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Dark pools in European equity markets: emergence, competition and implications

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Contents

Abstract

This paper considers the growth of dark pools: trading venues for equities without pre-trade transparency. It first documents the emergence and expansion of dark pools in European equity markets in the context of regulatory changes and increased high-frequency trading (HFT). It finds that the market share of trading conducted in dark pools has stabilised below 10% and is similar across groups of stocks from different countries. Second, this paper assesses the nature of competition between dark pools, which is based on price and services offered to clients. It documents a substantial degree of horizontal differentiation among European dark pools, with venues providing different options for placing and processing orders likely to attract different types of traders. The hypothesis that most dark pools are primarily used to shield large orders from information leakage is not supported by evidence. This finding is based on a simple indicator that assesses different dark pools in terms of the level of protection from information leakage due to trading with HFT or predatory traders. Finally, this paper evaluates the benefits and costs of the use of dark pools from the perspective of individual traders as well as for market efficiency and financial stability. Recent evidence appears to reject the notion that dark pools adversely affect volatility in stock markets.

Keywords: Dark pools, equity markets, market microstructure, liquidity, financial stability

JEL codes: G10, G14, G18

Non-technical summary

A growing share of equities trading in Europe has been moving away from traditional national stock exchanges to other venues. Dark pools are one of the new types of venues that have emerged; unlike lit trading venues where volumes of buy and sell orders looking for execution are displayed in an order book, dark pools do not have any pre-trade transparency. This paper analyses the growth of dark pools in Europe from 2009 to Q2 2016, with a focus on understanding the types of dark pools that have emerged, the conditions that determined their growth, and the benefits and costs to individual traders and for market stability and efficiency.

The demand for dark pools in Europe in recent years has increased in part due to regulatory changes regarding transparency. The Markets in Financial Instruments Directive (MiFID), which came into force in 2004 and was implemented in 2007, set uniform pre-trade transparency requirements across European equity trading venues, with a few exceptions (through special waivers). The increased level of transparency led to concerns among market participants that information regarding their orders could be detected and used by other traders before execution. Dark pools allowed concerned market participants to continue trading “in the dark”: by choosing a special pricing mechanism – matching orders at reference prices from other markets – dark pools could apply the pre-trade transparency waivers in MiFID.

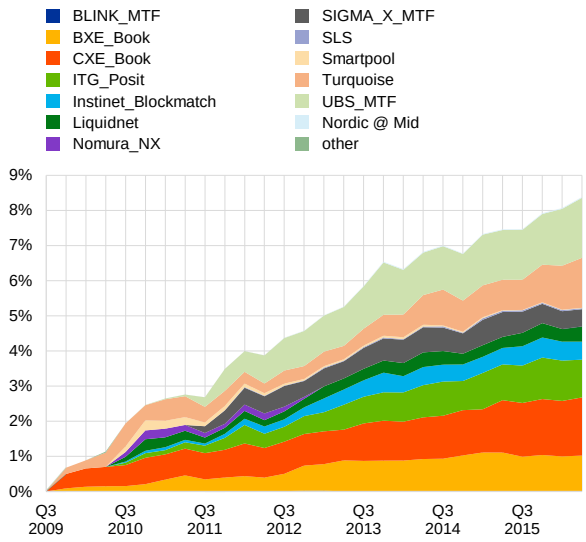
Another factor driving the demand for dark pools in recent years is the increased prevalence of traders who rely on obtaining and acting on information about existing orders in the market to make a profit. Technological advances allowed these traders to use algorithms to detect changes in demand and supply in order books and to rely on superior latency, i.e. faster trading, to take advantage of this information (including through predatory practices such as front running); their presence can lead to losses for other investors, especially those placing larger orders[1]. By limiting pre-trade transparency, dark pools reduce the risk that information about an order reaches such traders before execution. Moreover, some dark pools offer additional features in order placement and processing which reduce the chances of clients interacting with algorithmic traders employing predatory strategies.

[1] Vaananen (2015).

Chart 1

Market share of dark pools in trading in European stocks

(percentage of total volume traded, by value)



Sources: Bats Global Markets and authors' calculations.

Owing to a combination of these factors, the share of European equity trading conducted on dark pools has expanded rapidly in recent years, growing from less than 1% in 2009 to over 8% in 2016, as seen in Chart 1. Chart 1 further illustrates that multiple dark pools have emerged, competing for market share; most of these venues offer trading in a large number of equities listed in different countries.[2] Owing to the benefits of scale (offering sufficient liquidity to be able to match trades), there is a natural limit to the number of active dark pools; liquidity is concentrated in a few large venues which offer trading in a variety of instruments. Newer dark pools have attempted to target specific client bases, with some specialising only in large orders, and others focusing only on a few equity groups. Many dark pools operators also operate traditional (lit) order book exchanges, giving them access to a ready-made client base.

The market for dark pools is significantly less concentrated than the one for lit order books. For the latter, the primary exchange is dominant in each country and there are only two or three other exchanges with substantial volumes of trading. For dark pools, more venues are active in the stocks listed in each country, with none capturing more than 25% of the volumes traded on dark pools overall. The lower concentration may be due to a higher degree of horizontal differentiation among dark pools.

Competition between dark pools is based on price and quality. In addition to fees and price improvement, dark pools in Europe also compete by offering different order types and matching mechanisms. Some venues offer additional features to limit interactions with certain algorithmic traders, through restrictions on order types or by establishing a matching process that eliminates the advantage of speed. An indicator for the level of additional protection offered by different dark pools is generated to consider the development of market shares of dark pools that have more or less protection. The market share of venues that offer more options for additional protection has increased more quickly recently, doubling in recent years to reach 2.9% in Q2 2016. However, some of the largest European dark pools offer a few additional protection features, contradicting the hypothesis that protection against informational leakage is the most important feature of dark pool competition. Instead, prices and liquidity supply – which affect the probability of rapid execution – may be more important in shaping demand for each venue.

Regulators and financial authorities from the United States and Europe have expressed concerns regarding the effect of trading fragmentation between competing lit and dark venues on the quality of the price discovery process and on

[2] The listing refers to the location of the primary exchange (the London Stock Exchange, Deutsche Börse, etc.) where the equity is listed.

market liquidity. Competing theories present different mechanisms through which trading in dark pools can affect equity price volatility, but empirical evidence does not substantiate higher volatility resulting from the growth of dark pools in Europe.

The role of dark pools in equity markets, and their relationship with liquidity and stability, is particularly relevant in the light of the expansion of pre-trade transparency requirements to new instruments under MiFID II, which will come into force in January 2018. Moreover, as dark pools may expand to fixed income markets and as secondary market liquidity for fixed income is already a top financial stability risk, it is important to anticipate the role of dark pools in any changes to the structure of trading in these markets.

1 Introduction

In recent years, technology and regulation have rapidly transformed the landscape of equity trading in Europe. New trading venues and new types of traders have emerged, affecting the costs of trading for different participants. The growth of dark pools, trading venues where information about orders is not displayed before execution, has been one aspect of these structural developments. Dark pools have less transparency than "lit" exchanges, which display aggregated volumes of current orders to buy or sell at different prices.

Dark pools have grown in response to investors' demands for protection against information leakage in a rapidly changing trading environment. Regulation making more pre-trade transparency mandatory on the majority of European equity trading venues (MiFID I), as well as the growing presence of algorithmic traders who use latency advantages to obtain and act on information about supply and demand in order books, led investors to seek dark trading alternatives. A survey conducted by the Financial Conduct Authority (FCA) in 2016 found that individual users of dark pools welcome the lower risk of information leakage and the potential lower costs associated with using dark pools. Nevertheless, dark pools are not a panacea for vulnerable traders: investigations conducted by the US Securities and Exchange Commission (SEC) on US dark pools have found that many such venues are failing to provide the protection claimed and sometimes take advantage of clients.

A central focus of this paper is the landscape of competition between European dark pools. Competition between equity trading venues is driven by two opposing forces: first, externalities and economies of scale imply that traders benefit when liquidity is consolidated in one venue, increasing the probability of execution, securing a better price (lower spread) of execution, and reducing search costs. On the other hand, no single venue can serve the interests of all investors – in their motivation, size, type and frequency of orders – resulting in horizontal differentiation between venues in terms of the services offered and the clients targeted.[3] Previous theoretical analysis shows that when two venues differ in liquidity and entry costs or in the type of trading mechanisms, there is a stable separating equilibrium where both venues are active.[4]

For dark pools, these tensions imply that competition occurs in terms of both price and services. As trades are executed at reference prices determined from external venues (and usually calculated in similar ways across dark pools), the difference in the price of using different dark pools depends on liquidity. Liquidity – the volumes available and the order size – affects the speed and probability of execution. On the other hand, horizontal differentiation prevents full consolidation on a single venue. Different dark pools offer, inter alia, different options for order types and matching mechanisms. For dark pools, such differentiation appears to be more important than for traditional lit order books, as the market for dark pools is less concentrated.

3 Gomber et al. (2016).

4 Pagano (1989).

The effect of dark pools on the integrity and stability of financial markets is still being debated. When dark pools first emerged, regulators and financial authorities expressed concern about two mechanisms through which dark trading could have negative effects on market stability. First, trading in dark pools reduces the information available for the price discovery process, which relies on visible information about supply and demand volumes contained in order books. Price discovery is a public good that benefits all traders; without sufficient information, prices may become more volatile and uncertain, reducing market stability and hindering the ability of participants to identify trading opportunities. A second area of concern resulting from the growing number of dark pools is the potential for liquidity fragmentation, which can increase search costs and reduce market efficiency.[5]

Understanding the impact of dark pools on market stability is of particular relevance given the upcoming regulatory changes under MiFID II/MiFIR, which extend uniform pre- and post-transparency requirements for trading to additional financial instruments, including fixed income. These changes entail the possibility that dark pools will be used for additional instruments, including in secondary fixed-income markets, which have been identified as a primary concern for financial stability. Understanding the effects of such a structural shift in trading on market functioning can help anticipate potential effects on liquidity and volatility in these markets.

This paper focuses on assessing the growth of and the competition between dark pools in Europe. Section 2 addresses the historical events – regulatory changes and developments in algorithmic trading – that precipitated the emergence of dark pools in Europe. Section 3 considers the advantages and disadvantages of using dark pools for individual traders; such venues are particularly attractive for traders placing large trades, or traders who are patient but uninformed. Section 4 considers the growth of dark pools in Europe and the spread of dark pools across different equities and countries. Dark pools are used for trading in a variety of equities around Europe, with a slightly larger concentration in London stocks – a market that is relatively more liquid and has more algorithmic traders. This paper then addresses the two areas of competition between dark pools. Section 5 considers price, which depends on fees, pricing mechanisms, and liquidity. Section 6 considers the horizontal aspects of competition between dark pools, such as differences in order matching services and types of orders accepted; it also assesses implications of these features for protecting traders against information leakage. Section 7 considers recent evidence on the impact of dark pools on market functioning and financial stability.

