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# Trading Around the Close

## ABSTRACT

In this paper, we discuss the issues a trader should consider when trading in and around the closing auction. Specifically, we describe the auction mechanisms used by the exchanges, including the order types offered and pre-auction information that the exchanges publish. We then provide an empirical analysis of trading volume, auction imbalances, and price reactions to imbalances, and discuss how a trader should use these findings to execute orders “optimally”. Our results suggest that algorithms meant to target the close should focus much of their open market trading to the period *prior to the imbalance announcement*, as opposed to just prior to the close itself. We also show that these algorithms should trade differently depending on whether the trade is a rebalance trade or a flow trade. As an example, we discuss our new ITG Dynamic Close algorithm, which utilizes the research contained in this paper to implement rebalance and flow trades more effectively.

## INTRODUCTION

The close of trading is generally the most actively traded period of the day. Institutional traders in particular often trade around the close either because they are benchmarked to the close [e.g., indexers] or because they are drawn to the increased liquidity around this time. Traders have the option of trading in the closing auctions to ensure they receive the closing price. Alternatively, traders may opt to trade part of their order in the open market to limit their impact on the closing price and potentially capture some of the price impact caused by their own auction trading. The actual trading strategy a trader should follow depends on both the market dynamics [e.g., how his trading impacts prices] as well as on the motivation behind the trade [e.g., implementation of a flow trade].

In this paper, we discuss the issues a trader should consider when trading in and around the closing auction. Specifically, we describe the auction mechanisms used by the exchanges, including the order types offered and pre-auction information that the exchanges publish. We then provide an empirical analysis of trading volume, auction imbalances, and price reactions to imbalances, and discuss how a trader should use these findings to execute orders “optimally”. And lastly, we discuss our new ITG Dynamic Close algorithm, which utilizes the research contained in this paper to implement rebalance and flow trades most effectively.

Our results show that prices react to imbalances *at the time of the first imbalance announcement*. Traders and algorithms executing large orders in the closing auction should consider trading a portion of their order in advance of the imbalance announcement to capture the price impact caused by their own closing auction orders. We also show that the optimal trading strategy in light of our findings depends on the objective behind the trade, i.e., rebalance trade versus flow trade. For both large rebalance and flow orders, the optimal strategy involves executing a

fraction of the order in the closing auction and a fraction in the open market prior to the initial imbalance announcement. The key strategy difference between rebalance and flow trades is that rebalance trades will generally continue to trade in the open market up until the close. Flow trades, on the other hand, will often do little or no open market trading after the initial imbalance announcement. This finding is in stark contrast to how most “close algorithms” work, as they typically concentrate their open market trading to just prior to the close. Our research suggests that Close Algorithms should concentrate more of their open market trading prior to the initial imbalance announcement and should trade flow trades differently than rebalance trades.

**NYSE & NASDAQ CLOSE AUCTION MECHANICS**

**1. A Brief Review**

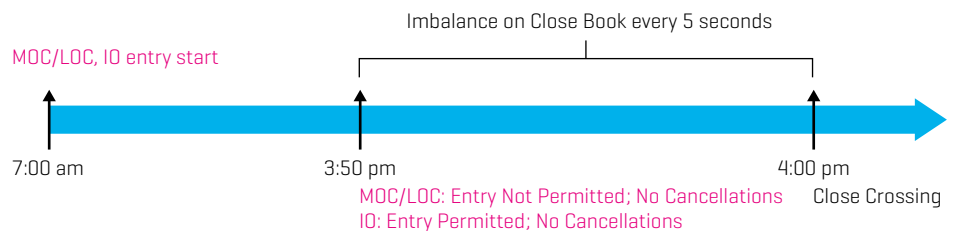
**NASDAQ**

NASDAQ provides two special order types to participate in the closing auction: “On-Close” orders, i.e., Market-on-Close (MOC) and Limit-On-Close (LOC), and “Imbalance-Only” (IO) orders. On-Close orders allow traders to participate in the closing auction directly, regardless of whether any imbalance exists at the time of the auction. Imbalance-Only orders, on the other hand, execute only when there is an opposite side imbalance and serve as a tool for traders to specifically offset imbalances without amplifying the imbalance when trading on the same side as the imbalance. MOC/LOC and Imbalance-Only orders can be cancelled and modified until 3:50 PM. After that only Imbalance Only (IO) orders can be submitted, but neither on-close orders nor IO orders can be canceled or modified.<sup>1</sup>

From the 3:50 PM cut off until 4 PM, NASDAQ publishes imbalance information, which is updated every 5 seconds. Imbalance direction, quantity, reference price, near price and far price are included in the feed.<sup>2</sup> As such, traders must decide whether to send their MOC/LOC orders prior to receiving any of imbalance feed information.

