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Related analysis:

Jeria & Sofianos, **Passive in SIGMA X: quantifying the trade-offs**, *Street Smart* Issue 36, November 12, 2008

Jeria & Sofianos, **Passive orders and natural adverse selection**, *Street Smart* Issue 33, September 4, 2008

**Goldman Sachs Equity Execution Strategies**

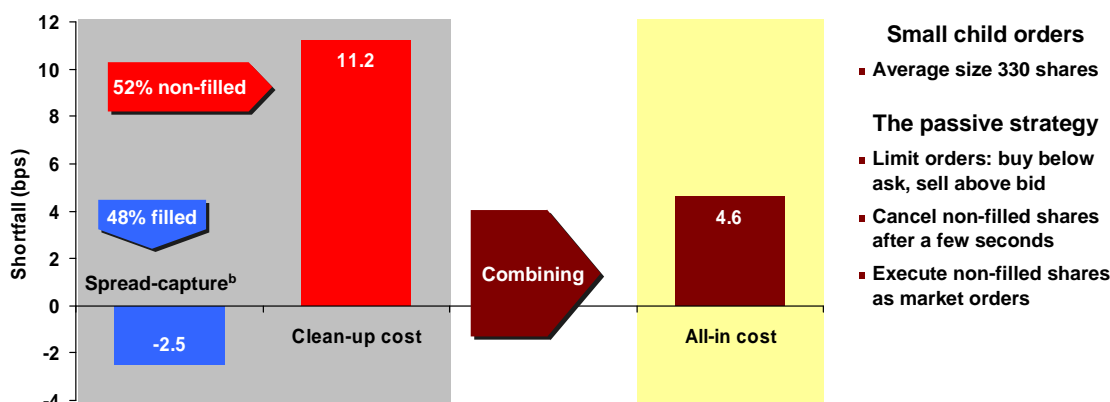
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### The all-in cost of passive limit orders

In this issue of *Street Smart*, we use a unique sample of orders to examine the all-in cost of small passive limit orders.<sup>1</sup> The all-in cost includes both the spread capture on filled shares, but also the often-ignored cost of the clean-up trades for the non-filled shares. The all-in cost is usually difficult to measure because the clean-up trades are hard to identify.<sup>2</sup> The unique sample we use, however, contains the actual clean-up trades for all the non-filled shares, so **we can directly and precisely calculate the true clean-up cost and hence the all-in cost of passive limit orders**. Moreover, our sample also includes aggressive orders so we can directly compare the all-in cost of similar passive and aggressive executions.

Our sample consists of passive and aggressive child orders executed by the Goldman Sachs Piccolo algorithm in April 2009. The Piccolo passive child orders in our sample are non-marketable limits (buy below ask, sell above bid). Piccolo's clean-up strategy cancels any non-filled shares after a few seconds and immediately executes them as market orders.

**Exhibit 1. The all-in cost of passive limit orders<sup>a</sup>**



a. Piccolo algo; 19,821 passive child orders, April 3 to 30, 2009; \$ value-weighted averages.  
b. Relative to the prevailing midquote when Piccolo created the child order.

Source: Goldman Sachs Equity Execution Strategies

Exhibit 1 summarizes our main findings on the passive child orders:

- The fill rate is **48 percent** and on the filled shares the spread capture relative to the prevailing midquote when Piccolo created the order is **2.5 bps<sup>3</sup>**
- On the non-filled shares, the actual clean-up cost relative to midquote is **11.2 bps**
- Combining spread capture and clean-up cost, the all-in cost is **4.6 bps<sup>4</sup>**.

**The 4.6 bps all-in cost highlights the fallacy in the widely-held view that passive orders “capture spread.” This misconception results from ignoring the clean-up cost of the non-filled shares.** The cost of the aggressive child orders in our sample is 4.1 bps (Exhibit 3). **The similar all-in costs on the passive and aggressive orders suggest that Piccolo is close to the optimal passive-aggressive mix.**

Our Piccolo analysis is an example of the Goldman Sachs proprietary **COPE (Child Order Performance Evaluation) framework** in action. We next discuss our Piccolo findings in more detail and conclude with a discussion of how we are using COPE to fine tune Goldman Sachs algo performance.

## The Goldman Sachs Piccolo algorithm

Our sample consists of 19,821 passive and 6,919 aggressive child orders generated by the Piccolo algo over the period April 3 to 30, 2009.<sup>5</sup> Piccolo is designed for traders who want to **execute small orders and are willing to wait a few minutes so as to minimize impact. Piccolo minimizes impact by using an optimized mix of passive and aggressive executions.** The ideal Piccolo order size is less than five times quoted depth. The average Piccolo parent order size in our sample is 675 shares. Our sample includes a mix of large cap (59 percent), mid cap (29 percent) and small cap (12 percent) stocks.