5 IOSCO (2010).

2 The emergence of dark pools in the context of technological innovation and regulation

The growth of dark pools in Europe follows a period of regulatory and technological change, which had a profound impact on the structure and dynamics of equity markets. While dark trading existed previously in stock markets – through over the counter (OTC) trading or special hidden order types on exchanges – the emergence of dark pools marks the first time that exchanges operating fully outside transparency requirements attracted substantial volumes of trading. The growth of dark pools can be linked to two synchronous developments: the growth in high-frequency trading (HFT) and the entry into force of regulations that implemented increased and uniform transparency rules. With technological improvements, the latency in trading fell and the share of algorithmic trading, and particularly HFT, grew. One profit-making strategy for these types of traders is to use their speed advantage to detect information about trading interest in the market and trade based on this information. These strategies can increase trading costs for other market participants. At the same time, the new financial markets regulation, MiFID, which came into force in 2007, implemented uniform pan-European rules on pre- and post-trade transparency, which made it more difficult to hide trading intent when placing orders on existing exchanges. Within this context, dark pools emerged as new trading venues catering to the demand of investors for opportunities to trade with reduced transparency and reduced exposure to information leakage.

2.1 High-frequency trading and dark pools

One factor linked with the rapid rise of dark pools is investors' growing demand for alternative venues offering protection from HFT practices. The growth of dark pools followed an increase in the HFT share of total equities trading in Europe; the share of trades involving HFT grew from a negligible amount to over 30% by 2009, and since then has remained around one-third.[6]

HFT emerged in recent years as advancements in trading technologies drastically reduced the time for information to travel between venues and participants. HFT relies on the use of algorithms and the superior latency obtained by co-location (proximity to the exchange venue) to gather and react to information on the supply and demand of trades in order books and execute trades more quickly than other participants.[7] High-speed computer programs generate, send and (sometimes)

6 Deutsch Bank Research (2016).

7 Ibid.

cancel many orders rapidly, generating very small profits from the entering or exiting of each trade[8].

Not all HFT or algorithmic strategies increase the costs of trading for other market participants – some strategies may even improve market efficiency and functioning. For example, one strategy is to place many small-volume buy and sell orders at the best current prices and profit from the difference in bid-ask spreads – in such cases these algorithmic traders act as electronic market makers by supplying liquidity.[9] HFT may also use their speed advantage to engage in arbitrage (targeting temporary price differences between products or venues).

However, the presence of HFT can also lead to higher costs of trading for other participants due to predatory practices. For example, one HFT strategy is to use algorithms and high speed to obtain and exploit information about current market supply and demand, especially concerning the presence of large orders.[10] This information can be used for front running some orders, which increases trading costs for investors placing these orders. In some trading venues, high frequency traders pay a premium to receive more detailed order and trading data before it becomes available to other investors, allowing them to incorporate the information in their trading strategies.[11]

Moreover, as HFT strategies rely on successions of small trades with low latency, the presence of HFT on a venue can lead to prices changing very frequently. Such dynamics can cause prices to change between the time an order is submitted by another (non-HFT) participant and the time it arrives at the venue and is executed, implying higher uncertainty and risk for investors who may pay different prices at execution than they expected at submission.

Finally, because HFT relies on small orders, as the presence of HFT has expanded, average order sizes in equity trading have decreased. It has thus become more costly to execute large orders, driving up demand for alternative venues from traders looking to place such orders.[12]

Some traders may thus face higher expected costs of trading and increased risk on exchanges where HFT is common, driving them to seek alternative methods to hide information about their orders. On a traditional exchange (with pre-trade transparency in the order book), information about the size and price of an order is not displayed pre-trade when the order is sufficiently large to meet the large-in-scale waiver for pre-trade transparency. For smaller orders, it is possible to hide the true size by splitting the order and executing it piece by piece, or by using special order types, which hide part of the volume of the order.[13] However, HFT have developed complex algorithms that allow them to detect hidden orders and volumes on

8 Clarke (2014) and Vaananen (2015).

9 Deutsche Bank Research (2016).

10 Gomber (2011).

11 Clarke (2014).

12 Aguilar (2015).

13 Vaananen (2015).

traditional order books by using available information on the current orders and executed trades.[14] For example, HFT often relies on pinging – sending small orders – to obtain information about hidden demand and supply on an exchange. Once such an order is executed, a ping or series of pings alerts the algorithm about the potential presence of a large order. As HFT algorithms became better at detecting hidden information, investors sought to execute orders on other venues with more limited pre-trade transparency or with other mechanisms to reduce the presence of HFT[15].

In this context, the demand for dark pools, which operate with waivers from pre-trade transparency, has grown. By not disclosing information about volumes and prices of orders in the order book, dark pools may help reduce the likelihood that HFT will find and use this information. Many dark pools also offer additional features, which may reduce the likelihood of clients interacting with HFT, such as minimum size restrictions or non-immediate matching options (see Section 5 for further discussion).

While dark pools are often marketed as providing protection from HFT or predatory trading, there are incentives for dark pool operators to breach promises to clients for profit. US SEC Commissioner Luis Aguilar (2015) remarked that "dark pools were initially portrayed as havens from predatory traders. They achieved this, in part, by excluding high-frequency traders, who supposedly use brute speed to front run institutional investors' large orders. Lured by this promise of safety, institutional traders embraced [dark pools] as a solution to their trading needs. Unfortunately, all too often the safety these investors sought proved illusory."

There have been multiple instances when dark pools abused client trust and did not provide the terms promised. For example, there are strong incentives for operators to allow HFT on their venues without informing clients.[16] HFT can increase liquidity on an exchange in terms of (total volumes available for trading), as it places many small buy and sell orders. Additional liquidity in a dark pool implies a higher likelihood of execution for orders, which reduces trading costs for clients. In the United States, several dark pools were found to be engaging in practices to increase liquidity that were potentially harmful to their clients, including giving special benefits to HFT (see Box 2).

2.2 Regulatory change facilitating the emergence of dark pools

The landscape of equities trading in Europe changed after MiFID came into force in 2007. MiFID introduced a new market structure framework with the goals of increasing the competitiveness of EU financial markets and harmonising protection for investors in financial instruments; this framework, *inter alia*, sought to harmonise pre and post-trade transparency requirements for equity trades on regulated

14 Clarke (2014).

15 Vaananen (2015).

16 Vaananen (2015).

platforms, and to promote competition between equity trading platforms.[17] The implementation of these requirements led to a variety of new platforms emerging, among them dark pools which responded to demand from market participants who wished to continue trading "in the dark".

The reforms in MiFID liberalised the market for equity trading venues and led to the registration of many new such venues in Europe, increasing competition. Prior to MiFID, most venue-based equity trading in Europe was conducted on large national exchanges (such as the London Stock Exchange or Deutsche Börse's Xetra); these exchanges, which were also the primary listing venue for the stocks, acted as near-monopolies in each country. The Investment Services Directive, which preceded MiFID, permitted countries to use a "concentration rule" where all equity trading had to be executed on a national stock market, giving primary exchanges a dominant role. However, MiFID eliminated the use of the concertation rule, meaning that primary exchanges could face competition from other venues across all Member States.[18] This reduced the costs of entry for new venues, as they could now compete for volumes across a broader set of instruments (from a larger set of countries).

In order to facilitate competition between existing and new venues, MiFID sought to establish a comprehensive regulatory regime for trading in equity instruments in Europe irrespective of the trading method or platform; for this purpose it implemented a framework for regulating the main types of order execution arrangements in the European financial market (i.e. the main types of exchanges).[19] Venues of primary listing (national stock exchanges) had already been subject to some requirements as regulated markets. MiFID introduced a new category of multilateral trading facilities (MTFs) to encompass all other organised multi-party trading facilities with non-discretionary execution that were not already registered as regulated markets.[20] MiFID established rules under which MTFs could be registeredand operated by investment firms or other operators. Under MiFID, the requirements for regulated markets and MTF were closely aligned; the two categories of venues were subject to similar pre- and post-trade transparency requirements as well as rules on customer protection.[21]

With the removal of barriers to competition, new trading venues emerged and grew rapidly and the European market for trading equities became substantially more fragmented. MTFs such as BATS, Chi-X, and Turquoise began offering trading in stocks from several European countries (of primary listing) and, benefiting from economies of scale and network effects, captured substantial shares of trade volumes; for large investors with diversified portfolios, these MTFs could cater to all

17 See European Commission Markets in Financial Instruments Directive (MiFID II) FAQs.

18 See European Commission Markets in Financial Instruments Directive (MiFID): FAQs.

19 Directive 2004/39/EC of the European Parliament and of the Council.

20 Markets in Financial Instruments Directive, Article 4, (15). MiFID also introduced a category of Systematic Internalisers, for large brokers or banks who act as an "investment firm, which on an organised, frequent and systematic basis, deals on own account by executing client orders outside a regulated market or MTF." It defined harmonised rules for such investors, who were further not allowed to trade on their own account. Very few firms have signed up as Systemic Internalisers. See Markets in Financial Instruments Directive, Article 4.

21 See Title II in Directive 2004/39/EC.

trading needs. The share of equities trading on MTFs in Europe increased quickly from 0% of turnover in 2008 to 18% by early 2011.[22] Although primary exchanges still account for the largest share of exchange-based equity trading in each country (around 60%), MTFs currently account for around 40% of equity trading volumes. While the largest MTFs in Europe are "lit" order books operating in similar ways to primary exchanges, dark pools are also among the new venues emerging from the liberalisation of competition after MiFID.

As removal of barriers to competition facilitated the emergence of dark pools, further regulatory changes in MiFID relating to pre-and post-trade transparency in equities trading strengthened demand for such venues. Among the harmonised pre-trade transparency requirements for regulated markets and MTFs, MiFID made it mandatory to disclose the bid and offer prices and depth of interest (volumes in the order book at different prices) on a continuous basis for equity and equity-like instruments.[23] Such pre-trade transparency requirements increase the probability that information about larger orders in the order book can be detected by predatory traders, which could be costly to investors if it resulted in front running. MiFID provided exemptions from pre-trade transparency. Information on very large block trades, which would be particularly vulnerable to front running, is exempt. In addition, MiFID provided venue-wide exemptions for venues that did not match trades based on internally determined prices, but used external reference prices instead.[24] Box 1 describes the different waivers for pre-trade transparency. Consequently, new MTFs were established with a trading mechanism that allowed them to use waivers for pre-trade transparency obligations for the entire order book. By matching orders based on an external price, these dark pools use the reference price waiver and allow clients to place orders in an order book without disclosing information pre-trade.

