The Opportunity Cost of Inaction in Financial Markets: An Analysis of Institutional Decisions and Trades

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Abstract

We present the first comprehensive analysis of an often ignored component of implementation shortfall -- the opportunity cost of unexecuted institutional decisions. The proportion of total decisions partly or wholly unfilled is 8.36% and the mean unfilled rate within the unfilled decisions is 51.64%. Opportunity costs of this failure to trade are 24 basis points or $20 billion in our sample period, much higher in magnitude when compared to price impact and five times that of commissions. There is a significant asymmetry in opportunity cost of buy versus sell decisions based on whether market conditions are bullish or bearish. Opportunity costs decrease with firm size, speed of transaction, number of brokers, and exchange listing whereas they increase with market volatility. Opportunity loss of non-execution persists and increases slightly with the passage of time. Transaction cost risks are higher for small stocks and volatile stocks.

Introduction

Recognizing the concept that reality in financial markets involves the cost of trading and the cost of not trading, Perold (1988) launched the pioneer work on institutional trading costs, defining implementation shortfall as the difference between paper performance and actual performance of a portfolio manager or an investment strategy. The implementation shortfall of institutional trading has two basic components. The first, execution cost, relates to the transactions you actually execute and arises from price impact, commission, and other transaction fees and taxes. The second, opportunity cost, relates to transactions that you fail to execute. An order that the manager does not fulfill to his satisfaction contains the gain that the investor had to forgo by failing to achieve an ideal investment.

The first component of institutional trading cost is widely studied. For instance, Berkowitz, Logue and Noser (1988), Keim and Madhavan (1995, 1996, 1997), Chan and Lakonishok (1993, 1997), Jones and Lipson (2001), Conrad, Johnson, and Wahal (2001, 2003) analyze the relationship between investment styles, trade motivations, exchange listing, trading systems and price impact of trades within the U.S. Chiyachantana, Jain, Jiang and Wood (2004) provide new evidence on determinants of price impact and changes in asymmetry of price impact of buys and sells in bull and bear markets in 37 countries. Goldstein, Irvine, Kandel, and Weiner (2009) examine the impact of commission costs on institutional trading patterns. All these studies focus on completely filled decisions. However, not all decisions are completely filled. To get a complete picture of implementation shortfall, it is necessary to analyze the complete decision and not just its filled portion

A comprehensive analysis of this second component of opportunity costs of unfilled buy or sell decisions is largely missing from the literature due to data limitations. What happens on the road that was planned but not taken by the institutional trader? Our paper fills this gap in the literature by presenting the first empirical analysis of institutional trading opportunity cost using a very comprehensive institutional trading data from Abel Noser Corporation. Our study spans 776 institutional clients who collectively transact over $20 trillion over period of 1999-2005 which accounts for the lion's share of trading in the United States. Our research design and the unique features of the dataset offers several advantages by tracking each intuitional buy or sell decision down to order placement and trade implementation. This enables us to characterize the distribution of institutional decisions that result or do not result in actual transactions as well as understand the determinants of the fill rate. The fact that we don't need to infer trade direction makes our results more accurate compared to research designs that rely on trade only datasets. Issues like implementation shortfall and fill rates can only be studied with detailed information about the direction, timing, and quantity of the institutional investment decision, which are missing from most standard microstructure datasets[1].

Our paper contributes to literature in several ways. First, we show that opportunity costs are almost twice in magnitude when compared to price impact and four times that of commissions. The dollar magnitude of opportunity costs is nearly $20 billion in our sample period. Therefore, institutional portfolio managers and academic readers of our paper can have a more accurate idea of the total transaction costs shaved from the paper portfolio return of their investment strategies. Including the opportunity costs, one-way total execution costs can be as high as 42 basis points resulting in a round trip estimate of 84 basis points. The 106% annual turnover computed from CRSP mutual fund dataset from 1999-2005 implies that transaction

[1] A large body of market microstructure research examining the impact of transaction costs focuses exclusively on observed costs (e.g. spread). The widely used database, such as Trade and Quote (TAQ), only provides information on actual execution of trades. We have access to both trading decisions and actual transactions.

costs ate into nearly 20% of the value weighted CRSP return of 4.60% in that period. Second, we decompose the opportunity costs into its two components – the unfilled rate due to partial execution or non-execution of order and the return loss. We conjecture that the former are governed by trading strategies where as the latter demonstrates the research superiority of the institution. Third, we analyze how the effect of the determinants of both fill rates and opportunity vary dramatically across bull or bear market condition. Fourth, we provide a comparison of opportunity costs across NYSE and Nasdaq exchanges at the institutional level. Fifth, we compare mutual fund opportunity costs to pension fund opportunity costs. Sixth, we analyze transaction cost risk and opportunity cost persistence. Firm-specific and decision-specific variables that stand out as the main determinants of opportunity costs in the multivariate regression framework include firm size, speed of transaction, number of brokers, exchange listing, and market volatility.

The results have several practical and academic implications. Institutional investors can use them as benchmarks to analyze their own implementation shortfall. The numbers can also provide guidance of whether or not it pays to be aggressive in completing the investment decisions. More importantly, the implementation policy can be customized to address the affect of market conditions, type of institutions, firm-specific characteristics and order-dynamics. From the academic perspective, these measures of transaction costs provide the limits to arbitrage and also implore models to include the transaction costs because they can lead to significant deviations from the ideal performance of a paper portfolio that we so often see in theoretical and empirical papers.

The remainder of this study is organized as follows. In Section I, we provide the background information about opportunity cost and discuss the potential variables that can affect order fill rates and the opportunity costs of unfilled orders. In Section II, we describe our data sources, research design, empirical methods, and related literature. Section III empirically documents the decision fill rate and its determinants. Section IV computes the opportunity cost resulting from the failure to fully execute an investment decision. Apart from the magnitude, we characterize the variance and persistence of opportunity costs. This section also discusses the determinants of the magnitude opportunity cost using the regression framework. Section V contains concluding remarks and potential directions for future research.

I. Opportunity Costs Background

Opportunity cost is a fundamental theoretical concept spanning many areas of financial decision making. In the field of portfolio management, Perold (1988) highlights the importance of opportunity costs in accurately computing the implementation shortfall, which is the difference between paper performance and actual performance of a portfolio manager or an investment strategy. Yet, the empirical estimation of opportunity costs has been a challenge due to data limitations. Even though the standard microstructure datasets such as TAQ provide detailed time-stamped ex-ante information about quotes and ex-post information about trades, they do not entirely reveal the intention of the traders in terms of their desired order size. Limit order book datasets such as NYSE OpenBook take us a step further by making the submitted orders transparent but do not completely resolve the situation. Institutions often use order splitting over time and across venues and brokers, thus fragmenting the information contained in the limit order book. Datasets containing decision information about original institutional intention to trade such as those by Elkins/McSherry, Plexus and Abel/Noser have been used sporadically by Perold and Sirri (1993) and Domowitz, Glen and Madhavan (2001) but these datasets are proprietary in nature. Limited access to such data have restricted the proliferation of empirical research leaving ample scope for further research to enhance our understanding about institutional trading costs.

Our paper contributes to the literature by presenting the first comprehensive analysis of an important component of the institutional trading cost – the opportunity costs of unexecuted trades. Opportunity cost of an order has two aspects. It is the product of proportion of the order size that is unfilled and the quantum of return in the stock that is sacrificed by not doing the trade. When an order is completely filled, the opportunity cost of non-execution is zero because the unfilled rate is zero. Similarly, an unfilled order also can also have zero opportunity cost if the stock return after trade execution is zero. Therefore, we simplify our research problem by looking at the fill ratesseparately before studying the interaction between the two items. The first term in the equation, the unfilled order rate, depends on the quality of microstructure and trading skills of trading desk manager. The second term in the equation, the return on stock, depends on quality of information and research skills of the equity analyst or portfolio manager.

We analyze order fill rates with two alternative measures. The first measure divides the sample into two categories based on whether a given order is completely filled or not. The focus is on the proportion of all orders that are not completely filled, which is obtained simply by dividing the unfilled orders by total number of orders submitted. The goal here is to identify any trading strategies or features that are associated with full versus partial execution. This method treats all partially filled orders as equivalent to each other whether the order is filled only 20% or 98% even though the latter is not much different from a completely filled order. We fine-tune the concept in the alternative measure, which is calculated by taking the average unfilled rate of partially filled orders. This measure can help us understand the strategies that help institutions increase the fill rate of the orders, conditional on the fact that they are using execution methods that do not result in complete fill.

The second component of opportunity costs is lost returns on unfilled orders. We compute this component with two alternative measures as well. The first measure computes the difference between the stock return from one day before the date of decision to ten days after the last trade implementing that institutional decision. This formula represents the transaction cost opportunity loss relative to ideal portfolio assuming that it could be created on the decision date itself. From a portfolio perspective, this measure fully captures the implementation shortfall by showing the difference between a paper portfolio and the actual portfolio. This method represents a useful measure of implementation costs, especially for academic studies that form portfolios based on firm characteristics or corporate events and then compute the returns generated by those portfolios. The second alternative measure is based on a similar formulae but it computes the return from the beginning of the last trading day in a decision package to ten days after that date. This alternative method offers a useful measure from a trading perspective. It separates the component of opportunity loss from price impact. In some sense this measure represents money left on the table after considering other major costs that institutions face. This measure assumes that institutions cannot improve their trading performance or lower the price impact that they faced in our sample. Since each method offers its own unique benefit, the combination of the two measures can serve as powerful tool for in-depth analysis of implementation shortfall.

The product of order unfilled rate and lost return represents the opportunity cost of not trading as decided. The proportion of unfilled orders or the unfilled rates is expected to be affected by a variety of microstructure and trading variables. Lost returns on unfilled orders are likely to be affected by quality of research and information environment. We also expect that both components of opportunity costs will be affected by institution-type, firm-specific and order-specific characteristics. We first present the results of our analysis of fill rate and then characterize the total opportunity cost which includes both components outlined above.

There are two types of institutions in our sample – mutual funds and pension funds. Trading aggressiveness as well as research capacity is likely to differ significantly between the two groups. Mutual funds may have a short term focus relative to pension funds. We expect that active mutual funds are likely to more aggressive traders and could have higher order cancellation and unfilled rates. We also expect that they spend more resources in researching the short term potential of stocks which indicates a lower lost returns component for mutual funds.

Order direction is the second important variable that may affect opportunity costs. In conjunction with market conditions, order direction can directly affect the fill rates if less aggressive strategies are used. Buys will have higher unfilled rates in bull markets whereas sells will be more difficult to fill in bear markets. The extant literature, especially Chan and Lakonishok (1993) and Keim and Madhavan (1996), also suggests that buys are more informed because institutions choose a few stocks buys out of thousands available after a lot of research. In contrast sell may be more mechanical based on existing portfolio return goals. Most institutions only sell what they have and do not exploit information by short selling stock that they do not possess. Thus, the lost returns are expected to be bigger for buys than for sells especially in up markets.

Our next variable of interest is firm size. Bigger firms have more trading activity than smaller firms. So, the problem of unfilled order is expected to be more acute for smaller firms due to lack of liquidity. Similarly, big firms are more heavily researched by the entire market leaving little room for information advantage for any particular institution. Smaller firms offer more research opportunities for finding bargains and therefore the lost returns would be a bigger concern particularly when trading smaller stocks.