At 4 PM, regular session trading on NASDAQ ends, and the continuous book and the close book are merged for the final closing cross. The official closing price is determined by maximizing the number of shares executed.<sup>3</sup> Better-priced orders will be executed at the official closing price. Orders priced at the official closing price will be executed based on order type and time priority, which implies that LOC orders priced at the closing price may not fill. Figure 1 summarizes the Nasdaq auction mechanism.

**FIGURE 1:**  
NASDAQ Auction Mechanics



Source: ITG

<sup>1</sup> IO orders can be entered anytime until 3:59:59 p.m., but they cannot be cancelled or modified after 3:50:00 except to increase the number of shares or to increase (decrease) the buy (sell) limit price. See NASDAQ Rule 4709 (a)(2)(3)(4).  
<sup>2</sup> Far price is the hypothetical auction clearing price on the close book which includes On-Close and Imbalance Only orders. Near price on the other hand is the hypothetical auction price based upon the liquidity available in both the close book and the continuous book. Current reference price and Near Price change along with the market.  
<sup>3</sup> If multiple prices meet this criteria, secondary criteria are to first choose the price that reduces minimizes the imbalance and then minimize the distance from the 4 PM NASDAQ quote. If the resulting price is outside the benchmarks established by NASDAQ, the cross will occur at a price within the threshold that best meets these optimization objectives [NASDAQ Rule 4709 (c)(2) (A) (B)(C)(D)].



## NYSE

The NYSE closing auction permits submission of MOC and LOC orders, as well as a special “Closing Offset” (CO) order that can offset any imbalances at the closing price, similar in spirit to NASDAQ’s IO order. MOC and LOC orders can be submitted and canceled until 3:45 PM without restriction. After 3:45 PM, MOC/LOC orders will only be accepted if they are on the opposite side of any Regulatory Imbalance [discussed below]. In the case where there is no Regulatory Imbalance, submissions of MOC/LOC after 3:45 PM will be rejected. CO orders, however, may be entered on both sides of the market till 4:00PM, and are not restricted to only offsetting Regulatory Imbalances.<sup>4</sup>

Starting at 3:45 PM<sup>5</sup>, the exchange publishes informational order imbalance messages every 5 seconds, which provide reference price, paired quantity, imbalance size, and indicative clearing prices.<sup>6</sup> In addition, if a large imbalance exists at 3:45 PM, the exchange is required to publish a specific “Regulatory Imbalance” message.<sup>7</sup> This message is important as it governs the entry of offsetting interests after the cut-off. As noted above, MOC and LOC orders are permitted after 3:45 PM only if they offset a Regulatory Imbalance. If an imbalance exists but is not large enough to trigger a Regulatory Imbalance, a trader may not submit an MOC or LOC order after 3:45 PM, even if the imbalance feed shows that an imbalance exists. Once a Regulatory Imbalance is disseminated, traders can send orders on the opposite side of the imbalance until 4PM **regardless of whether future imbalance messages show that the imbalance is eventually eliminated or even reversed**. For example, if there were a Regulatory sell imbalance of 50,000 shares, traders could send buy MOC/LOC orders until 4PM even if the sell imbalance turned into a buy imbalance. It is interesting to note that while the Regulatory Imbalances provide an opportunity for traders to offset imbalances, these occur only about 11% of the time.

Floor brokers and DMMs have several advantages over other market participants in NYSE’s closing auction. From 2 PM until 3:45 PM, floor brokers get a “sneak peek” of the close book every 15 seconds, including the MOC/LOC interests, imbalances, and even the CO interest that is not available in any other feed.<sup>8</sup> Closing D-quotes used by Floor brokers can add to an imbalance or create an imbalance anytime until 10 seconds before the market close. Closing D-quote interest from Floor brokers are included in the imbalance feeds starting at 3:55 PM.<sup>9</sup>

Unlike that in the automated process in NASDAQ, NYSE’s closing price is manually set by the DMM so that MOC/LOC orders, floor broker interests, orders in the Display Book, and the DMMs own interest are paired up.<sup>10</sup> Limit and/or LOC orders trading against the imbalance amount are not guaranteed an execution in the closing transaction even if the price of such order is the same as the closing price.<sup>11</sup> Figure 2 summarizes the NYSE Auction mechanism.

