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ITG® INVESTMENT TECHNOLOGY GROUP

Choosing the 'Right' Algorithm Can Minimize Trading Costs in Today's Volatile Markets

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Market volatility over the past few months of 2008 has clearly been unprecedented. The Chicago Board Options Exchange Volatility Index (VIX) has climbed sharply, for example, from 30 in March to highs of 70 in October. More recently, we have seen wild swings of 700 to 1,200 bps in the major market indices—in just one day. Market volume is up considerably as well. Not only is it increasingly difficult to trade under these current conditions, it is much more costly—wild swings have resulted in a widening of spreads across all market capitalizations. And it doesn't seem to be ending anytime soon. Regardless of which direction the market ultimately heads, most analysts predict that the volatility is here to stay, at least for the next several months.

In such uncertain conditions, is it possible for traders to maximize executions while simultaneously minimizing costs? Can their choice of algorithm have a significant effect on trading performance? ITG investigated these issues in an attempt to help guide traders through today's volatile market environment. Our analysis of 3.5 billon shares of 2008 ITG client execution data indicates that choosing the 'right' algorithm during highly volatile market conditions saved our customers, up to 60 bps in trading costs (as compared to 20 bps of cost savings during low volatility periods). Dispersion of cost was significantly tighter—up to 100 bps.

It is clear that performance maximization during extreme volatility scenarios emphasizes the valuable role a trader can play in all three areas of the investment management process: alpha generation, alpha preservation, and risk management. Our analysis underscores the importance of not only evaluating low-touch algorithms that can help traders minimize transaction costs and better manage risk, but also high-touch algorithms that allow a trader to generate alpha.

In this paper, with the insight of ITG client execution data, we evaluate which algorithms are most appropriate during volatile market conditions for each objective (alpha generation, alpha preservation and risk management). Our goal is to help traders evaluate and select appropriate algorithms across brokers. As such, we also investigate which elements, if any, of ITG Algorithms℠ play a key role in improving performance.

Contents:

Key Observations on Changing Market Conditions

Fig. 1. CBOE VIX

The VIX index, which is a broad measure of market volatility, has risen to approximately 70, its highest level ever.

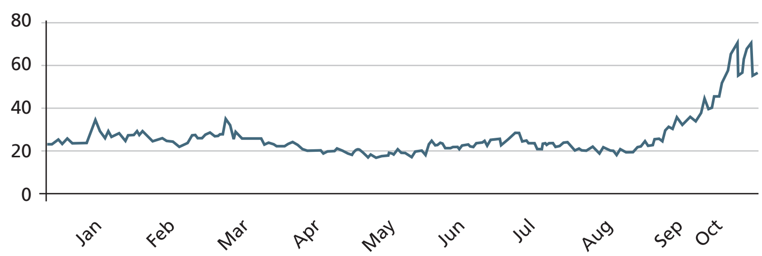


Fig. 2. Average Spread Size (bps) (all US stocks – 2008)

Market cap weighted average spreads have gone up from 5 bps to 9 bps since the beginning of the year.

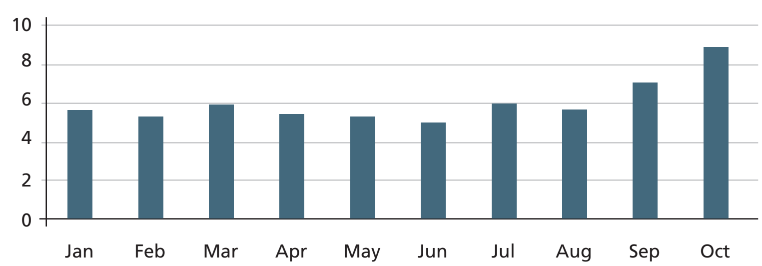


Fig. 3. Average Spread Size by Market Cap (bps) (all US stocks – 2008)

The spread increase is most pronounced in small cap stocks (almost 20 bps increase) followed by mid cap stocks (5 bps increase) and large cap stocks (2-3 bps increase).

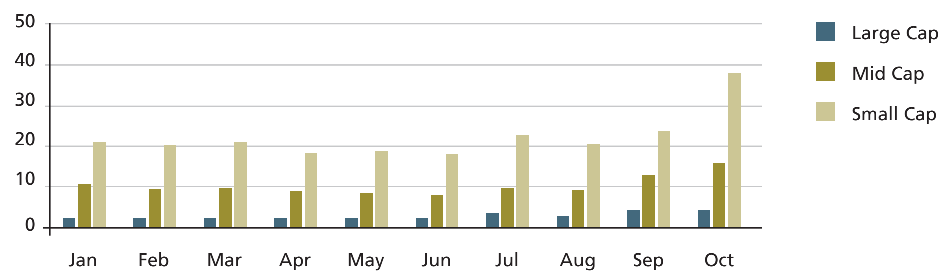


Fig. 4. Market Volume (US composite)

Market volume is up by 50% since the beginning of 2008.

