0.58	0.64	0.65	0.62	0.62	0	0	1
N	8058	0.71	0.72	0.63	0.62	0.69	0.77	0.75		0	0	1
N	7752	0.70	0.69	0.58	0.67	0.72	0.71	0.67		1	0	1
N	8601	0.67	0.58	0.57	0.56	0.58	0.62	0.57	0.54	0	1	1
N	8001	0.59	0.54	0.60	0.50	0.55	0.61	0.60	0.62	0	0	0
N	8332	0.54	0.52	0.52	0.52	0.56	0.54	0.50	0.59	1	1	0
N	8604	0.49	0.50	0.60	0.58	0.53	0.48	0.52	0.51	1	1	0
N	5201	0.57	0.49	0.47	0.52	0.52	0.52	0.50	0.53	1	0	1
N	8002	0.51	0.49	0.45	0.46	0.52	0.56	0.54	0.55	0	0	0
N	7202	0.49	0.49	0.50	0.41	0.48	0.51	0.50	0.52	0	0	0
N	7011	0.43	0.43	0.53	0.48	0.48	0.50	0.51	0.52	0	1	0
N	7201	0.51	0.49	0.58	0.50	0.56	0.57	0.51		0	1	1
N	6501	0.47	0.45	0.45	0.44	0.46	0.47	0.49	0.46	0	0	1
N	3402	0.50	0.49	0.56	0.53	0.54	0.53	0.50		1	1	1
N	8309	0.42	0.41	0.40	0.47	0.43	0.43	0.40	0.40	0	1	1
N	6702	0.47	0.46	0.45	0.44	0.46	0.52	0.45		0	0	1
N	4188	0.38	0.35	0.29	0.38	0.41	0.41	0.36	0.39	1	0	0
N	9531	0.40	0.39	0.34	0.35	0.35	0.37	0.37	0.39	0	0	1
N	9532	0.33	0.35	0.34	0.37	0.34	0.38	0.38	0.40	0	0	0
N	5020	0.38	0.31	0.37	0.34	0.35	0.37	0.37	0.36	0	1	1
N	8308	0.32	0.34	0.34	0.37	0.35	0.34	0.35	0.37	1	0	0
N	6502	0.33	0.30	0.32	0.36	0.33	0.38	0.41		0	0	1
N	8306	0.32	0.26	0.32	0.33	0.31	0.30	0.30	0.30	1	1	1
N	5401	0.25	0.26	0.24	0.23	0.23	0.24	0.24	0.27	0	0	0
N	9202	0.25	0.26	0.31	0.26	0.26	0.28	0.23		0	1	1
N	8411	0.15	0.14	0.13	0.15	0.15	0.15	0.12	0.12	0	1	1

Figure 5: Bird's Eye View Spread Comparison Detail for Jan 14, 2014

		Average Execution Size								Execution Size Comparison		
Affected	Ticker	6-Jan-2014	7-Jan-2014	8-Jan-2014	9-Jan-2014	10-Jan-2014	14-Jan-2014	15-Jan-2014	16-Jan-2014	14th and 10th	15th and 8th	16th and 6th
Y	8801	2,138	1,908	2,114	2,174	2,798	1,775	1,579	1,515	1	1	1
Y	8830	2,113	1,983	1,929	2,135	2,679	1,499	1,425	1,282	1	1	1
Y	1963	1,745	1,689	1,867	1,779	3,026	1,567	1,452	1,526	1	1	1
Y	7751	1,061	875	1,254	1,247	1,319	652	663	687	1	1	1
Y	8316	1,220	899	1,371	950	1,168	651	672	598	1	1	1
Y	2914	1,002	873	1,186	1,194	1,201	644	440	712	1	1	1
Y	7203	1,086	963	929	995	1,145	675	569		1	1	1
Y	4502	868	889	670	968	1,135	553	482	547	1	1	1
Y	8766	735	757	968	690	1,080	516	589	479	1	1	1
Y	9984	891	844	825	778	1,027	470	393	481	1	1	1
Y	7267	915	735	790	732	1,124	653	603		1	1	1
Y	5108	715	608	795	809	945	541	508	492	1	1	1
Y	4578	686	592	914	813	764	527	558	519	1	1	1
Y	6902	746	903	623	630	1,055	352	339	361	1	1	1
Y	6971	656	620	645	537	1,304	403	345	323	1	1	1
Y	3382	601	572	848	459	934	427	391	423	1	1	1
Y	4523	667	664	532	701	959	409	352	338	1	1	1
Y	4503	654	632	742	674	899	311	362	297	1	1	1
Y	4452	603	510	647	486	912	494	407	472	1	1	1
Y	9433	531	642	558	701	899	413	350	401	1	1	1
Y	8035	724	612	440	492	1,099	347	271	295	1	1	1
Y	9432	669	721	602	716	877	378	300		1	1	1
Y	4063	583	615	548	616	811	312	252	270	1	1	1
Y	9735	537	496	519	475	1,047	317	229	242	1	1	1
Y	6367	542	464	462	509	868	320	290	288	1	1	1
Y	6988	472	412	512	516	611	398	367	311	1	1	1
Y	9021	427	433	458	487	579	347	310	318	1	1	1
Y	9020	436	422	434	502	588	289	292	292	1	1	1
Y	8113	418	432	439	399	522	330	328	336	1	1	1
Y	6981	422	381	481	479	436	199	248	327	1	1	1
Y	6594	307	342	435	366	380	279	277	340	1	1	0
Y	6954	334	314	282	337	538	319	256	229	1	1	1
Y	9022	296	275	270	316	421	304	328	261	1	0	1
Y	1878	287	277	313	287	351	197	212	239	1	1	1
Y	7974	310	311	291	288	279	242	212	221	1	1	1
Y	9983	315	262	264	265	403	206	167	176	1	1	1
Y	4661	237	252	260	256	305	219	263	248	1	0	0
Y	6861	195	208	168	172	204	152	133	136	1	1	1
Y	6273	196	165	181	158	186	148	166	139	1	1	1
N	8411	12,389	15,069	15,628	16,808	16,081	12,155	8,183	12,613	1	1	0
N	9202	15,906	15,065	14,461	10,489	16,155	9,666	7,772		1	1	1
N	5401	11,243	9,288	10,581	9,783	11,306	9,342	11,075	15,799	1	0	0
N	6502	8,930	8,688	10,786	10,706	7,928	8,807	11,575		0	0	1
N	6501	7,223	7,926	7,007	5,181	6,085	5,702	7,329	5,839	1	0	1
N	8306	6,596	4,757	7,513	6,401	7,848	5,867	6,237	6,844	1	1	0
N	7011	4,528	4,838	10,484	6,232	6,964	4,832	7,532	6,585	1	1	0
N	8309	5,831	6,232	6,153	5,861	8,701	5,672	5,471	6,420	1	1	0
N	8604	3,993	4,244	7,444	6,059	5,220	3,919	5,320	5,220	1	1	0
N	7202	4,805	3,689	5,709	4,221	5,605	5,401	6,122	4,768	1	0	1
N	8308	4,951	3,382	5,474	6,028	4,452	2,976	4,453	6,201	1	1	0
N	8002	4,496	4,337	5,322	4,175	5,125	4,632	4,459	4,961	1	1	0
N	9532	4,056	3,919	3,614	5,224	4,440	4,393	3,846	7,997	1	0	0
N	9531	4,842	3,864	3,582	3,936	4,994	4,522	4,037	5,820	1	0	0
N	6702	4,906	5,300	4,962	4,220	5,466	4,514	4,090		1	1	1
N	8601	4,148	3,510	4,379	4,021	4,281	3,888	3,915	4,011	1	1	1
N	5201	3,982	3,725	3,246	3,706	3,920	3,498	3,710	4,110	1	0	0
N	8332	4,466	3,127	3,968	3,447	4,143	3,778	3,538	2,937	1	1	1
N	3402	3,695	3,913	4,135	4,576	4,292	3,525	4,269		1	0	1
N	3407	3,295	2,790	3,669	4,060	4,169	3,039	2,952	3,624	1	1	0
N	2503	2,531	2,743	2,949	3,016	4,035	3,076	2,269	2,579	1	1	0
N	6503	2,711	2,583	2,940	2,850	3,486	2,743	2,715		1	1	1
N	7201	2,885	2,496	3,596	2,978	3,295	2,588	1,995		1	1	1
N	6326	2,366	2,391	2,667	2,563	2,801	2,269	2,307	2,389	1	1	0
N	4188	2,331	2,113	1,775	1,699	3,556	3,136	2,397	2,367	1	0	0
N	8802	2,716	2,446	2,669	2,837	2,397	2,133	1,807	1,916	1	1	1
N	5713	2,307	2,207	2,915	2,146	2,955	2,055	2,081	2,080	1	1	1
N	5020	2,515	2,198	2,245	2,182	2,497	2,198	2,614	2,070	1	0	1
N	7912	2,425	1,979	1,924	2,120	3,471	2,270	2,021	1,927	1	0	1
N	1925	1,977	1,993	1,915	2,203	2,743	2,011	2,111	1,999	1	0	0
N	2802	1,929	2,058	1,826	1,948	2,936	2,048	1,916	2,038	1	0	0
N	6752	1,478	1,378	1,330	1,385	1,419	1,227	1,435	1,315	1	0	1
N	8031	1,182	1,014	1,220	1,117	1,458	1,203	1,262	1,644	1	0	0
N	8053	1,344	1,111	1,293	1,143	1,296	1,149	1,201	1,181	1	1	1
N	8001	1,160	1,059	1,057	1,027	1,280	1,486	1,173	1,275	0	0	0
N	9437	1,626	1,547	1,402	1,166	1,524	1,126	1,070		1	1	1
N	1928	1,125	1,059	1,116	1,007	1,583	1,038	1,231	1,130	1	0	0
N	7752	1,217	1,143	1,237	1,365	1,469	1,254	1,497		1	0	1
N	6758	1,058	949	1,286	1,615	1,484	1,320	1,044		1	1	1
N	6301	1,012	1,040	1,002	935	1,256	994	894	1,147	1	1	0
N	1605	1,141	832	1,014	962	1,051	1,114	915	998	0	1	1
N	8058	1,200	1,181	983	1,059	1,306	1,122	1,091		1	0	1
N	8267	902	799	974	1,019	1,116	929	825	858	1	1	1
N	9503	756	825	880	908	915	1,183	940	1,014	0	0	0
N	8591	774	737	879	741	1,078	1,067	1,147	996	1	0	0
N	7270	826	816	1,110	996	1,101	735	899	732	1	1	1
N	4568	905	864	940	808	1,365	698	768	645	1	1	1
N	7731	710	938	671	842	876	942	714	724	0	0	0
N	5802	724	597	767	803	1,077	731	728	750	1	1	0
N	8750	701	582	723	780	757	872	800	788	0	0	0
N	5411	680	607	653	786	705	762	802	775	0	0	0
N	9502	564	591	702	584	803	808	874	669	0	0	0
N	4911	615	638	697	770	878	693	600	654	1	1	0
N	9064	519	603	607	647	956	722	579	545	1	1	0
N	8795	589	524	506	568	720	746	702	624	0	0	0
N	4901	546	500	582	711	901	448	535	425	1	1	1
N	7269	591	493	486	471	714	467	428	402	1	1	1
N	7741	502	378	749	404	541	542	475	429	0	1	1
N	2502	432	447	441	453	743	491	537	437	1	0	0
N	8725	392	490	406	473	520	456	324	365	1	1	1
N	8630	360	367	350	323	399	439	452	418	0	0	0