<sup>4</sup> vNYSE Rule 123C(2)(b)(iii)

<sup>5</sup> NYSE may publish informational imbalances before 3:45 PM with Floor Official’s approval. NYSE Rule 123C (5)(b)

<sup>6</sup> NYSE Rule 123C (4) and (5)

<sup>7</sup> NYSE Rule 123C(1)(d) when disparity between MOC and marketable LOC is larger than 50,000 shares, or is significant in relation to the average daily trading volume in the security with prior approval

<sup>8</sup> NYSE Rule 123C(6)(b)

<sup>9</sup> [http://www.nyse.com/pdfs/fact\\_sheet\\_nyse\\_orders.pdf](http://www.nyse.com/pdfs/fact_sheet_nyse_orders.pdf) for more about d-quotes and e-quotes

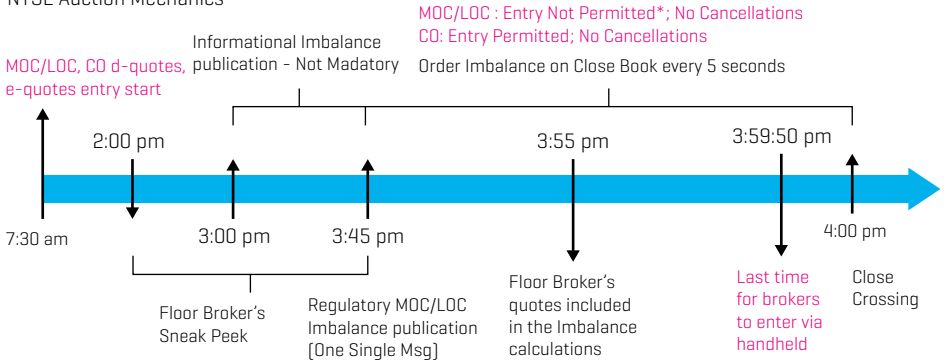
<sup>10</sup> NYSE Rule 123C(7)

<sup>11</sup> These orders may be included in full or in part at the discretion of the DMM, based on market conditions and the availability of offsetting



**FIGURE 2:**

NYSE Auction Mechanics



\* Unless offsetting Regulatory Imbalance if exists

Source: ITG

**AN EMPIRICAL STUDY OF THE CLOSE**

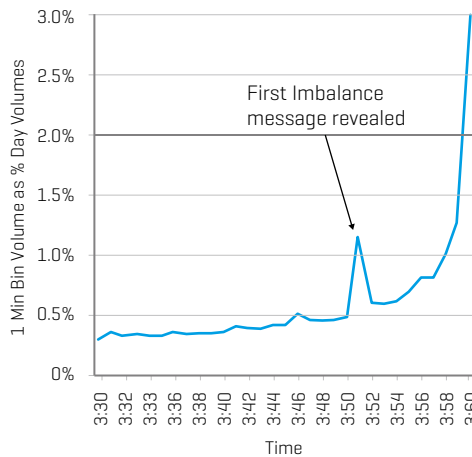
**1. Volume Profile around the Close**

While most traders are aware that volume generally increases substantially as the close nears, the fact that there is a “mini spike” around the time the exchanges begin publishing imbalance information is not as well-known. As shown in Figure 3, volume increases right after the initial imbalance on both exchanges, i.e., at 3:45 PM on the NYSE and 3:50 PM on NASDAQ. This is indicative of market participants reacting to the first imbalance publication. For the NYSE, a second, less pronounced “bump” occurs at 3:55 PM, when the floor broker interest is included in the imbalance calculation, suggesting that market participants respond to this incremental information as well.

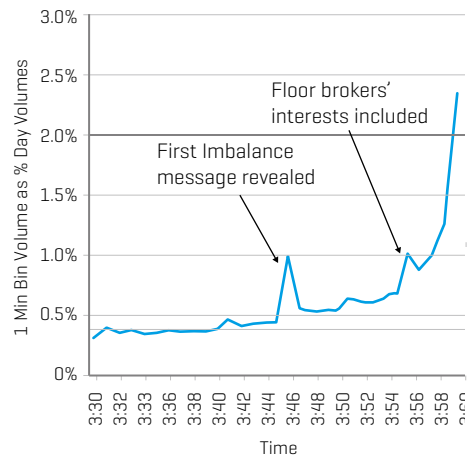
**FIGURE 3:**

Volume Profile 3:30 PM to 4:00 PM

NASDAQ Common Stocks  
1 Minute Volume Profile on Normal Days  
3:30 pm - 4:00 pm



NYSE Common Stocks  
1 Minute Volume Profile on Normal Days  
3:30 pm - 4:00 pm



\* Sample includes all NYSE- and Nasdaq-listed stocks for all full days in 2011.