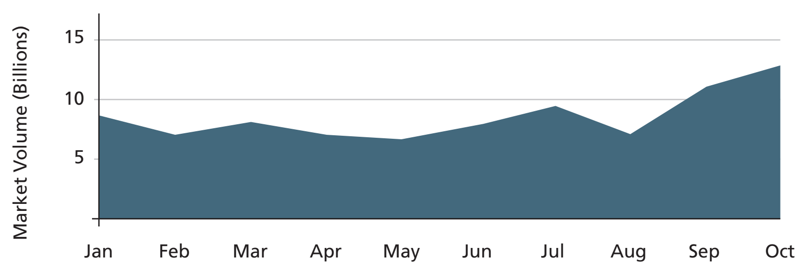
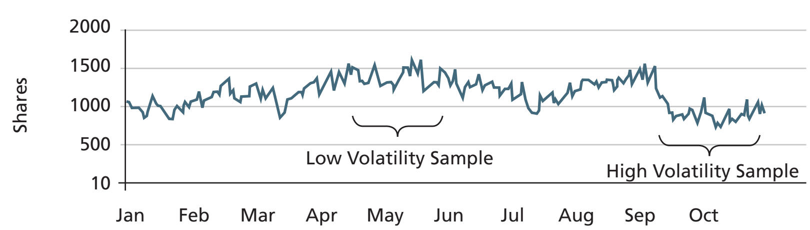


Fig. 5. Market Cap Weighted Average Displayed Size (all US stocks 2008)

Displayed size dropped severely in the recent volatility spike. In high volatility it is 37% smaller than in low volatility.



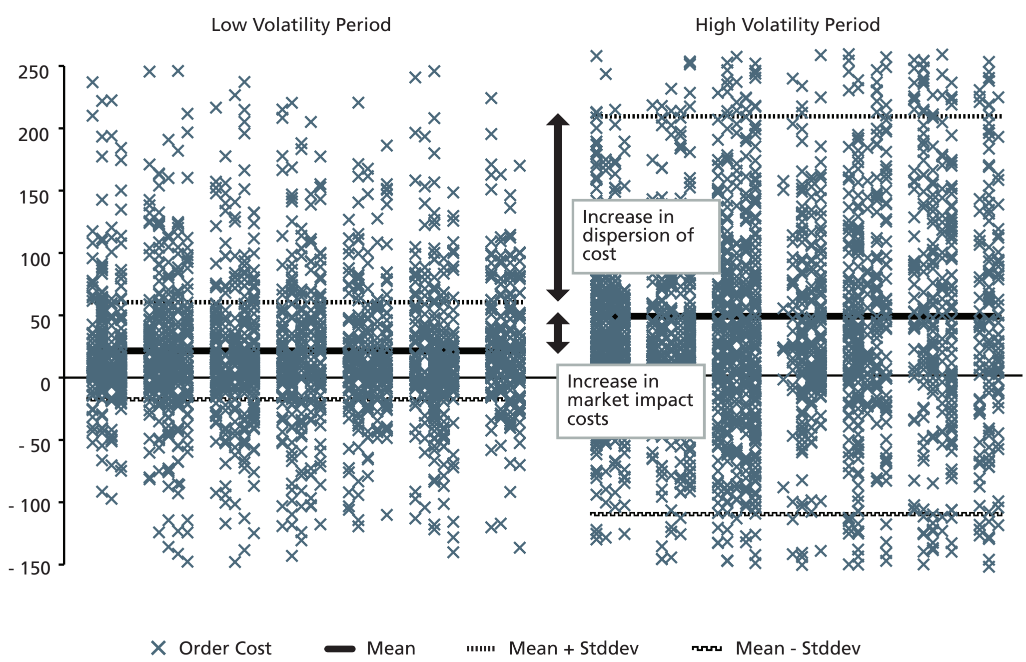
Volatility Impact on Trading Costs

Volatility has a triple negative effect on trading costs in the forms of dispersion of cost, market impact cost, and spread cost.

- **Dispersion of Cost** - The most obvious result of high volatility is higher dispersion of cost.

- **Market Impact Cost** - The less obvious effects, however, are on the market impact cost and spread cost. Most traders view market impact cost as simply a function of order size as a portion of volume. The most typical measure is order size represented in % ADV (21 days trailing average daily volume). A large order, relative to the stock's volume, creates a demand and supply imbalance that affects the stock price adversely. In higher volatility periods, demanding the same amount of liquidity affects the stock even more adversely. That is in a period of high volatility, an order will have higher market impact costs than an order with the same % ADV size during a low volatility period. As a result, the dispersion of the cost (i.e., opportunity cost) is not only going to be higher, but the cost on average will also be higher in high volatility period (Fig. 6).

Fig. 6. Cost in Low and High Volatility Periods



Market Impact and dispersion of cost in low and high volatility periods for orders that are 1-5% of ADV.

- **Spread Cost** - The third adverse effect of volatility is on spread cost. While impact cost is measured at the entire order level [Average Execution Price – Arrival Price] spread cost is measured at execution level. When an algorithm takes liquidity it pays the entire spread. On the other hand, when an algorithm posts an order it may pay part of the spread if it improved the bid (for a buy order). So the spread cost is directly proportional to the spread of the stock. Why do the spreads become wider in a high volatility period even when the volume is also higher? The reason is that market makers are typically the beneficiaries of the spread since they provide liquidity. In high volatility periods, they take higher risk for providing liquidity (since getting out of a position is riskier). As a result, they charge a premium for the increased risk by posting liquidity at wider spreads. This practice results in higher spread cost for institutions (Fig. 3).