Figure 6: Bird's Eye View Execution Size Comparison Detail for Jan 14, 2014

		Weighted Average Spread										Spread Comparison		
Affected	Ticker	14-Jul-2014	15-Jul-2014	16-Jul-2014	17-Jul-2014	18-Jul-2014	22-Jul-2014	23-Jul-2014	24-Jul-2014	25-Jul-2014	28-Jul-2014	22nd and 18th	24th and 17th	28th and 14th
Y	8830	2.43	2.32	2.30	2.39	2.26	1.84	1.60	1.85	1.71	1.68	1	1	1
Y	1963	1.86	2.11	1.70	1.77	1.96	1.82	1.24	1.50	1.78	1.61	1	1	1
Y	6971	1.35	1.49	1.34	1.39	1.64	1.26	1.22	1.11	1.15	1.07	1	1	1
Y	4523	1.31	1.37	1.28	1.29	1.81	1.33	1.13	1.15	1.18	1.17	1	1	1
Y	4452	1.18	1.44	1.33	1.28	1.43	0.93	1.09	1.06	1.07	1.25	1	1	0
Y	6988	1.29	1.32	1.30	1.31	1.44	1.19	0.84	0.99	0.92	1.11	1	1	1
Y	9021	1.31	1.31	1.22	1.26	1.64	0.98	0.91	1.11	1.03	0.94	1	1	1
Y	7741	1.17	1.24	1.22	1.21	1.38	1.28	0.96	0.98	0.92	1.02	1	1	1
Y	8801	1.18	1.19	1.40	1.26	1.41	1.08	0.90	1.00	0.94	0.90	1	1	1
Y	6902	1.20	1.18	1.14	1.06	1.44	1.06	0.91	1.04	0.86	0.93	1	1	1
Y	3382	1.10	1.23	1.32	1.19	1.46	0.90	0.79	0.94	0.91	0.95	1	1	1
Y	7269	1.13	1.15	1.07	1.12	1.50	1.00	0.87	0.87	0.77	0.94	1	1	1
Y	4578	1.09	1.15	1.11	1.09	1.24	1.08	0.91	0.92	0.80	0.85	1	1	1
Y	1925	1.08	1.08	1.11	1.05	1.32	0.95	0.98	0.82	0.80	0.91	1	1	1
Y	4502	1.04	1.18	1.12	1.15	1.34	0.85	0.75	0.72	0.76	0.81	1	1	1
Y	5713	1.09	1.15	1.09	1.14	1.11	0.76	0.84	0.83	0.90	0.78	1	1	1
Y	8630	0.99	1.01	1.01	1.00	1.04	0.77	0.90	0.91	1.02	0.98	1	1	1
Y	5108	0.99	1.16	1.12	1.06	1.18	0.85	0.73	0.76	0.79	0.80	1	1	1
Y	2502	1.05	1.04	1.03	1.04	1.09	0.75	0.89	0.86	0.78	0.86	1	1	1
Y	8802	1.01	1.00	1.01	1.04	1.17	0.86	0.82	0.81	0.80	0.84	1	1	1
Y	8766	1.03	1.06	1.04	1.10	1.09	0.75	0.76	0.72	0.86	0.89	1	1	1
Y	8725	1.04	1.15	0.98	1.04	1.09	0.91	0.77	0.75	0.71	0.81	1	1	1
Y	8316	1.14	1.08	1.16	1.12	0.94	0.67	0.61	0.62	0.75	0.80	1	1	1
Y	7270	1.03	1.09	0.95	1.03	1.14	0.75	0.74	0.65	0.68	0.79	1	1	1
Y	4901	0.91	0.89	0.93	0.97	1.25	0.76	0.72	0.78	0.74	0.80	1	1	1
Y	2802	0.97	1.00	0.98	0.95	1.10	0.79	0.70	0.73	0.69	0.76	1	1	1
Y	2914	1.00	0.96	0.95	0.94	1.10	0.73	0.61	0.61	0.62	0.70	1	1	1
Y	7267	0.88	0.91	0.96	0.96	1.11	0.72	0.60	0.65	0.67	0.69	1	1	1
Y	4911	0.79	0.91	0.85	0.82	0.90	0.64	0.63	0.70	0.64	0.70	1	1	1
Y	9064	0.82	0.88	0.83	0.85	0.96	0.67	0.61	0.63	0.65	0.65	1	1	1
Y	7751	0.84	0.89	0.80	0.95	0.99	0.62	0.57	0.54	0.64	0.61	1	1	1
Y	4568	0.78	0.79	0.85	0.87	0.97	0.68	0.62	0.64	0.59	0.57	1	1	1
Y	1605	0.86	0.92	0.89	0.89	0.95	0.52	0.48	0.54	0.58	0.58	1	1	1
Y	6326	0.87	0.85	0.86	0.88	0.84	0.56	0.54	0.55	0.58	0.61	1	1	1
Y	7912	0.74	0.78	0.72	0.74	0.82	0.70	0.69	0.61	0.59	0.71	1	1	1
Y	5411	0.74	0.79	0.81	0.85	0.89	0.63	0.55	0.58	0.57	0.58	1	1	1
Y	6301	0.81	0.83	0.78	0.84	0.88	0.59	0.48	0.55	0.53	0.60	1	1	1
Y	9502	0.81	0.86	0.76	0.78	0.88	0.65	0.56	0.56	0.50	0.50	1	1	1
Y	5802	0.68	0.79	0.80	0.83	0.85	0.60	0.47	0.46	0.54	0.56	1	1	1
Y	7731	0.74	0.77	0.75	0.79	0.79	0.52	0.52	0.51	0.47	0.51	1	1	1
Y	8795	0.75	0.78	0.73	0.74	0.75	0.56	0.51	0.50	0.54	0.52	1	1	1
Y	2503	0.67	0.79	0.62	0.75	0.76	0.48	0.45	0.55	0.57	0.54	1	1	1
Y	8591	0.66	0.69	0.68	0.70	0.71	0.56	0.52	0.45	0.50	0.48	1	1	1
Y	1928	0.75	0.72	0.69	0.61	0.78	0.49	0.46	0.46	0.43	0.51	1	1	1
Y	4503	0.65	0.67	0.68	0.71	0.75	0.53	0.47	0.45	0.42	0.50	1	1	1
Y	6503	0.79	0.87	0.66	0.74	0.76	0.53	0.48	0.51	0.50		1	1	1
Y	8750	0.70	0.75	0.70	0.71	0.64	0.38	0.43	0.46	0.47	0.50	1	1	1
Y	9503	0.74	0.76	0.69	0.73	0.77	0.35	0.42	0.38	0.37	0.28	1	1	1
Y	9437	0.69	0.71	0.64	0.75	0.74	0.51	0.44	0.49	0.46		1	1	1
Y	6758	0.72	0.74	0.68	0.69	0.71	0.46	0.42	0.45	0.54		1	1	1
Y	8053	0.65	0.68	0.51	0.59	0.64	0.45	0.45	0.40	0.45	0.48	1	1	1
Y	8031	0.48	0.63	0.56	0.65	0.69	0.45	0.42	0.41	0.48	0.51	1	1	0
Y	8058	0.57	0.68	0.71	0.68	0.70	0.49	0.42	0.49	0.48		1	1	1
Y	8267	0.58	0.65	0.59	0.63	0.63	0.43	0.39	0.37	0.45	0.48	1	1	1
Y	7752	0.68	0.64	0.63	0.65	0.68	0.51	0.46	0.43	0.46		1	1	1
Y	6752	0.59	0.65	0.56	0.54	0.58	0.43	0.42	0.42	0.42	0.44	1	1	1
Y	8001	0.47	0.53	0.48	0.54	0.57	0.41	0.39	0.45	0.46	0.49	1	1	0
Y	3407	0.54	0.55	0.51	0.55	0.59	0.29	0.20	0.23	0.25	0.27	1	1	1
Y	6702	0.53	0.53	0.52	0.48	0.54	0.28	0.26	0.23	0.21	0.26	1	1	1
Y	8601	0.50	0.49	0.47	0.48	0.54	0.26	0.25	0.22	0.26	0.26	1	1	1
Y	7202	0.44	0.43	0.41	0.44	0.46	0.28	0.31	0.32	0.27	0.36	1	1	1
Y	5201	0.49	0.50	0.44	0.42	0.44	0.35	0.24	0.27	0.24	0.27	1	1	1
Y	8332	0.42	0.46	0.46	0.44	0.47	0.26	0.22	0.22	0.22	0.20	1	1	1
Y	8604	0.46	0.47	0.51	0.49	0.52	0.19	0.15	0.15	0.16	0.16	1	1	1
Y	7201	0.40	0.47	0.43	0.45	0.46	0.26	0.19	0.19	0.17	0.24	1	1	1
Y	3402	0.45	0.44	0.42	0.44	0.47	0.26	0.25	0.24	0.25		1	1	1
Y	8002	0.41	0.41	0.41	0.42	0.48	0.21	0.23	0.19	0.20	0.24	1	1	1
Y	9531	0.37	0.40	0.40	0.41	0.44	0.21	0.19	0.21	0.20	0.20	1	1	1
Y	7011	0.37	0.40	0.37	0.40	0.39	0.19	0.21	0.19	0.21	0.21	1	1	1
Y	6501	0.34	0.36	0.35	0.40	0.41	0.20	0.18	0.17	0.20	0.22	1	1	1
Y	8308	0.38	0.40	0.39	0.38	0.39	0.21	0.16	0.16	0.17	0.16	1	1	1
Y	9532	0.31	0.35	0.35	0.33	0.36	0.20	0.17	0.17	0.15	0.18	1	1	1
Y	5020	0.33	0.35	0.35	0.35	0.36	0.18	0.15	0.15	0.18	0.16	1	1	1
Y	8309	0.31	0.33	0.30	0.33	0.34	0.19	0.15	0.14	0.15	0.15	1	1	1
Y	6502	0.29	0.31	0.35	0.35	0.33	0.18	0.15	0.14	0.16		1	1	1
Y	4188	0.26	0.29	0.29	0.30	0.34	0.19	0.14	0.15	0.13	0.14	1	1	1
Y	8306	0.24	0.27	0.28	0.29	0.35	0.17	0.14	0.12	0.13	0.13	1	1	1
Y	9202	0.27	0.35	0.38	0.29	0.33	0.14	0.12	0.11	0.11		1	1	1
Y	5401	0.25	0.28	0.23	0.27	0.27	0.15	0.12	0.12	0.12	0.11	1	1	1
Y	8411	0.16	0.19	0.18	0.17	0.17	0.11	0.10	0.10	0.10	0.10	1	1	1
N	6861	22.74	25.37	25.13	26.67	34.48	24.04	22.12	22.35	23.86	26.79	1	1	0
N	6273	17.21	18.42	16.74	19.13	18.78	16.49	14.68	13.39	13.22	13.33	1	1	1
N	9983	10.41	10.71	11.78	11.37	12.87	11.45	10.23	11.39	10.02	8.90	1	0	1
N	4661	6.13	6.63	6.36	7.01	8.30	7.85	6.63	6.74	7.21	7.99	1	1	0
N	1878	5.99	5.68	6.25	6.39	8.67	8.24	5.54	5.42	5.90	4.98	1	1	1
N	9022	5.83	5.57	5.78	5.86	6.37	6.08	5.65	5.42	6.07	5.75	1	1	1
N	7974	5.81	6.03	5.50	5.98	6.97	5.87	5.47	5.96	5.54	5.18	1	1	1
N	6954	5.11	5.15	5.48	4.77	5.68	5.28	5.46	5.74	5.76	5.39	1	0	0
N	6981	2.38	2.25	2.22	2.49	3.08	2.50	2.30	2.40	2.45	2.38	1	1	1
N	8035	2.14	1.99	2.11	2.16	3.25	2.12	2.33	1.91	1.84	2.19	1	1	0
N	9735	1.87	1.71	1.68	1.70	2.39	1.69	1.76	2.33	2.08	2.13	1	0	0
N	8113	2.01	1.94	1.77	1.83	2.47	1.66	1.61	1.96	2.06	1.96	1	0	1
N	6367	1.97	2.02	1.90	1.81	2.11	1.76	1.66	1.88	2.06	2.10	1	0	0
N	9020	1.90	1.65	1.69	1.66	1.94	1.76	1.91	2.28	2.08	1.96	1	0	0
N	4063	1.62	1.60	1.78	1.54	2.04	1.63	1.60	1.75	1.71	2.37	1	0	0
N	6594	1.56	1.78	1.67	1.54	1.89	1.56	1.53	1.71	1.65	1.60	1	0	0
N	9432	1.54	1.60	1.46	1.47	2.10	1.61	1.60	1.54	1.45	1.35	1	0	1
N	9433	1.36	1.63	1.44	1.41	1.81	1.79	1.45	1.40	1.37	1.54	1	1	0