We illustrate Piccolo's logic with an example. Assume Piccolo receives a 2,200 share order and quoted depth is 500 shares. Piccolo will then:

- Place 1,000 shares (twice quoted depth) in an active tranche and the remaining 1,200 shares in an inactive tranche
- Temporarily place the 1,200 inactive shares in SIGMA X, the Goldman Sachs dark pool, pegged at midquote (dark leg)
- Depending on market conditions, either split the active tranche into a 500-share aggressive and a 500-share passive child order, or execute all 1,000 shares passively
- Execute aggressive orders immediately as marketable limits (buy at ask, sell at bid)
- Place passive orders in the public market as non-marketable limits (buy below ask, sell above bid)
- After a brief optimized interval, cancel any non-filled shares and execute immediately as market orders (buy at ask or above, sell at bid or below)

A few seconds after the active tranche fully executes, Piccolo creates a second active tranche from the residual shares in the dark leg. Our analysis focuses on the passive and aggressive orders generated by Piccolo's active tranches.

## Calculating the all-in cost of passive orders

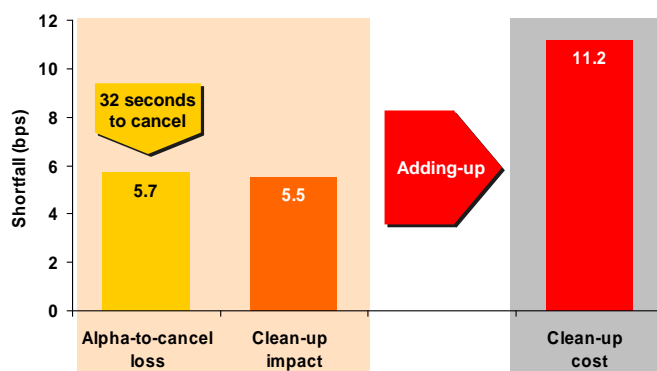
Exhibit 1 summarizes the all-in cost of the passive child orders in our sample. The average child order size is 330 shares. The Piccolo clean-up logic guarantees that these passive orders always fill.<sup>6</sup> The average completion time, including the clean-up trade, is 23 seconds.

We measure spread capture and clean-up cost relative to the prevailing midquote when the algo created the child order. The 2.5 bps spread capture on the filled shares is no surprise. Passive orders *when they fill* capture the spread by design, e.g. buy at bid. **The surprise in**

**Exhibit 1 is the high 11.2 bps cost of the clean-up trade.** To better understand the high clean-up cost, we break it up into two components (Exhibit 2):

1. The **alpha-to-cancel loss** measures how much the price moved away over the interval from when the algo created the order to when it canceled the non-filled shares. In our sample, the average time to cancel is 32 seconds and the alpha-to-cancel loss is 5.7 bps.
2. **Clean-up impact** is the cost of reaching across the market to execute the clean-up trade and possibly walking up the book. We measure clean-up impact relative to the prevailing midquote when the algo canceled the non-filled shares and created the clean-up order. In our sample, the average clean-up impact is 5.5 bps.<sup>7</sup>

### Exhibit 2. Clean-up cost components



a. Piccolo algo; 19,821 passive child orders, April 3 to 30, 2009; \$ value-weighted averages.

Source: Goldman Sachs Equity Execution Strategies

**The alpha-to-cancel loss, therefore, accounts for more than half of the clean-up cost and is the main reason the clean-up trade is so expensive.** The high alpha-to-cancel also highlights the effect of **natural adverse selection** on passive executions.<sup>8</sup>

## Comparing passive with aggressive executions

The Piccolo aggressive child orders in our sample are of similar size and in similar stocks as the Piccolo passive child orders in Exhibit 1. The cost of these aggressive orders, therefore,

provides an estimate of what the cost of the passive orders would have been had Piccolo executed them aggressively instead of passively. In Exhibit 3 we compare the all-in cost of the passive and aggressive Piccolo child orders in our sample.<sup>9</sup> The cost of the aggressive orders is 4.1 bps, slightly lower than the cost of their passive orders (4.6 bps).<sup>10</sup>

Exhibit 3 illustrates (once more<sup>11</sup>) the fallacy in the widely-held view that passive orders “capture the spread.” This popular misconception results from ignoring the clean-up cost (11.2 bps in our sample) of the non-filled shares.

But if the all-in cost of passive orders is close to the all-in cost of aggressive orders, what are the advantages of a passive strategy? A passive strategy has two main advantages:

- **Splitting an order into passive and aggressive legs lowers market impact by reducing the average order size.** Simultaneously executing 1,000 shares passively and 1,000 shares aggressively has less impact than executing 2,000 shares aggressively.<sup>12</sup>
- **Passive executions are less visible than aggressive executions.** Tape watchers often interpret prints above the midquote as indicating buy pressure and below the midquote as indicating sell pressure. Tape watchers, therefore, will interpret the execution of a passive buy order at the bid as sell pressure, reducing the information leakage of the buy order.

Exhibit 3 also suggests that **Piccolo is close to the optimal mix of passive and aggressive executions.** If the cost of the passive leg, for example, was much higher than the cost of the aggressive leg, Piccolo should be executing fewer shares passively and more shares aggressively.