  Since the impact cost measures the entire order average price vs. the arrival price, it also captures the spread cost. However, it is important to quantify the spread cost separately because it is one factor over which the trader or algorithm can exercise greater control. And through cost savings in spread cost, overall cost is reduced.

Volatility Impact on Realized Trading Costs when Using ITG Algorithms[SM]

Methodology

As one would expect, overall trading costs increase as volatility rises. To study the specific effects of volatility on the performance of ITG Algorithms, we looked at two distinct data groups: a low volatility trading period (April 15 through May 31, 2008) and a high volatility trading period (September 1 through October 15, 2008). During the low volatility period, the VIX averaged 19.38 while during the high volatility period the average was 37.54.

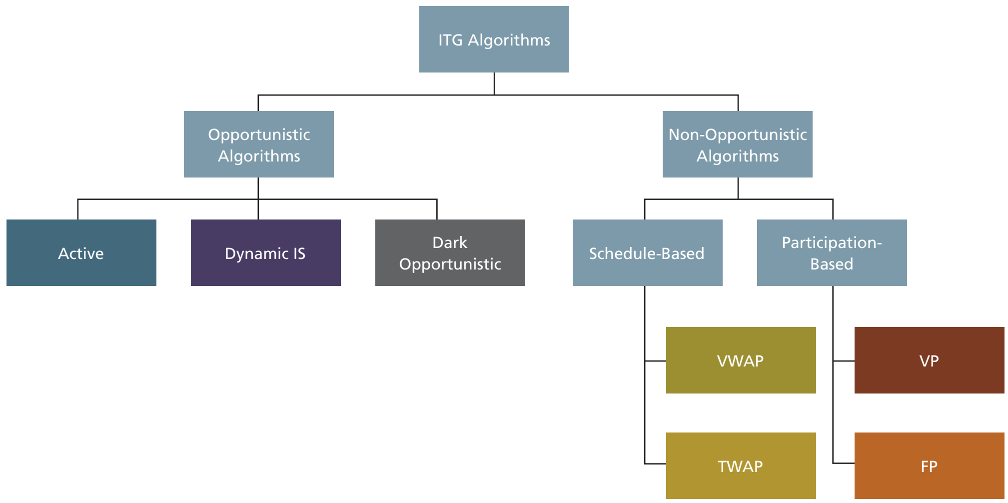
In order to avoid undesired bias, we excluded from the data set all limit orders as well as any orders that were not required to finish by end-of-day.

Overview of Algorithm Types

Before we present our findings, let's review the general categories of algorithms:

Type	Description	ITG Algorithms
VWAP	These algorithms slice and dice orders to match the volume distribution of the stock during the time horizon specified by the customer. The speed of the algorithm does not vary based on liquidity, spreads, or volatility of the stock.	VWAP
Participation-based (Scaling)	Participation algorithms slice and dice the orders to match a specified portion of the volume printed in the stock. So the speed of the algorithm is completely affected by the liquidity but not spread or volatility of the stock. Some of these algorithms can also automatically change the participation level based on a price change relative to a benchmark or a benchmark index and/or let the trader specify whether he thinks that the stock is going to have momentum or reversion.	Volume Participation (VP), Flexible Participation (FP)
Opportunistic	Opportunistic algorithms are not bound to any particular schedule or participation level. Opportunistic algorithms have the freedom to vary the speed of execution based on spread, liquidity, volatility, price relative to benchmark and/or signals from short-term alpha models.	Active, Dark Opportunistic, Active Ex
List-Based (Basket)	List-based (or basket) algorithms can be schedule-based or opportunistic. In addition to following the basic principles of schedule and opportunistic algorithms, these algorithms also use stock correlations in the basket to make order slicing decisions. These algorithms typically attempt to reduce the risk of an unexecuted basket during the trading horizon. ITG list-based algorithms are opportunistic.	Dynamic Implementation Shortfall (DIS)

Fig. 7. Categories of ITG Algorithms℠



Major Findings

When comparing the performance of ITG Algorithms from low to high volatility periods as described above, we found that:

- ITG's opportunistic algorithms (Active and Dynamic Implementation Shortfall) performed best in both low and high volatility periods. During high volatility, the cost savings as compared to other ITG Algorithms was even greater.
- ITG Algorithms beat the pre-trade estimate[1], in both low and high volatility periods, by a significant margin (up to 60 bps).
- The performance of ITG's VWAP algorithm against the VWAP benchmark was relatively better in the high volatility period.

[1]ACE 2.3 Discretionary with 1 Day VWAP

Fig. 8. Dispersion of Cost

Dispersion of cost increased from the low to the high volatility period.