N	9984	1.32	1.32	1.25	1.27	1.52	1.32	1.28	1.24	1.29	1.38	1	1	0
N	7203	1.16	1.16	1.15	1.15	1.28	1.20	1.13	1.16	1.11		1	0	1

Figure 7: Bird's Eye View Spread Comparison Detail for Jul 22, 2014

		Average Execution Size										Execution Size Comparison		
Affected	Ticker	14-Jul-2014	15-Jul-2014	16-Jul-2014	17-Jul-2014	18-Jul-2014	22-Jul-2014	23-Jul-2014	24-Jul-2014	25-Jul-2014	28-Jul-2014	22nd and 18th	24th and 17th	28th and 14th
Y	8411	9,602	7,804	12,323	14,728	7,046	15,698	14,382	14,802	17,205	16,358	0	0	0
Y	5401	7,120	9,501	8,957	9,420	7,341	6,778	6,724	5,442	6,585	7,060	1	1	1
Y	9202	7,382	7,634	6,465	4,553	8,199	5,461	4,592	8,613	6,201		1	0	1
Y	6502	5,667	8,558	9,578	6,967	5,732	3,545	3,945	4,866	3,753		1	1	1
Y	8309	6,913	5,982	5,873	6,115	4,981	2,902	3,794	3,452	4,309	3,870	1	1	1
Y	8306	6,684	6,600	5,819	5,756	4,707	2,621	3,047	2,552	2,594	2,612	1	1	1
Y	6501	4,321	4,961	4,061	4,886	5,410	3,198	3,462	3,261	3,465	3,508	1	1	1
Y	7011	4,364	4,392	3,170	4,105	3,698	3,296	2,786	3,614	4,309	3,952	1	1	1
Y	8002	4,211	3,490	3,977	4,051	4,265	2,844	2,646	2,819	2,675	2,722	1	1	1
Y	9531	3,744	3,682	3,928	3,518	4,722	2,874	2,496	2,880	2,570	2,833	1	1	1
Y	9532	2,964	3,948	4,118	4,140	3,488	2,803	2,519	2,732	2,819	2,570	1	1	1
Y	6702	3,547	3,903	3,400	3,520	3,828	2,583	2,828	2,277	2,226	2,707	1	1	1
Y	8601	3,711	3,203	3,283	3,589	3,971	2,724	2,418	2,505	2,616	2,377	1	1	1
Y	7202	3,614	3,373	3,237	4,034	3,778	2,641	2,138	2,164	2,314	2,988	1	1	1
Y	8604	3,127	3,721	4,953	5,182	3,011	1,879	1,601	1,982	2,482	1,486	1	1	1
Y	5201	4,237	3,553	2,892	3,614	2,420	1,970	2,501	2,340	2,109	2,724	1	1	1
Y	3402	3,971	4,112	3,420	2,974	3,238	2,679	2,208	2,248	2,787		1	1	1
Y	8332	2,944	2,926	2,668	2,721	3,000	1,990	2,354	2,197	2,108	2,102	1	1	1
Y	3407	2,532	3,086	2,840	2,887	2,455	2,274	2,408	2,118	1,987	2,322	1	1	1
Y	6503	2,250	2,761	2,377	3,180	2,556	2,540	2,709	2,357	2,435		1	1	1
Y	6326	2,405	2,126	2,493	2,985	2,577	2,223	2,090	2,204	1,748	2,105	1	1	1
Y	5713	2,110	2,105	2,397	1,903	2,261	1,935	1,823	1,696	1,567	1,707	1	1	1
Y	8750	1,583	1,812	2,761	1,672	1,863	982	1,419	3,805	1,793	1,021	1	0	1
Y	7912	2,174	2,016	2,055	2,069	1,925	1,742	1,472	1,618	1,561	1,782	1	1	1
Y	8802	1,766	2,010	2,020	2,096	1,827	1,756	1,761	1,660	1,586	1,869	1	1	0
Y	8801	1,956	2,257	2,161	1,613	1,807	1,723	1,692	1,599	1,691	1,715	1	1	1
Y	2802	1,870	2,046	2,343	2,046	1,732	1,588	1,694	1,640	1,411	1,773	1	1	1
Y	8308	1,860	2,061	2,456	2,920	2,076	1,091	864	1,146	1,057	1,330	1	1	1
Y	1925	1,618	1,799	1,737	1,674	1,673	1,498	1,357	1,601	1,742	1,624	1	1	0
Y	5020	2,014	2,469	2,802	1,578	1,539	740	1,145	1,077	1,120	1,118	1	1	1
Y	6752	1,608	1,629	1,302	1,685	1,356	1,307	1,486	1,276	1,704	1,118	1	1	1
Y	1963	1,305	1,419	1,748	1,381	1,468	1,377	1,217	1,383	1,374	1,352	1	0	0
Y	8830	1,441	1,638	1,539	1,385	1,465	1,288	1,363	1,260	1,252	1,292	1	1	1
Y	4188	1,317	2,002	1,191	1,667	1,037	1,178	898	1,078	1,070	1,841	0	1	0
Y	7201	1,439	1,617	1,631	1,450	1,254	1,057	1,100	975	919	1,192	1	1	1
Y	8031	1,068	1,131	1,159	1,506	1,231	1,159	1,091	1,041	1,220	1,034	1	1	1
Y	1928	1,284	832	814	1,681	1,017	812	843	960	919	2,364	1	1	0
Y	8001	1,055	1,091	1,044	1,161	1,011	803	877	1,028	1,041	754	1	1	1
Y	8053	920	1,036	894	1,167	1,026	953	1,012	989	817	736	1	1	1
Y	4503	970	1,145	1,092	998	935	888	779	713	763	1,007	1	1	0
Y	6758	995	992	1,110	1,030	752	727	878	1,101	1,182		1	0	1
Y	8267	853	992	993	1,181	856	755	845	862	698	724	1	1	1
Y	9437	803	887	779	1,556	885	832	876	831	1,152		1	1	1
Y	8058	960	897	917	1,189	954	862	891	853	1,036		1	1	1
Y	8795	1,014	777	932	1,213	936	806	558	797	571	752	1	1	1
Y	2503	1,022	1,068	655	743	802	688	806	689	570	911	1	1	1
Y	7731	819	868	800	822	806	891	580	672	700	835	0	1	0
Y	8591	995	1,013	932	658	696	719	673	682	532	689	0	0	1
Y	7752	812	770	820	812	704	713	769	792	915		0	1	1
Y	9503	819	1,094	1,160	980	800	509	401	373	468	362	1	1	1
Y	7751	884	777	695	814	677	622	570	543	540	697	1	1	1
Y	5802	591	836	691	914	734	564	660	471	527	761	1	1	0
Y	1605	663	758	814	882	830	576	566	497	491	540	1	1	1
Y	6301	603	721	613	806	831	538	534	491	602	656	1	1	0
Y	7267	592	651	707	744	735	527	723	533	505	673	1	1	0
Y	9502	697	770	689	766	603	589	622	602	547	460	1	1	1
Y	8316	649	679	780	820	662	548	615	596	538	434	1	1	1
Y	2914	715	780	726	656	863	513	639	459	451	490	1	1	1
Y	5411	644	551	792	756	778	573	497	503	474	702	1	1	0
Y	4911	815	541	620	661	650	522	420	509	537	502	1	1	1
Y	4568	576	505	464	752	573	576	493	519	438	502	0	1	1
Y	7270	562	620	526	630	573	427	361	615	419	472	1	1	1
Y	5108	566	612	473	590	547	492	345	363	383	388	1	1	1
Y	9064	443	447	443	544	568	355	400	456	472	629	1	1	0
Y	8766	555	579	493	431	505	499	459	357	342	363	1	1	1
Y	2502	567	477	513	531	487	463	393	421	298	429	1	1	1
Y	4901	499	525	470	407	481	394	324	486	337	409	1	0	1
Y	7269	433	408	505	401	513	351	254	437	388	414	1	0	1
Y	8725	420	470	570	336	390	341	307	360	397	421	1	0	0
Y	4502	462	469	420	541	468	323	330	283	333	380	1	1	1
Y	4578	390	500	462	495	382	274	247	298	271	384	1	1	1
Y	3382	373	399	360	416	366	320	338	295	363	291	1	1	1
Y	6902	349	359	351	382	340	314	278	320	316	408	1	1	0
Y	7741	385	362	337	374	340	305	298	279	313	316	1	1	1
Y	8630	421	352	383	353	405	309	313	270	222	254	1	1	1
Y	4523	328	341	361	352	337	271	251	270	271	329	1	1	0
Y	4452	377	315	314	318	333	304	259	252	237	264	1	1	1
Y	6988	320	285	281	305	321	273	317	266	263	266	1	1	1
Y	9021	277	254	370	323	261	237	195	224	217	247	1	1	1
Y	6971	271	266	266	255	279	245	219	259	232	284	1	0	0
N	7203	551	596	605	610	671	707	852	891	687		0	0	1
N	9984	484	443	525	465	409	467	480	490	451	397	0	0	1
N	9432	306	344	330	289	289	365	358	338	288	368	0	0	0
N	9433	302	279	267	324	291	309	354	312	335	292	0	1	1
N	4063	325	315	297	279	261	327	278	297	300	287	0	0	1
N	6594	237	246	324	313	272	353	280	275	291	271	0	1	0
N	8035	253	270	238	229	287	320	292	321	248	309	0	0	0
N	6954	251	224	217	242	275	269	264	312	329	276	1	0	0
N	6367	240	230	237	226	257	265	286	322	269	240	0	0	1
N	8113	247	259	232	208	275	274	289	277	250	211	1	0	1
N	7974	209	208	248	222	239	279	288	258	224	216	0	0	0
N	9020	219	221	236	270	286	250	228	206	225	236	1	1	0
N	9735	230	207	213	190	263	230	193	241	228	247	1	0	0
N	9022	201	227	211	211	188	223	188	204	207	213	0	1	0
N	6981	200	193	237	223	209	223	186	192	193	197	0	1	1
N	1878	180	201	200	208	205	192	196	229	201	197	1	0	0
N	9983	168	179	175	168	179	199	168	215	156	193	0	0	0
N	4661	191	176	183	180	172	182	175	181	180	165	0	0	1
N	6273	132	144	156	138	149	147	130	133	151	137	1	1	0
N	6861	140	128	139	122	130	124	124	115	133	134	1	1	1