Box 1

Pre-trade transparency waivers in MiFID

MiFID I harmonised pre-trade transparency requirements for regulated markets and MTFs, requiring information on bid and ask prices and depth at these prices to be reported on a continuous basis as soon as it became available.[25] The directive also outlined three scenarios under which these pre-trade disclosure obligations could be waived, which are described below.[26]

Waivers based on order size: large-in-scale waivers

Orders that are large-in-scale compared to the normal market size are subject to waivers for pre-trade transparency, regardless of which venues (MTF or Regulated Market) they are traded on. The minimum size for an order to qualify as large-in-scale is determined at instrument level, with more liquid instruments having a higher threshold, depending on the average daily turnover of shares

22 Fioravanti and Gentile (2011).

23 See Article 29 in Directive 2004/39/EC.

24 Ibid.

25 Ibid.

26 Ibid.

admitted to trading on a regulated market for that instrument (see Table B1).[27] The minimum threshold restricts the waiver only to exceptionally large orders in some cases: for less liquid instruments, an order must be at least 10% of the average daily turnover for that instrument to qualify as large-in-scale. Larger orders would be costly to execute immediately if sufficient liquidity were not available, but they would also be particularly vulnerable to front running if subject to pre-trade transparency while sitting in the order book. Some orders executed on dark pools are sufficiently large to qualify for this waiver, but dark pools generally use a reference price waiver that covers all transactions on the venue instead.

Table B1

Large-in-scale orders – minimum size for equities in MiFID I[28]

Category by average daily turnover (ADT), (EUR '000)	ADT < 500	500 ≤ ADT < 100	100 ≤ ADT < 2500	2500 ≤ ADT < 5000	ADT ≥ 5000
Minimum size of order to qualify as large-in-scale (EUR '000)	50	100	250	400	500

Waivers-based market model and transaction type: reference price and negotiated price waivers

Under the reference price waiver, if the trading system of a regulated market or MTF operates without internal price formation but instead matches orders at a price "determined in accordance with a reference price generated by another system, where that reference price is widely published", they may receive waivers for pre-trade transparency on prices and volumes.[29] This waiver is granted to the entire trading system and all orders in the order book, regardless of size.[30] Most dark pools in Europe rely on this waiver to allow clients to trade without pre-trade transparency (regardless of order size). Dark pools match volumes of orders using the displayed best bid/offer from one or more regulated markets and MTFs as the reference price.

Under the negotiated price waiver, if a regulated market or MTF formalises a transaction negotiated privately between participants, these transactions may be granted waivers from pre-trade transparency.[31] The waivers can be granted regardless of venue where the transaction is reported, but are most relevant for retail trading platforms or large pre-agreed block trades.

Finally, orders held in an order management system by a regulated market or MTF pending disclosure to the market can also benefit from a waiver for pre-trade transparency.[32] This allows special hidden or part-hidden order types, such as iceberg orders, where only a small part of the volume is displayed at one time, to continue to be placed on lit order books.[33] These special orders allow traders to hide some information from other participants and protect orders from information leakage and front running. However, algorithmic traders have developed methods to detect hidden

27 Commission Regulation (EC) No 1287/2006, implementing Directive 2004/39/EC of the European Parliament and of the Council, Article 20.

28 Table 2, Annex II, of Commission Regulation (EC) No 1287/2006.

29 See Article 18, Commission Regulation (EC) No 1287/2006, implementing Directive 2004/39/EC.

30 It is possible that some MTFs might offer more than one trading system to clients.

31 CESR, Waivers from Pre-trade Transparency Obligations under the Markets in Financial Instruments Directive (MiFID). See Article 19, Commission Regulation (EC) No 1287/2006, implementing Directive 2004/39/EC.

32 Article 18, MiFID Implementing Act Commission Regulation (EC) No 1287/2006.

33 Waivers from Pre-trade Transparency, Committee of European Securities Regulators (CESR) positions and European Securities and Markets Authority (ESMA) opinions.

volumes in lit order books by pinging based on the visible part of the order book and on executed and cancelled trades; consequently, these hidden order types did not remove the demand for completely dark order books.[34]

Restrictions on waivers under MiFID II/MiFIR

MiFID II/MiFIR, which is to come into force in 2018, imposes restrictions on the share of trading for equity and equity-like instruments that may occur under the reference price and negotiated transaction waivers; no restrictions apply to the large-in-scale waiver. Known as the "double volume cap", restrictions are based on reference price and negotiated price waiver usage in individual venues and in the market overall. First, in any 12-month rolling window, the volume traded under the (reference price or negotiated transaction) waivers for an individual financial instrument on any single venue is limited to 4% of the total volume traded in that instrument in the EU over the previous 12 months. Second, the total volume traded under the waivers for an instrument on all platforms in the EU is limited to 8% of total volume traded in that instrument over the previous 12 months. The caps apply to all equity and equity-like instruments, except those where there is no liquid market. Once a venue reaches the limit for an instrument, the use of reference price or negotiated price waivers on that venue for that instrument is suspended for six months; if the EU-wide limit for an instrument is reached, the use of reference price or negotiated price waivers for that instrument is suspended for all venues for six months.[35] The large-in-scale waiver can continue to be used regardless of whether or not the reference price has been suspended.

Table B2

Average and medium size of trades on large European dark pools June 2016 [36]

Dark Pool Venue	BXE Dark	Blockmatch	CHI-X Dark	Liquidnet	Nordic@mid	Posit	SG Alpha y	SLS	Turquoise	UBS
Average trade size (EUR '000)	7.3	9.5	7.4	901	6.8	21.2	5.1	295	7.9	6.7
Median trade size (EUR '000)	3.9	5.8	4.6	378	2.7	8.3	2.2	37.3	4.5	4.2

These thresholds are likely to affect trading on dark pools for some instruments, as the average market share of trading in dark pools is just over 8% across all instruments in 2016 Q2 (see Chart 1). If the waiver limit for an instrument were reached, dark pools would no longer be able to reduce pre-trade transparency for customers placing orders in that instrument, unless the orders were large-in-scale. New restrictions are thus likely to have different effects on the market share of different dark pools, depending on whether the venues cater for large orders. Table B2 above illustrates the average and median trade size in selected dark pools in June 2016. With the exception of Liquidnet, more than 50% of trades on all other venues would be too small to qualify for the large-in-scale waiver even under the lowest possible threshold of EUR 50,000. Since most trades in the largest dark pools would not qualify for large-in-scale waivers if the cap was reached, market share and competitiveness of dark pools focused on small-order venues might suffer. Moreover, traders placing small orders in these instruments may no longer be able to do so "in the

34 Vaananen (2015).

35 MiFIR, Article 5, Regulation (EU) No 600/2014.

36 LiquidMetrix Guide to European Dark Pools – June 2016.

dark". Thus the new cap might lead to a shift towards larger trades in dark pools, or consolidation in the dark pools serving small-sized orders.

2.3 Benefits and costs of trading in dark pools

For individual traders, using dark pools in lieu of traditional venues implies a trade-off between reducing costs (including transparency costs) and speed/immediacy of execution. Dark pools differ from other exchanges (i.e. "lit" order books, whether MTFs or regulated markets) because they lack pre-trade transparency.[37] Dark pools use external reference prices instead of prices based on the internal order book in order to obtain waivers for pre-trade transparency. This section considers how a standard lit venue operates, and then describes the advantages and disadvantages traders may incur when using a dark pool instead.

Lit exchanges operate as order books where prices are determined by supply and demand, and traders select between placing a limit order or a market order. The order book aggregates yet-to-be-executed orders received by the exchange and shows the volumes of the stock available for sale and for purchase at different prices. A market order is executed immediately based on the prices and volumes available at that time in the order book, sacrificing the possibility of better future prices for immediacy. A buy (sell) market order takes the volumes available for sale (purchase) at the best offer (bid) price; if there is insufficient volume at this price to fill the order, the remainder is filled from the volume available for sale (purchase) at the next best offer (bid), and so forth. If the order is too large to be executed given available volumes, any volumes left to be filled are placed in the order book, becoming part of the supply. The price of executing a market order is based on all the prices at which volumes are filled (also called the volume-weighted average price). A limit order is an order to be executed at a price outside the current bid-ask spread; it is added to the order book, becoming part of the supply or demand available on the exchange. The limit orders in the order book are thus subject to pre-trade transparency requirements, and are only executed if and when there is sufficient demand or supply.

Thus, lit order books present a trade-off between immediate execution at the current price (market order) or waiting for a better price while accepting exposure to risks, including risks from pre-trade transparency (limit order).[38] In a lit order book, the cost of executing a market order depends on the bid-ask spread and the depth of liquidity in the order book. The bid-ask spread – the difference between the best bid and best offer prices – can be seen as a cost of impatience paid by traders placing market orders. A trader who is looking to buy (sell) immediately must pay at least the best offer (bid). On the other hand, a patient trader could place a limit buy (sell) order at

[37] Dark pools and lit venues do not, however, differ in the level of post-trade transparency; all are currently required to report as close to real time as possible, at most within three minutes. See Article 29 of Commission Regulation (EC) 1287/2006 implementing Directive 2004/39/EC.

[38] Cohen et al. (1981).

the best bid (offer) price and wait for it to be executed as new demand (supply) arrives in the market. Moreover, the (average) price of executing a market order depends on the market impact cost: how far an order moves the market price. This is determined by the depth of liquidity in the order book at the time the order is placed. On the other hand, placing a limit order can ensure that, if executed, all the volume is executed at the desired price.

On the other hand, for a trader who is not a market-maker (i.e. not placing limit orders on both sides of the market), a limit order carries costs due to risks and uncertainty about future events. As it waits in the order book, this type of order is subject to pre-trade transparency rules, which disclose the volumes available at various price levels. Consequently, these orders may thus be more susceptible to front running or other similar predatory practices. Execution of a limit order is not guaranteed, but instead depends on future incoming orders and price movements. While favourable price movements may allow a trader who placed a limit order to obtain a better price than he would have if he had placed a market order, on the other hand, adverse price movements may cost him the opportunity to trade.

Given these dynamics of lit markets, there are several potential advantages for traders using dark pools instead of lit venues, linked with the lack of pre-trade transparency in dark order books as well as the reference pricing mechanisms employed by dark pools. Traders are likely to prefer dark pools to placing a limit order in a lit venue because of the reduced risks of information leakage, but they may also prefer them to placing a market order in a lit venue because the reference pricing mechanism reduces market impact costs. Consequently, traders whose concern with information leakage would deter them from placing a limit order on lit order books would find it more advantageous to place their orders on dark pools rather than place market orders on lit order books.