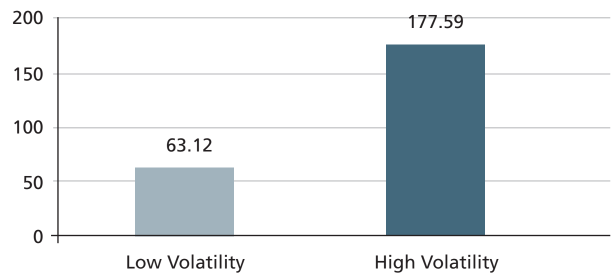


Fig. 9. Cost vs. Arrival Price by % ADV

Costs increased across all order sizes, relative to volume.

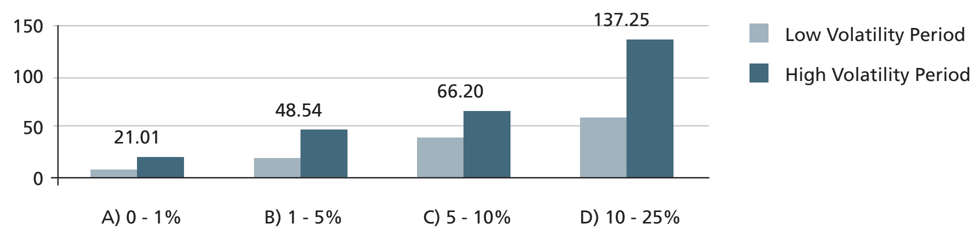


Fig. 10. Low Volatility Cost by % ADV

Active and Dynamic IS had the lowest cost across all order sizes during the low volatility period.

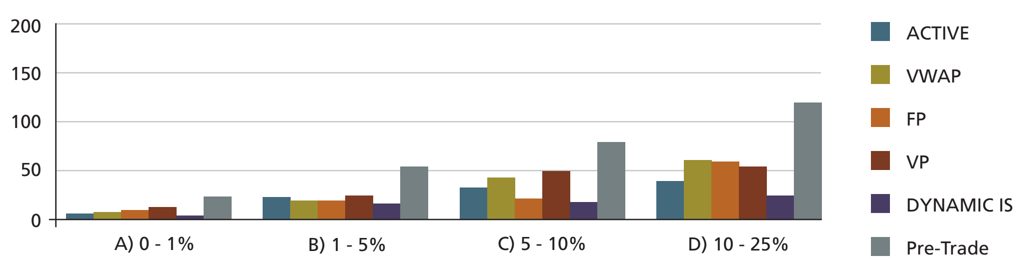


Fig. 11. High Volatility Cost by % ADV

During the high volatility period, Active and Dynamic IS had 1) the lowest cost across all order sizes and 2) beat the pre-trade estimates.

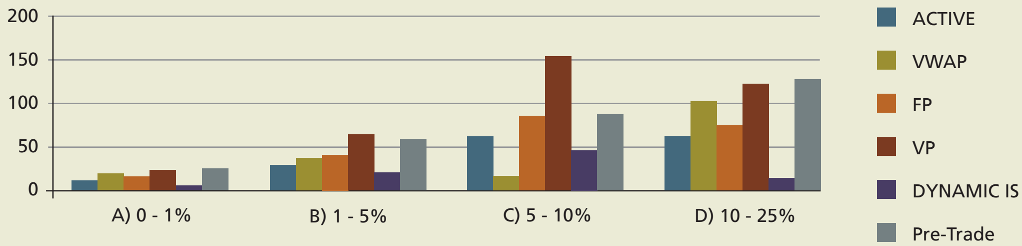
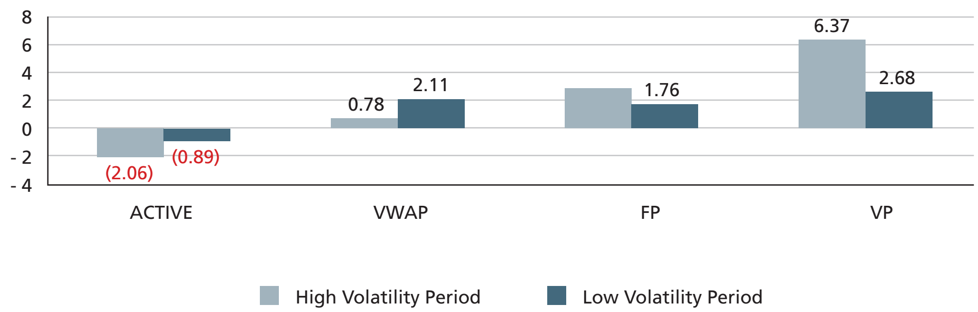


Fig. 12. Interval VWAP Cost

Interval VWAP costs did not change much from low to high volatility periods.



Using ITG Algorithms℠ to Reduce Trading Costs in Volatile Markets

Opportunistic Algorithms Best Minimize Costs

Our research found that, in volatile markets, ITG's opportunistic algorithms, Active and Dynamic Implementation Shortfall (Dynamic IS), did a better job in terms of cost savings than other ITG Algorithms. Active and Dynamic IS are both implementation shortfall algorithms. Active is used for trading single stock orders while Dynamic IS is optimized for trading baskets. The cost savings using these algorithms ranged from 10 bps for smaller orders (0-1% ADV) to almost 60 bps for larger orders (>10% ADV) in the high volatility period.