Figure 8: Bird's Eye View Execution Size Comparison Detail for Jul 22, 2014

9 Appendix - II (Deep Dive Comparisons)

- EW stands for Equal Weighted; VW for Volume Weighted; TW for Trade Weighted and USDW for USD Weighted.

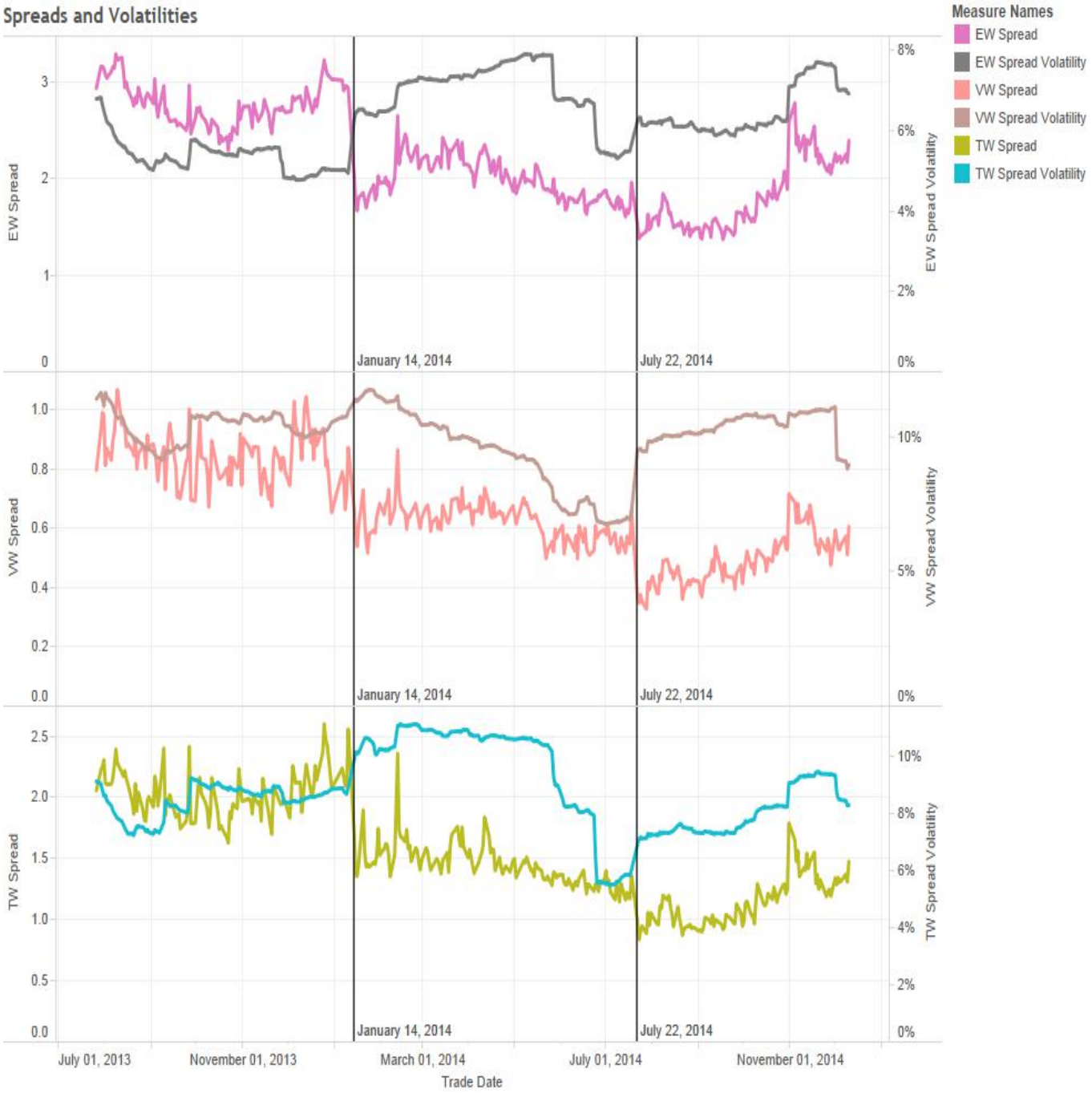


Figure 9: Spreads and Volatilities

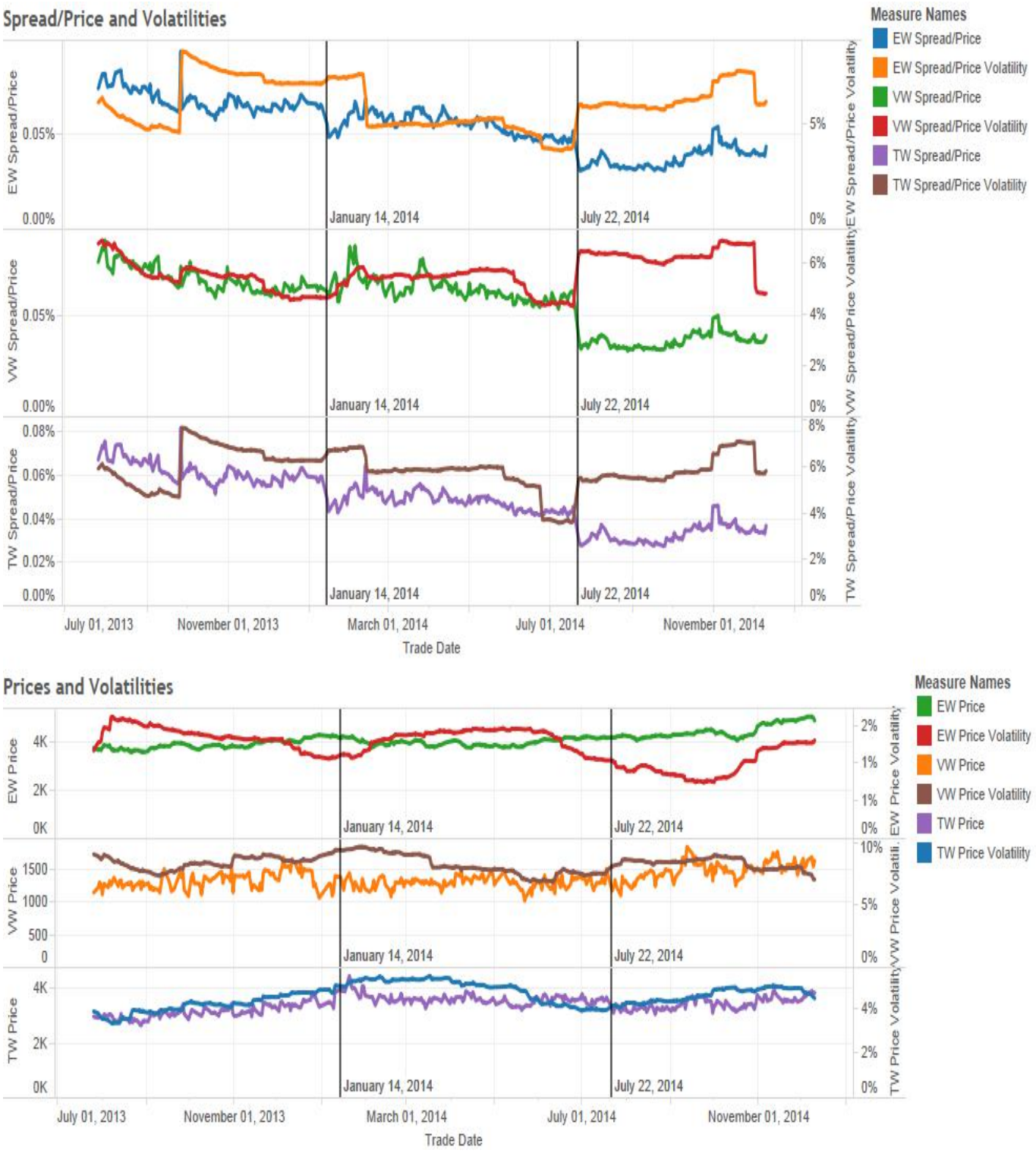


Figure 10: Spread/Price, Price and Volatilities

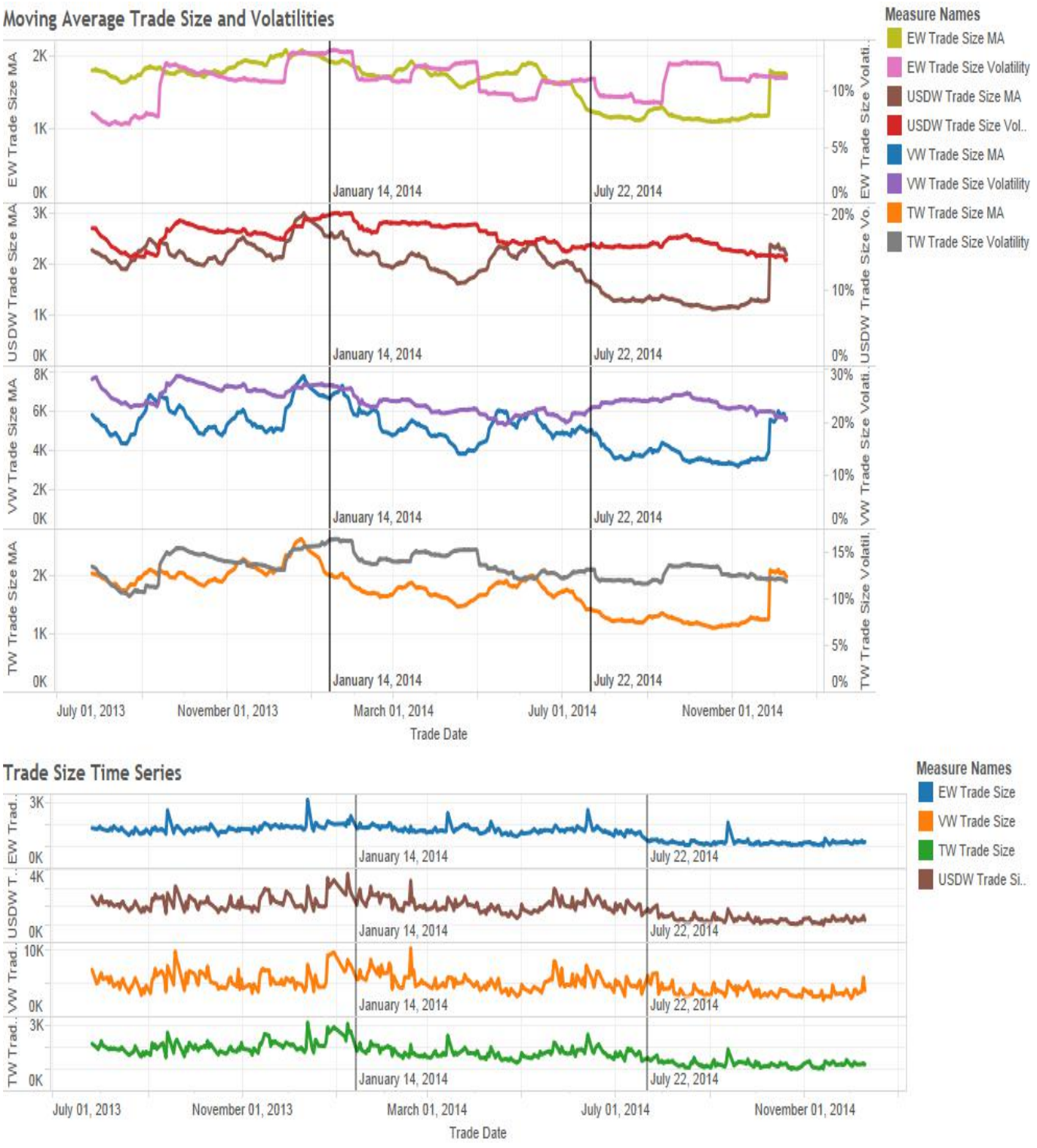


Figure 11: Trade Size and Volatilities

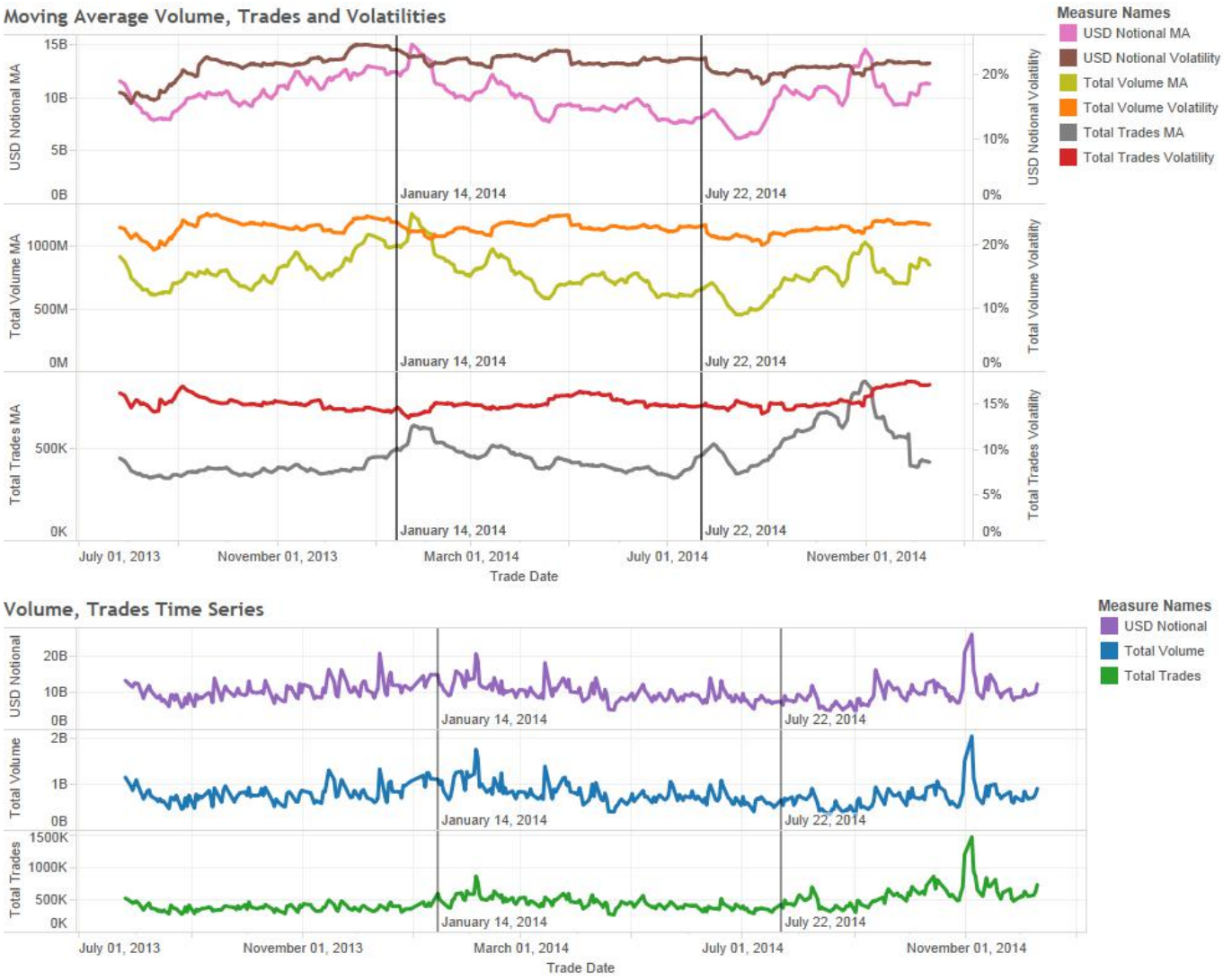
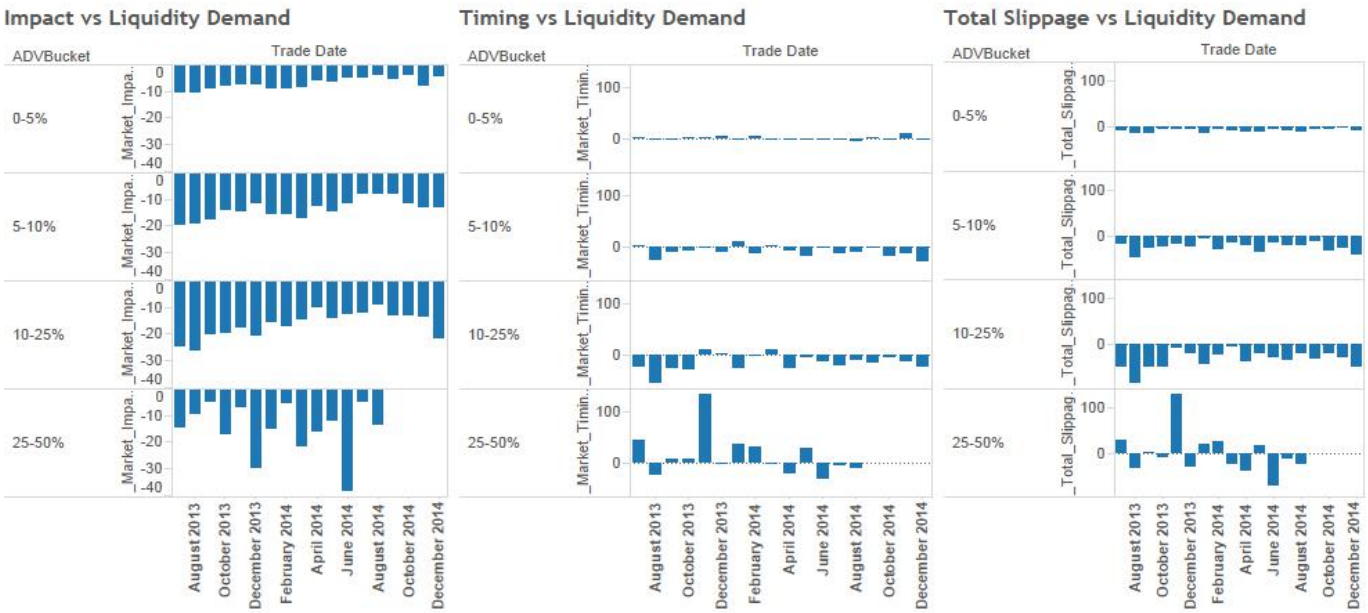


Figure 12: Volume, Trades and Volatilities

Order Liquidity Demand Buckets	USD Notional Buckets - I	USD Notional Buckets - II
0-5%	0-1MM	0-1MM
5-10%	1-5MM	1-10MM
10-25%	5-10MM	10-25MM
25-50%	10MM+	25MM+
50%+		

Figure 13: Order Liquidity Demand and USD Notional Size Buckets



Costs vs Liquidity Demand Table

	ADVBucket														
	0-5%			5-10%			10-25%			25-50%			50%+		
Month, Year ..	_Market_..	_Market_..	_Total_Sl..	_Market_..	_Market_..	_Total_Sl..	_Market_..	_Market_..	_Total_Sl..	_Market_..	_Market_..	_Total_Sl..	_Market_..	_Market_..	_Total_Sl..
July 2013	(10.70)	2.47	(8.24)	(19.69)	2.72	(16.97)	(25.16)	(23.68)	(48.84)	(14.58)	45.02	30.44	(9.98)	12.27	2.29
August 2013	(10.75)	(2.10)	(12.86)	(19.20)	(26.84)	(46.04)	(26.25)	(57.52)	(83.76)	(9.62)	(23.96)	(33.57)	(13.56)	(5.15)	(18.71)
September 2..	(9.14)	(3.34)	(12.48)	(17.70)	(9.80)	(27.50)	(20.39)	(27.25)	(47.64)	(5.12)	8.79	3.67	(13.02)	(12.66)	(25.68)
October 2013	(8.19)	3.48	(4.72)	(14.03)	(8.64)	(22.68)	(19.92)	(29.26)	(49.18)	(17.07)	7.41	(9.66)	(14.18)	0.49	(13.70)
November 2..	(7.53)	2.78	(4.75)	(14.63)	(3.37)	(18.00)	(18.05)	11.14	(6.91)	(6.90)	136.99	130.09			
December 20..	(7.78)	4.57	(3.20)	(11.58)	(10.99)	(22.57)	(20.96)	1.78	(19.18)	(30.30)	0.38	(29.92)	(21.75)	(18.42)	(40.17)
January 2014	(8.95)	(3.48)	(12.43)	(16.02)	9.17	(6.85)	(15.77)	(25.94)	(41.71)	(15.07)	36.07	20.99	(21.64)	46.41	24.77
February 2014	(9.05)	4.38	(4.67)	(16.02)	(13.09)	(29.11)	(17.52)	(3.52)	(21.04)	(5.71)	32.06	26.34	(4.39)	156.19	151.81
March 2014	(8.51)	0.54	(7.97)	(17.39)	2.66	(14.73)	(14.73)	10.64	(4.08)	(21.74)	(3.40)	(25.14)			
April 2014	(6.25)	(3.23)	(9.48)	(12.69)	(7.21)	(19.90)	(10.24)	(26.26)	(36.50)	(16.39)	(22.39)	(38.78)			
May 2014	(6.67)	(2.21)	(8.87)	(14.54)	(19.97)	(34.52)	(14.03)	(4.50)	(18.54)	(12.12)	29.12	17.00			
June 2014	(5.34)	0.12	(5.21)	(11.84)	(3.36)	(15.20)	(12.90)	(14.97)	(27.87)	(38.81)	(32.43)	(71.25)			
July 2014	(4.91)	(1.50)	(6.41)	(8.22)	(12.51)	(20.72)	(12.10)	(20.95)	(33.05)	(4.92)	(6.18)	(11.10)			
August 2014	(4.31)	(4.67)	(8.98)	(8.15)	(11.33)	(19.48)	(9.08)	(10.87)	(19.95)	(13.60)	(9.99)	(23.58)			
September 2..	(5.70)	1.27	(4.43)	(8.39)	(3.23)	(11.62)	(13.03)	(17.64)	(30.67)						
October 2014	(3.99)	(1.80)	(5.79)	(11.66)	(20.21)	(31.87)	(13.31)	(6.21)	(19.52)						
November 2..	(8.25)	9.07	0.82	(13.41)	(12.81)	(26.21)	(13.51)	(13.14)	(26.65)						
December 20..	(4.61)	(3.91)	(8.52)	(13.09)	(28.86)	(41.95)	(21.89)	(25.03)	(46.93)						

