Liquidity Begets Liquidity:
Implications for a Dark Pool Environment

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Abstract

Dark liquidity pools have emerged and proliferated in recent years. Do they lower market quality or are the worries about them much ado about nothing? It is not possible to answer this question without understanding the dynamics of liquidity creation and the sidedness of markets (the extent to which buyers and sellers are both actively present in a market in roughly equal proportions). In this paper, we summarize our findings on sidedness, and discuss their implications for liquidity generation in general and for the development of dark pool liquidity in particular. Our study has implications for algorithmic trading, transparency, and the effect of order flow fragmentation on liquidity creation.

In recent years we have seen the dramatic emergence and proliferation of so-called dark liquidity pools. These pools are generally privately run markets that cater to clients' efforts to realize large-volume trades with minimal price impact, an objective that typically calls for pre-trade opacity. By using a dark pool, a client can submit an order anonymously without revealing its side, size, or price. A dark pool is typically structured to give minimal information leakage about the very existence of an order. That is why it is called a dark pool.

Dark liquidity is not a recent phenomenon. As Domowitz, Finkelshteyn and Yegerman (2008) note, crossing systems (which are essentially dark pools) arrived on the scene as early as 1986.[1] Moreover, hidden orders have always been present in the mainstream markets. But the recent proliferation of dark pools has raised concerns for the very reason that they are dark, that they are not transparent, that their interaction with

[1] "Cul de Sacs and Highways," by Ian Domowitz, Ilya Fikelshteyn and Henry Yegerman, ITG Group Working Paper, 2008.

order flow directed to the broader market is limited. Can all of this lower market quality and, concurrently, make it more difficult for regulators to monitor the trading? Or are these worries about dark pools and the attendant reduction in overall market transparency much ado about nothing?

We suggest that it is not possible to comprehend dark pools without understanding the dynamics of liquidity creation. What leads orders that are hidden inside dark pools, orders that are hidden in limit order books and, even more so, orders that are in traders' pockets, to meet in a marketplace and be turned into trades? And, on the other hand, what is it that can prevent buyers and sellers from coming together and meeting each other when they all want to trade? Understanding the dynamics of liquidity creation can provide answers to these questions and, in the process, shed some light on what might be going on in the dark pools.

All markets, light and dark alike, face the following conundrum. For a large trader, shedding the light of transparency on his big order can be disastrous if the contra-side is not there. But, if all orders are dark, what can a trader expect may be in a liquidity pool? What kind of orders does a particular dark pool attract, benign or toxic? Some information about what is there may be gleaned from examining the most recent trades that have been consummated in a dark pool. To the extent that it is post-trade transparent, however, a dark pool may not be quite so dark.

The key aspect of markets that we address here is the extent to which they tend naturally to be two-sided (i.e., buyers and sellers are both present in roughly equal proportions), or are one-sided (i.e., a market is comprised predominantly of buyers or of sellers). A further question is whether orders and trades cluster in time [i.e., whether the

arrival of more buyers (or sellers) attract the arrival of more sellers (or buyers), or not]? These two questions together address the dynamic nature of liquidity creation, and answers to them can be useful to the large trader who is considering where and how to place a big order.

In our own research, we have gone back into history and looked at other liquidity pools that are not so dark (i.e. the NYSE and NASDAQ) in order to achieve a more fundamental understanding of the liquidity composition of markets. Concerning the joint presence of both buyers and sellers, we find, over a wide range of conditions, that markets are generally two sided, that trading begets trading, that liquidity begets liquidity. We further find that buyers and sellers tend to arrive in clustered fashion so that, within a day, two-sided trade bursts occur, interspersed with periods of relative inactivity. We consider the implications that these findings have for liquidity creation in general, and for dark pool liquidity in particular.

The multiplicity of dark pool systems has contributed to the fragmentation of the order flow. Technological solutions (for example, liquidity aggregators and smart order routers) have been seen as antidotes to the potentially detrimental effects of fragmentation, but it is not at all clear that connectivity will ever truly put Humpty Dumpty together again. With multiple, imperfectly integrated dark pools, the collective informational content of the order flow is impaired, liquidity creation is impaired, and it is more difficult for willing counterparties to find one another.

In this paper, we present our definition of sidedness, summarize our findings on sidedness, and discuss their implication for liquidity generation in general and for the development of dark pool liquidity in particular. Of particular importance, our study of

sidedness has fresh implications regarding the effect that order flow fragmentation might have on liquidity creation.