Why Do Opportunistic Algorithms Perform Better in Volatile Markets?

- **Opportunistic algorithms inherently allow for timing flexibility.** Unlike schedule or participation based algorithms, opportunistic algorithms like Active are not bound by any participation rate or schedule. As such, they have the leeway to adjust their aggressiveness based on real-time market conditions. For example, if a mid cap stock is trading at 42.95 – 42.96 2000 x 10000 (Fig. 13A), an opportunistic algorithm will take advantage of the posted size for a buy order. Similarly it can look even deeper into the book, and if it detects unusually large size, will capture it (Fig. 13B). In that same scenario, however, a schedule driven algorithm may not be able to take advantage of favorable conditions; doing so may violate the schedule. Since the opportunistic algorithms can make use of these liquidity opportunities it helps them in minimizing dispersion of cost.

Active will capture unusual liquidity opportunities at the opposite side of the NBBO.

Fig. 13A. Opportunities at the NBBO

NBBO at 42.95 – 42.96 2000 x 10000

Bid	Bid Size	Ask	Ask Size
42.95	2000	42.96	10000

Fig. 13B. Opportunities in the Book

NBBO at 42.95 – 42.96 600 x 200, 10 K offered @ level 2

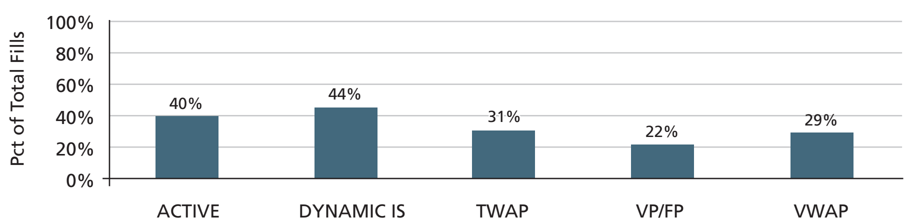
Bid	Bid Size	Ask	Ask Size
42.95	600	42.96	200
42.94	300	42.97	10000

- **Opportunistic algorithms allow for complete exposure to dark pools, resulting in price improvement and a reduction of market impact.** Active, for example (which does not have participation rate or schedule constraints as mentioned previously), can participate up to 100% of an order in dark pools. By contrast, participation algorithms like Flexible Participation and Volume Participation are designed to provide traders with control on how heavily they would like to participate along with market volume. Active, which is unconstrained, is able to automatically capitalize on the fact that trading in dark pools helps to reduce market impact and improve price. Furthermore:

- Our analysis shows that for the same size orders, there is less market impact in dark pool trading than there is in trading in the displayed market. (For more information on this analysis, please read ITG's September 2008 white paper: *Cul de Sacs and Highways: An Optical Tour of Dark Pool Trading Performance*).
- ITG dark pools POSIT Match[SM], POSIT Now[SM], and POSIT Alert[SM] all trade at midpoint or better. In addition, third party dark pools accessible via ITG Algorithms are configured for ITG to trade at midpoint or better. Since spread costs have increased significantly, crossing in a dark pool at the midpoint helps to reduce spread costs as well as market impact.
- We have tuned all ITG Algorithms to maximize the fills in dark pools without violating the trader's objective. This not only improves fill rates in scheduled and participation-based algorithms (up to a 25% higher fill rate) but also maximizes fill rates (approximately 45%) in opportunistic algorithms (Fig. 14) which reduces market impact and results in high levels of price improvement in our analysis.

Opportunistic algorithms have the freedom to execute more of an order in dark pools, whereas non-opportunistic algorithms are usually constrained to executing small pieces only in dark pools. As a result, non-opportunistic algorithms have to trade more in the open market and face increased spread costs and market impact.

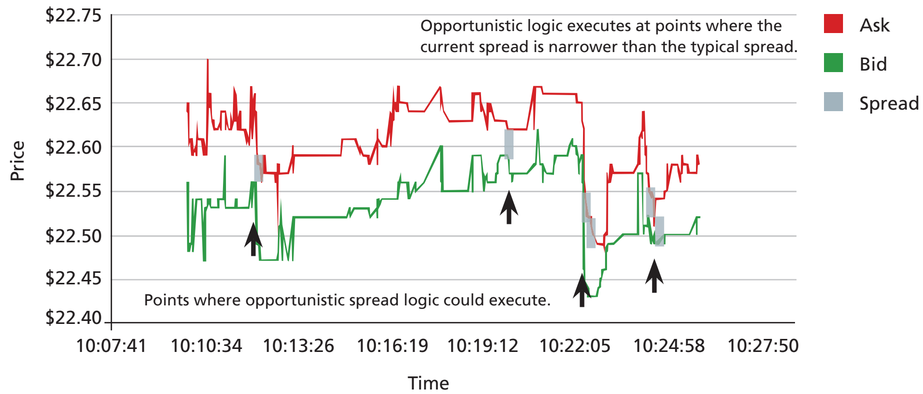
Fig. 14. Dark Fills



- **Opportunistic algorithms execute at "better" spreads, therefore reducing spread costs.** Because they have no schedule and they react to real time market conditions quickly, opportunistic algorithms like Active and Dynamic IS also can capture attractive spreads when available. For example, if a small cap stock stock has average spread of 10 cents and spread falls 2 cents, Active will immediately take advantage of that cheap liquidity.