Traders might prefer dark pools for large orders, which would otherwise have to be placed as limit orders on lit order books. Such orders might be so large that there would not be sufficient liquidity on any lit exchange to execute them immediately, or the market impact cost would be very high because they would consume a lot of the available liquidity on a lit order book.[39] If these orders were placed on a lit venue and did not meet the large-in-scale threshold for pre-trade transparency waiver, they would be subject to pre-trade transparency requirements while in the order book. Even if they did benefit from a large-in-scale waiver, trading algorithms might detect such an order.[40]

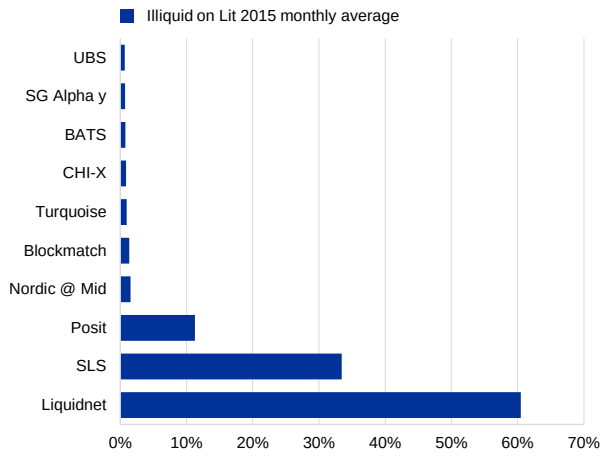
[39] Garvey et al. (2016).

[40] Vaananen (2015).

Chart 2

Orders larger than the available liquidity on any single lit/traditional exchange

(percentage of total dark pool orders, 2015 monthly average)



Sources: Dark pool guides and LiquidMetrix.

Chart 2 shows the share of orders executed in European dark pools that are so large that there would not have been sufficient liquidity on any single lit venue to execute them at one point in time. Some dark pools specialise in such large orders: over 60% of the orders executed on Liquidnet fall into this category. In a dark pool, large volume orders, which cannot be matched given the available supply and demand sit in the order book until the end of the trading day with no information about depth of trading interest made public. It is more difficult for algorithms to detect these trades because they cannot use other information in the order book for inference. Consequently, a main benefit of trading via a dark pool is the ability to execute (larger) orders without disclosing trading intent, and thus avoid information leakage that could cut into trading profits if fast algorithms were able to ascertain and trade against the direction of order flow.[41]

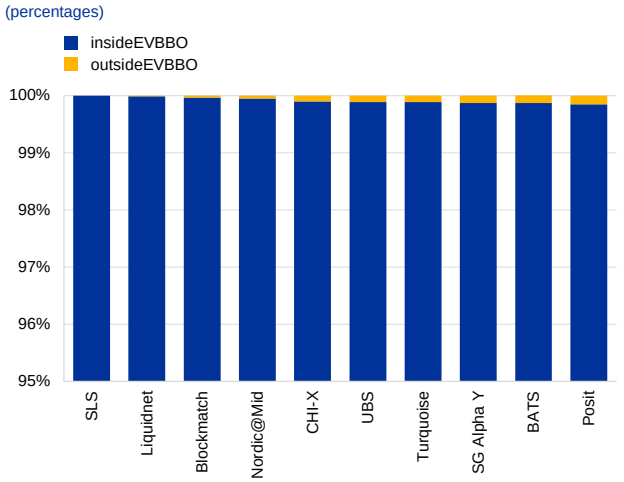
Fragmentation between lit and dark venues based on order size has also been explored in a theoretical framework. Madhavan (1995) finds that in a setting where disclosure of pre-trade information to other participants is voluntary, a fragmented market can be the equilibrium outcome: large traders prefer a market without disclosure to avoid front-running while small traders prefer a market with transparency.

Dark pools can also offer price improvements over market orders on lit venues because prices are based on an external reference price rather than determined internally based on own liquidity. On a dark pool, once buy and sell volumes are matched, the execution price for the entire volume is (usually the midpoint of) the current bid-ask spread on an external venue; the reference price often reflects the price from the primary venue of trading for the security. Consequently, there is no market impact cost, as the price is constant for the volume of the order and does not depend on the depth of volumes available in the order book (the order does not move the price by consuming liquidity at different price levels). This mechanism implies a price improvement over market orders for any order larger than the volume instantly available at the best bid-ask price at a single point in time on a lit venue. As long as there is sufficient volume available in the opposite direction, traders transact at the best price for their full volume. Second, when matching in dark pools is done at the midpoint of the reference price (see Section 5), neither side of the trade has to pay the full spread. The reduced trading cost from trading at the midpoint rather than paying the entire spread can be a particularly strong incentive to use dark pools for traders in stocks with high spreads. Ready (2014) finds that dark pools attract a lower share of trades in stocks with lower spreads, as the gains from trading at the midpoint might not be as high.

41 Eng et al. (2013).

Chart 3

Share of volumes traded in dark pools inside the EVBBO across all European equities, January 2016



Source: LiquidMetrix Guide to European Dark Pools, January 2016.

The price improvement for orders executed on dark pools over executing an order of same size for the same instrument on a lit order book can be substantial. In the United States, Garvey et al. (2016) find a price improvement compared to lit venues on more than 80% of dark orders executed. Thus traders, as well as brokers executing client (or own) trades, may prefer trading in dark pools to cut own trading costs or provide more competitive services for clients.[42] In Europe, the price obtained on the dark pool can be compared to the effective volume-weighted best bid and offer (EVBBO), the best price that could be obtained on any lit venue for a market order of that particular size. The depth and bid-ask spread at each lit order book determine the volume-weighted average price of execution on that venue; the EVVBO selects the best volume-weighted average price that would be achieved on any single lit venue at a certain point in time. Chart 3 illustrates the share of the volumes traded on different European dark pools that are inside the EVBBO: due to improvements from reference and midpoint pricing, the large majority of orders across dark pools achieved better prices than they would have if they had been placed as market orders on any lit venue.

Dark pools, however, present a trade-off between potential price improvement and the slower speed and lower likelihood of execution.[43] Dark pools do not have as much liquidity as lit venues and thus once an order is placed, the time for a matching order to arrive at the venue is longer, leading to slower average execution times.[44] This implies a higher chance that the price will move unfavourably between the time the order is placed and execution is finalised. Moreover, when trading in a dark pool, there is the risk that the order will not be matched and executed during the day.[45] The costs incurred by slower trading or missed trading opportunities can be significant.[46] In addition, reliance on a reference price does not remove the possibility of prices being manipulated. If the reference prices on the dark pool are not updated quickly enough, HFT can engage in quote manipulation of the reference price by sending limit orders to a lit venue to alter bid-ask spreads, and then sending orders to a dark pool to profit from the temporary change.[47]

Given the trade-off between speed of execution on the one hand, and price and information leakage on the other, dark pools may be attractive to different types of traders possessing different levels of information. Dark pools may be more advantageous to uninformed rather than informed traders. Informed traders have a

42 Vaananen (2015).
43 Iyer et al. (2015).
44 Garvey at al. (2016).
45 Iyer et al. (2015).
46 See Eng et al. (2013).
47 Vaananen (2015).

high preference for rapid execution so that they can take advantage of their information, and thus may prefer a lit venue. Moreover, informed traders are likely to be trading on the same side of the market, so in an equilibrium where informed traders use dark pools, the marginal informed trader would have a lower probability of finding a matching volume in a dark pool.[48] Garvey et al. (2016) use US trading data and find significant differences in the information content of marketable orders between lit and dark venues: orders in lit markets are informative about the direction of price changes, while those in dark pools are not. Therefore, the presence of dark pools can lead to fragmentation of liquidity based on the information levels of traders due to the costs and benefits inherent in using these venues.

Box 2
Dark pools in the United States

Dark pools – categorised as alternative trading venues (ATS) under US regulation – first emerged in the United States in the 1960s, but expanded significantly in the last decade.[49] Much like in Europe, factors behind dark pool expansion in the United States were the growth of HFT as well as new regulations (the adoption of Regulation National Market System, or Reg NMS).[50] From 2005 to 2015, the market share of trading on dark pools quadrupled reaching 15-18% of trading in exchange-listed securities.[51] Currently, around 40 ATS are registered and actively manage trading volumes.[52]

Much like in Europe, a primary driver of the growth of US dark pools was the increase in HFT and algorithmic trading, which raised costs of executing orders on lit venues and made venues without pre-trade transparency particularly appealing. HFT is more pervasive in the United States than in Europe, accounting for roughly 50% of equity trading volumes.[53] In addition to exploiting information on the supply and demand of existing orders, high-speed trading strategies have also led to smaller average trade sizes for equity trading. The average trade size is now just thousands of dollars, while previously it was in tens of thousands. Small average trade sizes reduce the market's ability to absorb larger orders without significant price movements. Thus dark pools cater to investors' need to execute large blocks without high costs or information leakage. While hidden or part-hidden orders – such as iceberg orders – are used on US exchanges to obtain some protection against information leakage, hidden volume on lit order books can be detected by HFT algorithms.

Regulation was another factor linked with the recent growth of US dark pools. While most of the transparency requirements in Reg NMS, which came into force in 2007, had also existed under the previous regulatory framework, the new trade-through rule (Rule 611) led to changes in trading and market structure.[54] This rule intended to promote "inter-market price protection of orders" by restricting the execution of trades on one venue at prices lower than displayed quotations at another venue. Thus if an order was placed at one venue but a better price was displayed at

48 Zhu (2014).
49 Aguilar (2015).
50 Shorter and Miller (2014).
51 Aguilar (2015).
52 See ATS Transparency Data Quarterly Statistics, 3Q 2015 FINRA.
53 Vaananen (2015).
54 SEC Market Structure Advisory Committee Memo on Rule 611 of Regulation NMS.

another, the order should either be re-routed to the second venue, or the current venue should find a volume at the better price. One aim of this rule was to encourage limit orders and liquidity provision.[55]

Some have argued Rule 611 supported the rapid growth in dark pool usage because it prevented competition to provide the best prices and liquidity between lit venues, but instead promoted competition in terms of speed, fees and availability of exotic order types – aspects that are less important for customers.[56] On the other hand, routing orders across venues or even scanning venues for prices could increase the time for execution and thus the risk of information leakage and the advantage of the low latency of HFT. Special trade types have developed to avoid some re-routing, but this is not always possible because the National Best Bid and Offer (NBBO) – a consolidated best bid and offer from across markets – is protected; when a buyer places a market order, any volume available at the NBBO on any venue must be used first to fill the order.[57]

As in Europe, US dark pools were marketed as offering protection from HFT and predatory practices. Yet attaining a critical mass of liquidity to provide efficient matching services for clients can be difficult for new dark pools, leading to conflicts of interest between providers and subscribers. In the United States, several dark pool operators sought to increase liquidity by means harmful to clients, resulting in investigations and lawsuits with fines and settlements.[58] For example, some dark pools were found to allow proprietary trading on their venue without disclosing this to clients.[59] Others allowed access for high-speed trading and misinformed clients about its prevalence.[60] Some dark pool operators gave informational advantages to their proprietary trading desk or to affiliates, allowing them to front run orders of other subscribers.[61] Another dark pool attempted to increase its market share by providing advantageous special conditions to high-frequency traders (who can create liquidity by placing many small orders).[62] Generally, clients of dark pools were not aware of such practices.