Order complexity and liquidity issues also come to mind as variables that can influence opportunity costs. When an institution is trying to execute an order that is several times the size of average daily volume, filling it completely is naturally going to be difficult. Such voluminous trading activity is also likely reveal information more quickly to the market resulting in greater amount of lost returns compared to smaller orders that can be camouflaged more easily. We also categorize momentum orders as those demanding liquidity versus contrarian orders as those that are supplying liquidity. This approach follows Wagner and Edwards (1993) who argue that liquidity characteristics of the order is one of the most important factors affecting transaction cost of institutional order. Liquidity demanding orders pay a higher price and are indicative of institutions aggressiveness. Contrarian orders can get a better price and are also more likely to be filled in the institutional trading framework. When everyone is buying, it is much easier to sell resulting in 100% fill rate and vice versa. Since institutions are more likely demand liquidity and pay a higher price when they possess information, lost returns are likely to be higher for the unfilled portion of liquidity demanding orders. Liquidity supplying order indicates institutions patience which comes with a lack of any special information. Therefore, such order may be associated with only marginal lost returns, if any.

Stock volatility generates easy predictions. Higher volatility can put an order's limit price outside execution range leading to higher unfilled rate. Higher volatility can also mean higher amounts of lost returns.

The last three variables represent transaction execution methods and properties. Institutions can use floor brokers or market makers who can work the orders slowly to exploit the evolving liquidity conditions. Orders executed over multiple days or using multiple brokers are defined as worked orders. However, the use of more intermediaries also opens the possibility of front running and manipulations. The issue relates to order splitting over time versus across brokers. By continuing to work on decision for several days, the institutions can increase its fill rate while keeping the price impact minimal. But such a strategy can aggravate the lost returns component with the passage of more time. In contrast use of multiple brokers saves time and increases fill rate simultaneously. However, the disadvantage of this approach is that the probability of information leakage increases which can again aggravate the lost returns component.

II. Data Sources and Research Design

We obtain institutional trading data from the Abel Noser Corporation (hereafter, Abel Noser). The company offers institutional investors goal-oriented trading strategies and also helps them with trade cost measurement to help the institutions improve their investment performance. The dataset includes details about the investment decisions and related purchase and sale transactions by Abel Noser's institutional clients. Abel Noser provides consulting services to 776 domestic clients who collectively transact nearly $20 trillion over period of 1999-2005. Abel Noser data have been used in a handful of previous institutional trading studies, none of which focused explicitly on opportunity costs[2].

[2] For example, Chemmanur and Hu (2007) study IPO allocations and informativeness of institutional trading in IPO, Lipson and Puckett (2007) examine institutional trading during extreme market movements. Puckett and Yan (2008) analyze the impact of short-term institutional herding. Goldstein, Irvine, Kandel, and Weiner (2009) use it to study commissions, the first component within executed transaction costs.

The data provide comprehensive information on institutional trading decisions and actual transactions. The variables provided in the dataset include scrambled institutional client code, scrambled institutional manager or trader code, scrambled broker code, scrambled order identifier number, stock ticker symbol, order direction (buy or sell), quantity of shares desired, order placement date, transaction execution date, value-weighted average stock prices (VWAP) on decision entry date, VWAP on 1 day prior to decision entry date, price at the time of order release, number of shares in the released order, transaction execution price, quantity of shares traded, commissions charged, and type of institution (Mutual Fund or Pension Fund) executing orders. The data are provided to us by the Abel Noser after removal of the actual names of the managers involved to maintain client anonymity and privacy.

To ensure the integrity of the data and filter out possible errors, we eliminate observations with missing prices or order quantities. In addition, following the approach of Keim and Madhavan (1995, 1997), we exclude orders or transactions of less than 100 shares, orders for stocks trading under $1.00, and decisions that took longer than 21 calendar days to complete.

We merge institutional trading data with CRSP to obtain stock specific information and value-weighted market index. These indices help us to control for market-wide returns. For instance, if the market index rose significantly on a given day, then all purchases, whether institutional or retail, may have more positive price impact for purchases and perhaps negative price impact for sells. Therefore, we conduct the analysis of both the raw transaction costs and market-adjusted costs.

As shown in Table I, the database contains details about 23 million institutional decisions to trade 628 billion shares aggregating to 19.23 trillion dollars. Of these 21 million decisions are completely filled and face only the execution costs. However, the remaining 2 million orders, which is roughly 8.36% of all decisions, are partially filled. The unfilled decision volume of 209.90 billion shares represents 6.53 trillion dollars. The mean fill rate among the unfilled decisions (not shown in the table) is 51.64%.

[Insert Table I about here]

Figure 1 presents a histogram of unfilled decisions by fill rates categorized into ten deciles. This figure essentially shows the distribution of 2 million unfilled decisions. The y-axis shows unfilled decisions in each category as a percentage of total unfilled decisions. For example, 14% of the unfilled decisions have an extremely low fill rate of less than 10% whereas 16% of the unfilled decisions have an extremely high fill rate of over 90%. The remaining unfilled decisions are distributed in single digit percent shares across all other fill rate categories in a somewhat U-shaped pattern with the exception of 50-60% fill rate category that has 15% of the unfilled decisions.

[Insert Figure 1 about here]

III. Decision fill rate and its determinants

A. Decision fill-rate variations related to firm and order-specific characteristics

Now we set out to understand the distribution and determinants of decision fill rates. Apart from the overall sample details, Table I reports the proportion of unfilled decisions in various categories based on type of institution, firm-specific and order-specific characteristics. The first partition is based on type of institution. Mutual funds in our sample not only have a higher number of total decisions, and unfilled decisions relative to pension funds, but also a higher proportion of them both in terms of decisions shares and decision dollars. Only 5% of pension fund decisions are unfilled where as 11% of mutual fund decisions remain unfilled. The filled and unfilled decisions are fairly evenly distributed between buys (8.35% unfilled) and sells (9.01% unfilled) as shown in the order direction partition. Firm size partitions reveal that although the total number of decisions and number and volume of unfilled decisions are highest for large market capitalization stocks, the proportion of unfilled decisions between 8% and 9% are similar across large, medium, and small capitalization stocks.

Following Chiyachantana et al (2004) we compute the order complexity of decision, defined as number of shares in an institutional order divided by the average daily share volume over the previous 5 days obtained from CRSP. As expected, most easy decisions are filled and unfilled rate is only 4% in contrast to difficult decisions with an unfilled rate of nearly four times at 16%. The difference is even more dramatic when we look at decision shares or decision dollars, both of which make it clear that difficult decisions are the dominant source of unfilled volume.

Next we split the sample based on liquidity characteristics of the order. We define a decision to buy (sell) on the day when stock return is positive (negative) as a liquidity demanding order. Conversely, purchase (sell) orders submitted at a time when the prices are falling (rising) are defined as liquidity supplying orders. Our approach is similar to Wagner and Edwards (1993). In the unconditional partition, even though more decisions are characterized as liquidity demanding decisions, the unfilled rates are similar for liquidity demanding and liquidity supplying decisions again between 8% and 9%. Unfilled decisions share volume and dollar volume are higher for liquidity demanding decisions but liquidity supplying decisions are not trivial either. Stock volatility is another important firm characteristic that can affect fill rates. We measure volatility as percentage difference in highest and lowest trading price in the one month preceding the institutional trading decision. Both filled and unfilled decisions appear to be evenly distributed in the three categories of high, medium, and low stock volatility. The cut-off points were determined such that each category has equal number for stocks. Unfilled decision rate of 10% for high volatility stock is greater than the 7% for low volatility stocks. Thus, prices must be escaping the target transaction price range more quickly for high volatility stocks.

The last three variables represent transaction execution methods and properties. We divide the decisions into two groups based on whether or not the orders were worked over multiple days or using multiple brokers or both. Table I shows that a vast majority of orders do not need to be worked. However, there is evidence that many high volume and high value order are worked. As a result, a smaller number of worked orders command a bigger share of filled and unfilled decision volume and value. The proportion of decisions unfilled is 6% for non-worked orders and 15% for worked orders. Orders given to floor brokers to be worked upon have a larger median unfilled rate which could reflect either the more difficult nature of implementation of such orders or inefficiency introduced by use of intermediaries.

Finally, we distinguish between the two types of order splitting over time versus across brokers. For each variable we partition the sample based on whether the decision was executed in a consolidated fashion or split. Vast majority of decisions are fully implemented in a single trading day. Again, however, there is evidence that the implementation of many high volume and high value decisions is spread over multiple days. The proportion of decisions unfilled is 6% for single day executions and 15% for multi-day executions. Similarly, we split the sample between decisions using single versus multiple brokers. Vast majority of decisions are implemented using a single broker and such decisions dominate share volume and value as well, both for filled and unfilled decisions. Nevertheless, many big decisions are split across multiple brokers. Decision unfilled rates are very similar across decisions ranging between 8% and 9% irrespective of the number of brokers used.

B. Regression analysis of determinants of fill rates

In Table II, we capture the incremental effect of each firm-specific and order-specific characteristic on fill rates in a multivariate regression setting. Analysis is conducted at two levels -- all institutional decisions and partly filled decisions. For all decisions, again two types of regressions are estimated. A probit regression for the likelihood of a decision being filled is estimated where the dependent variable is equal to one for completely filled decision and zero for decisions that are not completely filled. This regression is based on 23 million observations and has a pseudo R-squared of 5.5%. In the second regression, the full sample of the same 23 million observations is used for the OLS variation in which the dependent variable is the actual fill rate for each decision. Fully filled decision have 100% fill rate. partly filled decision can have the fill rate from 0.01% to 99.99%, and decisions without any trading activity have 0% fill rate. R-squared for this regression is 4.19%. The third regression is based on 2 million partly filled decisions only; the dependent variable in this OLS regression is again the actual fill rate. R-squared is 7.54% in this regression. Large sample sizes lead to powerful statistical tests and highly significant coefficients.

The estimated coefficients from the first regression show that, after controlling for other factors, the probability that a decision will be implemented fully decreases with mutual fund origination, market capitalization, decision complexity, liquidity demanding trading strategy, and order duration. The probability of a complete fill increases with stock buy direction, higher stock volatility, usage of more brokers, positive market returns, and Nasdaq listing. The direction and significance of the coefficients in the fill rate OLS version in the second regression are identical to those in the probit regression.

Coefficients from the third regression indicate that, controlling for other factors, decision fill rate within the unfilled decisions decreases with mutual fund origination, buy direction, market capitalization, decision complexity, liquidity demanding trading strategy, and order duration. The fill rate increases with stock volatility, usage of more brokers, positive market returns, and Nasdaq listing. The direction of coefficients in three regression are same for all variables with the exception of buy direction indicator. All coefficients in all three regressions are statistically significant.

Of course the complete interpretation of these regression results in terms of effectiveness of institutional trading needs to await the opportunity cost analysis presented in the next section.

[Insert Table II about here]

IV. Opportunity cost of unfilled decisions and its determinants

A. Measures of transaction costs

As mentioned before, total execution costs for institutions comprise opportunity cost (OC), price impact cost (PI) and commission cost (Com) all of which are defined below. Opportunity cost can be calculated at various horizons. The formulae below and majority of the results presented in the paper are based on a 10 day horizon after the last transaction. Later in the paper, we show that cost computations are fairly persistent and robust across different measurement periods ranging from 1 to 20 days. The base formula for opportunity cost is:

$$OC = \left(\frac{P_{t+10}}{P_{d-1}} - 1 \right) * (1 - w_e) \text{ for buys and negative of this expression for sells,} \quad (1)$$

where P_{t+10} is the closing price 10 days after the last trade implementing an institutional decision and P_{d-1} is the closing price on the day before the decision. w_e is the proportion of decision shares that actually execute, (1- w_e) is the proportion of unfilled shares. This formula represents the transaction cost opportunity loss relative to ideal portfolio assuming that it could be created on the decision date itself. Most of the analysis presented in the tables is focused on this measure although our main conclusions remain largely unchanged in direction and significance if we use alternative measures discussed below.