## COPE and optimizing algo performance

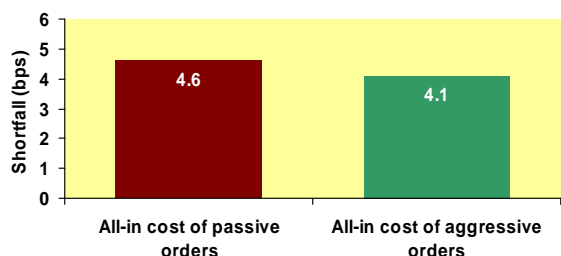
Our Piccolo analysis is an example of the Goldman Sachs proprietary COPE (Child Order Performance Evaluation) framework in action. We are developing COPE to help us optimize algo performance. COPE breaks up each algo into its main components. In our Piccolo example, COPE breaks up the algo into the inactive and active tranches, further breaks up the active tranche into the passive and aggressive orders, and the inactive tranche into the time sequence of active tranches. COPE then evaluates each component separately and can easily isolate where the algo logic may need improvement. Moreover, as we make improvements, COPE allows us to perform a targeted and hence more powerful evaluation of just the component we are changing.

Here are two examples of how we are using COPE to fine-tune Piccolo:

- Gradually adjust the cancel time on the passive orders to minimize the all-in cost. Waiting longer to cancel increases the fill rate but also increases the clean-up cost. The all-in cost, therefore, may go up or down and the optimal cancel time is an empirical question.
- Gradually adjust the aggressive-passive mix to reach the optimal balance. Exhibit 3 suggests we are close to the optimum, but with the passive orders slightly more expensive than the aggressive orders, Piccolo may benefit from a slight tilt away from passive.

The most important take-away from our analysis, however, is that **in order to optimize execution strategies, we must estimate the all-in cost, including the clean-up cost, of each strategy we are exploring.**

### Exhibit 3. Passive and aggressive compared<sup>a</sup>



a. Piccolo algo: 19,821 passive & 6,919 aggressive child orders, April 3 to 30, 2009; \$ value-weighted averages.

Source: Goldman Sachs Equity Execution Strategies

<sup>1</sup> Our current analysis continues the evaluation of passive orders we began in two earlier *Street Smart* reports, "Passive orders and natural adverse selection," Issue 33, September 4, 2008 and "Passive in SIGMA X: quantifying the trade-offs," Issue 36, November 12, 2008.

<sup>2</sup> In our earlier empirical analysis of passive orders (*Street Smart* issue 36), our sample consisted of passive orders clients placed directly in SIGMA X, the Goldman Sachs dark pool. The SIGMA X sample did not have the clean-up trades so we had to construct estimates of the clean-up cost based on the size of the clean up trade, the order's alpha to cancel and impact estimates generated by the Goldman Sachs trading cost model.

<sup>3</sup> As usual, our trading cost measure is execution shortfall. We use the term "spread capture" to indicate negative shortfall. Throughout, we measure shortfall relative to the prevailing midquote when Piccolo created the child order.

<sup>4</sup> We calculate the all-in cost as: \$ value of filled shares (at fill price) multiplied by shortfall on filled shares (in bps) plus \$ value of clean-up shares (at clean-up price) multiplied by shortfall on clean-up shares (in bps) divided by sum of \$ value of filled shares and \$ value of clean-up shares.

<sup>5</sup> Piccolo generates the 26,740 passive and aggressive child orders in our sample from 14,129 parent orders. We exclude parent orders with limit prices (a small percentage) and odd lot parent orders.

<sup>6</sup> Clients occasionally (rarely in our sample) cancel orders before Piccolo had the chance to completely fill them.

<sup>7</sup> The Piccolo clean-up orders are similar to the Piccolo bona fide aggressive orders. The clean-up impact however (5.5 bps) is higher than the cost of the aggressive orders (4.1 bps). There are three main reasons for this. (a) Because of natural adverse selection the clean-up orders will typically execute in less favorable market conditions than the bona fide aggressive orders. (b) The bona fide aggressive orders have a tight marketable limit price that prevents walking up the book. (c) When there is a simultaneous passive and aggressive leg, the passive leg clean-up may execute close to the aggressive execution without providing time for liquidity to be replenished.

<sup>8</sup> See Jeria & Sofianos, "Passive orders and natural adverse selection," *Street Smart* Issue 33, September 4, 2008.

<sup>9</sup> The aggressive orders are marketable limits so a small fraction (4 percent in our sample) does not fill. Piccolo then uses similar clean-up logic as for the passive orders: after a few seconds it cancels the non-filled shares and executes them as market orders, possibly walking up the book. Our 4.1 bps cost estimate for the aggressive orders is the all-in cost including the clean-up cost of the non-filled shares.

<sup>10</sup> Our finding that the all-in cost of small passive orders is close to the cost of similar aggressive orders is reassuring because it suggests that markets correctly price the natural adverse selection risk faced by passive orders and have the right balance of small passive (liquidity-providing) and aggressive (liquidity-taking) orders.

<sup>11</sup> We also highlighted this important point in Jeria & Sofianos "Passive in SIGMA X: quantifying the trade-offs," *Street Smart* Issue 36, November 12, 2008.

<sup>12</sup> In designing the optimal cancel strategy for the passive leg care is needed to make sure that the clean-up trade for the passive order is not too close to the execution of the aggressive order.

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