In the light of such events, the SEC proposed new rules to enhance operational transparency and regulatory oversight of dark pools. Rules proposed in 2015 would require dark pools to disclose detailed information on matching and trading procedures, including the type of market data used, order handling and trading execution processes, and any special priorities for various participants.[63] A final set of rules was expected in 2016.[64]

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55 Limit orders with the best price would be filled regardless of venue. See Shorter and Miller (2014).

56 Some have suggested that Rule 611 indirectly led to more dark trading by constraining the nature of competition on lit venues to factors such as speed, fees, and exotic order types, in contrast to factors that are more appealing to investors, such as liquidity and stability.

57 Vaananen (2015).

58 Luis Aguilar (2015).

59 See SEC (2015a) and SEC (2015b).

60 See article Reuters: Barclays fails to win dismissal of NY 'dark pool' lawsuit, and The People of the State of New York v Barclays Capital Inc. and Barclays Plc.

61 See Luis Aguilar (2015), on SEC (2011) and SEC (2015b).

62 See SEC (2015a) and SEC (2015b).

63 SEC Proposes Rules to Enhance Transparency and Oversight of Alternative Trading System.

64 SEC Preparing to Finalise Transparency Rules for Dark Pools, Mary Jo White Says, September 2016.

3 The growth and current status of dark pools in Europe

Since 2009, the number of registered dark pools operating in Europe, as well as their market share, has grown rapidly. In 2016, the volume traded on the dark pools accounts for over 8% of total value traded in equities in the EU. Dark pools are used for trading equities across several geographic markets and types of stocks. The following section considers (a) which dark pools currently operate in Europe, (b) growth in dark pool market share, and (c) the expansion of dark pools in different stock types.

In Europe, unlike in the United States, there is no publicly available standardised and consolidated detailed trading information for all venues (including OTC and internalised trading); this continues to present a challenge to a thorough analysis of the growth and impact of dark pools. For this analysis, data for daily trading volumes on different venues since 2009 for stocks listed on 15 major European exchanges is used, available from BATS Europe.

3.1 Active dark pools: entry and exit

In recent years, multiple dark pools have emerged and gained substantial market share in Europe; however not all venues were successful and some exited the market. The first dark pools that recorded substantial trading in 2009 were Chi-X, Turquoise and BATS. Many new dark pools entered the market between 2009 and 2011; after initial dynamic entry and exit, the number of dark pools has stabilised in recent years. Table 1 shows the main dark pools operating in Europe from 2009 to 2016, including the period in which they were active. At the end of 2016, there were 15 active dark pools in the sample.

The nature of demand and supply for the market of equity trading, and for dark pools in particular, favours an oligopolistic structure. There is a natural limit to the number of dark pools that can be competitive, due to positive spillovers through direct network effects: a dark pool requires sufficient liquidity (volumes of orders) to ensure a good probability of execution to attract clients. There are thus incentives for the consolidation of liquidity to ensure sufficient execution opportunities. One such example was that Nomura closed the Nomura NX dark pool instead of continuing to operate it alongside BlockMatch (the dark pool operated by its subsidiary Instinet) in 2012, in part in order to consolidate liquidity on one venue and provide greater matching opportunities for clients.[65] On the other hand, there appears to be sufficient demand for dark pools and sufficient potential for diversity in the services offered that

[65] Puaar (2012).

allows multiple dark venues to be profitable and make an oligopolistic market structure sustainable.

Table 1

Major dark pools active in Europe, 2009-2016

Venue	Operator	Operator type	Period active
CXE Dark	BATS Chi-X Europe	Exchange	2009m - current
UBS MTF	UBS	Bank	2010m11 – current
Posit	ITG	Broker	2010m7 – current
BATS Dark	BATS Chi-X Europe	Exchange	2009m9 – current
Turquoise	London Stock Exchange	Exchange	2009m9 – current
SIGMA X MTF	Goldman Sachs	Bank	2011m7 – current
Blockmatch	Instinet	Broker	2010m7 – current
Liquidnet	Liquidnet	Trading Network	2010m8 – current
SG CIB AlphaY	Societe Generale	Bank	2012m4 – current
SLS	SIX Swiss Exchange & Liquidnet	Trading Network & Exchange	2011m9 – current
Smartpool	Euronext	Exchange	2010m8 – current
Nordic@mid	NASDAQ OMX	Exchange	2012m5 – current
BLINK MTF	Kepler Cheuvreux	Broker	2012m3 – current
Xetra	Xetra (German stock exchange)	Exchange	2013 – current[1]
SwissAtMid	SIX Swiss Exchange	Exchange	2016m10 - current
Nomura	Nomura	Bank	2010m7 - 2012m11
BlockCross	ICAP	Broker	2010m12 -2012m8
NEURO	NASDAQ OMX	Exchange	2010m4 - 2010m7
Pipeline	Pipeline	Broker	2011m7 - 2011m11

Owing to the benefits of scale operations and established client networks, dark pools entering the market might find it difficult to secure volumes unless they can offer services that are sufficiently differentiated from existing venues to attract new clients (more about such features will be discussed in Section 6). Often dark pools rely on an existing client network of their own or of other entities to build liquidity. For example, Xetra began operating a dark order book alongside the main venue, allowing existing clients to place a special order type (midpoint) on a separate order book, which guaranteed pre-trade anonymity and the ability to match at midpoint.[66] Moreover, to secure higher liquidity on entry, from 2013 to 2015, Xetra operated with a midpoint "block agent" model, where the "block agent" (Liquidnet, another dark pool) had exclusive access to the orders placed by clients in the Xetra MidPoint order book. The block agent would inform its own clients of the possibility of execution, and, if there was agreement, would also put through a Xetra MidPoint

66 Grant and Wilson (2008).

order.[67] This mechanism allowed Xetra to boost liquidity, and was decommissioned in 2015.[68]

The closure of some dark pools demonstrates the challenge of retaining market shares and finding sufficient differentiation in functionality from other venues. For example, the ICAP BlockCross pool closed in 2012, in part because investors allegedly considered its services very similar to those offered by Liquidnet, another dark pool targeting large trades. [69] The NASDAQ OMX dark pool NEURO closed in 2010 as it was unable to attract sufficient volumes from competitors; the operator later opened dark pools specialised in trading Nordic stocks only, with the aim of becoming a significant player in these markets. [70]

3.2 Dark pool operators

Dark pools in Europe are most frequently operated by entities that already have a strong client base for equities trading, putting them in a better position to compete for market share. These include operators of other MTFs, banks, or brokers.

Brokers and banks with large trading arms operate dark pools as a way of internalising their own trades and those of their clients. Their own trading activities can help provide a minimum level of liquidity in the pool.[71] The benefit to banks and brokers of operating dark pools is that they no longer pay exchange fees or pay the spread when trading; this allows them to offer customers lower costs of trading, attract more volumes, and earn more from commissions.[72] In Europe, dark pools run by banks and brokers, including UBS, Goldman Sachs, Société Générale, as well as Instinet and ITG, account for just over half of the total market share of dark pools. Trading on dark pools operated by banks made up 27% of the volumes traded on all dark pools in Europe in 2016, while trading on dark pools operated by brokers accounted for 24%. Owing to the importance of scale and network effects, there are only a few major banks and brokers running such venues. UBS and Posit, bank and broker-run dark pools respectively, consolidate substantial amounts of liquidity in their dark pools, and are two of the largest such venues in Europe.

67 See deutsche-boerse-cash-market

68 See Xetra Circular 040/15, May 2015 and deutsche-boerse-cash-market/ Xetra-MidPoint

69 See article Dark pools face up to harsh realities.

70 Nasdaq OMX (2010).

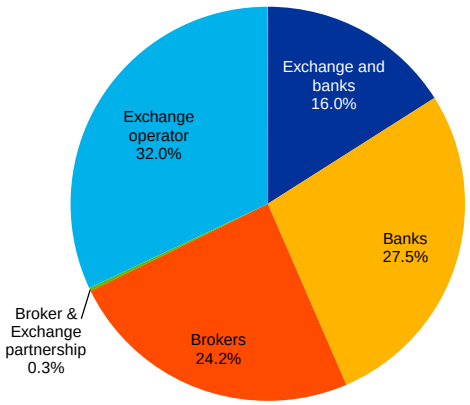
71 Vaananen (2015).

72 Eng et al. (2013).

Chart 4

European dark pool volumes by operator type, June 2015

(percentage of total volumes traded on dark venues in Europe)



Sources: Bats Global Markets and authors' calculations.