We also present an alternative definition of opportunity cost relative to the last transaction price, OC_t , which is more representative of real world opportunity loss net of transaction costs:

$$OC_t = \left(\frac{P_{t+10}}{P_t} - 1 \right) * (1 - w_e)$$ for buys and negative of this expression for sells, (2)

where P_t is the last trade price in implementing an institutional decision.

This measure separates the component of opportunity loss from price impact but assumes that institutions cannot improving their trading performance or lower the price impact they faced. As mentioned before, the combination of the two measures OC_t and OC_t can serve as powerful tool for in-depth analysis of implementation shortfall.

The other explicit measures of filled decisions that would complete the picture are price impact (PI) and commissions (Com), both of which have been widely studied before. Below, we follow the definitions of these measures as used in prior literature.

$$PI_d = \left(\frac{WTP}{P_{d-1}} - 1 \right) * w_e$$ for buys and negative of this expression for sells, (3)

where WTP is the volume-weighted trade price of the component trades.

$$Com = \left(\frac{C_t}{P_{d-1}} - 1 \right) * w_e$$

where C_t is volume-weighted commissions per share for all decisions. (4)

An important consideration in transaction cost measurement is the timing of a trade in relation to market conditions. Chiyachantana, Jain, Jiang and Wood (2004) show that buy decisions have a bigger price impact in bull markets and sell decisions have a bigger price impact in bear market. Therefore, it seems natural to control for market conditions in transaction cost analysis. We do this in several ways by computation of market-adjusted trading costs and inclusion of market wide returns in regression analysis. Market-Adjusted trading costs are transaction costs after controlling for market wide return. For example, market adjusted opportunity cost, OC_m, is calculated as follows:

$$OC_m = \left(\frac{P_{t+10}}{P_{d-1}} - \frac{MI_{t+10}}{MI_{i,d-1}} \right) \text{-1} * (1 - w_e)$$

for buys and negative of this expression for sells (5)

where $MI_{i,d-1}$ is the level of that index on the day before the decision is made, and MI_{t+10} is the same index 10 days after the last trade of institutional order. This concept is applied analogously to price impact costs. The concept is not applicable to commissions. Dollar trading costs are obtained by multiplying each component of trading cost to the dollar value of the institutional order.

Table III provides the estimates for these measures for the overall sample. Opportunity cost from decision date averages 24 basis points, price impact is 12 basis points and commission is 7 basis points. Opportunity costs from last trade price are 10 basis points. All these are one way costs while buying or selling shares. Market-adjusted numbers are similar to the unadjusted numbers. Total transaction costs for portfolio decisions in our sample are $40.71 billion and opportunity costs account for $19.75 billion of that amount.

[Insert Table III about here]

Figure 2 shows that opportunity costs represent 56% of the total transaction costs and are twice in magnitude compared to the price impact and four times that of commissions.

[Insert Figure 2 about here]

B. Transaction cost variations related to firm and order-specific characteristics

In Table IV, we assess the magnitude of opportunity costs and total transaction costs in previously defined categories based on institution-type, firm-specific characteristics, and order-specific categories. Mutual funds have marginally higher opportunity costs at 24 basis points compared to 23 basis points cents for pension funds but a lot lower price impact cost of 10 basis points than the 21 basis points for pension funds. Recall from previous discussion that the proportion of unfilled mutual fund orders of 11% is more than twice the proportion of unfilled pension fund orders of 5%, yet the difference between opportunity cost is not significant. Thus mutual funds appear to be skillful in completing those decisions that have better return potential and may be ignoring to complete decisions that do not have high return potential any more. Moreover, pension fund strategy of filling their decisions at a higher rate seems to make sense because even with very high fill rates they seem to stack up significant opportunity costs. The aggregate dollar transaction costs for mutual funds are about 10 times that for pension funds because mutual funds decision volume is also approximately 8 times the pension fund decision volume.

Opportunity cost for purchase decisions is similar to that for sell decisions, close to the overall sample average of 23 basis points, in line with the similar proportion of unfilled decisions for purchases and sells. Dollar opportunity costs are also approximately equal at $10 billion each for purchases and sells. In our sample, price impact cost is higher for sells which could be a result of somewhat bearish market conditions. This difference in price impact makes the overall dollar costs appear higher for sells in our sample.

Figure 3 conditions the analysis by order direction and market condition. The subset of buy orders in bull market and sell orders in bear markets experience much more acute opportunity costs at 33 and 44 basis points, respectively. Opportunity costs represent a higher share of the overall implementation costs for these orders.

[Insert Figure 3 about here]

Going back to Table 4, our next partition is based on firm size. Even though proportion of unfilled orders was similar for large, medium, and small market capitalization firms, the opportunity cost of 39 basis points for small firms is much higher than 17 basis points for large firms. However, with a lion's shares of filled and unfilled decisions, large capitalization stocks account for the bulk of dollar opportunity costs and total transaction costs.

Complexity of decision continues to be a key driver of opportunity costs, price impact costs, commissions, and aggregate dollar transaction costs just like it was the major driver of decision fill rate. Percentage opportunity costs for difficult orders of 16 basis points are over three times that for easy orders. The difficult order have $19 billion in opportunity costs and $40 billion in total costs which account for 97% of the total opportunity costs and total transaction costs, respectively. In our next partition, liquidity demanding decisions emerge as a major source of opportunity costs even though the proportion of unfilled decision were fairly similar between liquidity demanding and liquidity supplying decisions. Of course, the definition of decision type for this partition can directly lead us to the observed result. Liquidity supplying decisions, in fact, have a negative opportunity cost. The reason is fairly obvious. Liquidity supplying decisions are defined as sell orders in up markets and buy orders in down markets. Is such orders are not executed and the market continues its move in the same direction then there is no opportunity loss because one would be able to sell higher or buy lower later on. However during market reversals, liquidity supplying decisions would have higher opportunity costs than liquidity demanding decisions. In the stock volatility partition, high volatility stocks, which were earlier shown to have higher unfilled rates, also turn out to have the substantially higher opportunity costs compared to low volatility stocks. However, in dollar terms, the costs are again comparable in the 3 sub-samples suggesting the presence of some large vale decision that may be facing very little opportunity costs.

Our last three partitions represent transaction execution methods and properties, as before. In line with their higher unfilled rates, opportunity costs and total transaction costs are both higher for decisions given to floor brokers to be worked upon, which again could reflect either the more difficult nature of implementation of such orders or inefficiency introduced by use of intermediaries. Worked orders opportunity costs are 3 times that of non-worked orders in percentage terms and 6 times in dollar terms. We noted earlier that decisions filled over multiple days have higher unfilled rates. Consistent with that finding, such decisions also have higher opportunity costs and total transaction costs. Multi day execution decisions costs are over 3 times single day decisions. Multi day decisions opportunity costs of $16.70 billion account for 80% of all opportunity costs. Of course, if institutions had tried to execute them on a single day, perhaps they could have faced astronomical costs. So the appropriate interpretation of our result is that order splitting may help reduce transaction costs but yet it may not be sufficient to make them comparable for low value consolidated orders and high value difficult orders. The use of multiple brokers in executing large institutional orders seem to help reduce opportunity cost. Nevertheless, total transaction costs are higher with multiple brokers compared to single brokers because multiple brokers are associated with much higher price impact. Despite the higher percentage total costs, multiple broker decisions account for only one third of the dollar transaction costs because vast majority of the decisions are completed using a single broker.

[Insert Table IV about here]

We further expand the analysis of worked orders by plotting the opportunity costs as well as other components of total transaction costs in Figure 4. Unlike the binomial single versus multiple categories for days and brokers used to execute order in the tables, this figure shows the breakdown of orders using one, two, three, four, five, and more than five days in Panel A and similar breakdown for brokers in Panel B. Opportunity costs and total transaction costs initially increase with the number of days taken to execute orders. Compared to orders executed within a day, we see a big spike in costs for orders executed over two days. Another such spike is seen when comparing orders executed over 5 days compared to 4 days. The costs seem to plateau for orders taking more than 5 days to execute. Hence, we have collapsed such orders in the figure.

The picture in Panel B is not as clear for number of brokers involved in a decision. Opportunity costs and price impact initially rise with use of multiple brokers but then begin to decline. Perhaps this reflects a trade-off between confidentiality of information and liquidity search. Confidentiality can be very high with a single broker and there can be a regime shift as soon as we move to multiple brokers. In contrast, improvements in liquidity search could be more linear.

[Insert Figure 4 about here]

C. Opportunity cost variations related to market conditions

Bullish or bearish market conditions have a potentially large role in determining the eventual opportunity cost of non execution. We divide our sample into up market and down market and repeat the opportunity cost analysis in Table V. Up (Down) market condition for a stock is defined as positive (negative) monthly stock returns in excess of CRSP value weighted index for that month. According to this definition, a given stock will maintain the same classification of up or down for each day in a given month even though its daily prices may fluctuate in either direction.

[Insert Table V about here]

As expected and seen before in figures, unfilled purchase decisions have higher opportunity costs of 33 basis points than 11 basis points for sells in bull (up) markets. The difference of 22 cents is statistically significant at 1% level. Unfilled sell decisions have higher opportunity costs of 44 basis points in bear (down) markets than 8 basis points for purchases. Again the difference of 36 basis points is statistically significant. Viewed differently, opportunity costs of purchases is 24 basis point higher in bull markets than in bear markets whereas opportunity costs of sells is 33 basis points lower in up markets than in down markets, with all differences being statistically significant.

The asymmetric pattern of opportunity costs in up and down markets described above is evident in both mutual fund and pension fund decisions. The phenomenon is especially acute for small stocks where opportunity cost rises dramatically. The pattern of asymmetry is also present in large stocks but the magnitude is much smaller.

Decision complexity plays out differently in bull and bear markets. As expected more complex purchase decisions face bigger opportunity costs in bull markets. However, the less complex order exhibits a surprisingly high asymmetry in bear markets. Of course, the opportunity costs of the difficult (more complex) decisions remain high in both bull and bear markets for both buys and sells. Liquidity supplying and liquidity demanding decisions are both generating largely similar asymmetry patterns as the overall sample. Results for stock volatility are consistent with our expectations that more volatile stocks display a greater asymmetry in the opposite directions for purchases and sells in bull and bear markets, respectively.

Worked decisions and decisions implemented over multiple days have a higher degree of asymmetry than non-worked and single day decisions, respectively, although the differences in each sub-sample are in the same direction as the overall sample. Number of brokers used does not appear to make a huge difference in terms of asymmetry relative to the overall average. Overall, in Table V, the sell decision column in bear markets contains the most severe opportunity costs.

D. Opportunity cost variations related to listing exchange

Given the uniqueness of trading systems on NYSE and Nasdaq and the differences in the nature of firms that list on each exchange, we also explore the differences in transaction costs between the two exchanges in Figure 5. Commissions, price impact, and opportunity costs are all lower on NYSE and higher on Nasdaq. Consistent with Chan and Lakonishok (1997) who did not examine opportunity costs but looked at other transaction costs, Nasdaq seems to be efficient in executing small stocks and the difference in execution costs between two exchanges is mainly driven by large stocks.

[Insert Figure 5 about here]

For a more detailed analysis of opportunity costs, we divide our sample into two groups based on their listing exchange in Table VI. The analysis of buys and sells throws some more light on the small stock issue. The opportunity cost for sells is consistently higher on Nasdaq. However, for small stock buys, the opportunity cost of non-execution are higher on NYSE than Nasdaq. This does not mean that one should not implement buy decisions in Nasdaq stocks. Note that opportunity cost of non execution is still high and positive for small Nasdaq stocks. It's just smaller than the opportunity costs for small NYSE stocks. One would still be better off completely executing the buy decisions in Nasdaq stocks instead of facing the opportunity costs. Irrespective of the decision complexity, large stocks have higher opportunity costs on Nasdaq. However, for medium and small stocks, only easy decisions have lower opportunity costs for NYSE. For difficult decisions, the difference between exchanges appears to be marginal or insignificant for medium and small stocks.