Source: ITG



## 2. Evolution of imbalances over time

Since imbalance information is meant to draw liquidity into the market, the imbalance situation generally evolves over time, via price adjustments and/or offsetting liquidity. Recall that the imbalance is calculated relative to the current reference price, so a change in imbalance not only reflects additional liquidity submitted to the close book [e.g., offsetting MOC/LOC orders on the NYSE] but also reflects any changes in the reference price.

To investigate how imbalances change over time, we determined the frequency with which initial imbalances were reduced, eliminated, or reversed for all NYSE and NASDAQ common stocks for 2011. The results are given in Tables 2 and 3. For NASDAQ, initial buy [sell] imbalances are neutralized 46% [49%] of the time, while only 1% of these initial imbalances actually change direction. Recall that NASDAQ only allows IO orders to be submitted after the initial imbalance is published, and IO orders will not affect the reference price formation. A shrinking buy [sell] imbalance, therefore, indicates that market participants reduce imbalances by pushing regular session trading prices in the direction of the imbalance, or submitting more offsetting IO orders at or better than current reference price.<sup>12</sup>

**TABLE 1:**  
NASDAQ Imbalance Direction Change

First Imbalance Direction	NASDAQ	Last Imbalance Direction			
		B	N	O	S
<b>B: Buy Imbalance</b>		53%	46%	0%	1%
<b>N: No Imbalance</b>		8%	84%	0%	7%
<b>O: No Cross Found</b>		1%	0%	99%	0%
<b>S: Sell Imbalance</b>		1%	49%	0%	50%

Source: ITG

**TABLE 2:**  
NYSE Imbalance Direction Change<sup>13</sup>

First Imbalance Direction	NYSE			
		B	S	N
<b>B: Buy Imbalance</b>		83%	15%	2%
<b>S: Sell Imbalance</b>		14%	84%	3%
<b>N: No Imbalance</b>		9%	10%	81%

Source: ITG

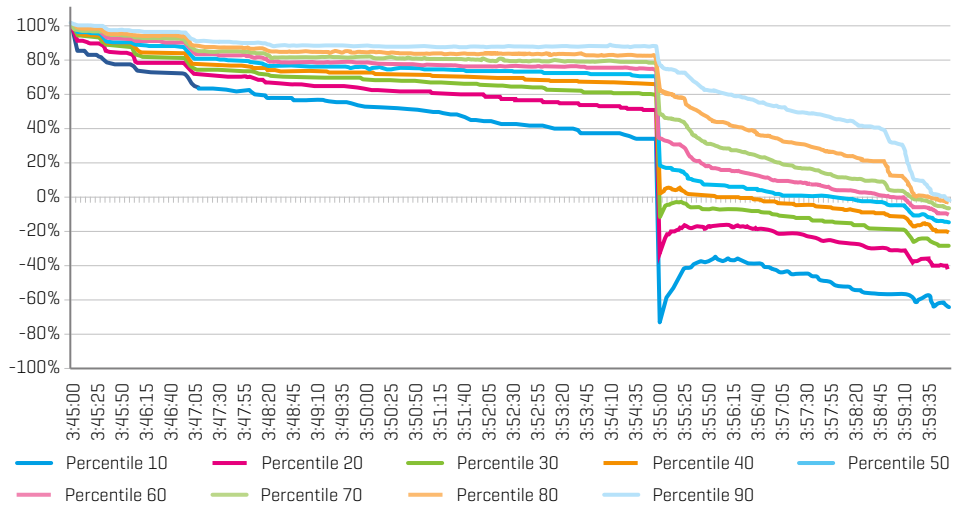
For the NYSE, Table 2 shows that a relatively large number of NYSE imbalances [approximately 15%] actually flip sign between the initial imbalance and the final imbalance. To better understand these imbalance “flips”, we created a subsample of our Regulatory Imbalance data containing only cases where the imbalance actually flips direction [i.e., from buy to sell or from sell to buy] and track how the imbalance evolves between 3:45 PM and the close.

<sup>12</sup> Current reference price is bounded by NASDAQ BBO. Thus current reference price moves along with regular session trading price.