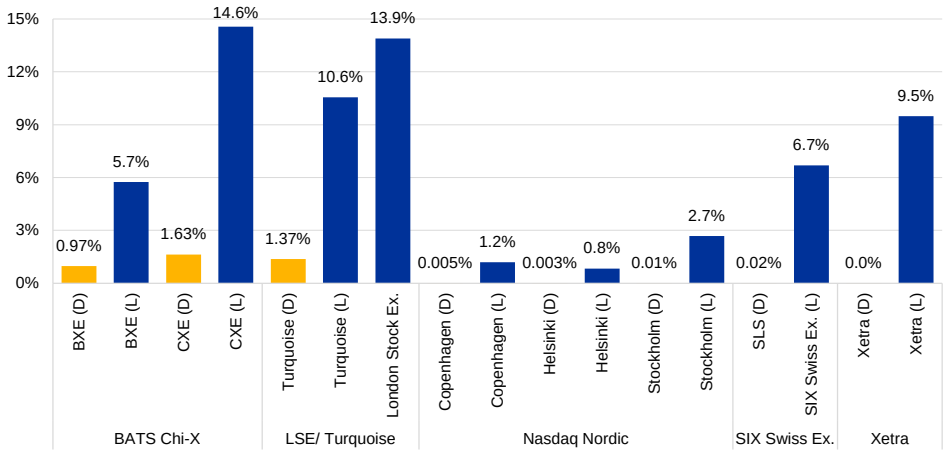
Other dark pools are operated by entities which already run transparent (lit) exchanges – whether regulated markets or MTFs. These dark pool operators have the advantage of an established client base and expertise for equity trading. In Europe, the main dark pools are BATS and CXE (operated by BATS Europe), the Nordic@mid venues (operated by Nasdaq OMX), Turquoise (which operates a lit order book as well as a dark one) and Xetra dark (operated by Deutsche Boerse). BATS Europe operates two European dark pools following the 2012 merger of BATS and Chi-X. Turquoise was set up by 12 member banks but is now majority-owned by the London Stock Exchange. These venues accounted for 48% of the volumes traded in dark pools in Europe in 2016. Chart 4 shows dark pool trading volumes in Europe in 2015 according to type of operator.[73]

New dark pools operated by institutions without large lit order books often struggled to establish a market share as operators of multiple exchanges can help drive orders to their own dark venues.[74] Chart 5 shows that when an operator owns both lit order books and dark order books, there is a correlation between the volumes of trades on these two venues: the larger the lit order book, the more liquidity is in the dark order book.

Chart 5

Equity trading on dark and lit order books owned by the same operator, June 2016

(percentage of equity volume traded in Europe)



Sources: Bats Global Markets and authors' calculations.
Note: Lit order books are represented by blue bars and dark pools by yellow bars.

73 For some dark pools, the ultimate shareholders are sometimes banks. For example, BATS shareholders include financial institutions JP Morgan, Deutsche Bank, Credit Suisse, Getco and Morgan Stanley, Before being taken over by BATS, Chi-X Europe was owned by a consortium of financial institutions.

74 Grant (2011).

3.3 Growth of dark pool trading in Europe

In 2009, trading in dark pools accounted for less than 1% of the volumes of equities trading recorded on European exchanges.[75] By 2016, this number had grown to 8%. Chart 1 shows growth in the market share of dark pools from 2009 to 2016. While some of the initial growth in market share coincided with the emergence of new venues, in later years, growth of trading in dark pools was primarily driven by existing venues consolidating liquidity and increasing their market share.

Growth in the market share of dark pools in Europe represents a gradual expansion within geographic markets rather than entry into new geographic markets. Chart 6 illustrates the breakdown of volumes traded on dark pools by country of the primary venue where an instrument is listed (for the European countries where data are available). Dark pools were active in trading stocks from each of the 15 countries as early as 2010. The distribution of dark pool volumes between equities from the most liquid markets of primary listing (London, Frankfurt and Paris) and from the least liquid (Lisbon, Dublin and Vienna) remained largely constant over time as dark pool market share expanded.

Moreover, the increase in the dark pool market share in Europe did not substantially differ between more and less liquid stocks. Chart 7 illustrates the growth in the market share of dark pools for stocks included in various indices from 2010 to 2016; growth is shown as the differences between two years in the total market share of dark pools for trading in stocks in each index. It might be expected that initial growth in dark pool trading volumes occurred in stocks with more HFT where there were more incentives to “hide” trading intent. HFT is more prevalent for the most liquid stocks as it relies on placing many small orders very quickly to obtain information without moving the market price.[76] This hypothesis is not fully supported by the evidence in Chart 7. Dark pools trading in the most liquid stocks (those in the FTSE100, CAC40, DAX and SMI) did not grow faster than those trading in relatively less liquid stocks (e.g. the CACNEXT20, Nordic stocks or the PSI).

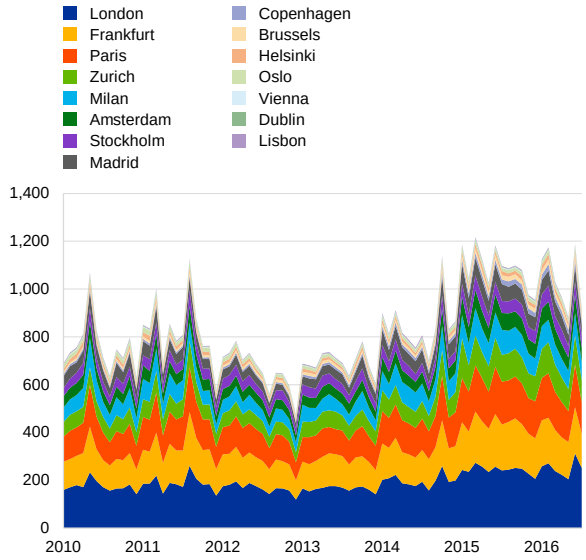
[75] Volumes recorded on European MTFs and regulated markets, which primarily include volumes traded on the venue, but may also include transactions negotiated independently and reported to the venue.

[76] Deutsche Bank Research (2016).

Chart 6

Volume of trade in equities occurring on dark pools, by country of equity listing

(EUR billions traded quarterly)

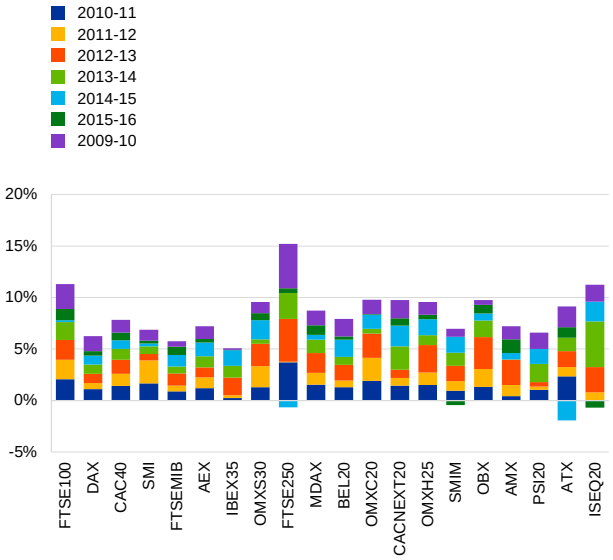


Sources: BATS Global Markets and authors' calculations.

Chart 7

Change in share of trading occurring on dark pools, by stock index category

(change in traded market share in percentage points; indices ranked left to right by total value traded in 2015)



Sources: Bats Global Markets and authors' calculations.
Note: Growth is measured from the first half of one year to the first half of the following year.

3.4 Dark pools in Europe in 2016

Equity trading in Europe is fragmented across a variety of exchanges, both regulated markets and MTFs, while dark pools are active across several countries and stock indices. There are currently around 15 main dark pools competing for volume across Europe. No single venue is dominant overall, or for stocks from any country or index.

European dark pools are active in stocks from a variety of countries or indices, as seen in Charts 8 and 9. These include stocks with different levels of capitalisation and liquidity. The level of fragmentation in Europe is consistent with findings in the United States, which show that as long as there are opportunities for trading on multiple venues, fragmentation affects all stocks regardless of stock type or its liquidity. Generally, stocks with more fragmented trading have been found to have more efficient pricing (closer to a random walk) and lower transaction costs but higher price volatility.[77]

Dark pools are especially prominent for trading in stocks listed in London, managing almost 12% of total volume traded. Dark pools also manage 12% of the volumes traded in the FTSE100 and 15% of those in the FTSE250. The London market is one of the most liquid and thus very attractive to HFT; moreover, a large share of the

[77] O'Hara and Ye (2011).

Fintech industry, which also develops HFT algorithms, is located there. The greater HFT presence might provide stronger incentives for traders to use dark pools.

However, considering stocks by primary venue of listing, evidence suggests that the market for dark pools may be European-wide rather than country-specific. Most European dark pools are active in trading a wide variety of stocks; this includes stocks from the most liquid stock groups – stocks listed in London, Frankfurt or Paris – as well as stocks listed in countries with less active trading (illustrated in Chart 8). There are a few small dark venues which focus on stocks of selected geographic origin – Nordic@mid for Scandinavian markets and Xetra for the German market – but the largest European dark pools do not specialise in stocks from particular countries (identified by venue of primary listing). There is, moreover, no dominant dark pool for groups of stocks listed in the same region: the largest dark pools rarely manage more than 25% of the dark pool trading in any such stock group. Finally, the market share of individual dark pools does not differ substantially between groups of stocks issued in different countries.

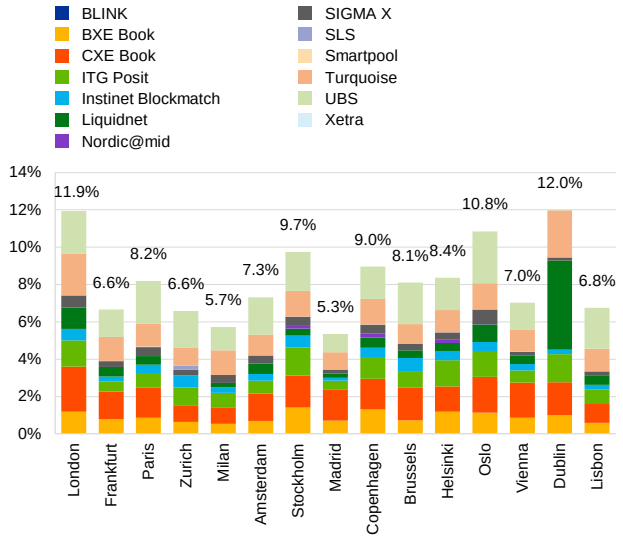
A comparison of the proportion of trading managed by dark pools across different stock indices shows that the share of trading in dark venues is slightly higher for indices where traded volumes of the stocks are on average lower (thus less liquid). Chart 9 illustrates the market share of dark pools on different indices, ranked according to total trading volumes (liquidity): stocks in less liquid indices have higher shares of dark pool trading than those in the more liquid indices. Within one country, dark pools generally account for a larger market share for stocks with somewhat lower liquidity: Chart 9 shows that dark pools account for a larger share of trading in mid-cap indices like FTSE250, MDAX and CACNEX20 than in FTSE100, DAX, and CAC respectively. In contrast, in the United States more dark pool trading occurs for stocks which are more liquid and for stocks which have higher volumes traded and higher market capitalisation.[78]

[78] Buti et al. (2010).