Liquidity suppliers have negative opportunity costs on both exchanges for large or small stocks whereas liquidity demanders face positive opportunity costs. This pattern is consistent with the notion that more informed parties demand liquidity to trade hurriedly before their information advantage disappears. Thus, their incomplete trades represent missed opportunities. In contrast liquidity suppliers may less informed and their business model may be based on earning transaction cost spreads instead of information exploitation. For example, Kyle (1985) model liquidity suppliers lose out to informed traders and earn from uninformed liquidity traders. An interesting point about this analysis is that differences in market structure of NYSE and

Nasdaq do not dramatically alter the opportunity cost dynamics related to liquidity provision. Both exchanges have the same asymmetry as the overall sample. However, in the next partition, the floor brokers and specialist features of NYSE do seem to matter for worked decisions and multi-day decision implementations both of which are consistently producing lower opportunity cost on NYSE than on Nasdaq. No such clear pattern emerges for non-worked orders or decisions completed on a single day. Similarly, number of brokers does not seem to matter much in terms of the differences between the two exchanges.

[Insert Table VI about here]

E. Opportunity cost variations related to type of institution and order complexity

The dataset provides information about the decision originator which can be either a mutual fund or a pension plan. The two types of institutions differ significantly in terms of their cash flow patterns, research activity, business model and fiduciary responsibilities. Those differences motivate us to analyze the transaction costs separately for mutual funds and pension funds in Figure 6. Commissions are comparable for both types of institutions. Difficult orders have higher commissions than easy ones. For the difficult decisions, pension funds face a higher price impact but a lower opportunity cost than mutual funds. For easy decisions, all components are higher for pension funds.

[Insert Figure 6 about here]

We also conduct a more detailed analysis of the opportunity costs separately by the type of institution and order complexity similar to the exchange partition table. The main results of that analysis are well captured in the Figure 6 and so we do not explicitly present a table for the sake of brevity, but will make it available upon request. Instead, we discuss the highlights of the analysis here in the text format. The analysis partitions the sample into easy, medium, and difficult orders. Then within each of the three partitions, mutual funds and pension funds are the two sub-partitions. The main result is that mutual fund opportunity costs are lower than pension fund opportunity costs for easy decisions but higher for more difficult decisions. One possible interpretation of this result juxtaposed on their fill rates is that pension funds are perhaps in a better position to communicate to market participants that their large difficult decisions are uninformed and liquidity driven and not guided by high level informed research. The difference between mutual funds and pension funds is more pronounced for mutual funds purchases although sells have the same pattern with a smaller magnitude. The increasing opportunity costs from easy to difficult order for mutual funds and the change in sign of the difference between mutual and pension funds are seen for all stock whether large, medium , or small capitalization.

Mutual funds and pension funds are similar in the sense that as we saw in other sub samples earlier both types of institutions have negative opportunity cost for liquidity supplier and positive for liquidity demander. However, within each category we also see that the difference between the two types of institution going from easy to difficult is also maintained in these sub-samples.

In terms of stock volatility, difficult decisions result in higher opportunity cost for mutual funds compared to pension funds for all stocks. However, lower opportunity cost for easy orders for mutual funds is mainly seen in high volatility stocks and not in low volatility stocks. Opportunity costs for worked decision, multi-day decision or multi-broker decision sub-samples are not statistically different for mutual and pension funds.

F. Persistence of opportunity costs

In this section we conduct a robustness test of opportunity cost results by altering the measurement period. In addition to the 10 day period used in equation (1), we now consider periods of 1 to 20 days after the completion of last transaction in a decision package. Figure 7 presents the cumulative opportunity costs beginning from the date of decision. The first plotted point cumulates the return from decision to last transaction. From the second point onwards, one day is added consecutively for the next 20 trading days. For brevity results are shown only for the sub-samples based on complexity but we discuss various other categories as well in the text below.

For the overall sample, opportunity costs begin with 20.6 basis points in the decision to transaction period. Thereafter, the trend is of monotonically increasing cumulative opportunity cost. At day 10, opportunity costs are 24 basis points as was shown previously in Table III. Our short-term analysis ends at 20 days when the opportunity costs are 27.2 basis points for the overall sample. Next, we divide the sample into various categories based on based on type of institution, firm-specific and order-specific characteristics to study the persistence of opportunity costs with each sub-sample.

The first split is based on type of institution. In the decision to transaction period, pension plans and mutual funds have almost similar opportunity costs of about 20 basis points. As we progress to the 20^{th} day, mutual fund opportunity costs (28 basis points) rise somewhat faster than the pension funds (23.3 basis points). Nevertheless, opportunity costs are persistent for both types of institutions.

Our second set of sub-samples is based on order direction. During our sample period, opportunity costs of purchases start low at 18 basis points but then increase dramatically to 51.9 basis points by day 20. In contrast opportunity costs of sells start high at 23 basis points and decline to almost zero by day 20. Sells represent the only sub-sample in the entire analysis that is not associated with an increase in opportunity costs with passage of time. This pattern highlights the potential importance of market conditions, especially when interacted with order direction.

Rest of the sub-samples have results similar to the first split. For example, in the size base categories, opportunity costs increase in the 20 days after the trade for all stocks whether they have small, medium, or large capitalization. The rise is slightly bigger for larger stocks but smallest stocks have the highest opportunity costs on any day in the cumulative analysis. Similarly, order-complexity based sub-samples experience increasing opportunity costs with the passage of time as shown in Figure 7. Moderate orders are associated with a bigger increase in opportunity costs relative to difficult or easy orders but the difficult orders consistently have the highest cumulative opportunity costs on each of the 20 days that we have analyzed. In the liquidity based sub-samples, liquidity suppliers have negative opportunity costs and liquidity demanders have positive opportunity costs cumulated for each of the 20 days. For stock volatility, once again cumulative opportunity costs rise for all sub-samples although high volatility stocks have the highest opportunity cost on each day. Likewise, single or multiple days or broker orders all experience an increasing level of opportunity costs but the differences among sub-samples on any of the 20 days are the same as those presented for 10 days in Table IV.

[Insert Figure 7 about here]

Overall the analysis demonstrates that opportunity costs are highly persistent across the board in various sub-samples.

G. Regression analysis

Several important factors have emerged in the discussion above as potential determinants of opportunity costs. In Table VII, we capture the incremental effect of each institution-type, firm-specific and order-specific characteristic on opportunity costs in a multivariate regression setting. As discussed earlier, the opportunity costs for purchase and sell decisions can be affected in opposite ways by various variables, especially market conditions. Therefore, a pooled regression can not only nullify important variables through averaging affects but also lead to model misspecification. To circumvent such problems, we separately estimate the regressions for up markets and down markets. Within each category we present purchase and sell decisions separately in addition to the pooled all decisions regressions. Opportunity cost is the dependent variable in all regressions. We expect incremental effects of each independent variable to be significant for buy (sell) orders in up (down) market conditions. Statistical significance of coefficients is indicated with asterisks.

Controlling for other variables, mutual funds face a higher opportunity costs in the pooled sample and in the purchases regression. However, mutual funds have lower opportunity costs than pension funds at the time of selling. Thus mutual funds seem to be slow in purchasing good stocks and acting more quickly in selling stocks with bad news.

In up market the coefficient for purchase decision indicator variable is positive and in down markets it is negative. Thus, market condition and trade direction jointly play an important role in determining the opportunity costs after controlling for a host of other variables. The negative coefficient on market capitalization implies that large stocks have lower opportunity costs. The coefficients for this variable are negative for all regressions except for sell orders in up market.

The coefficient on decision complexity is positive in most regressions, indicating that difficult decisions face higher opportunity costs especially for failed purchases. Liquidity demanding decisions are associated with higher opportunity costs as we have seen all along in various sub-samples.

Stock volatility variable has a positive coefficient in all decision regression in both up and down markets. However, a careful observation reveals that the volatility effect is again related to the interaction between market condition and trade direction. Institutions attempt to execute large buy (sell) orders in up (down) markets in volatile stock would incur higher opportunity cost as the probability to completely fill the orders is low and stock prices could move to undesirable range. As expected, higher volatility increases opportunity cost only for purchase decisions in up markets and sell decision in down markets.

Longer durations of decision implementation are associated with higher opportunity costs consistent with univariate results. Opportunity costs are amplified when trading in the same direction as the overall market. In contrast, the negative coefficient on number of brokers suggests that use of more brokers helps bring down the opportunity costs after we control for other differences in among decisions in the multivariate setting. The coefficients on these trading method and trade duration variables again is sensitive to trade direction and switches signs from buys to sells, which again justifies the specifications that examine purchases and sells separately. As expected, higher market returns increase opportunity costs of missed buys but lower the opportunity costs of missed sales. Even though the Nasdaq listing variable was shown to increase fill rates in the order completion regressions, it has a positive coefficient in most of the opportunity cost regressions. Thus, the adverse price movements must be really so severe for Nasdaq stocks that even smaller unfilled rates represent larger dollar losses.

[Insert Table VII about here]

The regression analysis helps us identify situations that can result in higher opportunity cost. However, the focus thus far has been on average opportunity costs. In the next section we present additional analysis focusing on opportunity cost variance to understand transaction cost risk.

G. Transaction cost risk

The average opportunity costs statistics provide very good benchmarks for overall institutional performance in a repeated trading setting. However, any single decision carries risk because its transaction cost can be very different from the average. For the overall sample, standard deviation is 4.57 basis points for opportunity costs and 5.41 basis points for total transaction costs. Standard deviation of total transaction costs for various sub-groups are presented in Table IV. Small stocks and high volatility stocks stand out as high transaction cost risk categories whereas decisions of lower complexity and lower volatility have low transaction cost risks. We provide additional insight into transaction cost risk issue in Figure 8. In each Panel, the x-axis captures the transaction cost variation by forming categories with one percent interval. We truncate the categories by clubbing the decisions that have less than -10% or more than 10% opportunity cost. The y-axis plots the proportion of all decisions that fall in any transaction cost category. For example, in Panel A which is based on firm size, 22% of all large stock decisions have opportunity costs ranging between 0% and 1%. In contrast, 18% of all small stock decisions have such low opportunity costs. Only 2% of large stock decisions have opportunity costs exceeding 10% whereas a staggering 5% of small stock decisions have those exorbitant costs. Thus, the narrower bell shaped curve for large stocks and a flatter curve for small stocks indicate that small stocks carry a more severe transaction cost risk.

In Panel B, we focus on variance in opportunity cost conditional on liquidity provision. Liquidity supplier and liquidity demander decisions have similar variance opportunity cost variance. However, we can see that the costs are asymmetric. Liquidity supplier curve tilts to the left demonstrating that a higher proportion of liquidity supplier orders realize negative opportunity costs. Finally, we analyze the implications of using multiple brokers in Panel C. Multiple brokers appear to sharply reduce the opportunity cost variance. Whereas 54% of multiple broker orders have low opportunity costs ranging between -1% and +1%, only 38% of single broker orders contain opportunity costs within that range.

V. Conclusions

Institutional money managers such as mutual funds and pension funds typically transact large volumes of shares to implement their portfolio investment strategies. The nature of their activity often results in large transaction costs that can undermine their performance by creating significant implementation shortfall. One of shortfall's component, the execution cost, is fairly well understood. It relates to the transactions you actually execute and arises from bid-ask spread, price impact, commission, and other transaction fees and taxes. The second component, the opportunity cost, relates to transactions that you fail to execute.