<sup>13</sup> Only Order Imbalances published from 3:45pm to 4pm are included. Informational imbalances happened before 3:45pm are not included. Regulatory Imbalance message if exists will be the same as order imbalance message at 3:45pm.

Figure 4 shows the imbalance quantity in every message as a percentage of the first imbalance message. The figure shows that imbalances are eroded gradually as time goes by, with the most dramatic change happening at 3:55 PM. The median imbalance as of 3:55 PM [i.e., the 50th percentile] is still in the direction of the imbalance, but is only 20% of the initial size. This suggests that floor brokers tend to offset imbalances, though not completely. It also indicates that the informational imbalances published prior to 3:55 PM provide an incomplete picture of the true imbalance since floor broker interest has yet to be incorporated.

**FIGURE 4:**  
Imbalance Reversals: Imbalance Quantity Over Time



Source: ITG

### 3. Impact of imbalances on prices

To determine how prices respond to imbalances, we look at returns over two horizons: 1) the period between the initial imbalance and the end of regular trading at 4PM and 2) the period between the end of trading and the closing auction itself. Figure 6 summarizes our results by showing the typical price path from the time of the initial imbalance publication through the closing auction.

With regard to the first horizon, we find that the initial imbalance message results in both an immediate price reaction and excess market volume. For example, for an actively traded NYSE stock with an imbalance equal to 1% of ADV, the price impact is about 4 bps. This price effect occurs almost immediately and persists throughout the end of [non-auction] trading. More precisely, prices react upon the first imbalance information within seconds, and the average return from that point on is not statistically different from zero on average, even for relatively large imbalances. This implies that signals based on imbalance information are valuable, but capturing that alpha requires traders to react immediately.

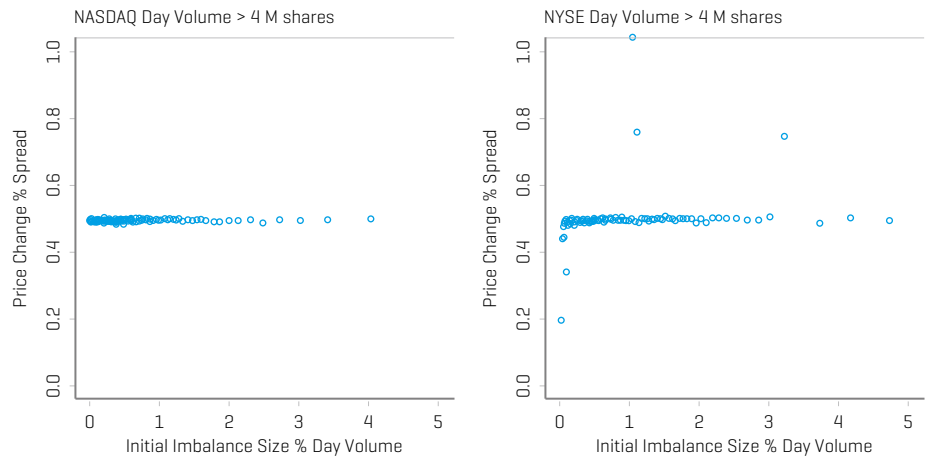
Turning to the effect of imbalance information on the second period, Figure 5 provides the median 4PM-to-closing returns for different imbalance levels using a sample of liquid common stocks. Specifically, we bucketed observations by imbalance [as % of ADV], computed the median return for that subsample [as a fraction of spread], and plotted each median as a point in Figure 5. For example, the right most dot in the Nasdaq panel provides the median return [the y-axis] for all observations with an imbalance equal to roughly 4 percent of ADV [the x-axis].

Figure 5 shows that, even for relatively large imbalances, the median price change is about 0.5 times spread. This implies that closing prints tend to occur at the 4PM bid or offer on average regardless of imbalance size. Imbalances therefore predict the **direction** of the price change between the last regular session quote and the closing auction itself, but **not the magnitude**. This finding together with our earlier finding that prices react immediately to the initial imbalance announcement suggests that the market tends to push quotes in the direction of the imbalance to compensate liquidity providers to such an extent that the closing trade itself executes at the 4PM quoted prices.

The implication of our findings are profound given that many traders and algorithms attempt to “beat the close” by trading in the minutes leading up to the close to capture some of the price impact caused by the trader’s own on-close order. For example, a trader may send 90% of the order into the closing auction as an MOC, but trade 10% in the open market to capture the impact caused by their own MOC order. Our results suggest that this strategy is not profitable since the price reaction to any imbalance typically occurs **at the time of the initial imbalance message**. The only benefit of trading into the close itself would be to avoid the [implicit] half-spread that those in the auction typically pay when they are on the same side of the imbalance.