Dark Pools and Algorithmic Trading

Dark pools have a significant presence in the market. Rosenblatt Securities calculates that the 18 dark pools which it tracks accounted for 788.1 million shares (single counted) worth of trading volume in July 2008, comprising 8.18% of total U.S. equity trading volume. In all, roughly 40 dark pools are currently in operation, with rival platforms being offered by bulge bracket firms including Goldman Sachs, Morgan Stanley, Credit Suisse, and UBS. Using a dark pool can decrease transaction costs for the large trader if the other side is there in size. At the same time, however, the proliferation of these pools can be having a negative liquidity impact.

A concurrent and closely related market development is the advent of algorithmic trading. Algorithms search electronically for hidden liquidity which they seek to access at reasonable prices. As Domowitz, Finkelshteyn and Yegerman (2008) point out, algos have allowed dark pools to exist at a smaller liquidity scale, thus enhancing the viability of dark pool business models. However, these authors also find that algos do not help to reduce transaction costs and increase execution sizes, and so this technological solution to fragmentation appears to be deficient.

Our measure of *market sidedness* is intended to capture the ease with which counterparties can find each other in a market (a process that is referred to as "quantity discovery"), and it is intimately related to the depth of the order book, a traditional aspect of liquidity. By focusing on the sidedness variable, we can see how fragmenting order

flow into multiple dark pools might pose a threat to market liquidity. In particular, we show that fragmentation may lead to more one-sided markets and, consequently, to higher trading costs as buyers find fewer sellers to meet, and sellers find fewer buyers.

Market Sidedness: Definition and Discussion

The *sidedness of markets* refers to the extent to which buyers and sellers are both present in the market at the same time. As we have noted, a *buyers only* or a *sellers only* market is "one-sided," while a market that is comprised of both buyers and sellers in roughly balanced numbers is "two-sided." Trades rather than traders, however, are classified and counted. By matching a trade price with the quotes that prevailed at the time that a transaction has occurred, we are able to classify the trade as buy-triggered (e.g., a trade priced at the offer would be so classified) or as sell-triggered (e.g., a trade priced at the bid would be so classified). The sidedness of a market can be assessed according to the balance, within a relatively brief interval of time, between buy-triggered and sell-triggered trades.

In our research, we have used a more stringent definition of market sidedness.[2] We measure it as the *correlation* between the number of buy-triggered trades and the number of sell-triggered trades in a particular security over a sequence of brief (five minute) time intervals. A high and positive correlation indicates a more two-sided market, while a low positive or negative correlation indicates a more one-sided market. When the correlation between buyer-initiated trades and seller-initiated trades is high and

[2] Our key findings are reported in Asani Sarkar and Robert A. Schwartz, "Market Sidedness: Insights into Motives for Trade Initiation," *Journal of Finance*, 2008, forthcoming.

positive, buyers and sellers are both active in the market at the same time, and it is relatively easy for traders to find counterparties. When the correlation is low and the market is more "one-sided," it is more difficult for a trader on the heavy side of the market to find a willing counterparty.

Market sidedness is related to three traditional aspects of liquidity: immediacy, depth, and the size of bid-ask spreads. When a market is two-sided, it can offer a high level of immediacy, as traders on either side of the market have relatively little difficulty finding willing counterparties with whom to execute a trade. A two-sided market should also offer a high level of depth, as anyone wishing to trade in one direction should have access to others who wish to trade on the other side of the market. A two-sided market may also have relatively narrow bid-ask spreads, as buyers competing with buyers, and sellers competing with sellers, naturally tightens the quotes. Conversely, a one-sided market would be associated with reduced liquidity in all three dimensions: less immediacy, lower depth, and wider bid-ask spreads.

The sidedness of a market can be influenced by the conditions that motivate trading. A market driven by asymmetrically informed traders would be one-sided. For example, if some traders have bearish news that is not generally known, there is likely to be a predominance of sell orders. In such a market, we would expect to see high price volatility, toxic order flow, and high trading costs. A market driven by divergent expectations and/or by differential information would be two-sided as bears and bulls are both active participants. In the two-sided case, we would expect to see high price volatility, a more benign order flow, and a large number of trades.

We also expect market sidedness and the bid-ask spread to interact dynamically. Whereas a two-sided market may result in low spreads, low spreads in turn may lead to two-sidedness as more traders on both sides of the market react to lower trading costs by submitting more trade triggering market orders.

Market Sidedness and Liquidity: Empirical Evidence

In our empirical analyses of U.S. equities, we have examined the association between sidedness, volatility, trading volume, and bid-ask spreads using simultaneous equations estimation on a sample of NYSE and Nasdaq stocks during the period January-May 2003. The evidence is strong that market sidedness is an important determinant of trading intensity and price volatility, with more two-sided markets being associated with more trades and higher volatility. Examining the reverse direction of causality, we find that high volatility, high trading intensity, and low effective bid-ask spreads all predict that markets will be more two-sided.