We present a comprehensive analysis of this often ignored component of implementation shortfall -- the opportunity cost of unexecuted institutional decisions. The proportion of total decisions partly or wholly unfilled is 8.36% and the mean unfilled rate within the unfilled decisions is 51.64%. When considering all 24 million decisions in the sample, the probability of executing or completely filling a trading decision decreases significantly with mutual fund instead of pension fund origination, higher market capitalization, higher decision complexity, liquidity demanding decisions and longer order duration. It is marginally higher for, multi-day executions, and buy decisions. The probability of executing a trading decision completely increases with stock volatility, usage of more brokers and Nasdaq listing.

Within the sub-sample of 2 million decisions that are not fully filled, we also examine the fill rate and find that it decreases significantly with higher market capitalization, adverse market movement, higher decision complexity, liquidity demanding decisions and longer order duration. The fill rate increases with mutual fund instead of pension fund origination, stock volatility, usage of more brokers and Nasdaq listing.

Opportunity costs of the failure to trade are 24 basis points or $20 billion in our sample period, almost twice in magnitude when compared to percentage price impact and also significantly more than dollar price impact. Opportunity costs are over three times that of percentage commissions dollar opportunity costs are over five times dollar commissions. Market condition and trade direction jointly play an important role in determining the opportunity costs. Unfilled purchase decisions have higher opportunity costs in bull markets and unfilled sell decisions have higher opportunity costs in bear markets. This phenomenon is especially acute for small stock where opportunity cost rises dramatically. The pattern of asymmetry is also present in large stocks but the magnitude is much smaller.

The opportunity costs of the difficult, more complex, decisions is higher than easy to implement decisions in both bull and bear markets for both buys and sells. Results for market volatility are consistent with our expectations that more volatile stocks display a greater asymmetry in the opposite directions for purchases and sells in bull and bear markets respectively.

Opportunity costs are higher on Nasdaq for large stocks. Surprisingly the difference between exchanges is insignificant for small stocks. The analysis of buys and sells throws some more light on this issue. The opportunity cost for sells is consistently higher on Nasdaq. However, for small stock buys, the opportunity cost of non-execution are higher on NYSE than Nasdaq. This does not mean that one should not implement buy decisions in Nasdaq stocks. Note that opportunity cost of non execution is still high and positive for small Nasdaq stocks. It's just smaller than small NYSE stocks. One would still be better of completely executing the buy decisions in Nasdaq stocks instead of facing the opportunity costs.

Liquidity suppliers have negative opportunity costs on both exchanges for large or small stocks whereas liquidity demanders face positive opportunity costs. This pattern is consistent with the notion that more informed parties demand liquidity to trade hurriedly before their information advantage disappears. Thus, their incomplete trades represent missed opportunities. In contrast liquidity suppliers may less informed and their business model may be based on earning transaction cost spreads instead of information exploitation. Decision unfilled rates, opportunity costs, and total costs are all higher for decisions given to floor brokers to be worked upon, which again could reflect either the more difficult nature of implementation of such orders or inefficiency introduced by use of intermediaries.

Mutual fund opportunity costs are lower than pension fund costs for easy decisions but higher for more difficult decisions. One possible interpretation of this result juxtaposed on their fill rates is that pension funds are perhaps in a better position to communicate to market participants that their large difficult decisions are uninformed and liquidity driven and not guided by high level informed research.

We demonstrate that opportunity costs are persistent by analyzing the benchmark periods ranging from one day after the unexecuted order to 20 days after the order. We also assess the transaction cost risks by computing standard deviation of 4.57 basis points for opportunity costs and 5.41 basis points for total transaction costs. Small stocks and high volatility stocks stand out as high transaction cost risk categories whereas decisions of lower complexity, lower volatility, or multiple brokers have low transaction cost risks.

The results have several practical and academic implications. Institutional investors can use them as benchmarks to analyze their own implementation shortfall. The numbers can also provide guidance of whether or not it pays to be aggressive in completing the investment decisions. More importantly, the implementation policy can be customized to address the affect of market conditions, firm-specific characteristics, order-dynamics, and type of institutions. From the academic perspective, these measures of transaction costs provide the limits to arbitrage and also implore models to include the transaction costs because they can lead to significant deviations from the ideal performance of a paper portfolio that we so often see in theoretical and empirical papers.

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Table I
Magnitude of Filled and Unfilled Institutional Trading Decisions

Data are from Abel Noser and represent 776 institutional clients who collectively transact nearly $20 trillion over period of 1999-2005. After presenting the overall statistics, we partition the sample several times based on key determinants of institutional trading costs. Partitioning factors include type of institutions, order direction (purchase versus sell), firm size, complexity of decision, liquidity, stock volatility, work versus non work orders, trade duration (single versus multiple days) and order splitting (single versus multiple broker).

		Type of Institutions		Order Direction	
Institutional Orders	**All Decisions**	**Pension Fund**	**Mutual Fund**	**Purchase**	**Sell**
All Institutional Orders:					
Number of Decisions	23,194,214	7,899,305	15,294,909	12,484,109	10,710,105
Decision Shares (Billion)	627.96	120.41	507.55	311.79	316.17
Decision $ (Trillion $)	19.23	3.58	15.65	9.49	9.73
Incomplete Orders:					
Number of Decisions partly unfilled	2,008,007	363,320	1,644,687	1,042,657	965,350
Decision Shares (Billion)	209.90	24.97	184.93	102.63	107.27
Decision $ (Trillion $)	6.53	0.72	5.81	3.17	3.36

		Firm Size			Complexity of Decision	
Institutional Orders	**Small**	**Medium**	**Large**	**Easy**	**Moderate**	**Difficult**
All Institutional Orders:						
Number of Decisions	2,943,231	6,839,509	13,411,474	8,074,581	7,672,451	7,447,182
Decision Shares (Billion)	53.71	147.88	426.37	28.51	63.64	535.81
Decision $ (Trillion $)	0.68	3.22	15.33	0.86	2.25	16.11
Incomplete Orders:						
Number of Decisions partly unfilled	268,891	567,061	1,172,055	307,062	525,211	1,175,734
Decision Shares (Billion)	15.42	46.41	148.06	1.04	9.69	199.18
Decision $ (Trillion $)	0.22	1.06	5.26	0.04	0.34	6.15

Table I (Cont.)
Magnitude of Filled and Unfilled Institutional Trading Decisions

	Liquidity		Stock Volatility		
Institutional Orders	**Demander**	**Supplier**	**High**	**Medium**	**Low**
All Institutional Orders:					
Number of Decisions	12,099,367	10,705,196	7,439,142	7,674,941	8,080,131
Decision Shares (Billion)	363.01	255.36	245.09	201.09	181.77
Decision $ (Trillion $)	11.11	7.90	6.22	6.43	6.57
Incomplete Orders:					
Number of Decisions partly unfilled	1,083,688	895,363	556,147	684,353	767,507
Decision Shares (Billion)	121.88	85.29	75.33	69.87	64.70
Decision $ (Trillion $)	3.78	2.69	1.90	2.21	2.42

	Work Versus Nonwork		Single versus Multiple Days		Single versus Multiple Brokers	
Institutional Orders	**Nonwork**	**Work**	**Single**	**Multiple**	**Single**	**Multiple**
All Institutional Orders:						
Number of Decisions	16,561,145	6,633,069	17,276,563	5,917,651	19,706,030	3,488,184
Decision Shares (Billion)	238.34	389.62	276.72	351.24	401.60	226.36
Decision $ (Trillion $)	7.55	11.68	8.74	10.49	12.29	6.94
Incomplete Orders:						
Number of Decisions partly unfilled	1,044,059	963,948	1,108,914	899,093	1,715,771	292,236
Decision Shares (Billion)	63.38	146.52	71.80	138.10	149.72	60.18
Decision $ (Trillion $)	2.09	4.45	2.36	4.18	4.65	1.89

Table II
Probit and OLS Regressions: Determinants of Order Completion

This table presents the estimates of Probit for the likelihood of a decision being filled and OLS estimates of all decision and partly filled decision. For Probit regression, the dependent variable is equal to one for completely filled order and zero for incomplete order. For OLS, the dependent variable is filled rate. Mutual Fund Indicator takes a value of 1 if trading decision comes from Mutual Fund and 0 if it comes from a pension fund; Market Capitalization refers to the natural logarithm of market capitalization of the firm in dollars; Indicator for a Buy Order is dummy variable for purchase decisions; Complexity of Decision is calculated as the ratio of decision shares relative to average daily trading volume over the prior five trading days; Liquidity Demander takes a value of 1 if decision to buy (sell) is made when stock return on decision date is positive (negative); Stock Volatility is calculated as percentage difference in highest and lowest trading price in the past 30 calendar days prior to institutional trading decision. Duration is the numbers of days elapsed from the date of decision to the date of final trade for that decision package; Number of Broker is the number of brokers involved in the trades pertaining to the particular decision; Adverse Market Movement is the return on the CRSP value weighted index from the day of institutional trading decision to the last trading day, multiplied by 1 for buys and -1 for sells; Nasdaq Listing takes value of 1 if stock is listed on Nasdaq and 0 if it is on the NYSE. Statistical significance is indicated by ** for one percent level and * for five percent level.

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	Probit Regression	*OLS Regression*	
Order Characteristics	**Probability of Fully Filling a Decision**	**All Decisions**	**Partly Filled Decisions**
Intercept	1.635 **	0.949 **	0.439 **
Mutual Fund Indicator	-0.487 **	-0.038 **	-0.069 **
Indicator for a Buy Order	0.059 **	0.005 **	-0.002 **
Market Capitalization	-0.326 **	-0.046 **	-0.119 **
Complexity of Decision	-0.038 **	-0.080 **	-0.028 **
Liquidity Demander	-0.027 **	-0.003 **	-0.007 **
Stock Volatility	0.262 **	0.023 **	0.098 **
Duration	-0.176 **	-0.025 **	-0.020 **
Number of Broker	0.122 **	0.034 **	0.088 **
Market Returns	0.233 **	0.027 **	0.090 **
Nasdaq Listing	0.006 **	0.003 **	0.023 **
Number of Observations	23,194,214	23,194,214	2,008,007
Pseudo R-square	0.0550		
Adjusted R-square		0.0419	0.0754

Table III
Institutional Transaction Cost and Its Components

Total transaction costs of implementing institutional portfolio decisions comprise of opportunity cost, price impact cost, and commission cost, each of which is defined below.

Opportunity Cost: $OC = \left(\frac{P_{t+10}}{P_{d-1}} - 1 \right) * (1 - w_e)$ for buys and negative of this expression for sells,

where P_{t+10} is the closing price 10 days after the last trade implementing an institutional decision and P_{d-1} is the closing price on the day before the decision. w_e is the proportion of decision shares that actually execute, (1- w_e) is the proportion of unfilled shares. This formula represents the transaction cost opportunity loss relative to ideal portfolio assuming that it could be created on the decision date itself. We also present an alternative definition of opportunity cost relative to the last transaction price, OC_t , which is more representative of real world opportunity loss net of transaction costs:

$OC_t = \left(\frac{P_{t+10}}{P_t} - 1 \right) * (1 - w_e)$ for buys and negative of this expression for sells.

Price Impact Cost: $PI_d = \left(\frac{WTP}{P_{d-1}} - 1 \right) * w_e$ for buys and negative of this expression for sells,

where WTP is the volume-weighted trade price of the component trades.

Commission Cost, $Com = \left(\frac{C_t}{P_{d-1}} - 1 \right) * w_e$

where C_t is volume-weighted commissions per share.

Market-Adjusted trading costs are transaction costs after controlling for market wide return. For example, market adjusted opportunity cost, OC_m, is calculated as follow.