**FIGURE 5:**

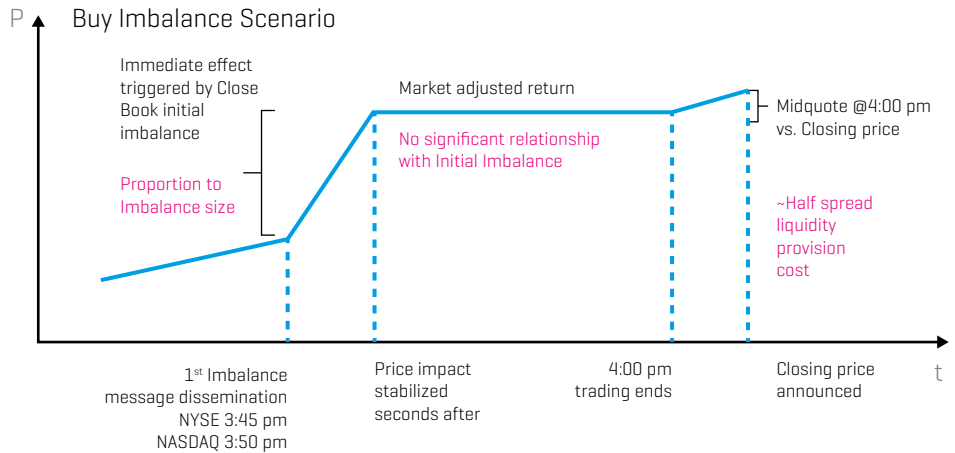
Median return between 4:00 PM mid-quote and close price by imbalance size



Source: ITG

**FIGURE 6:**

Price Trajectory Illustrations



Source: ITG



## TRADING STRATEGY IMPLICATIONS: REBALANCE TRADES VS. FLOW TRADES

Institutional trades done around the close typically fall into two categories: rebalance trades and flow trades. Rebalance trades are those where a portfolio manager is using existing positions to finance a trade. Flow trades, on the other hand, are those where the trade is being done to invest inflows of cash from investors or to generate cash to fund a redemption. An investor redeeming mutual fund shares, for example, would receive the closing price on the date of the redemption, as opposed to at the actual price received when the fund sold shares to raise cash.

### 1 Rebalance trades

For rebalance trades, traders should aim to minimize implementation shortfall costs, as these are consistent with “buying low and selling high” and are therefore consistent with fund return maximization. To see why, suppose instead that traders tried to minimize slippage relative to the closing price rather than to a pre-trade benchmark. In this case, submitting large quantities to the closing auction will, by design, have zero slippage, as the execution price will always equal the closing price benchmark. But as our research documents, trading large quantities at the close will tend to move prices adversely [following the imbalance publication] and will lead to implicit spread costs in the auction itself. Since these impacts are generally liquidity-induced and are therefore likely to revert, the fund basically buys high and sells low.<sup>14</sup>

For rebalance trades, the goal of minimizing implementation shortfall involves balancing the impact of trading in the closing auction against the impact of trading in the open market. If the closing auction were sufficiently more liquid than the open market, a trader should execute entirely in the closing auction. If, on the other hand, the order is sufficiently large that it starts to have a significantly large impact on the closing auction price, the trader can reduce trading costs by trading a portion of his order in the open market.

Our research suggests that, for sufficiently small order sizes, the closing auction is indeed cheaper than trading in the open market on an implementation shortfall basis. But as order size increases, a trader could reduce implementation shortfall by executing some of the order in the open market. Interestingly, for the open market trading, our empirical results suggest that a trader should trade disproportionately more **before the imbalance announcement** than just prior to the close. Trading just prior to the close itself doesn’t really reduce costs since the impact of any imbalance actually occurs well before the auction, specifically at the time the initial imbalance is released.