Fig. 15. Opportunistic Spread Logic

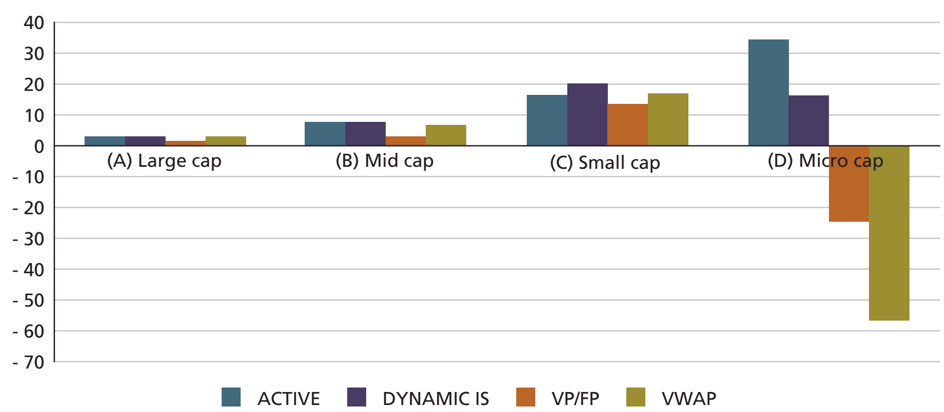
Opportunistic logic executes at points where the current spread is smaller than the typical spread. ITG's Active algorithm contains opportunistic spread logic—it waits for spreads to tighten to a point that is narrower than the symbol's typical spread size—to help mitigate the increasing spread costs.



Because of all these reasons we tend to see more spread savings in Active and Dynamic IS than in other algorithms across all market capitalizations (Fig. 16). Spread savings are measured as the difference between the average spread of the stock and the spread cost paid by the algorithm. Spread cost is measured as [Execution Price - Bid Price] for buys and [Ask Price - Execution Price] for sells.

Fig. 16. Spread Cost Improvement (bps)

Positive results indicate the algorithm paid less for liquidity relative to the typical spread. Negative indicates the algorithm had to pay more than the typical spread.



Caveat: Not All Implementation Shortfall Algorithms are Opportunistic

It is important to note that even though ITG's Active and Dynamic IS algorithms both fall under ITG's implementation shortfall category, not all implementation shortfall algorithms are necessarily opportunistic. In fact, the implementation shortfall algorithms of most brokers are based, either directly or indirectly, on an implementation shortfall model designed Almgren and Chriss (Robert F. Almgren and Neil Chriss. *Optimal Execution of Portfolio Transactions*. Journal of Risk, 3:5–39, 2000.). The Almgren model is participation-based and not opportunistic; it forces the algorithm to follow a specified schedule or participation rate. Over time, some brokers have modified their models to be more continuous in nature but they still force participation, even if the participation rate is set to change over time. In our experience, all of these models (whether static or continuous) result in higher costs because they are inherently less opportunistic.

Similarly, not all opportunistic algorithms are implementation shortfall algorithms. For example, ITG's Dark Opportunistic is not an implementation shortfall algorithm. Our research revealed that like our other opportunistic algorithms, Dark Opportunistic also performed better than most other algorithms during volatile periods. However, we excluded this algorithm from our analysis (as mentioned in *Methodology*) because Dark Opportunistic is not required to finish the order; not needing to finish can favorably affect an algorithm's performance and we wanted to avoid that bias.

Using ITG Algorithms℠ to Reduce Dispersion of Costs in Volatile Markets

Most traders are not interested in solely reducing long-term average cost as measured by market impact. Reducing the dispersion of that cost, is also important and even more so in a high volatility period. The most obvious way to reduce dispersion of cost is by trading faster; however, that method results in higher impact—it is a win-lose scenario.

Traders can also reduce dispersion of cost by executing orders in a way that minimizes the risk associated with an unexecuted basket of orders. For example, if the unexecuted basket is cash-balanced at the industry, sector or entire basket level, it will have lower risk associated with it. Our list-based algorithms use a proprietary risk model that takes into account these factors, as well as others, to minimize the risk associated with the unexecuted portion of the basket. Lower risk associated with an unexecuted basket allows the trader or algorithm to execute more patiently, thus reducing market impact. This approach creates a win-win scenario for traders, and it can also be used in conjunction with increased speed if the trader requires higher levels of risk reduction.

When are List Algorithms Preferable?

There are a few general rules of thumb that traders can use to determine when list algorithms might be advantageous. During volatile market periods, list algorithms are most useful when all of the following apply:

- **Two-sided lists/baskets (vs. one-side baskets).** Many traders use VWAP algorithms to control risk while trading two-sided baskets. A VWAP algorithm does a better job of controlling risk than other single-stock algorithms because the VWAP algorithm spreads the buys and sells in a more evenly dispersed fashion. But basket algorithms like Dynamic IS can do significantly better through residual risk optimization (Fig. 17).