$OC_m = \left(\frac{P_{t+10}}{P_{d-1}} - \frac{MI_{t+10}}{MI_{i,d-1}} \right) \text{-} 1 * (1 - w_e)$ for buys and negative of this expression for sells

Where $MI_{i,d-1}$ is the level of that index on the day before the decision is made, and MI_{t+10} is the same index 10 days after the last trade of institutional order. This concept is applied analogously to price impact costs. The concept is not applicable to commissions.

Dollar trading costs are obtained by multiplying each component of trading cost to the dollar value of institutional order.

Trading Cost Components	**One-Way Institutional Trading Cost**		
	Raw	**Market-Wide Adjusted**	**Institutional Trading Cost (Billion $)**
Opportunity Cost from Decision Date	0.24	0.23	19.75
Price Impact Cost	0.12	0.12	17.44
Commission Cost	0.07	0.07	3.52
Total Execution Cost	0.42	0.42	40.71
Opportunity Cost from last trade price	0.10	0.10	2.01

Table IV
Variations in Transaction Costs based on Decision Characteristics and Implementation

Market-adjusted institutional transaction costs are presented in percent and dollar formats. Total execution costs comprise of opportunity cost, price impact cost and commission cost. We partition the sample several times based on key determinants of institutional trading costs. Partitioning factors include type of institution, order direction (purchase versus sell), firm size, complexity of decision, liquidity, stock volatility, work versus non work orders, trade duration (single versus multiple days) and order splitting (single versus multiple broker).

Order Characteristics		**Opportunity Cost**	**Price Impact Cost**	**Commission Cost**	**Total Execution Cost**	**Standard Deviation of Total Execution Costs**	**Total Opportunity Cost (Billion $)**	**Total Execution Cost (Billion $)**
Fund Type	*Pension Fund*	0.23	0.21	0.07	0.50	0.06	2.07	3.79
	Mutual Fund	0.24	0.10	0.06	0.40	0.05	17.67	36.93
Purchase Versus Sell	*Purchase*	0.23	0.07	0.06	0.37	0.05	9.82	17.28
	Sell	0.23	0.17	0.07	0.47	0.05	9.93	23.43
Market Capitalization	*Small*	0.39	0.18	0.12	0.70	0.07	0.79	1.65
	Medium	0.30	0.14	0.07	0.52	0.06	2.59	6.34
	Large	0.17	0.09	0.05	0.30	0.05	16.36	32.72
Complexity of Decision	*Easy*	0.08	0.05	0.05	0.18	0.04	0.04	0.08
	Moderate	0.17	0.07	0.05	0.29	0.05	0.64	1.00
	Difficult	0.30	0.16	0.08	0.54	0.06	19.07	39.63
Liquidity	*Supplier*	-0.63	-0.67	0.06	-1.24	0.05	-20.09	-39.58
	Demander	0.95	0.77	0.07	1.79	0.05	39.70	79.99
Stock Volatility	*High*	0.35	0.22	0.10	0.66	0.07	6.54	14.49
	Medium	0.23	0.11	0.06	0.40	0.05	7.57	14.75
	Low	0.16	0.05	0.04	0.26	0.04	5.64	11.47
Work versus NonWork	*NonWork*	0.11	0.02	0.06	0.19	0.05	2.79	5.51
	Work	0.36	0.22	0.07	0.66	0.06	16.95	35.20
Single versus Multiple Days	*Single Day*	0.11	0.03	0.06	0.20	0.05	3.04	6.76
	Multiple Days	0.38	0.23	0.07	0.69	0.06	16.70	33.95
Single versus Multiple Brokers	*Single Broker*	0.23	0.09	0.06	0.38	0.05	14.58	27.08
	Multiple Brokers	0.23	0.30	0.10	0.62	0.06	5.17	13.64

Table V
Market Conditions and Opportunity Cost of Institutional Trading

This table presents estimates of market-adjusted opportunity cost of institutional decisions. Opportunity costs are reported separately for purchase and sell decision in Up and Down market conditions. Up (Down) market classification is based on positive (negative) CRSP value weighted return for the month in which institutional portfolio decision is made. In addition, the sample is partitioned based on factors considered important determinants of institutional trading costs. The difference numbers in the *Diff* column are in bold if they are statistically significant at one percent level.

Order Characteristics		**Up Market**			**Down Market**			**Diff (Up - Down)**	
		Purchase	**Sell**	***Diff***	**Purchase**	**Sell**	***Diff***	**Purchase**	**Sell**
All Orders		0.327	0.105	**0.222**	0.080	0.444	**-0.364**	**0.246**	**-0.339**
Fund Type	*Pension Fund*	0.212	0.195	**0.018**	0.057	0.471	**-0.414**	**0.155**	**-0.277**
	Mutual Fund	0.355	0.082	**0.273**	0.084	0.439	**-0.355**	**0.271**	**-0.357**
Market Capitalization	*Small*	0.630	0.034	**0.595**	0.043	0.885	**-0.843**	**0.587**	**-0.851**
	Medium	0.461	0.113	**0.348**	0.123	0.504	**-0.382**	**0.338**	**-0.391**
	Large	0.177	0.116	**0.061**	0.067	0.327	**-0.260**	**0.110**	**-0.211**
Complexity of Decision	*Easy*	0.020	0.127	**-0.107**	-0.164	0.380	**-0.543**	**0.184**	**-0.252**
	Moderate	0.196	0.121	**0.075**	-0.020	0.399	**-0.419**	**0.216**	**-0.279**
	Difficult	0.464	0.092	**0.373**	0.190	0.481	**-0.292**	**0.275**	**-0.390**
Liquidity	*Liquidity Supplier*	-0.532	-0.633	**0.101**	-0.834	-0.559	**-0.275**	**0.303**	**-0.073**
	Liquidity Demander	0.949	0.798	**0.151**	0.974	1.153	**-0.180**	**-0.024**	**-0.355**
Stock Volatility	*High*	0.699	-0.087	**0.786**	-0.162	0.968	**-1.130**	**0.862**	**-1.055**
	Medium	0.302	0.094	**0.208**	0.224	0.314	**-0.090**	**0.077**	**-0.220**
	Low	0.094	0.236	**-0.142**	0.152	0.144	**0.008**	**-0.057**	**0.093**
Work versus NonWork	*NonWork*	0.154	0.092	**0.061**	-0.060	0.253	**-0.313**	**0.214**	**-0.161**
	Work	0.524	0.120	**0.403**	0.211	0.630	**-0.419**	**0.313**	**-0.510**
Single versus Multiple Days	*Single Day*	0.154	0.093	**0.061**	-0.065	0.252	**-0.317**	**0.220**	**-0.159**
	Multiple Days	0.547	0.121	**0.426**	0.237	0.660	**-0.423**	**0.310**	**-0.539**
Single versus Multiple Brokers	*Single Broker*	0.329	0.099	**0.230**	0.091	0.447	**-0.356**	**0.238**	**-0.349**
	Multiple Brokers	0.315	0.144	**0.170**	0.027	0.428	**-0.402**	**0.288**	**-0.284**

Table VI
Opportunity Cost of Institutional Trading by Exchange Listing and Firm Size

Market-adjusted opportunity costs are reported separately for exchange listings (NYSE and Nasdaq) and firm sizes. There are three firm size classifications by market capitalization, corresponding to the terciles of the distribution of the value of outstanding equity at the end of the prior quarter for all NYSE stocks. For Nasdaq stocks, we use the same cut-off points to create matched sub-samples, and thus make meaningful comparisons between exchanges. In addition, the sample is partitioned based on factors considered important determinants of institutional trading costs. The difference numbers in the *Diff* column are in bold if they are statistically significant at one percent level.

Order Characteristics		Small			Medium			Large			Diff (S-L)	
		NYSE	NASD	*Diff*	NYSE	NASD	*Diff*	NYSE	NASD	*Diff*	NYSE	NASD
All Orders		0.388	0.397	-0.009	0.266	0.354	**-0.088**	0.143	0.263	**-0.120**	**0.245**	**0.134**
Fund Type	*Pension Fund*	0.241	0.323	**-0.082**	0.244	0.329	**-0.085**	0.147	0.267	**-0.120**	**0.094**	**0.057**
	Mutual Fund	0.435	0.421	0.015	0.272	0.360	**-0.088**	0.142	0.262	**-0.120**	**0.293**	**0.158**
Purchase Versus Sell	*Purchase*	0.531	0.391	**0.140**	0.368	0.270	**0.098**	0.131	0.152	-0.021	**0.400**	**0.239**
	Sell	0.232	0.405	**-0.173**	0.151	0.451	**-0.300**	0.156	0.382	**-0.226**	**0.076**	0.023
Complexity of Decision	*Easy*	-0.268	0.556	**-0.824**	0.104	0.225	-0.121	0.059	0.116	**-0.057**	**-0.327**	**0.439**
	Moderate	0.309	0.341	-0.031	0.205	0.224	-0.019	0.105	0.287	**-0.182**	**0.204**	0.054
	Difficult	0.404	0.403	0.001	0.291	0.403	**-0.112**	0.209	0.373	**-0.163**	0.195	0.031
Liquidity	*Liquidity Supplier*	-0.672	-0.857	**0.185**	-0.656	-0.792	**0.136**	-0.547	-0.640	**0.093**	**-0.125**	**-0.217**
	Liquidity Demander	1.262	1.418	**-0.156**	1.010	1.260	**-0.250**	0.725	1.024	**-0.299**	**0.538**	**0.394**
Stock Volatility	*High*	0.370	0.455	-0.084	0.447	0.412	0.035	0.252	0.240	0.012	**0.118**	**0.215**
	Medium	0.357	0.370	**-0.014**	0.252	0.325	**-0.073**	0.130	0.311	**-0.182**	**0.227**	0.059
	Low	0.441	0.305	**0.136**	0.162	0.261	**-0.099**	0.112	0.238	**-0.126**	**0.329**	0.067
Work versus NonWork	*NonWork*	0.240	0.215	0.025	0.096	0.044	**0.053**	0.077	0.230	**-0.154**	**0.163**	-0.015
	Work	0.510	0.563	**-0.053**	0.402	0.578	**-0.176**	0.233	0.304	**-0.071**	**0.277**	**0.259**
Single versus Multiple Days	*Single Day*	0.244	0.214	0.030	0.093	0.042	**0.051**	0.077	0.225	**-0.148**	**0.167**	-0.011
	Multiple Days	0.520	0.591	**-0.070**	0.422	0.614	**-0.192**	0.245	0.318	**-0.073**	**0.275**	**0.273**
Single versus Multiple Brokers	*Single Broker*	0.401	0.407	-0.006	0.269	0.364	**-0.095**	0.138	0.271	**-0.134**	**0.264**	**0.136**
	Multiple Brokers	0.294	0.338	-0.044	0.249	0.300	-0.051	0.176	0.218	-0.042	**0.118**	**0.120**

Table VII
Regression Analysis: Determinants of Opportunity Cost

This table presents the estimates for the following regression model with opportunity cost, *OC*, as the dependant variable in each specification:

$$OC = \alpha + \beta_1 Buy + \beta_2 Cap + \beta_3 Complex + \beta_4 Volatility + \beta_5 Duration + \beta_6 Bro\ker s + \beta_7 Liquidity + + \beta_8 Nasdaq + \beta_9 MutualFund + \varepsilon$$

where *OC* is measured in percentage. The model is estimated separately for up and down markets, respectively. Within each market condition we estimate the coefficients for all decisions pooled together and also separately for buys and sells. Mutual Fund Indicator takes a value of 1 if trading decision comes from Mutual Fund and 0 if it comes from a pension fund; Market Capitalization refers to the natural logarithm of market capitalization of the firm in dollars; Complexity of Decision is calculated as the ratio of decision shares relative to average daily trading volume over the prior five trading days; Liquidity Demander takes a value of 1 if decision to buy (sell) is made when stock return on decision date is positive (negative); Stock Volatility is calculated as percentage difference in highest and lowest trading price in the past 30 calendar days prior to institutional trading decision. Duration is the numbers of days elapsed from the date of decision to the date of final trade for that decision package; Number of Broker is the number of brokers involved in the trades pertaining to the particular decision; Adverse Market Movement is the return on the CRSP value weighted index from the day of institutional trading decision to the last trading day, multiplied by 1 for buys and -1 for sells; Nasdaq Listing takes value of 1 if stock is listed on Nasdaq and 0 if it is on the NYSE. Buy and sell columns represent separate regressions for each order type during the two periods. These regressions do not have the indicator for order direction but include the Market Return as an additional variable, which is the return on is the return on CRSP value weighted index during institutional trading decision. Statistical significance is indicated by ** for one percent level and * for five percent level.