Chart 8

Share of value traded in equities occurring on dark pools, for stocks listed in various markets

(percentage of total traded volume of stocks traded on dark venues, by location of exchange of primary listing)

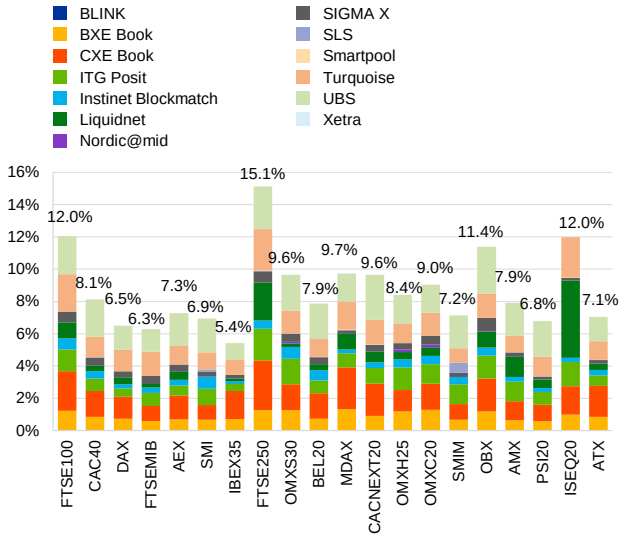


Sources: Bats Global Markets and authors' calculations. Liquidity is decreasing from left to right.

Chart 9

Share of value traded in equities occurring on dark pools, for stocks in various stock indices

(percentage of total traded volume of stocks traded on dark venues, by stock index)



Sources: Bats Global Markets and authors' calculations. Liquidity is decreasing from left to right.

A potential driving factor of the various fragmentation patterns for the most liquid stocks and other stocks is the difference in the cost of executing a block trade. Traders who are not willing to place a limit order in a lit order book due to the risk of information leakage while waiting to be matched have a choice between placing their market order on a lit order book or placing an order in a dark pool. For less liquid stocks there is, on average, less volume available in order books for immediate trading, which leads to higher market impact costs. The resulting higher cost of placing market orders in a lit order book may lead more traders to prefer using dark pools instead, as for dark pools there is no such market impact cost.

Thus, the market for equity trading in Europe sustains a small group of venues that offer limited pre-trade transparency for a large variety of instruments. The supply of such trading opportunities is particularly important for investors with diversified portfolios of pan-European stocks as they can easily conduct their business on a single platform. Similarly to all MTFs emerging in recent years, the majority of dark venues offer trading services in a wide variety of products and compete with each other for volume across such products (though a few venues focus only on a subset of instruments).

4 Competition between dark pools: prices and costs

Dark pools in Europe compete by providing the lowest cost and best quality of service for clients. For clients, the financial costs of placing an order on a dark pool depend on three factors: 1) the execution price of the trade (which depends on the reference price used), 2) the fees paid for placing an order, and 3) the speed and probability of execution of the trade (depending on the level of liquidity in the dark pool). Some dark pools aim to structure fees for clients to encourage liquidity provision, as higher liquidity generates spillover effects for other clients, increasing the speed and probability of execution for orders, and reducing total costs of trading.

4.1 Reference prices

Dark pools compete in offering clients the best prices for order execution. As explained in Section 2.3, the reference pricing mechanisms in dark pools result in the matched volumes being executed at a price determined on an external venue. The mechanism by which dark pools identify and apply the reference price determines the costs for clients to execute orders on this venue.

The process of determining the reference price may differ between dark pools, leading to potential differences in execution prices. In the absence of consolidated pricing feeds across European venues, dark pools often use the bid and offer from a stock's primary listing exchange for the reference price, implying similar prices across venues. However, in 2012, Instinet's BlockMatch became the first European dark pool to use (proprietary) consolidated data about European best bid and offer (EBBO) as the reference price. EBBO considers the best bid and offer for a stock on all lit exchanges. Currently, most dark pools continue to rely only on primary venues – national listing markets like the London Stock Exchange. However, BlockMatch and the Société Générale's AlphaY offer reference prices based on more than just primary venues. With trading in Europe increasingly fragmented on multiple lit exchanges, the investment in systems to consolidate data feeds may allow a dark pool to offer more competitive prices.

A second factor that may lead to differences in between the prices at which traders are matched in different dark pools is the use of a pricing mechanism to reimburse liquidity providers and attract more liquidity provision. Liquidity provision has positive spillover effects, as higher liquidity enables dark pools to match more orders and attract more clients because of the higher speed and likelihood of execution. Initially, dark pools matched supply and demand at the midpoint of the reference bid and offer price. In these midpoint-match dark pools, the orders are executed at the midpoint regardless of which order arrived first and thus both parties pay only half

the spread from the lit venue.[79] However, starting in 2013, some dark pools began offering an alternative pricing mechanism of bid-offer matching. Under this alternative, orders are matched at the best bid or best offer price from the venue of reference, rather than the midpoint. This mechanism requires dark pools to distinguish between passive and active orders: a "passive" sell (buy) order would be placed by a participant willing to keep the order waiting in the dark pool to be matched (thus providing liquidity) and an aggressive buy (sell) order would be one placed for immediate execution. Once volumes are matched, the price is based on reference best ask (best bid) prices – with the spread going to the investor placing the passive order.[80] Owing to the absence of pre-trade transparency, providers of passive orders still benefit from more protection against information leakage than in a lit venue. In Europe, the majority of dark pools continue to offer midpoint matching, but UBS and BlockMatch also offer the possibility of bid and offer matching.[81] This pricing mechanism allows dark pools to reimburse participants providing liquidity; liquidity providers might not otherwise internalise the positive externality of their action. Venues with bid-offer matching imply lower trading costs for liquidity providers. Traders who are not liquidity providers face higher costs on these venues but may be compensated by a higher likelihood of execution (if there are enough liquidity providers present).

4.2 Fees

Trading venues compete, *inter alia*, through the fees they charge; for dark pools, these include membership fees and per-order fees. Table 2 shows fees charged by different dark pools for orders executed, which range from 0.10 to 1 basis points and vary significantly across exchanges. Substantial differences in per-order fees suggest dark pools also compete in other areas (e.g. through horizontal differentiation in the types of orders targeted and services provided).

79 LiquidMetrix (2013a).

80 LiquidMetrix (2013a).

81 LiquidMetrix European Dark Pools, June 2016.

Table2

Fees charged for trading on dark order books as of January 1, 2017

Venue	Trading fees per order (bps)	Membership/Other Fees
CHI-X	0.20 non- IOC / 0.30 IOC*	Monthly connectivity charges for access to all BATS Europe exchanges (lit & dark)
BATS	0.20 non- IOC / 0.30 IOC*	Monthly connectivity charges for access to all BATS Europe exchanges (lit & dark)
UBS	0.10	None. Starting later in 2017: Annual connectivity fee (£5000-6000) and monthly fees per trading session above 5 sessions (£50)
Turquoise	0.30	Monthly connectivity charges for access to Turquoise exchange (lit)
SIGMA X MTF	0.10	None
SLS	1	No additional membership/connectivity fees for users of SIX Swiss Exchange Others N/A
Smartpool	Volume-tiered by monthly total trading: 0.50 first €200m, 0.30 for €200m- €750m, 0.25 above €750m	No additional fees for members already connected to Euronext non-Euronext member fees N/S
Nordic@Mid	Option I 0.23 non-IOC / 0.35 IOC**	Monthly connectivity charges for access to all Nasdaq Nordic venues
	Option IIA: 0.11 non-IOC/ 0.18 IOC	Additional monthly fee: Option I: None; Option IIA & IIB: DKK 188,000
	Option IIB: 0.25 non-IOC / 0.39 IOC	Transaction fee per executed order; Option I: 4.00 DKK non-IOC/5.96 DKK IOC; Option IIA: 2.00 DKK non- IOC/2.98 DKK IOC; Option IIB: None.
Blink MTF	0.25	Used by Cheuvreux clients (no extra fees)
Xetra	0.480 -0.552**	Monthly connection and other charges for access to Xetra exchange (lit)

* For immediate-or-cancel orders, any amount that cannot be executed immediately when the order reaches the exchange due to insufficient liquidity is cancelled and does not remain in the order book; for other orders, any amount not executed immediately remains in the order book until executed/end of day.
** Members of Nordic exchanges can choose fee schedule I, IIA or IIB, which determines trading costs on all Nordic equities venues (lit and dark).

On several venues, per-order fees depend on the volume traded, with lower per-order fees for clients trading higher volumes; this mechanism encourages clients to bring more liquidity to the dark pool. For example, for Smartpool, fees are based on monthly executed volume according to three tiers: 0.50 bps for the first EUR 200m traded, 0.30 bps for volumes between EUR 200m and EUR 750m, and 0.25 bps for volumes above EUR 750m.[82] Since higher levels of liquidity allow a dark pool to match orders more efficiently and draw more clients, such a differentiated fee structure allows clients to internalise some of the positive spillover effects of increasing the venue's liquidity when placing orders.

With regard to membership fees, for dark pools that are operated by lit exchange operators there is no extra cost for using the dark pools once the (often substantial) connectivity charges to the lit exchange have been paid. Usually, there is no option to just connect to the dark pool. Such connectivity fees include a number of charges and can vary significantly depending on the speed of the connection as well as the number of ports and selection of additional features (anywhere from under EUR 1,000 per month to EUR 5,000-10,000 per month). For the Nordic exchanges, there are options for fee schedules but the options apply to all (lit and dark) trading pools.

82 Euronext, Trading fee changes on SmartPool, October 2011.

For dark pools that operated separately from lit exchanges i.e. by brokers, either there are no fees apart from trading fees or the information is unavailable. The exception is UBS, which previously charged trading fees and will start implementing some annual fees in 2017.

4.3 Available liquidity

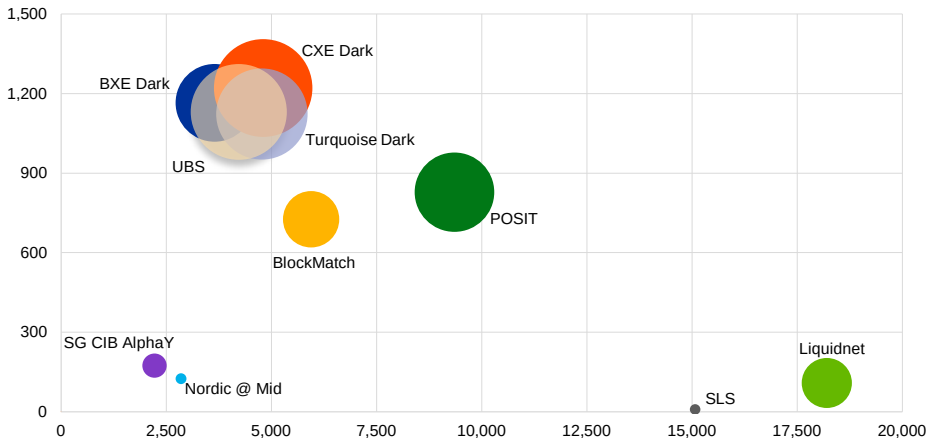
Liquidity in a dark pool determines costs of trading by affecting the probability and speed of execution for an order. Owing to price volatility and the potential for adverse price movements, a trader whose order is executed late (after the price has moved) or not at all can incur a high cost of trading in a dark pool. In European dark pools, if an order is not matched by the end of the day, any remaining volumes are cancelled at close of trading.