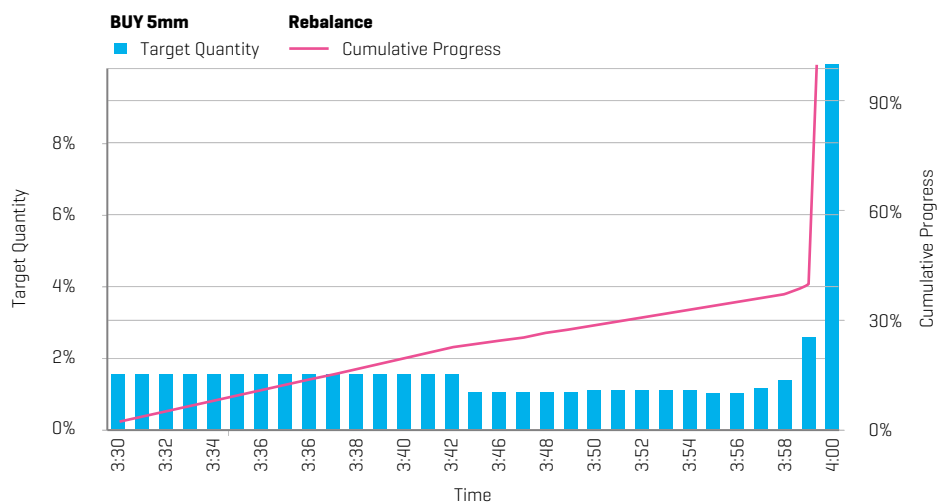
Figure 7 shows a hypothetical “optimal” trade schedule for a relatively large rebalance trade.<sup>15</sup> In this example, the trader executes the majority of the order in the close and the remainder in the open market. For the open market trading, the trader executes a disproportionate amount prior to 3:45 PM, before the market responds to the 3:45 PM imbalance publication. The front-loading captures some of the price impact caused by the trader’s own closing trade. The trader will continue to trade in the open market even after 3:45 PM, but this is done to reduce total market impact.

<sup>14</sup> If trades are completely “informationless”, post-trade prices will revert to pre-trade prices once the market fully absorbs the order. In the case where trades have permanent price impact or have alpha, post-trade prices on average will not equal pre-trade prices. But even in these cases, it can be shown that in usual circumstances, minimizing shortfall is equivalent to maximizing fund performance.

<sup>15</sup> We assume that the objective here is to minimize expected shortfall without regard to risk. If the trader were risk averse, the optimal trading strategy would involve trading more in the closing auction, as well as back-loading more of the open market trading around the 4PM close.



**FIGURE 7:**  
"Optimal" NYSE rebalance trade: An illustration



Source: ITG

## 2 Optimal strategy for flow trades

For flow trades, the economics are different. Specifically, when a fund has a flow that is priced relative to the closing price, the end investor receives the closing price regardless of how the cash was actually raised.<sup>16</sup> Any slippage from the actual closing price incurred when selling a position to fund a flow will ultimately be borne **by the remaining fund investors**, not by the redeeming investor. For example, if the NAV at the close of trading were \$20, but the net proceeds of the trade were only \$19.99, the net loss of \$0.01 would be borne by the fund, since the investor will get \$20 regardless of the execution price. For flow trades, then, the objective should be to get the closing price or better in order to avoid losses to the fund. Or put another way, the trader should execute the trade in the closing auction, unless the trader can somehow beat the closing price on average.

For flow trades, the optimal strategy looks somewhat similar to that of rebalance trades, but with some important differences. For smaller orders, a flow trader should execute all of his order in the closing auction since the order is unlikely to create sufficiently large "capturable" impact to offset the open market trading costs. For sufficiently large orders, though, a trader can benefit by trading some portion of the order in the open market. But as with rebalance trades, capturing the price impact of any imbalance requires trading **prior to the imbalance announcement, not prior to the close itself**. In fact, trading between the initial imbalance announcement and the closing auction is not a particularly good time to execute flow trades since the impact of one's own closing auction quantity is felt **prior** to this, so the trader is actually paying the post-impact cost during this period.