  Has higher volatility had any effect on the rules we just described here? The answer is clearly yes. Not only has volatility increased, but, the correlations among stocks have increased. Our estimate is that average correlation in the high volatility period is 0.73 as compared to 0.35 in the low volatility period. These estimates are based on the average correlation between every pair of stocks in DJIA during these periods. Therefore, a two-sided basket was better hedged in the high volatility period. On the other hand, for single-sided baskets, list algorithms provided a smaller benefit, because there were fewer diversification opportunities in that list due to high correlation among stock.

- **At least 30 stocks.**

- **Duration greater than 30 minutes.**

If list algorithms are not opportunistic (that is if they are schedule-driven) the benefits of lower dispersion of cost may be washed away by higher market impact cost. We found that both market impact cost and spread cost are relatively lower in non-opportunistic algorithms. On the other hand, Dynamic IS's price improvement and dark fill rates are comparable with Active's rates.

For every Dynamic IS list, we construct a matching VWAP list with similar characteristics. Then we measure the performance of the list against order arrival mid-point. The plot shows higher dispersion in VWAP lists versus Dynamic IS lists.

Fig. 17. Dispersion of Cost for Dynamic IS and VWAP

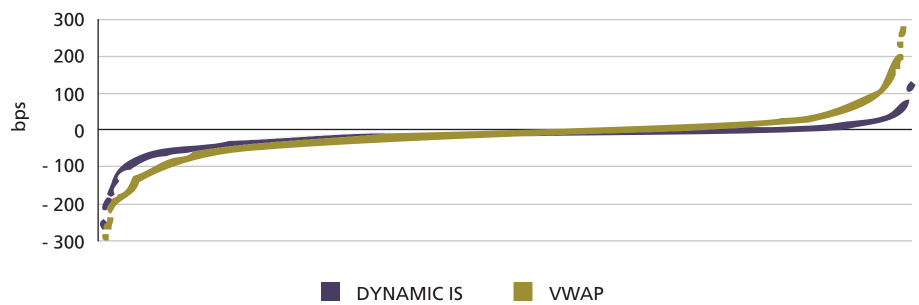


Fig. 18. Price Improvement (bps)

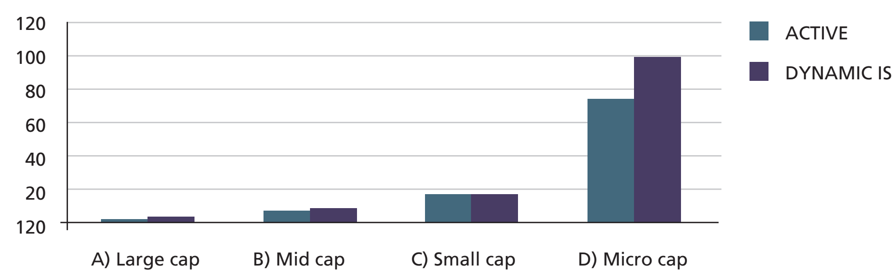
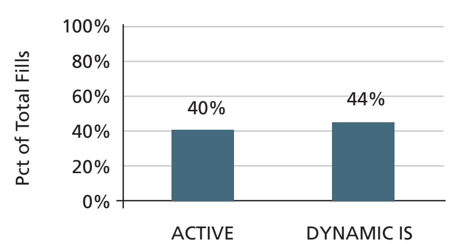


Fig. 19. Dark Fills



When Might Single-Stock Algorithms Perform Better for Lists?

If the lists do not meet the above criteria, then we recommend using single-stock algorithms like Active.

ITG Algorithms℠ for High-Touch Trading in Volatile Markets

There are times when it is preferable for the trader to dictate how the algorithm should behave—for example, when he or she has a specific "view" of the market. What tools are available to assist in these high-touch situations?

Although the opportunistic algorithms prove to be preferable in volatile markets, based on our analysis, they have one limitation. By definition, opportunistic algorithms are the least predictable in terms of their execution style. For example, an order that is 2% of ADV can execute in 10 minutes or 1 hour depending on the market conditions and dark liquidity available in dark pools. This uncertainty makes it more challenging for traders to use these algorithms.
In high volatility periods, if a trader makes the right call about the direction of the market, he can generate significant alpha by controlling the execution style of the algorithm. If a trader has a view of the market direction, then it is desirable to have an algorithm that behaves in tandem with the trader's view. Based on our analysis, we believe that the following algorithms are useful tools for traders to help implement a high touch strategy:

If you need to:	Use this Algorithm:
Change execution speed based on a market view	**Flexible Participation**

Generally, Flexible Participation is best when a trader has specific views on:

- Particular price levels
- Whether the stock will exhibit reversion or momentum
- Whether the stock will go against the market or go along with the market
- Whether execution in dark pools will help or hurt at specific price levels

Flexible Participation is very similar to Volume Participation in that it participates along with the market. The difference is that Flexible Participation gives the trader greater control on varying his participation rate in displayed markets and dark pools based on his views. Our analysis (Fig. 20) shows that performance in Flexible Participation was far better than Volume Participation, which indicates that traders were able to generate some alpha using this algorithm.