Our research indicates that markets are generally two-sided. Specifically, the numbers of buy-triggered trades and sell-triggered trades in five minute intervals are positively correlated. This finding is robust under a range of market conditions. Two-sidedness generally holds under different market structures (NASDAQ and NYSE stocks), at all times of the trading day (at the open, mid-day, and at the close), on days with stock-related news as well as on days with no relevant news, and for different order sizes (both large and small). Markets are seen to be two-sided both for stocks in aggregate, and for individual shares. For instance, among the 41 NYSE stocks in our sample, the average correlation between the number of buy-triggered trades and sell-

triggered trades in five minute windows was 0.49, while the average correlation for a matched sample of NASDAQ stocks was 0.60. The correlation for large orders is 0.57 in the NYSE stocks and 0.69 in the NASDAQ stocks.

Along with having discovered the ubiquity of two-sidedness in terms of the correlation between buy-triggered and sell-triggered trades, we have observed something else. We have found that two-sided markets cluster in time. In other words, periods with little trading tend to be interspersed with periods of heavy trading by both buyers and sellers. For this to occur, a significant number of orders on both sides of the market must be latent. That is, traders on both sides of the market must be waiting for something to happen before they reveal their own orders to a trading system. When that something does occur, the traders step forward, and they do so on both sides of the market. Buyers coming forth attract sellers; sellers coming forth attract buyers. It is in this sense that liquidity builds on both sides of the market. It is in this sense that "liquidity begets liquidity."

We observe high persistence for volatility and trading intensity. Of particular interest is the fact that market sidedness is itself highly persistent. This suggests that a two-sided market is likely to remain two-sided, with new traders entering on both sides, and that a one-sided market, when it does occur, is likely to remain one-sided (presumably traders who believe themselves to be at an informational disadvantage are discouraged from entering the thin side of a market).

Combined with our finding that two-sided markets are associated with higher liquidity, the persistence of market sidedness has strong implications for the dynamics of liquidity creation. Simply put, liquidity begets liquidity, and illiquidity begets illiquidity.

That is, liquid and two-sided markets tend to attract both additional buyers and additional sellers, responses that reinforce liquidity provision by lowering bid-ask spreads and increasing the depth of the book. Conversely, it appears that illiquid and one-sided markets tend to discourage traders from entering the relatively unpopulated side of a market, a response that leads to continued market illiquidity.

These findings have important implications for the dynamics of liquidity creation in dark pool environments, and for the role of algos therein. The findings have further implications for the fragmentation of markets. We next enumerate some of these implications.

Into a Dark Pool Lightly

To what extent do the insights that we have gleaned concerning the two-sidedness of markets, trade clustering, and liquidity creation in the so-called light pools (the NYSE and NASDAQ) apply to the dark pools? Can liquidity build as effectively in a dark pool as in one that is relatively light? The dynamics of liquidity creation that we have observed yield several implications:

1. A "transparent market" may itself be fairly dark. Disclosing orders on an open limit order book provides valuable pre-trade transparency, but large participants do not fully reveal their orders to an open book. There are hidden orders, iceberg orders, orders with special conditions on them, and so forth that prevent them from being entered on a strict price and time priority limit order book. More importantly, there are orders that have not been entered into the market at all,

which are sitting in traders' pockets. These orders represent latent liquidity. Our evidence suggests that latent liquidity gets tapped when trading heats up in the marketplace. Apparently, even in the so-called transparent markets, trading begets trading, and liquidity begets liquidity because of the latency of orders.

2. Our evidence that markets are generally two-sided, not one sided, strongly suggests that much trading is motivated, not because some traders are better informed than others (i.e., because of asymmetric information, which would lead to more one-sided markets), but because traders differ in their assessments of share value (i.e., have divergent expectations, which would lead to more two-sided markets). To what extent can dark pools provide two-sided liquidity? Orders from better informed investors make a dark pool toxic, which enervates liquidity creation; conversely, orders motivated by differential expectations reduce the toxicity of dark pool order flow and lead to mutually beneficial trading. Yet either way, as Mittal (2008) argues, an execution in a dark pool contains information that strategic traders and smart order routers are able to exploit.[3] The information leakage from dark pools is more likely greater, Mittal finds, when the dark pool order flow is delivered by smart order routers that also interact with displayed order flow (the interaction makes it easier for traders to figure out what is going on).

[3] "Are You Playing in a Toxic Dark Pool? A Guide to Preventing Information Leakage, " by Hitesh Mittal, *Journal of Trading*, Volume 3, No. 3, Summer 2008.