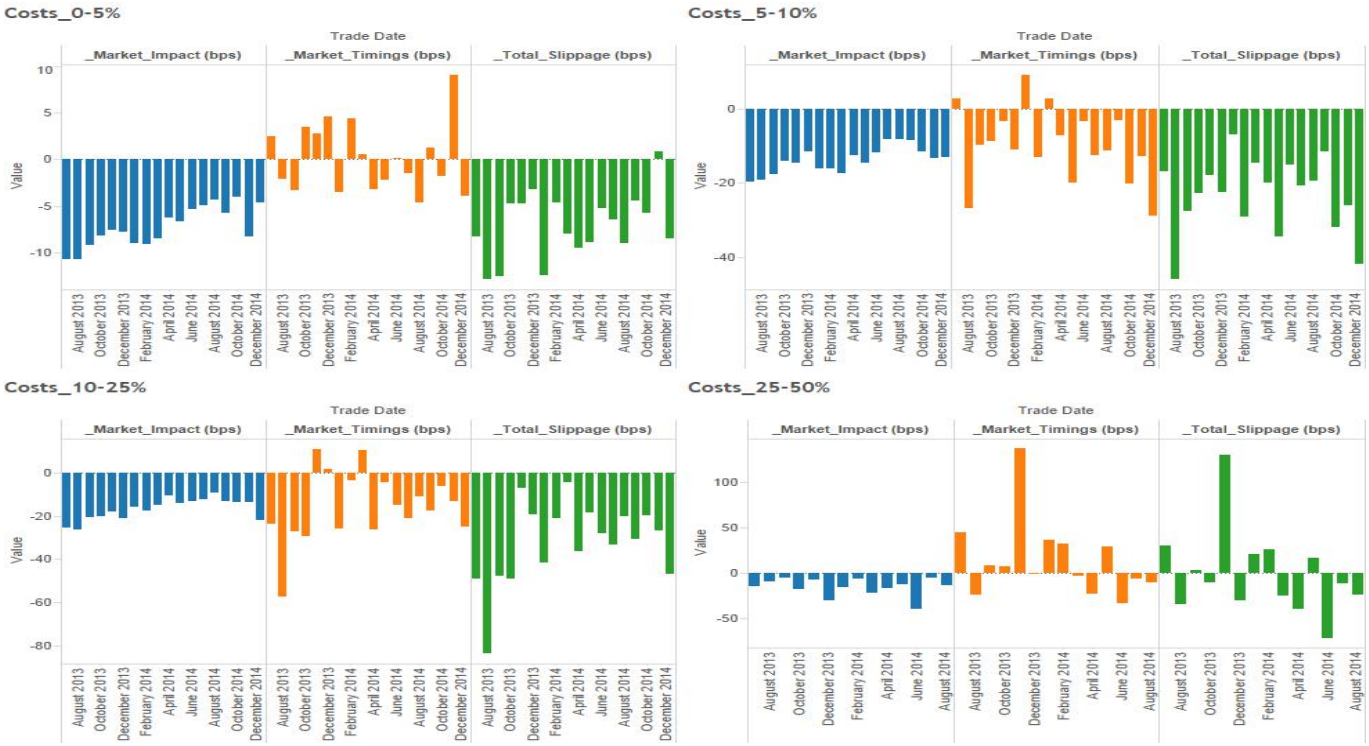
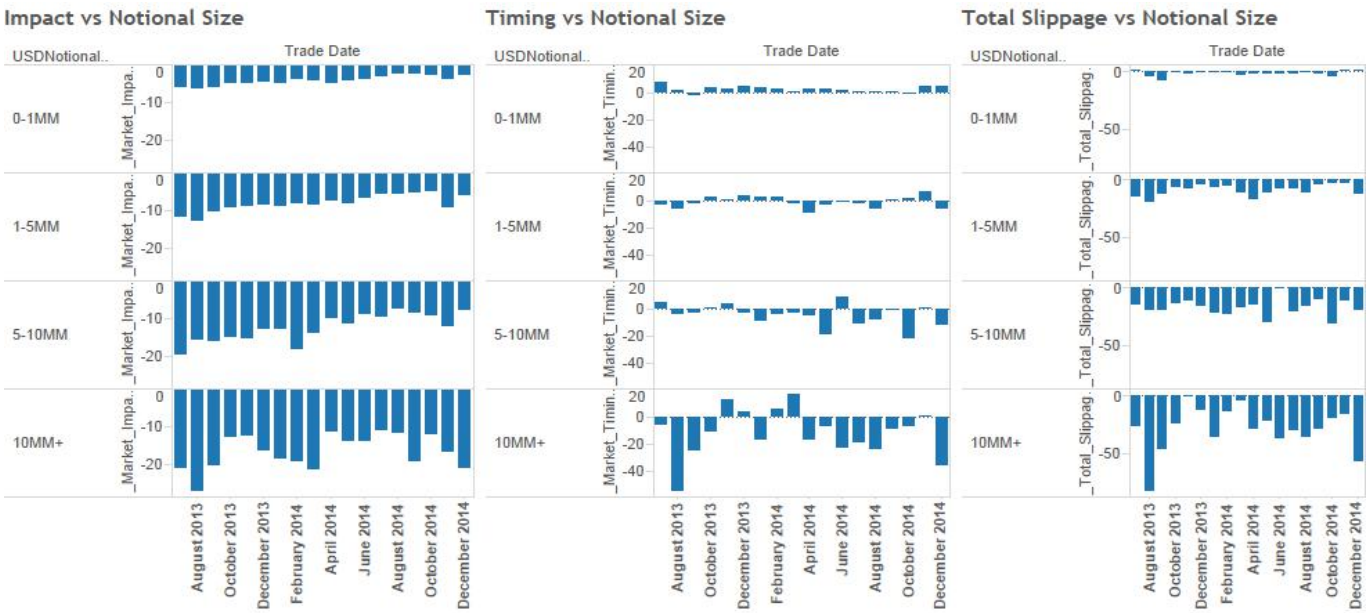


Figure 14: Trading Costs by Liquidity Demand



Costs vs Notional Size Table

	USDNotionalBucket											
	0-1MM			1-5MM			5-10MM			10MM+		
Month, Year of T..	_Market_Im..	_Market_Ti..	_Total_Slip..	_Market_Im..	_Market_Ti..	_Total_Slip..	_Market_Im..	_Market_Ti..	_Total_Slip..	_Market_Im..	_Market_Ti..	_Total_Slip..
July 2013	(5.96)	6.92	0.96	(11.67)	(3.73)	(15.40)	(19.45)	4.20	(15.25)	(20.90)	(6.01)	(26.90)
August 2013	(6.40)	1.38	(5.03)	(12.71)	(6.49)	(19.20)	(15.54)	(4.61)	(20.15)	(27.06)	(55.12)	(82.19)
September 2013	(6.00)	(2.61)	(8.61)	(10.16)	(2.87)	(13.02)	(16.09)	(3.80)	(19.89)	(20.22)	(25.46)	(45.69)
October 2013	(5.15)	3.57	(1.58)	(9.34)	1.99	(7.36)	(14.81)	0.99	(13.82)	(12.66)	(11.67)	(24.32)
November 2013	(4.94)	2.55	(2.39)	(8.76)	0.28	(8.48)	(15.28)	3.42	(11.86)	(12.44)	12.47	0.04
December 2013	(4.53)	4.68	0.14	(8.36)	3.14	(5.22)	(12.93)	(3.86)	(16.79)	(16.26)	3.66	(12.60)
January 2014	(4.90)	3.67	(1.23)	(9.05)	2.52	(6.53)	(12.89)	(9.32)	(22.21)	(18.43)	(17.67)	(36.10)
February 2014	(4.07)	2.68	(1.39)	(8.25)	2.69	(5.56)	(17.99)	(4.86)	(22.84)	(19.03)	4.95	(14.08)
March 2014	(4.31)	0.78	(3.53)	(8.60)	(2.86)	(11.46)	(14.02)	(3.47)	(17.49)	(21.28)	16.65	(4.64)
April 2014	(4.92)	2.79	(2.13)	(7.52)	(9.59)	(17.10)	(9.96)	(5.42)	(15.38)	(11.51)	(16.99)	(28.51)
May 2014	(4.39)	2.13	(2.26)	(8.27)	(3.24)	(11.51)	(11.20)	(19.08)	(30.28)	(13.90)	(7.88)	(21.79)
June 2014	(4.03)	1.84	(2.19)	(6.72)	(1.56)	(8.28)	(9.02)	8.21	(0.81)	(13.74)	(23.64)	(37.38)
July 2014	(3.03)	0.90	(2.13)	(5.59)	(2.82)	(8.41)	(9.64)	(11.01)	(20.65)	(11.00)	(18.95)	(29.94)
August 2014	(2.48)	0.68	(1.80)	(5.61)	(6.55)	(12.16)	(7.43)	(8.61)	(16.04)	(11.86)	(24.31)	(36.18)
September 2014	(2.38)	0.35	(2.03)	(5.16)	0.61	(4.55)	(8.56)	(1.83)	(10.39)	(19.01)	(9.47)	(28.48)
October 2014	(2.86)	(1.93)	(4.79)	(4.83)	1.19	(3.65)	(9.11)	(22.07)	(31.18)	(11.99)	(7.70)	(19.69)
November 2014	(3.81)	4.87	1.05	(9.33)	6.07	(3.27)	(12.14)	0.86	(11.28)	(16.66)	0.64	(16.02)
December 2014	(2.68)	4.08	1.40	(6.05)	(6.26)	(12.31)	(7.70)	(11.97)	(19.67)	(21.07)	(35.98)	(57.05)

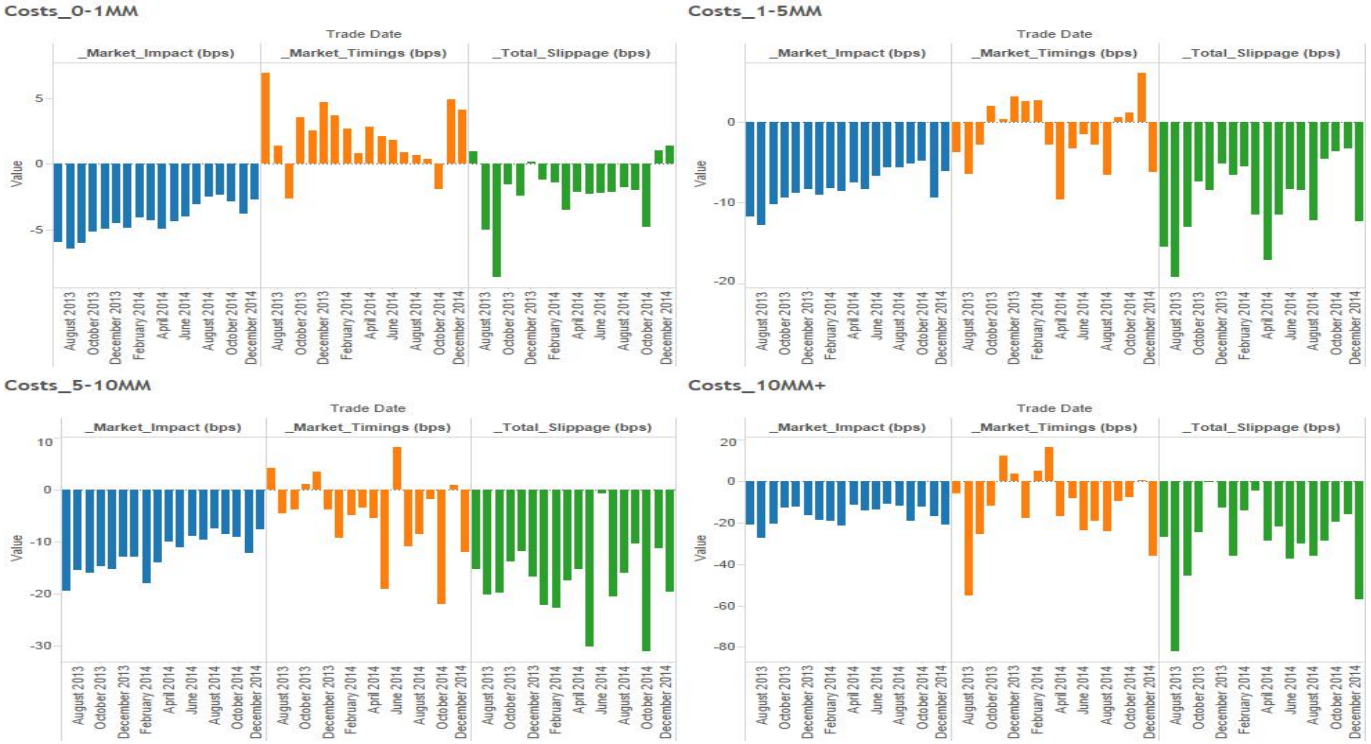
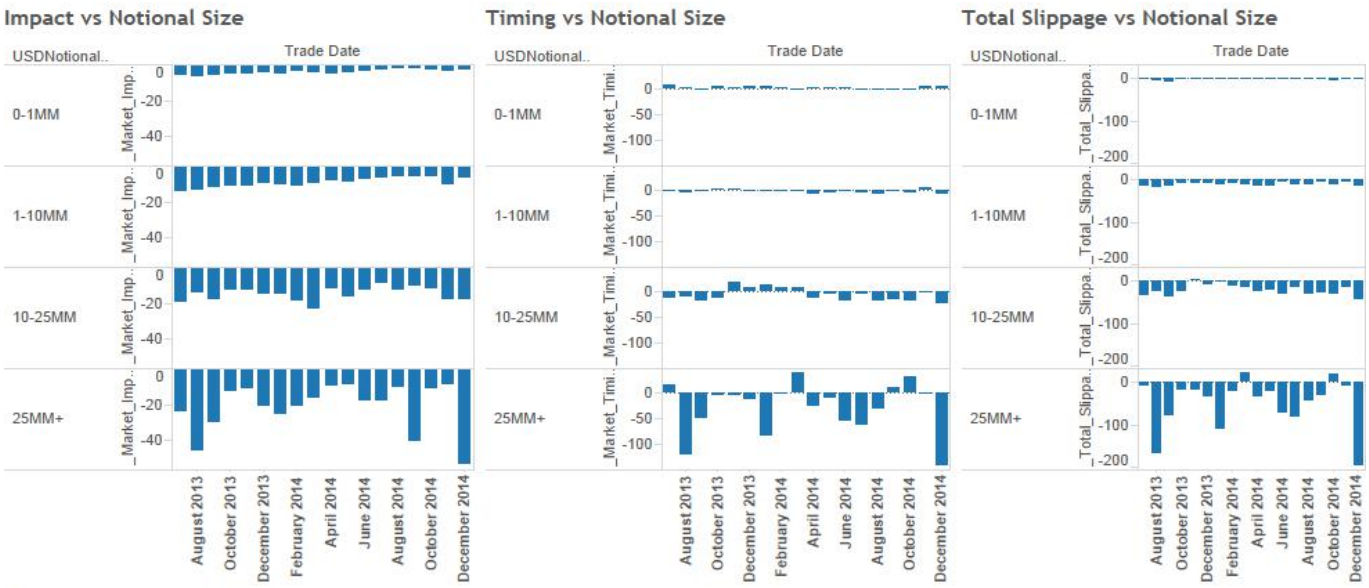


Figure 15: Trading Costs by Notional Size - 10MM+



Costs vs Notional Size Table

	USDNotionalBucket											
	0-1MM			1-10MM			10-25MM			25MM+		
Month, Year of T..	_Market_Im..	_Market_Ti..	_Total_Slip..	_Market_Im..	_Market_Ti..	_Total_Slip..	_Market_Im..	_Market_Ti..	_Total_Slip..	_Market_Im..	_Market_Ti..	_Total_Slip..
July 2013	(5.96)	6.92	0.96	(14.26)	(1.09)	(15.35)	(19.80)	(13.47)	(33.27)	(24.07)	15.57	(8.51)
August 2013	(6.40)	1.38	(5.03)	(13.53)	(5.94)	(19.48)	(14.48)	(9.74)	(24.23)	(45.74)	(122.49)	(168.23)
September 2013	(6.00)	(2.61)	(8.61)	(11.98)	(3.15)	(15.13)	(17.61)	(19.01)	(36.63)	(30.22)	(50.22)	(80.45)
October 2013	(5.15)	3.57	(1.58)	(11.00)	1.69	(9.31)	(12.72)	(13.15)	(25.87)	(12.42)	(5.82)	(18.24)
November 2013	(4.94)	2.55	(2.39)	(10.86)	1.29	(9.57)	(12.84)	17.82	4.99	(11.05)	(6.09)	(17.13)
December 2013	(4.53)	4.68	0.14	(9.92)	0.74	(9.18)	(15.25)	7.24	(8.01)	(21.31)	(14.27)	(35.58)
January 2014	(4.90)	3.67	(1.23)	(10.25)	(1.17)	(11.42)	(15.21)	13.70	(1.50)	(25.43)	(85.65)	(111.07)
February 2014	(4.07)	2.68	(1.39)	(11.07)	0.51	(10.56)	(18.40)	7.04	(11.36)	(21.05)	(1.80)	(22.85)
March 2014	(4.31)	0.78	(3.53)	(10.06)	(3.03)	(13.09)	(23.19)	7.59	(15.60)	(16.77)	38.02	21.24
April 2014	(4.92)	2.79	(2.13)	(8.18)	(8.45)	(16.64)	(12.33)	(12.89)	(25.22)	(9.67)	(26.22)	(35.90)
May 2014	(4.39)	2.13	(2.26)	(8.94)	(6.87)	(15.81)	(16.23)	(6.18)	(22.41)	(8.95)	(11.51)	(20.46)
June 2014	(4.03)	1.84	(2.19)	(7.21)	0.54	(6.68)	(13.02)	(17.86)	(30.88)	(17.68)	(55.41)	(73.10)
July 2014	(3.03)	0.90	(2.13)	(6.76)	(5.18)	(11.94)	(8.85)	(5.56)	(14.41)	(18.12)	(63.43)	(81.55)
August 2014	(2.48)	0.68	(1.80)	(6.17)	(7.18)	(13.35)	(12.56)	(19.85)	(32.42)	(10.64)	(32.07)	(42.71)
September 2014	(2.38)	0.35	(2.03)	(6.13)	(0.09)	(6.22)	(10.42)	(17.26)	(27.67)	(40.47)	9.97	(30.50)
October 2014	(2.86)	(1.93)	(4.79)	(5.96)	(4.92)	(10.88)	(12.29)	(18.60)	(30.89)	(10.94)	30.25	19.30
November 2014	(3.81)	4.87	1.05	(10.23)	4.40	(5.82)	(17.79)	0.79	(17.01)	(8.83)	(0.38)	(9.21)
December 2014	(2.68)	4.08	1.40	(6.60)	(8.13)	(14.73)	(17.80)	(25.34)	(43.14)	(53.47)	(141.48)	(194.95)