Fig. 20. Flexible Participation vs Volume Participation Arrival Cost (bps)

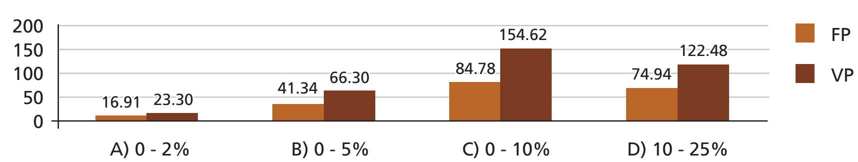
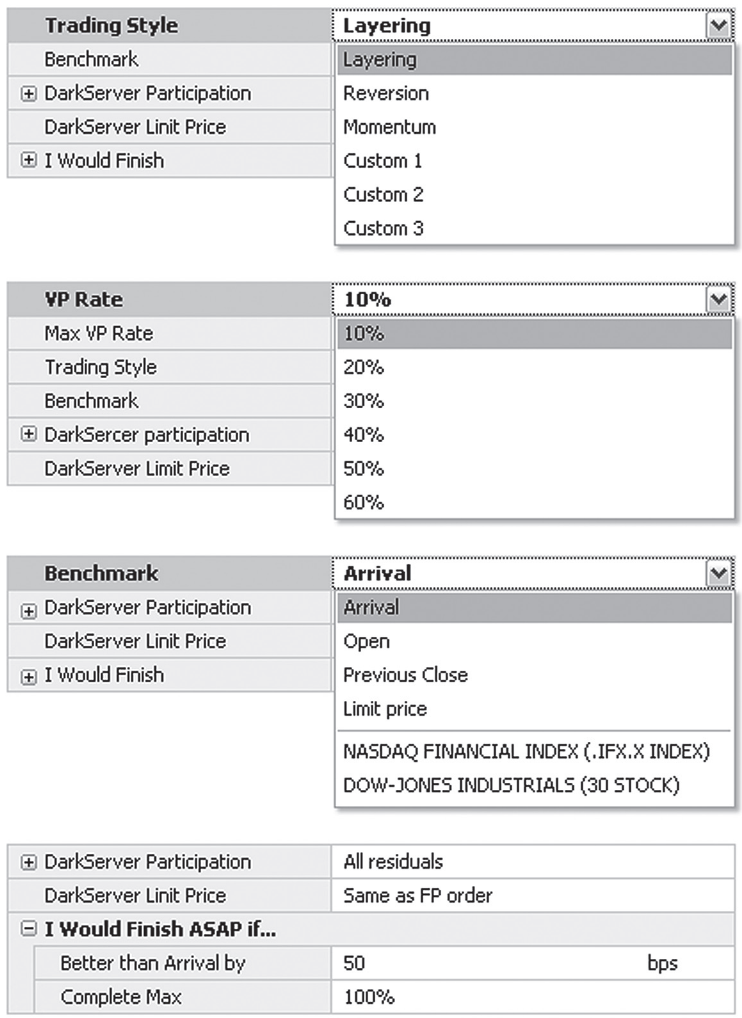


Fig. 21. ITG's Flexible Participation Algorithm



If you need to:	Use this Algorithm:
Finish an order very quickly	**Active with extreme urgency (a.k.a. Active Ex)** ITG's Active algorithm has an extreme urgency setting (Active Ex). It benefits from the opportunistic logic of Active and yet executes at a very high speed, which a trader might desire when the market is moving very quickly. In these situations we recommend Active Ex vs. a participation algorithm with a very high participation rate.

Conclusion

- In volatile markets, using the right algorithm can save up to 60 bps of trading costs, on average.

- Volatility has tripled this year– resulting in wider spreads (almost doubled), lower depth, and higher impact cost (almost doubled).

- Despite these conditions, traders have the power to control and even reduce these costs by choosing the right algorithms and tools.

- Our research shows that opportunistic algorithms (Active and Dynamic IS), overall, perform much better than other algorithms in high volatility periods. Both Active and Dynamic IS:
    - do a far better job of reducing market impact cost by adapting quickly to tough market conditions.
    - can save traders anywhere from 10 bps to 60 bps, on average, in trading costs.
    - beat the pre-trade cost estimates by 10 bps to 60 bps depending on trade size.
    - can achieve Dark Fill rates of 45%, which helps in reducing large spread cost and impact cost.

- Most non-ITG implementation shortfall algorithms are not opportunistic; they are either schedule-based or participation-based.

- Higher volatility has resulted in higher correlations; together, these conditions emphasize the benefit of using list algorithms (Dynamic IS) for two-sided baskets to reduce dispersion of cost and market impact cost.
- Opportunistic algorithms may not be sufficient for high-touch traders who want to make specific market calls. Flexible Participation is the most suitable algorithm in those situations.

- Recommendations:

Trading Style	**Recommendations:**
Low Touch:	• Active for smaller baskets • Dynamic IS for two-sided larger baskets
High Touch:	• Active Ex for orders < 10 minutes • Flexible Participation for orders when trader has a view whether stock will follow reversion or momentum.