3. Algorithmic trading has become prevalent in the industry in recent years. Our evidence that high volatility, high trading intensity, and low effective bid-ask spreads predict that markets will be more two-sided, coupled with the substantial persistence which we have observed for all of these variables, suggests that participants can form liquidity expectations about a market even in the absence of pre-trade transparency, and that profitable order placement algorithms can be based on these expectations. Algorithms formulated with repect to post-trade information can help both in selecting the specific dark pool to send an order to, and in determining how best to market-time an order that is being sent to the dark pool of choice. It appears that algos which explicitly consider the sidedness of markets can enhance performance.

4. Algorithms themselves should, collectively, be two-sided; if not, they could destabilize a market. Some algos are momentum plays while others are contrarian strategies. The balance between the two resembles the balance between market orders (which are liquidity absorbing) and limit orders (which are liquidity providing). Momentum algos have the same effect as one-sided market orders. Contrarian algos can involve the use of two-sided limit orders. The existence of one kind of algo can support the profitability of the other kind, provided that both types of algos interact in the same dark pool. Order flow generated by heterogeneous algos can be naturally two-sided.

5. Opacity is one thing, fragmentation is another. The natural tendency of markets may be to be two-sided, but fragmenting one large pool into multiple smaller pools can under-cut the natural two-sidedness of markets. One small pool, by chance, may receive orders predominantly from sellers while another small pool, also by chance, is receiving orders predominantly from buyers. Together, the pools would be two-sided; separately, they are not. This is a law of large numbers result: flip a fair coin many times and the proportion of heads will be very close to 0.5; flip it just a few times and either heads or tails may, by chance, predominate.

6. Dealer markets are a good example of the effect that multiple markets can have on the sidedness of a market. One dealer may, by chance, be seeing predominantly buyer-driven order flow while another, also by chance, is seeing predominantly seller-driven order flow. This is one reason why market share is so important in a dealer market: larger market share provides a better reading of the market. When the sidedness of order flow is different for different dealers, differential inventory imbalances result and this leads to inter-dealer trading. The inter-dealer trading effectively disperses the sidedness differentials across the dealer firms and balances the markets. Connectivity between multiple dark pools could possibly achieve the same end, but it is not clear that it does.

Dynamic Liquidity Creation

Liquidity does not just happen, it does not simply appear. Rather, liquidity is generated in a dynamic environment that may be thought of as an ecology. In that

ecology, and for their own reasons, some participants want to buy while others are looking to sell; some are eager to trade and will absorb liquidity, while others are patient and will supply liquidity; and some may be better informed than others, some may be differentially informed, and many, in possession of the same information, may simply have different expectations about where a stock's price may be heading. Underlying all of the above is the reality that diversity is required for markets to be two-sided, and it is the two-sidedness of markets that underlies liquidity creation.

Our findings from two so-called light pools (the NYSE and NASDAQ) suggest that markets are naturally two-sided under a wide array of conditions (time of day, market structure, on news days, on non-news days, for larger orders and for smaller orders). We also observe that trades tend to cluster in time. Will the dynamics of liquidity creation work similarly in the dark pools? Our discussion suggests that it may, but the conclusion should not be taken for granted. The actual sidedness of a dark pool market depends critically on the balance between how well it contains pre-trade information leakage while, at the same time, disclosing critical post-trade information to its customers.

As we all know, opacity is needed by the big players. The large traders seek the protection of opacity by either going to a dark pool or, when going to a more transparent limit order book market, by hiding their orders in a stream of retail flow by slicing and dicing them. Nevertheless, there is post-trade reporting for all trades, information can be gleaned on the general sidedness of markets, and smart algos can either help to provide liquidity, or they can game an opaque environment and, in so doing, undermine liquidity creation. The efficacy of liquidity creation hangs in the balance.

Opacity is one thing, fragmentation is another matter. Whether liquidity pools are light or dark, fragmentation can disrupt the natural two-sidedness of markets. We have noted for a dealer market that inter-dealer trading can effectively disperse sidedness differentials across competing dealer firms. Can connectivity between the roughly forty dark pools that exist today be equivalently effective? Inter-dealer trading is an economic response on the part of dealers, while connectivity, in and of itself, is only a technological linkage. The real concern about the dark pools of today should not be that they are dark; it should be that connectivity may not be a viable substitute for consolidation.

It is well known that order flow attracts order flow. We have also seen that, over time, the equity markets have always tended to consolidate. Consolidation and two-sidedness are natural processes for an equity market. They are the main dynamics that underlie liquidity creation. However, modern technology facilitates the increased fragmentation of markets, and it supports the possibility of increasingly fragile, one-sided markets proliferating. True, technology also promises greater integration of markets, but such liquidity aggregation may prove inadequate. The extent to which the natural two-sidedness of markets stays resilient in the face of these developments remains to be seen.