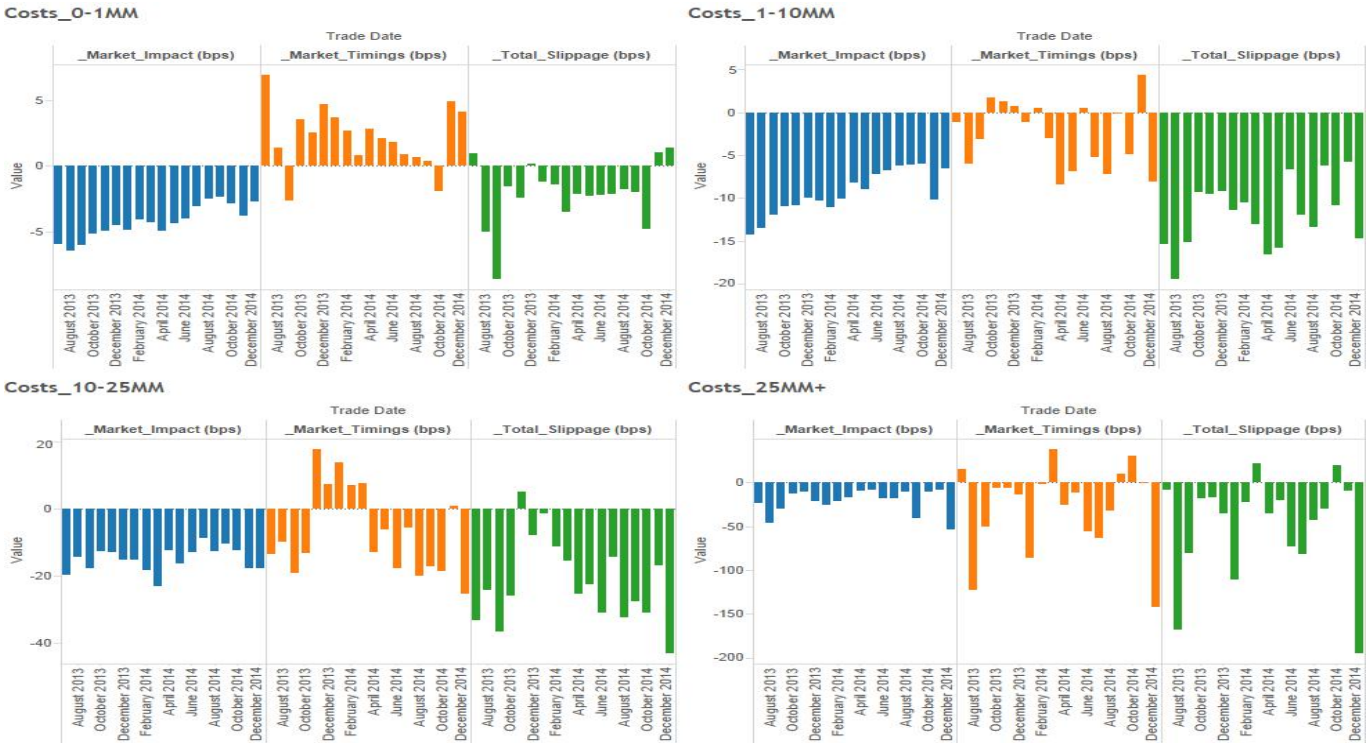


Figure 16: Trading Costs by Notional Size - 25MM+

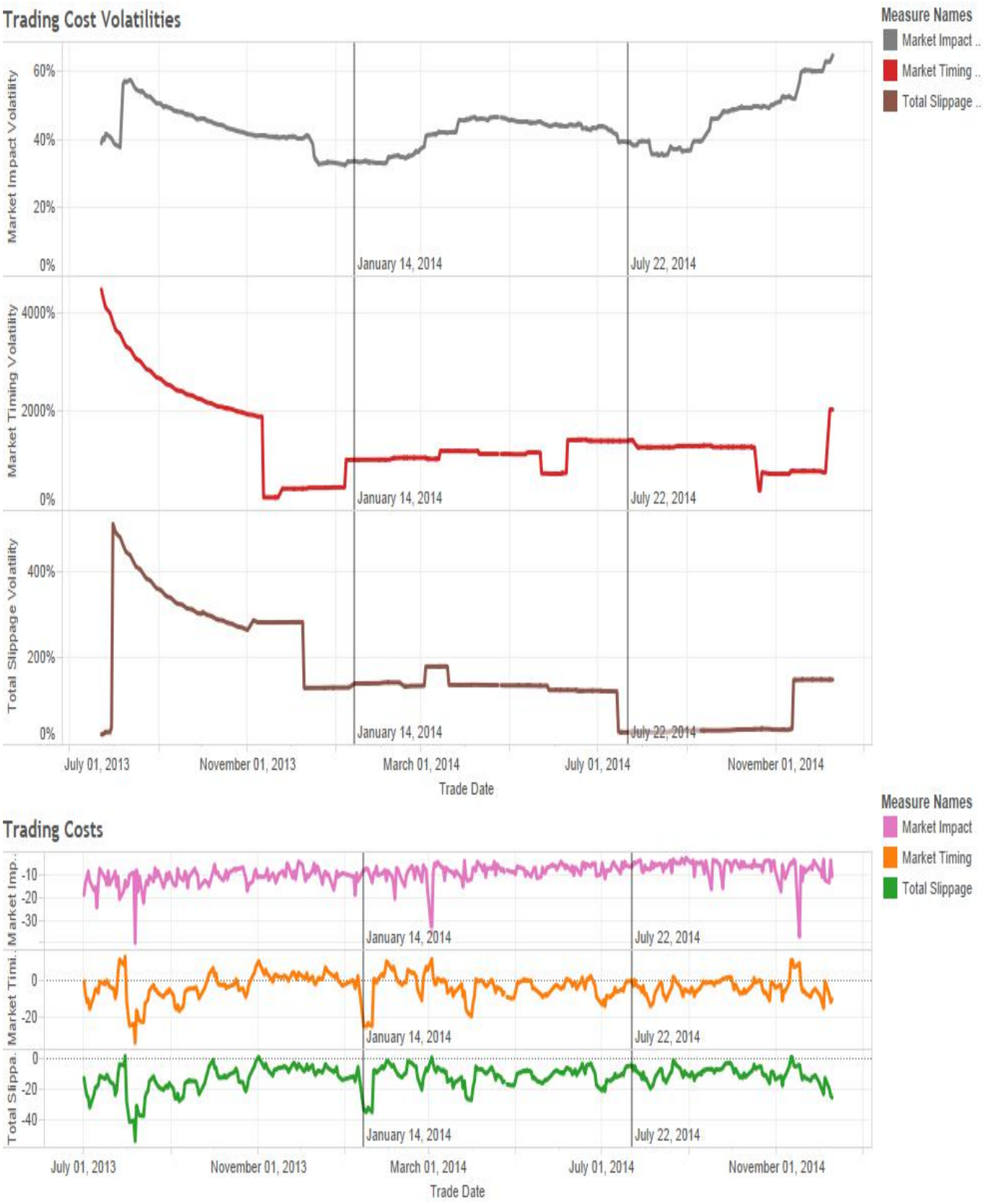


Figure 17: Trading Costs and Volatilities

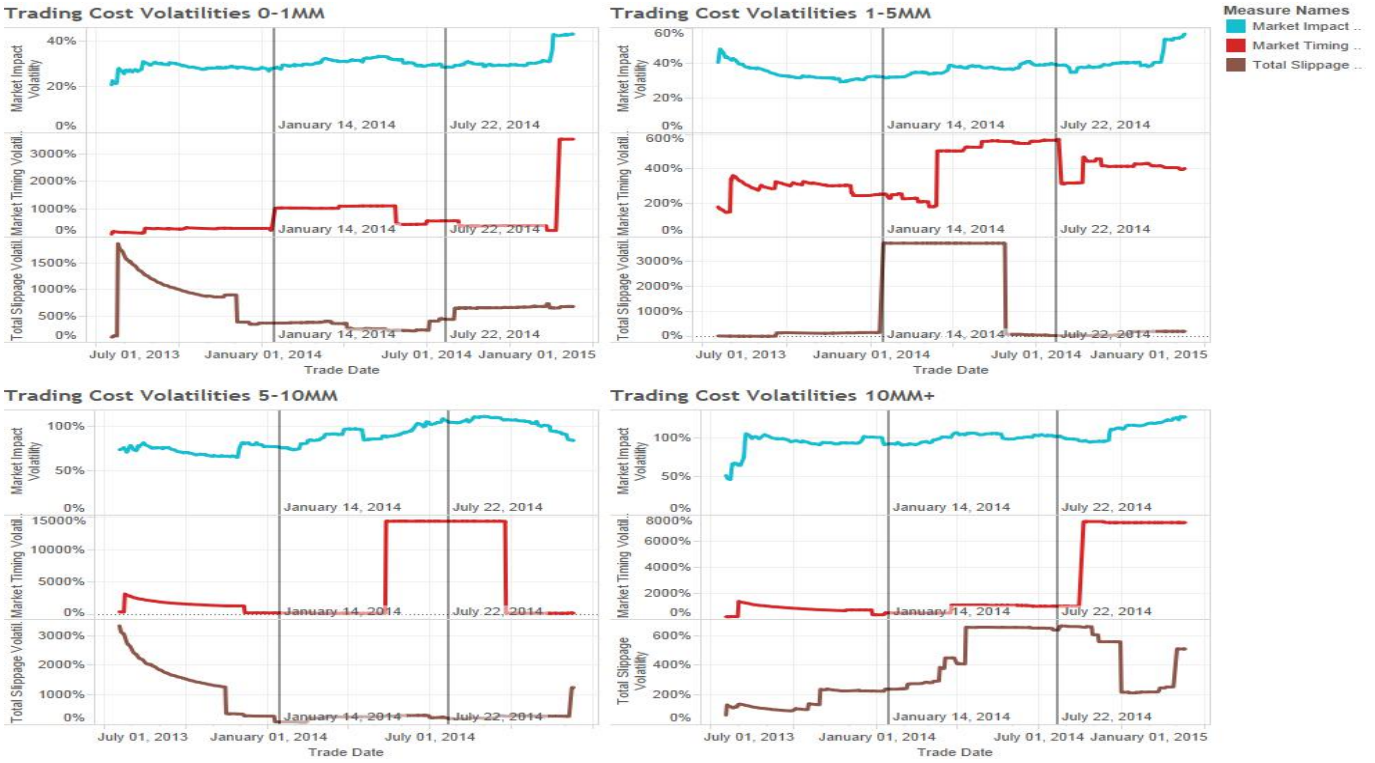


Figure 18: Trading Cost Volatilities By Notional Buckets - 10MM+

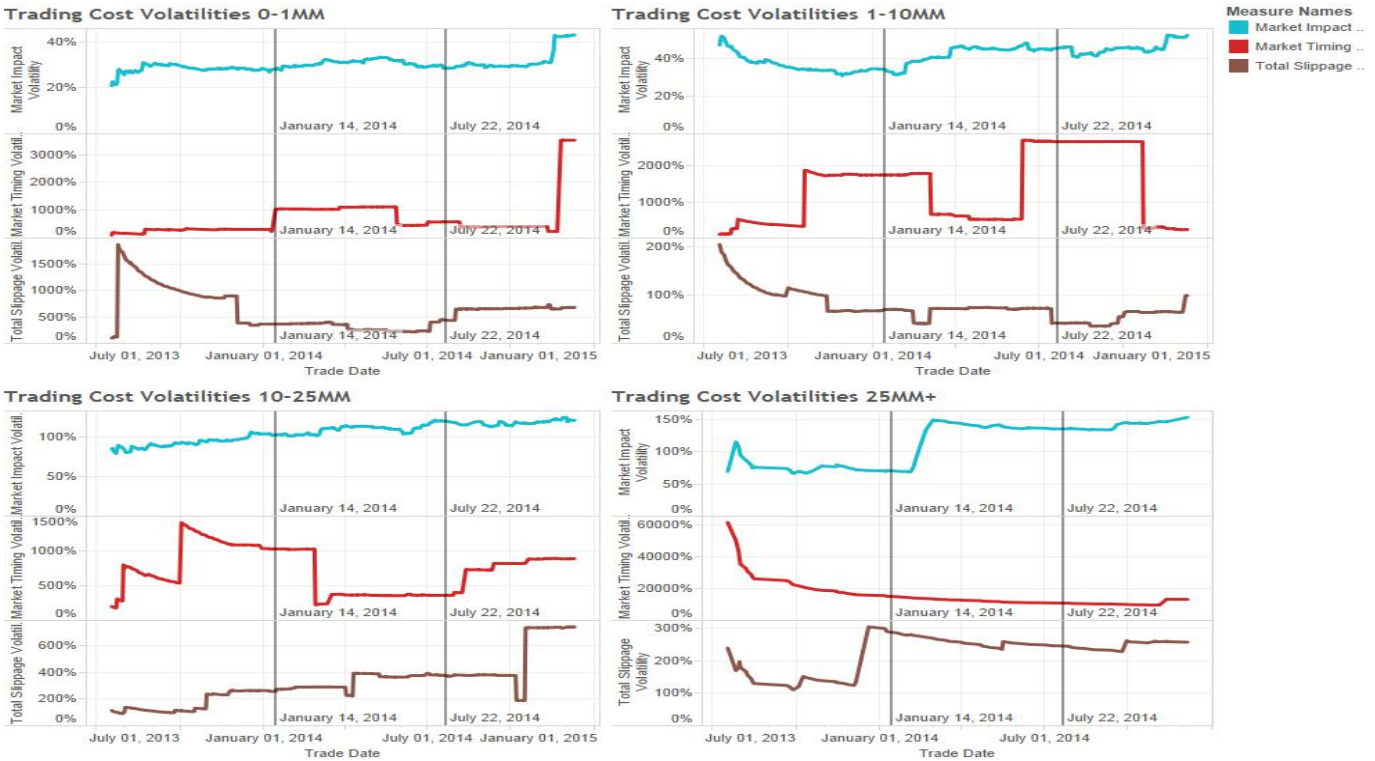


Figure 19: Trading Cost Volatilities By Notional Buckets - 25MM+

Stationary Test Results showing count of Securities with p-value less than 0.05 - (Jul-01-2013 to Dec-10-2014)							
Variable Name	Total Securities	ADF - explosive	ADF - stationary	KPSS - Level	KPSS - Trend	PP - explosive	PP - stationary
Average Bid Ask Spread	100	1	15	98	96	0	83
Total Daily Volume	100	0	89	58	84	0	100
Total Daily Trades	100	0	80	83	94	0	100
Avg Volume	100	0	50	98	89	0	100
Close Price	100	6	13	94	99	5	9
Close Price Diff	100	0	100	2	0	0	100
USDJPY	1	1	0	1	1	1	0
USDJPY Diff	1	0	1	1	0	0	1
Total Volume 5DMean	100	0	78	60	88	0	96
Price Inverse	100	3	12	93	100	1	12
Price Inverse Diff	100	0	100	1	0	0	100
Spread / Price	100	0	18	100	96	0	92
Stationary Test Results showing count of Securities with p-value less than 0.05 - (Jul-01-2013 to Jan-10-2014)							
Variable Name	Total Securities	ADF - explosive	ADF - stationary	KPSS - Level	KPSS - Trend	PP - explosive	PP - stationary
Average Bid Ask Spread	100	4	17	75	85	0	94
Total Daily Volume	100	0	60	41	46	0	100
Total Daily Trades	100	0	68	49	44	0	100
Avg Volume	100	0	52	72	55	0	99
Close Price	100	8	3	94	94	4	9
Close Price Diff	100	0	100	1	0	0	100
USDJPY	1	0	0	1	1	0	0
USDJPY Diff	1	0	1	0	0	0	1
Total Volume 5DMean	100	3	4	59	71	0	57
Total Volume 5DMean Diff	100	0	100	0	0	0	100
Price Inverse	100	4	3	94	93	1	13
Price Inverse Diff	100	0	100	0	0	0	100
Spread / Price	100	3	19	82	82	0	95
Stationary Test Results showing count of Securities with p-value less than 0.05 - (Jan-14-2014 to Jul-18-2014)							
Variable Name	Total Securities	ADF - explosive	ADF - stationary	KPSS - Level	KPSS - Trend	PP - explosive	PP - stationary
Average Bid Ask Spread	100	0	44	93	80	0	100
Total Daily Volume	100	0	73	79	36	0	100
Total Daily Trades	100	0	74	85	35	0	100
Avg Volume	100	0	56	42	39	0	100
Close Price	100	0	9	98	100	0	4
Close Price Diff	100	0	100	1	0	0	100
USDJPY	1	0	100	100	0	0	100
USDJPY Diff	1	0	100	0	0	0	100
Total Volume 5DMean	100	1	7	87	62	1	57
Total Volume 5DMean Diff	100	0	100	0	0	0	100
Price Inverse	100	0	9	98	100	0	5
Price Inverse Diff	100	0	100	1	0	0	100
Spread / Price	100	0	43	95	91	0	95
Stationary Test Results showing count of Securities with p-value less than 0.05 - (Jul-22-2014 to Dec-10-2014)							
Variable Name	Total Securities	ADF - explosive	ADF - stationary	KPSS - Level	KPSS - Trend	PP - explosive	PP - stationary
Average Bid Ask Spread	100	0	6	96	93	0	94
Total Daily Volume	100	0	61	74	42	0	100
Total Daily Trades	100	0	45	81	53	0	99
Avg Volume	100	0	61	36	40	0	99
Close Price	100	2	1	90	95	3	0
Close Price Diff	100	0	79	2	0	0	100
USDJPY	1	0	0	1	1	0	0
USDJPY Diff	1	0	1	0	0	0	1
Total Volume 5DMean	100	1	32	82	74	0	17
Total Volume 5DMean Diff	100	0	100	0	1	0	100
Price Inverse	100	0	1	90	95	3	2
Price Inverse Diff	100	0	81	0	1	0	100
Spread / Price	100	0	7	88	88	0	94
Stationary Test Results showing count of Securities with p-value less than 0.05 - (Jul-01-2013 to Jul-18-2014)							
Variable Name	Total Securities	ADF - explosive	ADF - stationary	KPSS - Level	KPSS - Trend	PP - explosive	PP - stationary
Average Bid Ask Spread	100	0	28	88	90	0	93
Total Daily Volume	100	0	85	59	73	0	100
Total Daily Trades	100	0	67	81	84	0	100
Avg Volume	100	0	65	80	81	0	100
Close Price	100	2	2	96	100	2	8
Close Price Diff	100	0	100	0	0	0	100
USDJPY	1	0	0	1	1	0	0
USDJPY Diff	1	0	1	0	0	0	1
Total Volume 5DMean	100	0	65	72	90	0	85
Price Inverse	100	2	2	96	100	1	8
Price Inverse Diff	100	0	100	0	0	0	100
Spread / Price	100	0	33	86	90	0	97
Stationary Test Results showing count of Securities with p-value less than 0.05 - (Jan-15-2014 to Dec-10-2014)							
Variable Name	Total Securities	ADF - explosive	ADF - stationary	KPSS - Level	KPSS - Trend	PP - explosive	PP - stationary
Average Bid Ask Spread	100	3	5	97	99	0	94
Total Daily Volume	100	0	73	75	88	0	100
Total Daily Trades	100	0	59	91	97	0	100
Avg Volume	100	0	59	81	72	0	100
Close Price	100	1	18	91	99	1	5
Close Price Diff	100	0	100	6	0	0	100
USDJPY	1	1	0	1	1	1	0
USDJPY Diff	1	0	1	1	0	0	1
Total Volume 5DMean	100	1	34	79	95	0	85
Price Inverse	100	1	18	89	100	0	8
Price Inverse Diff	100	0	100	1	0	0	100
Spread / Price	100	0	10	99	99	0	94

Figure 20: Stationary Test Results

Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jul-01-2013 to Dec-10-2014)						Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jul-01-2013 to Oct-30-2014)					
Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient	Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient
Average Bid Ask Spread	100	100	0	7	93	Average Bid Ask Spread	100	100	0	3	97
Total Daily Volume	100	100	0	40	60	Total Daily Volume	100	100	0	24	76
Total Daily Trades	100	100	0	91	9	Total Daily Trades	100	100	0	72	28
Avg Volume	100	100	0	10	90	Avg Volume	100	100	0	14	86
Close Price Diff	100	41	59	76	24	Close Price Diff	100	61	39	50	50
USDJPY Diff	1	0	1	1	0	USDJPY Diff	100	0	100	100	0
Total Volume 5DMean	100	100	0	41	59	Total Volume 5DMean	100	100	0	30	70
Price Inverse Diff	100	55	45	30	70	Price Inverse Diff	100	37	63	50	50