Regression Variables	**Up Market**						**Down Market**					
	All Decisions		**Buy**		**Sell**		**All Decisions**		**Buy**		**Sell**	
Intercept	-1.447	**	-0.192	**	-1.129	**	-0.352	**	-1.518	**	-0.136	**
Mutual Fund Indicator	0.077	**	0.303	**	-0.186	**	0.004	*	0.539	**	-0.507	**
Indicator for a Buy Order	1.422	**					-1.139	**				
Market Capitalization	-0.297	**	-2.737	**	1.884	**	-0.937	**	-1.280	**	-0.531	**
Complexity of Decision	0.068	**	0.139	**	-0.001		0.039		0.424	*	0.006	
Liquidity Demander	0.157	**	0.146	**	0.146	**	0.211	**	0.193	**	0.182	**
Stock Volatility	0.309	**	1.247	**	-0.739	**	0.082	**	-0.926	**	1.089	**
Duration	0.065	**	0.153	**	-0.048	**	0.023	**	-0.039	**	0.128	**
Number of Broker	-0.059	**	-0.220	**	0.116	**	-0.036	**	0.060	**	-0.146	**
Market Returns			0.211	**	-0.173	**			0.277	**	-0.261	**
Nasdaq Listing	0.062	**	0.028	*	0.104	**	0.105	**	-0.201	**	0.497	**
Adjusted R-square	0.056		0.042		0.034		0.055		0.053		0.059	

Figure 1. Histogram of Unfilled Decisions By Fill Rates

This figure shows the distribution of 2 million unfilled decisions. Ten categories of fill rates are shown on x-axis. Y-axis shows unfilled decisions in each category as a percentage of total unfilled decisions.

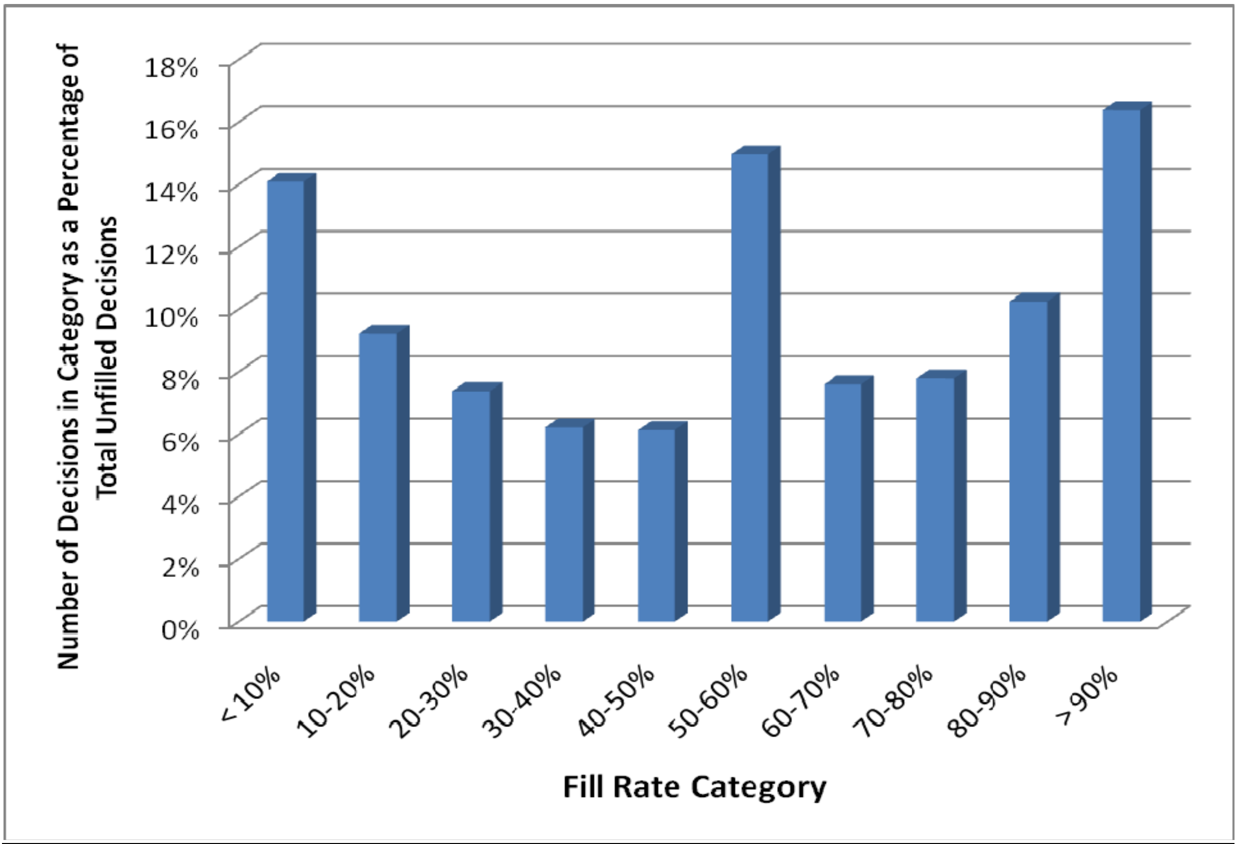

Figure 2. Components of Institutional Trading Costs

All Decisions for the Entire Sample Period

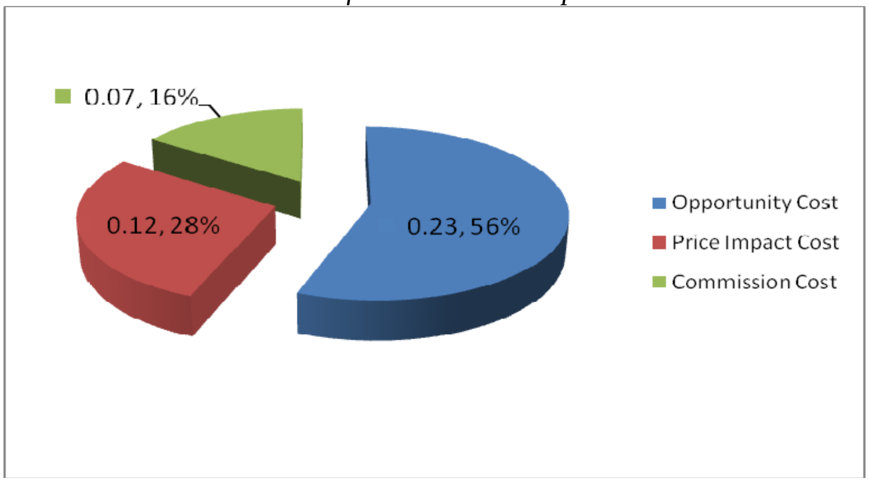

Figure 3 A. Institutional Trading Costs: Bull versus Bear markets

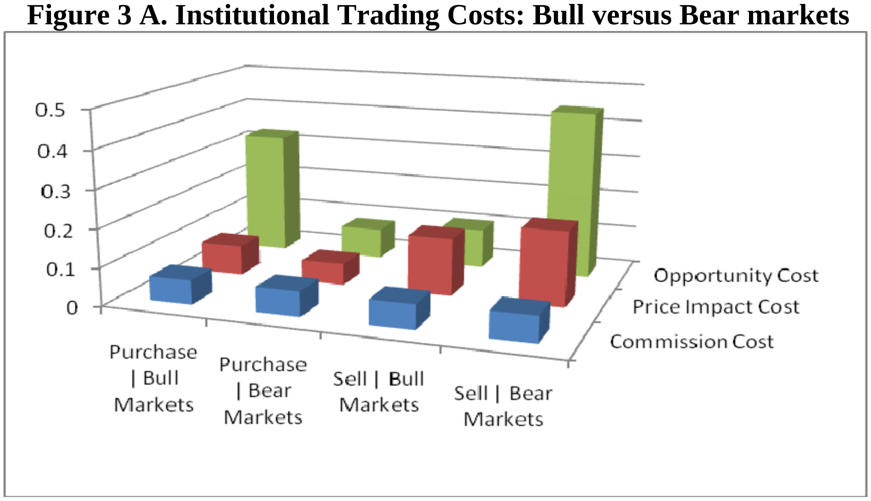

Figure 4 A. Institutional Trading Costs and Number of Days Taken to Execute Orders

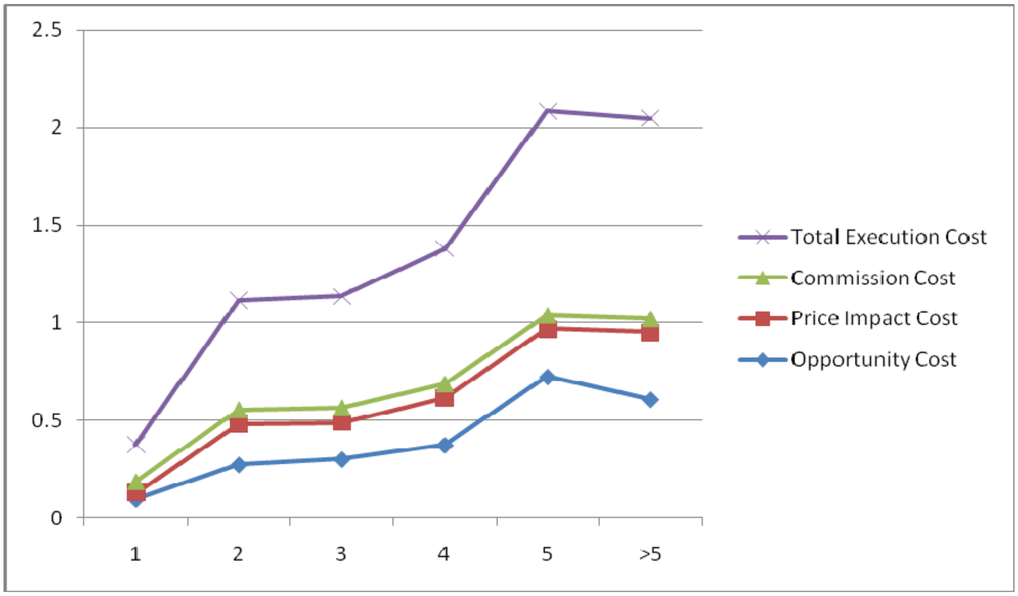

Figure 4 B. Institutional Trading Costs and Number of Brokers Used to Execute Orders