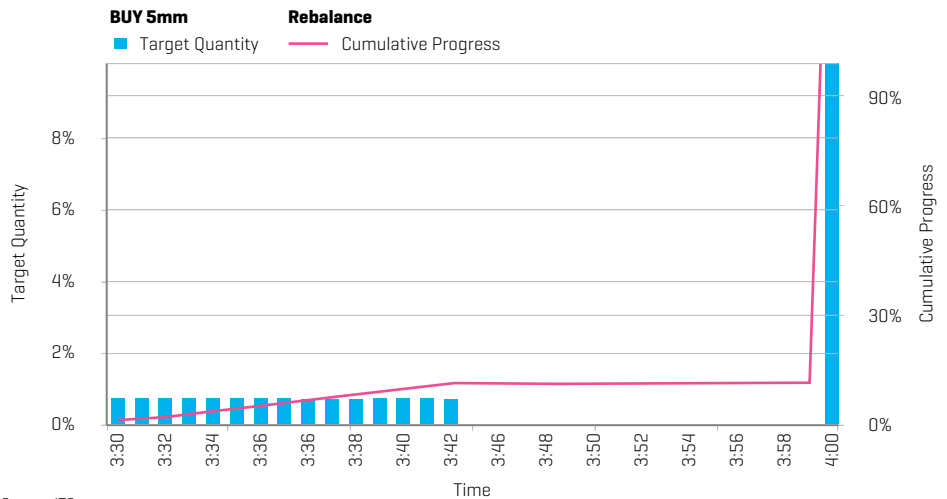
To see why, suppose a trader puts 90% of a relatively large NYSE order into the closing auction at 3:30 PM, prior to the initial imbalance publication. If the trader executes the remaining 10% in the opening market prior to 3:45 PM, she is able to execute prior to the adverse price movement that will occur when her demand is revealed to the market at 3:45 PM as part of the imbalance message. But if she waits until after 3:45 PM to trade the 10% residual, it would be too late to capture the price impact since the price reaction typically occurs just after the 3:45 PM announcement.

<sup>16</sup> More formally, the investor receives the net asset value (NAV) of the fund as of the close of trading, which is simply a weighted average of each position's closing price. A fund need not trade out of each individual position pro rata to fund a flow. But intuitively, if a trader funds a flow by executing trades away from their 4PM values, any losses incurred relative to these 4PM values are incurred by the fund, not the investor who is cashing out.



Figure 8 shows a hypothetical optimal trade trajectory for a relatively large flow trade. The trader here will execute most of the trade in the closing auction, which will have zero slippage relative to the close since it is guaranteed the closing price. But since that on-close order will lead to a price reaction when revealed as part of the 3:45 PM imbalance announcement, the trader should execute a disproportionate amount of the remaining 10% prior to the initial imbalance publication. Note that, unlike with an identical rebalance trade, a trader would actually trade **nothing** between the 3:45 PM imbalance publication and the 4PM close. Intuitively, a trader has no upside from trading between 3:45 and 4 PM because the price impact of any imbalance has already occurred. Trading during this period would only result in increased spread costs and market impact. A trader therefore would prefer to simply trade in the closing auction instead since he is assured of a zero slippage execution relative to the closing price.

**FIGURE 8:**  
"Optimal" NYSE flow trade: An illustration



Source: ITG

**ITG DYNAMIC CLOSE ALGORITHM**

The new ITG Dynamic Close algorithm incorporates this research directly by taking into consideration the fact that 1) imbalance impact tends to occur immediately after the announcement of the imbalance and 2) the objective for rebalance trades is different than flow trades. As such, the ITG Dynamic Close Algorithm takes a dramatically different approach relative to other "Into the Close" algorithms. The algorithm has two modes, Rebalance and Flow, to accommodate the two different objectives traders typically have when trading around the close. The algorithm automatically adapts its strategy to either reduce implementation shortfall costs [Rebalance mode] or to outperform the closing price [Flow mode]. The algorithm can also offset Regulatory Imbalances, though it may opt to continue trading in the open market if it thinks it is advantageous to do so.



## CONCLUSION

A deep understanding of the closing auction mechanics and market dynamics are essential for traders to implement trades efficiently around the closing auction. This paper reviews auction mechanics in NYSE and NASDAQ, discusses empirical patterns around the close, and provides suggestions on how to use this information most effectively when trading. Specifically, our results indicate that a trader wishing to “beat the close” needs to consider trading before the announcement of imbalances, as opposed to just prior to the closing auction. Our analysis also suggests that traders and algorithms that target the close of trading should trade differently depending on whether they are implementing rebalance trades or flow trades. By taking into account the price dynamics around the close and tailoring their trading strategy to fit the motivation behind the trade, traders who execute around the close can improve their performance significantly relative to the more conventional approach of trading into the close.

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NYSE Regulation Rule 123C .The Closing Procedures

[http://rules.nyse.com/NYSETools/PlatformViewer.asp?selectednode=chp\\_1\\_3\\_8\\_13&manual=%2Fnyse%2Frules%2Fnyse-rules%2F](http://rules.nyse.com/NYSETools/PlatformViewer.asp?selectednode=chp_1_3_8_13&manual=%2Fnyse%2Frules%2Fnyse-rules%2F)

NASDAQ Rule 4709 Closing Cross

<http://www.gpo.gov/fdsys/pkg/FR-2004-03-18/html/04-6068.htm>

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