Spread / Price	100	100	0	0	100	Spread / Price	100	100	0	0	100
Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jul-01-2013 to Jan-10-2014)						Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jul-01-2013 to Jan-10-2014)					
Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient	Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient
Average Bid Ask Spread	100	100	0	31	69	Average Bid Ask Spread	100	100	0	31	69
Total Daily Volume	100	97	3	60	40	Total Daily Volume	100	97	3	60	40
Total Daily Trades	100	100	0	35	65	Total Daily Trades	100	100	0	35	65
Avg Volume	100	97	3	85	15	Avg Volume	100	97	3	85	15
Close Price Diff	100	42	58	69	31	Close Price Diff	100	42	58	69	31
USDJPY Diff	1	0	1	1	0	USDJPY Diff	100	0	100	100	0
Total Volume 5DMean	100	97	3	65	35	Total Volume 5DMean	100	97	3	65	35
Total Volume 5DMean Diff	100	33	67	73	27	Total Volume 5DMean Diff	100	33	67	73	27
Price Inverse Diff	100	55	45	36	64	Price Inverse Diff	100	55	45	36	64
Spread / Price	100	100	0	15	85	Spread / Price	100	100	0	15	85
Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jan-14-2014 to Jul-18-2014)						Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jan-14-2014 to Jul-18-2014)					
Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient	Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient
Average Bid Ask Spread	100	100	0	5	95	Average Bid Ask Spread	100	100	0	5	95
Total Daily Volume	100	100	0	8	92	Total Daily Volume	100	100	0	8	92
Total Daily Trades	100	100	0	8	92	Total Daily Trades	100	100	0	8	92
Avg Volume	100	100	0	39	61	Avg Volume	100	100	0	39	61
Close Price Diff	100	12	88	94	6	Close Price Diff	100	12	88	94	6
USDJPY Diff	1	0	1	0	1	USDJPY Diff	100	0	100	100	0
Total Volume 5DMean	100	100	0	8	92	Total Volume 5DMean	100	100	0	8	92
Total Volume 5DMean Diff	100	50	50	40	60	Total Volume 5DMean Diff	100	50	50	40	60
Price Inverse Diff	100	88	12	7	93	Price Inverse Diff	100	88	12	7	93
Spread / Price	100	100	0	7	93	Spread / Price	100	100	0	7	93
Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jul-22-2014 to Dec-10-2014)						Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jul-22-2014 to Oct-30-2014)					
Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient	Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient
Average Bid Ask Spread	100	100	0	98	2	Average Bid Ask Spread	100	100	0	84	16
Total Daily Volume	100	100	0	97	3	Total Daily Volume	100	98	2	88	12
Total Daily Trades	100	100	0	97	3	Total Daily Trades	100	99	1	93	7
Avg Volume	100	100	0	47	53	Avg Volume	100	100	0	47	53
Close Price Diff	100	46	54	76	24	Close Price Diff	100	61	39	33	67
USDJPY Diff	1	1	0	1	0	USDJPY Diff	100	100	0	0	100
Total Volume 5DMean	100	100	0	95	5	Total Volume 5DMean	100	98	2	94	6
Total Volume 5DMean Diff	100	73	27	32	68	Total Volume 5DMean Diff	100	19	81	94	6
Price Inverse Diff	100	55	45	26	74	Price Inverse Diff	100	38	62	68	32
Spread / Price	100	100	0	97	3	Spread / Price	100	100	0	92	8
Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jul-01-2013 to Jul-18-2014)						Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jul-01-2013 to Jul-18-2014)					
Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient	Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient
Average Bid Ask Spread	100	100	0	13	87	Average Bid Ask Spread	100	100	0	13	87
Total Daily Volume	100	100	0	31	69	Total Daily Volume	100	100	0	31	69
Total Daily Trades	100	100	0	50	50	Total Daily Trades	100	100	0	50	50
Avg Volume	100	100	0	41	59	Avg Volume	100	100	0	41	59
Close Price Diff	100	58	42	50	50	Close Price Diff	100	58	42	50	50
USDJPY Diff	1	1	0	0	1	USDJPY Diff	100	100	0	0	100
Total Volume 5DMean	100	100	0	32	68	Total Volume 5DMean	100	100	0	32	68
Price Inverse Diff	100	42	58	50	50	Price Inverse Diff	100	42	58	50	50
Spread / Price	100	100	0	13	87	Spread / Price	100	100	0	13	87
Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jan-15-2014 to Dec-10-2014)						Time Trend Regressions showing count of Securities with positive and negative co-efficients - (Jan-15-2014 to Oct-30-2014)					
Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient	Variable Name	Total Securities	Positive Intercept	Negative Intercept	Positive Co-efficient	Negative Co-efficient
Average Bid Ask Spread	100	100	0	17	83	Average Bid Ask Spread	100	100	0	7	93
Total Daily Volume	100	100	0	39	61	Total Daily Volume	100	100	0	16	84
Total Daily Trades	100	99	1	83	17	Total Daily Trades	100	99	1	57	43
Avg Volume	100	100	0	15	85	Avg Volume	100	100	0	16	84
Close Price Diff	100	23	77	88	12	Close Price Diff	100	34	66	73	27
USDJPY Diff	1	0	1	1	0	USDJPY Diff	100	0	100	100	0
Total Volume 5DMean	100	100	0	37	63	Total Volume 5DMean	100	100	0	22	78
Price Inverse Diff	100	73	27	14	86	Price Inverse Diff	100	65	35	28	72
Spread / Price	100	100	0	2	98	Spread / Price	100	100	0	2	98

Figure 21: Time Trend Regression Results

Volume Regressions Correlation Matrix for Full Sample								
(Intercept)	1.00							
Time Trend Coefficient	0.45	1.00						
ln(Average Bid Ask Spread)	(0.09)	0.17	1.00					
ln(Spread / Price)	0.82	0.56	0.10	1.00				
ln(Total Trades)	(0.09)	0.19	0.29	0.48	1.00			
USD JPY First Difference	0.00	(0.09)	(0.01)	(0.01)	(0.02)	1.00		
Close Price First Difference	0.00	(0.00)	(0.04)	0.01	0.01	(0.13)	1.00	
Price Inverse First Difference	0.00	(0.01)	(0.02)	(0.01)	(0.01)	0.20	0.09	1.00