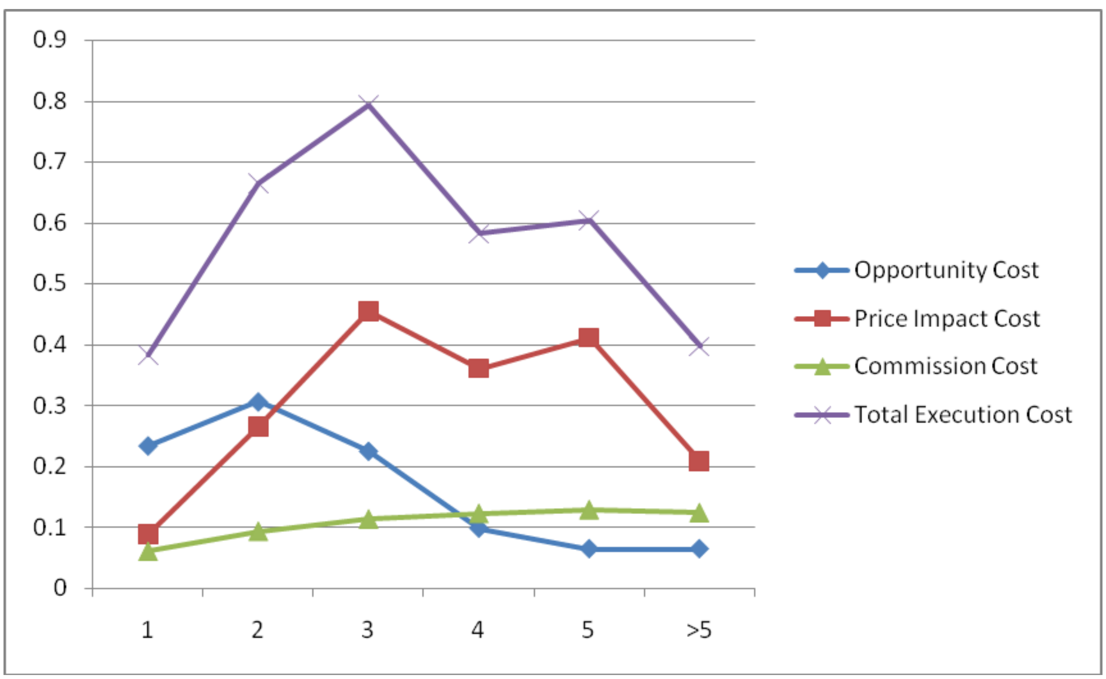

Figure 5 Institutional Trading Costs: NYSE versus NASDAQ listed stocks

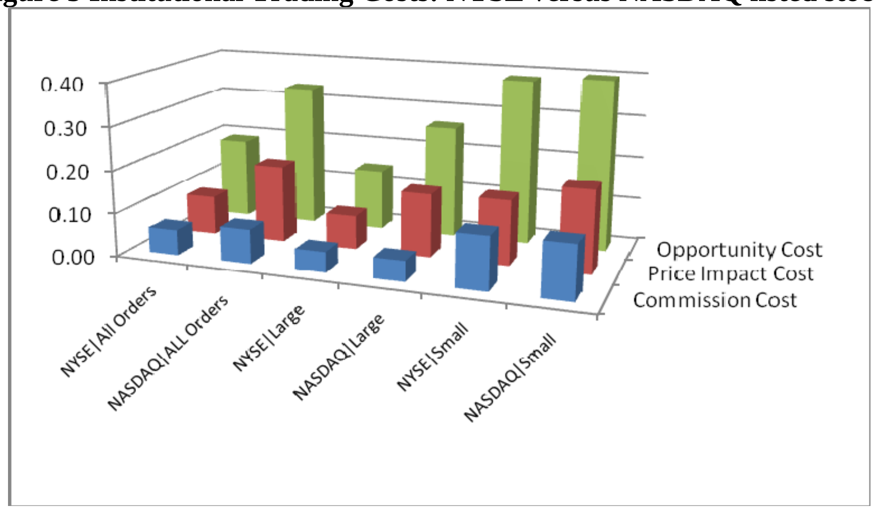

Figure 6 Institutional Trading Costs: Pension Fund versus Mutual Fund and Order Complexity

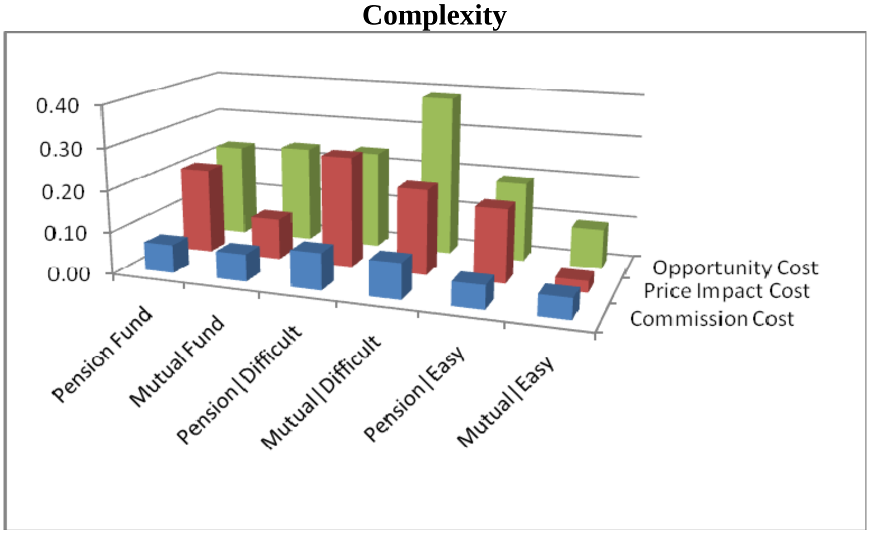

Figure 7. Persistence of opportunity costs. Opportunity costs are measured from decision date to last transaction date, and then cumulated by consecutively adding a day at a time for each of 20 trading days following the last trade.

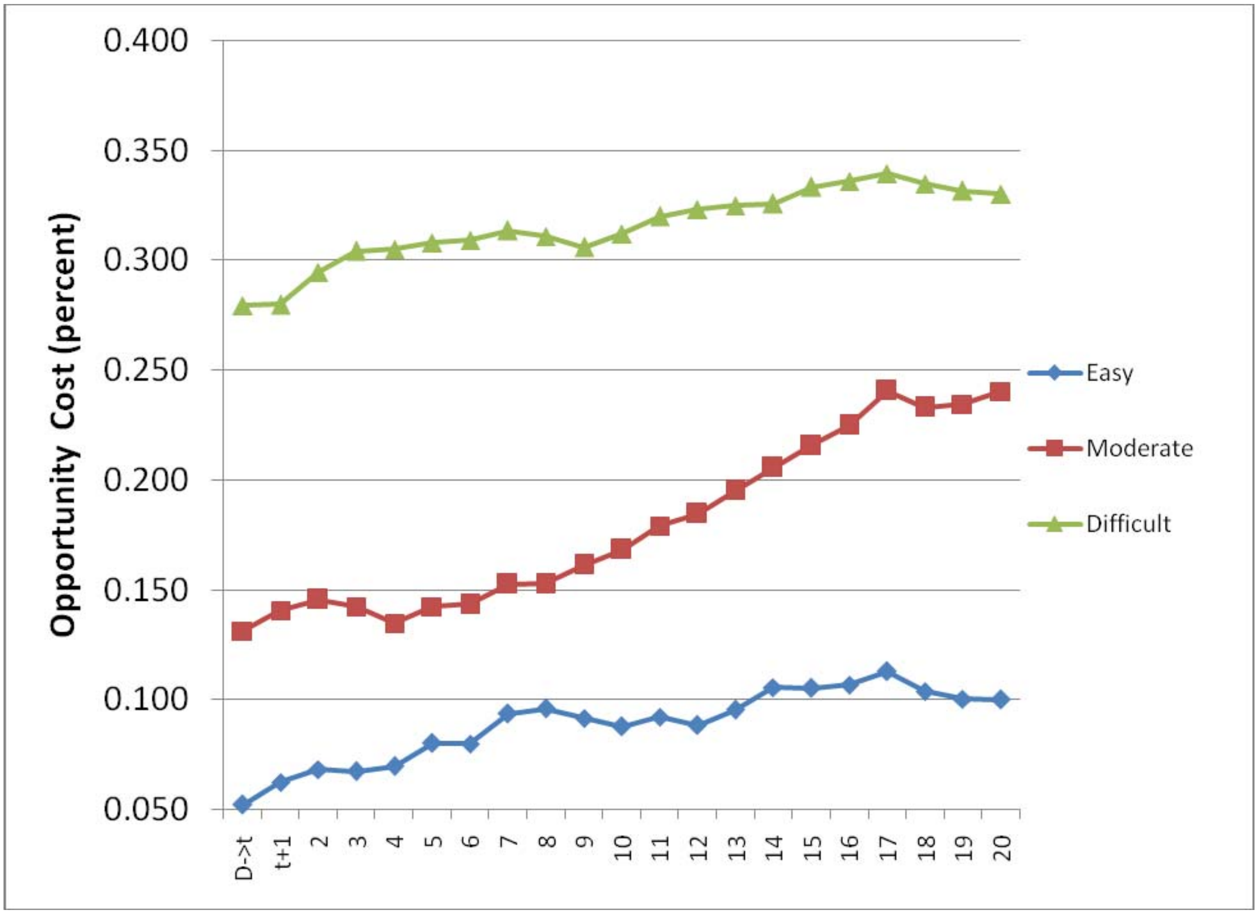

Figure 8 A: Opportunity Cost Variance Across Firm Sizes

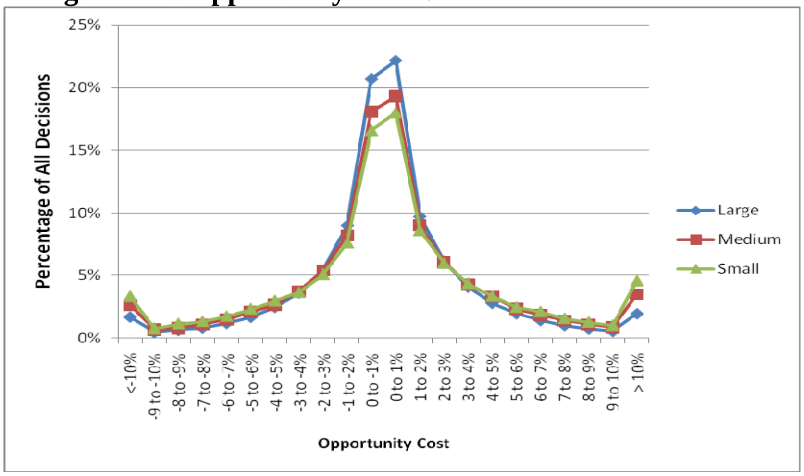

Figure 8 B: Opportunity Cost Variance Across Liquidiy Provision

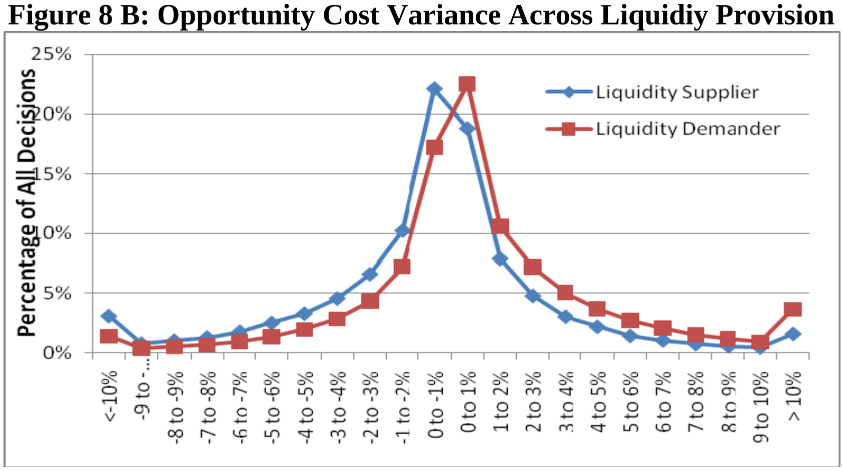

Figure 8 C: Opportunity Cost Variance Across Use of Brokers