Figure 22: Volume Regression Correlation Matrix

Volume Regressions for Different Sample Periods						
Variable Name	Jul-01-13 to Dec-10-14	Jul-01-13 to Jan-10-14	Jan-14-14 to Jul-18-14	Jul-22-14 to Dec-10-14	Jul-01-13 to Jul-18-14	Jan-15-14 to Dec-10-14
(Intercept)	16.58	16.72	16.51	14.60	16.90	16.37
Time Trend Coefficient	0.00	0.00	0.00	0.00	0.00	(0.00)
ln(Average Bid Ask Spread)	(0.76)	(0.73)	(0.79)	(0.75)	(0.75)	(0.78)
ln(Spread / Price)	1.30	1.44	1.34	0.95	1.42	1.22
ln(Total Trades)	1.01	1.09	1.04	0.89	1.07	0.97
USD JPY First Difference	0.01	0.02	(0.03)	0.02	0.02	(0.00)
Close Price First Difference	0.00	0.00	(0.00)	0.00	0.00	0.00
Price Inverse First Difference	(759.26)	(1,231.03)	(606.00)	(348.11)	(873.05)	(439.73)
Adjusted R Squared	0.77	0.67	0.85	0.85	0.75	0.85
Sample Size	35,580	12,992	12,880	9,692	25,880	22,480
Volume Regressions without Trade Count for Different Sample Periods						
Variable Name	Jul-01-13 to Dec-10-14	Jul-01-13 to Jan-10-14	Jan-14-14 to Jul-18-14	Jul-22-14 to Dec-10-14	Jul-01-13 to Jul-18-14	Jan-15-14 to Dec-10-14
(Intercept)	17.76	17.47	16.97	11.12	17.48	17.68
Time Trend Coefficient	-	-	-	0.01	-	-
ln(Average Bid Ask Spread)	(0.93)	(0.88)	(1.12)	(0.88)	(0.97)	(0.97)
ln(Spread / Price)	0.33	0.32	0.12	(0.09)	0.29	0.30
USD JPY First Difference	0.03	0.02	(0.14)	0.10	(0.02)	0.05
Close Price First Difference	-	-	-	-	-	-
Price Inverse First Difference	(312.29)	(1,581.81)	(461.47)	164.59	(518.49)	445.66
Adjusted R Squared	0.55	0.46	0.67	0.67	0.54	0.63
Trade Count Regressions for Different Sample Periods						
Variable Name	Jul-01-13 to Dec-10-14	Jul-01-13 to Jan-10-14	Jan-14-14 to Jul-18-14	Jul-22-14 to Dec-10-14	Jul-01-13 to Jul-18-14	Jan-15-14 to Dec-10-14
(Intercept)	1.17	0.69	0.44	(3.90)	0.54	1.35
Time Trend Coefficient	-	-	(0.01)	0.01	-	-
ln(Average Bid Ask Spread)	(0.18)	(0.14)	(0.31)	(0.15)	(0.20)	(0.20)
ln(Spread / Price)	(0.96)	(1.02)	(1.17)	(1.16)	(1.05)	(0.94)
USD JPY First Difference	0.03	-	(0.11)	0.09	(0.04)	0.06
Close Price First Difference	-	-	-	-	-	-
Price Inverse First Difference	441.76	(321.68)	138.99	574.44	331.17	910.11
Adjusted R Squared	0.31	0.28	0.44	0.39	0.33	0.31

Figure 23: Volume Regression Results

Cost Regressions Correlation Matrix for Full Sample																									
(Intercept)	1.00																								
Time Trend Coefficient	0.63	1.00																							
ln(Average Spread)	0.03	(0.02)	1.00																						
ln(Total Volume)	0.06	0.09	0.08	1.00																					
ln(Average Volume)	(0.29)	(0.10)	(0.11)	(0.70)	1.00																				
ln(Spread / Price)	(0.03)	0.13	(0.69)	0.35	(0.29)	1.00																			
ln(Close Price Volatility)	(0.20)	(0.22)	(0.05)	(0.21)	0.20	(0.12)	1.00																		
ln(Average Spread Volatility)	0.11	(0.04)	(0.05)	0.07	(0.02)	0.07	(0.05)	1.00																	
ln(Total Volume Volatility)	(0.01)	(0.03)	(0.01)	0.09	(0.22)	(0.00)	(0.15)	0.04	1.00																
ln(Average Volume Volatility)	(0.24)	(0.24)	0.03	(0.23)	0.35	(0.10)	0.31	(0.16)	(0.59)	1.00															
ln(Total Trades Volatility)	(0.05)	(0.21)	(0.02)	(0.00)	0.13	0.02	(0.05)	(0.13)	(0.67)	0.38	1.00														
ln(USD JPY Volatility)	0.50	0.60	0.01	(0.11)	(0.01)	(0.19)	(0.35)	(0.08)	0.07	(0.22)	(0.13)	1.00													
USDJPY First Difference	0.15	(0.02)	(0.01)	(0.13)	0.08	(0.07)	0.06	0.01	(0.02)	0.05	(0.00)	(0.00)	1.00												
Close Price First Difference	0.01	0.01	(0.01)	0.01	(0.02)	0.01	0.01	(0.01)	0.00	(0.01)	0.00	0.01	(0.14)	1.00											
ln(Execution Value)	(0.96)	(0.63)	(0.16)	(0.09)	0.20	0.18	0.25	(0.09)	0.01	0.24	0.06	(0.47)	(0.15)	(0.00)	1.00										
ln(Number of Shares)	0.18	(0.01)	0.88	0.09	(0.41)	(0.60)	(0.07)	(0.01)	0.11	(0.15)	(0.09)	0.07	(0.00)	0.01	(0.23)	1.00									
ln(Number of Executions)	(0.00)	0.02	0.00	(0.06)	0.18	(0.02)	0.02	0.02	0.00	(0.04)	0.01	0.02	0.01	(0.01)	0.00	(0.12)	1.00								
Liquidity Demand Bucket 10-25%	(0.01)	0.01	0.25	0.06	0.00	(0.20)	0.01	0.01	(0.01)	0.01	(0.00)	0.00	(0.00)	(0.00)	(0.04)	0.20	(0.03)	1.00							
Liquidity Demand Bucket 25-50%	(0.00)	(0.00)	0.29	0.01	0.01	(0.23)	0.00	0.00	(0.01)	0.01	0.01	(0.00)	(0.00)	(0.00)	(0.04)	0.25	(0.01)	0.11	1.00						
Liquidity Demand Bucket 5-10%	(0.01)	(0.00)	0.15	0.07	0.00	(0.12)	0.01	0.01	(0.01)	0.01	(0.00)	(0.00)	(0.00)	0.00	(0.02)	0.11	(0.05)	0.21	0.08	1.00					
Liquidity Demand Bucket 50%+	0.01	0.00	0.47	0.01	0.01	(0.37)	(0.00)	0.01	(0.03)	0.01	0.02	0.00	0.00	(0.00)	(0.08)	0.41	(0.01)	0.14	0.15	0.10	1.00				
USD Notional Bucket, 1-5MM	0.06	0.00	(0.05)	(0.07)	0.01	0.02	0.00	0.01	0.01	(0.02)	(0.00)	(0.01)	(0.00)	(0.00)	(0.03)	(0.02)	(0.18)	(0.08)	(0.02)	(0.16)	(0.03)	1.00			
USD Notional Bucket, 5-10MM	0.04	0.01	(0.11)	(0.07)	0.00	0.08	(0.00)	0.00	0.01	(0.01)	(0.01)	(0.00)	(0.00)	0.01	(0.00)	(0.08)	(0.10)	(0.27)	(0.08)	(0.33)	(0.06)	0.24	1.00		
USD Notional Bucket, 10MM+	0.03	0.01	(0.14)	(0.07)	0.00	0.11	(0.00)	(0.00)	0.01	(0.01)	(0.00)	(0.00)	0.00	0.00	0.00	(0.10)	(0.07)	(0.38)	(0.10)	(0.27)	(0.09)	0.19	0.23	1.00	
Price Inverse First Difference	(0.01)	(0.03)	(0.00)	(0.06)	0.04	(0.03)	0.07	0.01	(0.01)	0.00	0.00	(0.01)	0.28	0.07	0.01	0.00	(0.02)	(0.00)	(0.00)	(0.00)	0.00	(0.01)	(0.01)	(0.00)	1.00

Figure 24: Cost Regression Correlation Matrix

Market Impact Regressions by 10MM+ Notional Buckets for Different Sample Periods							Percentage Change with Jul-01-2013 to Jan-10-2014 ($1) as the Reference Sample					
Variable Name	Jul-01-13 to Dec-10-14	Jul-01-13 to Jan-10-14	Jan-14-14 to Jul-18-14	Jul-22-14 to Dec-10-14	Jul-01-13 to Jul-18-14	Jan-15-14 to Dec-10-14	Full	$1	$2	$3	$4	$5
(Intercept)	(17.47)	(21.48)	12.24	(1.82)	(59.99)	(5.78)	-19%	0%	-157%	-92%	179%	-73%
Time Trend Coefficient	0.29	0.32	(0.03)	3.76	0.18	0.44	-9%	0%	-108%	1089%	-42%	38%
ln(Average Spread)	(0.26)	(0.07)	0.39	0.50	(0.26)	0.26	278%	0%	-658%	-819%	280%	-472%
ln(Total Volume)	(0.61)	(0.52)	(0.73)	(0.54)	(0.71)	(0.58)	18%	0%	41%	4%	37%	13%
ln(Average Volume)	0.72	0.61	0.88	0.93	0.78	0.73	17%	0%	43%	51%	27%	18%
ln(Spread / Price)	(2.50)	(2.66)	(3.43)	(2.59)	(2.93)	(2.91)	-6%	0%	29%	-2%	10%	10%
ln(Close Price Volatility)	0.19	0.14	0.35	0.24	0.42	0.05	34%	0%	148%	74%	202%	-65%
ln(Average Spread Volatility)	0.02	(0.06)	(0.23)	(0.28)	0.09	(0.11)	-135%	0%	276%	353%	-246%	79%
ln(Total Volume Volatility)	0.27	0.90	0.13	(0.47)	0.42	(0.18)	-70%	0%	-85%	-153%	-54%	-120%
ln(Average Volume Volatility)	(0.15)	(0.43)	(0.03)	0.33	(0.29)	0.05	-64%	0%	-93%	-176%	-32%	-111%
ln(Total Trades Volatility)	(0.18)	(0.59)	0.27	0.04	(0.40)	0.69	-70%	0%	-146%	-106%	-33%	-217%
ln(USD JPY Volatility)	(0.22)	(0.28)	0.73	0.03	0.12	0.22	-23%	0%	-360%	-112%	-144%	-180%
USDJPY First Difference	0.09	0.09	(0.01)	0.04	0.07	0.06	5%	0%	-108%	-54%	-15%	-34%
Close Price First Difference	0.00	(0.00)	0.00	0.00	0.00	0.00	0%	0%	0%	0%	0%	0%
ln(Execution Value)	0.22	0.46	(5.43)	(7.38)	9.75	(2.38)	-53%	0%	-1287%	-1713%	2031%	-619%
ln(Number of Shares)	(0.43)	(0.25)	0.06	0.21	(0.42)	0.04	72%	0%	-123%	-184%	70%	-117%
ln(Number of Executions)	(0.50)	(0.54)	(0.57)	(0.16)	(0.69)	(0.38)	-7%	0%	6%	-71%	28%	-30%
Liquidity Demand Bucket 10-25%	(2.18)	(3.17)	(2.67)	(0.33)	(2.00)	(2.64)	-31%	0%	-16%	-90%	-37%	-16%
Liquidity Demand Bucket 25-50%	(2.59)	(2.95)	(2.53)	(1.58)	(2.97)	(2.06)	-12%	0%	-14%	-46%	1%	-30%
Liquidity Demand Bucket 5-10%	(1.56)	(0.81)	9.73	-	(1.36)	8.44	93%	0%	-1302%	-100%	68%	-1143%
Liquidity Demand Bucket 50%+	(0.13)	(0.52)	4.94	6.81	(9.71)	1.97	-75%	0%	-1051%	-1411%	1769%	-479%
USD Notional Bucket, 1-5MM	(1.85)	(1.89)	(1.32)	(1.88)	(1.64)	(1.67)	-2%	0%	-30%	0%	-13%	-12%
USD Notional Bucket, 5-10MM	(4.79)	(5.55)	(4.81)	(3.87)	(4.93)	(4.51)	-14%	0%	-13%	-30%	-11%	-19%
USD Notional Bucket, 10MM+	(6.54)	(7.94)	(7.53)	(7.81)	(5.67)	(7.96)	-18%	0%	-5%	-2%	-29%	0%
Price Inverse First Difference	1,051.14	(81.67)	(697.00)	225.69	1,169.13	139.28	-1387%	0%	753%	-376%	-1532%	-271%
Adjusted R Squared	0.08	0.11	0.13	0.03	0.12	0.06	-24%	0%	14%	-74%	7%	-43%
Sample Size	230,016	84,083	74,058	90,675	139,314	164,296	174%	0%	-12%	8%	66%	95%
Market Impact Regressions by 25MM+ Notional Buckets for Different Sample Periods							Percentage Change with Jul-01-2013 to Jan-10-2014 as the Reference Sample					
Variable Name	Jul-01-13 to Dec-10-14	Jul-01-13 to Jan-10-14	Jan-14-14 to Jul-18-14	Jul-22-14 to Dec-10-14	Jul-01-13 to Jul-18-14	Jan-15-14 to Dec-10-14	Full	$1	$2	$3	$4	$5
USD Notional Bucket, 1-10MM	(2.03)	(2.12)	(1.51)	(1.98)	(1.85)	(1.82)	-4%	0%	-29%	-7%	-13%	-14%
USD Notional Bucket, 10-25MM	(5.42)	(6.21)	(6.79)	(6.51)	(4.66)	(6.90)	-13%	0%	9%	5%	-25%	11%
USD Notional Bucket, 25MM+	(9.49)	(13.96)	(6.42)	(13.31)	(7.69)	(9.54)	-32%	0%	-54%	-5%	-45%	-32%
Time Trend Coefficient	0.29	0.32	-	3.72	0.18	0.43	-10%	0%	-100%	1061%	-43%	34%
Adjusted R Squared	0.08	0.11	0.13	0.03	0.12	0.06	-27%	0%	18%	-73%	9%	-45%
Market Impact Regressions by Notional Buckets with Interaction Effects Between Liquidity Demand and Notional Size for Different Sample Periods							Percentage Change with Jul-01-2013 to Jan-10-2014 as the Reference Sample					
Variable Name	Jul-01-13 to Dec-10-14	Jul-01-13 to Jan-10-14	Jan-14-14 to Jul-18-14	Jul-22-14 to Dec-10-14	Jul-01-13 to Jul-18-14	Jan-15-14 to Dec-10-14	Full	$1	$2	$3	$4	$5
USD Notional Bucket, 1-5MM	(1.78)	(1.79)	(1.22)	(1.88)	(1.56)	(1.60)	0%	0%	-32%	5%	-13%	-11%
USD Notional Bucket, 5-10MM	(5.05)	(6.33)	(5.65)	(3.59)	(5.09)	(5.10)	-20%	0%	-11%	-43%	-20%	-19%
USD Notional Bucket, 10MM+	(7.16)	(9.61)	(9.52)	(8.97)	(6.12)	(9.72)	-25%	0%	-1%	-7%	-36%	1%
Time Trend Coefficient	0.29	0.32	(0.02)	3.76	0.18	0.43	-10%	0%	-107%	1071%	-44%	35%
Adjusted R Squared	0.08	0.11	0.13	0.03	0.12	0.06	-24%	0%	14%	-74%	6%	-43%

Figure 25: Trading Cost Regression Results