The volumes available for an individual instrument on the order book of a dark pool determine the probability and speed of execution for an order and thus the risk inherent in trading on that venue.[83] There is no information on the liquidity in different venues for individual instruments, but this can be inferred from a variety of indicators. First, the higher the average volumes traded in a dark pool on a single day, the higher the liquidity, contingent on the number of instruments traded. Comparing two dark pools with similar average trading volume, the liquidity for a single instrument is lower in the venue that trades in more instruments on an average day. Additionally, smaller trade sizes in a dark pool may reflect the fact that even if there is high liquidity, this might be spread across various times of day and instruments, reducing the probability of rapid execution for a large order.

Chart 10

Number of instruments traded, average trade size and total trading volume of the dark pool, June 2016

(y-axis: average number of instruments traded; x-axis: median trade size, EUR; bubble size: total average daily trading volumes)



Sources: LiquidMetrix Dark Pool Guides and authors' calculations.

[83] Unlike in a lit venue, the liquidity on a dark pool does not directly affect the order execution price, due to the reference price mechanism.

Chart 10 shows the median daily trade size and the average number of instruments traded for European dark pools, as well as the daily average volume traded across all instruments. The largest European dark pools (the dark order books of BATS Europe BXE and CXE, Turquoise and UBS) trade in many instruments, suggesting their liquidity may not be as substantial as the total volume traded indicates. A venue like Posit, although smaller in overall volumes traded, may be considered just as liquid for individual instruments as the four largest venues (UBS, BSE, CXE and Turquoise); while the average daily trading volumes on Posit are about 20% lower than on the other venues, it also trades on average in 20% fewer instruments per day. On the other hand, a venue like Liquidnet may be considered the most liquid for individual instruments as it has substantial trading volumes (a third as much as the large-volume dark pools) for substantially fewer instruments (ten times fewer instruments, on average, per day than the larger-volume dark pools). Moreover, Liquidnet has high median trade sizes (four times the size of the large-volume dark pools).

5 Competition between dark pools: horizontal differentiation

In addition to competing through prices, dark pools also compete by offering different order placement and processing services. No single venue can serve the interests of all investors, who differ in motivation, as well as size, type, and frequency of orders.[84] Horizontal product differentiation in trading services allows dark pools to target and attract different sets of clients. Higher levels of differentiation may help sustain the presence of multiple venues even though economies of scale and network effects favour consolidation. Pagano (1989) shows that when two venues differ in liquidity and entry costs or in the type of trading mechanisms, there is a stable separating equilibrium where both venues are active.

Demand for different types of dark pools may also reflect differences in investor types. Passive investors who trade for reasons unrelated to the value of the asset – for example diversifying a portfolio – may wish to place orders in a venue matching large size trades without pre-trade transparency to avoid moving the market price before or during execution. Retail investors (or their brokers) may choose a dark trading venue that allows them to minimise trading costs for a single, small order. Meanwhile, active investors – who research information about the asset and then trade based on their understanding of its fundamental value – may prefer venues where they can send multiple small orders for different kinds of stocks and preserve anonymity (so as not to divulge their private information).[85]

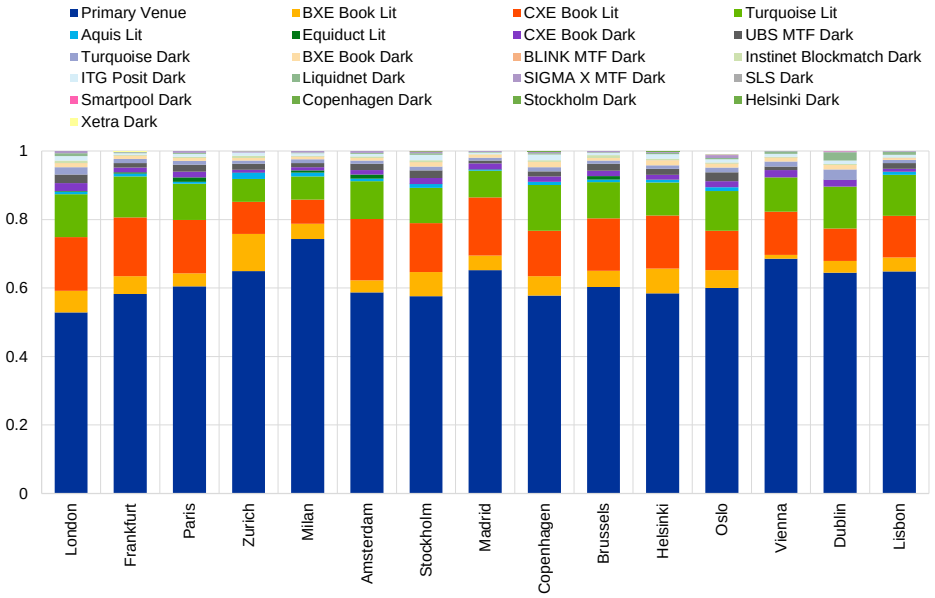
84 Gomber (2016).

85 Gomber et al. (2016).

Chart 11

Volumes of stocks traded on lit and dark order books, by country of listing, June 2016

(percentage of total volume traded for stocks listed in each country)



Sources: Bats Global Markets and authors' calculations.

The competition between dark order books is stronger and the market less concentrated than that between lit order books. As seen in Chart 11, the competition between lit venues relates to the dominant listing venue and a few other MTFs: for stocks listed in different countries, the primary listing venue (i.e. the London Stock Exchange for London-based stocks) is dominant, with two or three other MTFs also capturing a substantial trading share. However, there are more (close to ten) dark pools active in the stocks listed in different countries, even though each captures only a small market share. The fact that multiple dark pools can exist and compete without further consolidation may be an indicator that horizontal differentiation is a more important factor for competition in dark pools than for lit venues. There are more options that dark pools can offer clients to differentiate their services, while lit order books usually operate with more similar mechanisms.

Trading services of European dark pools can be differentiated along four central dimensions. Providing different trading services has implications for the types of clients the dark pools attract. First, dark pools may choose to cater for all orders or only large orders. Second, dark pools may adopt different mechanisms to match orders: period matching, unlike continuous matching, reduces the advantage of traders with low latency. Third, dark pools differ in the types of order and order features they allow investors to use; some order types may be beneficial to investors looking for protection against certain counterparties (such as minimum quantity restrictions) while others are particularly suited to traders using algorithms to detect information about the market (such as orders with time-in-force options). While these three services are different, they can all be used to limit the risk of trading against high-frequency traders. Finally, dark pools may offer trading in a diverse set of

instruments listed in different countries or may specialise in a subset of instruments listed in one or a few countries. These different features are discussed in more detail in the next section to explain how they are associated with offering investors protection against various risks and counterparties, especially as related to predatory trading or HFT. The type of protection resulting from these attributes may be direct or indirect. Table 3 summarises these central features of horizontal differentiation for currently active and recently active dark pools in Europe. Table 3 highlights that only a few dark pools have requirements such as minimum order size that would significantly discourage HFT activities.

Table 3

Availability of order placement and execution features related to investor protection in European dark pools

Green = available; white = not available

Feature	Block-cross	Block-match	BXE	CXE	Pipeline	Posit	Liquid-net	Noridc@-Mid	Nomura	SIGMA X	SLS	Smart-pool	Turquoise	UBS	Xetra
Min. Order Size Req.	■				■		■				■				
Min. Acceptable Quant. Option		■	■	■		■		■	■	■		■	■	■	■
Non-continuous matching option						■			■				■		
No time in force option for orders						■	■				■				
Time in force option with higher fees			■	■					■						
Located near primary exchange								■			■				■

Sources: Based on Intelligent Financial Systems' LiquidMetrix reports, supplemented by information from venues' websites.

5.1 Minimum order size

Some dark pools set minimum size thresholds that restrict orders to large block trades only. Such dark pools (called block-oriented dark pools) are relatively free of HFT, which use algorithms based on small orders to detect information about existing liquidity and are unlikely to take large positions. Block-oriented dark pools may be preferred by clients such as investment fund managers and pension funds looking to execute large trades away from exchanges and avoid the risk of price movement during execution (i.e. from market impact costs).[86] On the other hand, streaming liquidity pools are those which have no or a very low minimum share

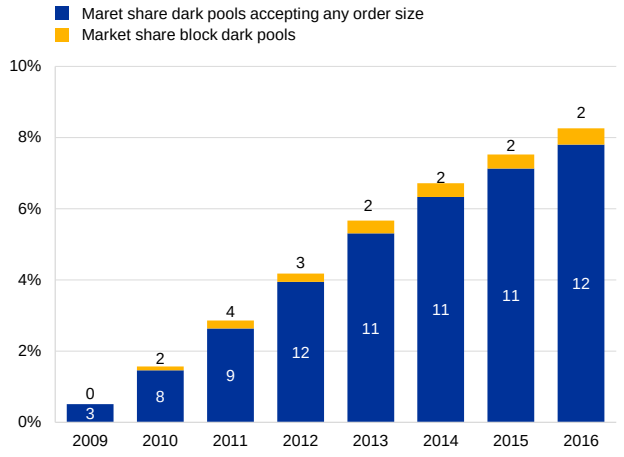
[86] Stafford (2016).

requirement for trading, and lower average trade sizes. Because they are less restrictive these venues may be able to amass larger amounts of liquidity.

Chart 12

Market share of equities trading in Europe for dark pools with and without minimum order sizes, October 2009 to July 2016

(percentage of equity traded volumes in Europe)



Sources: Bats Global Markets, Intelligent Financial Systems Ltd and authors' calculations.
Notes: Liquidnet and SLS are considered to be trading in block orders. Bar labels reflect the number of venues. Nordic@Mid pools in Copenhagen, Helsinki and Stockholm are considered as a single venue.

The desire to trade without pre-trade transparency (whether via dark pools or via hidden orders on lit order books) has traditionally been associated with investors who place large orders and wish to reduce the market impact or risk of losses from information leakage.[87] Despite this, dark pools specialising in large orders account for a small share of total dark pool trading in Europe. Only two European dark pools restrict trading to large orders – the dark order books of Liquidnet and SLS. These venues are linked as SLS is operated by the broker Liquidnet in conjunction with the Swiss Exchange and provides clients with access to Liquidnet's institutional buy- and sell-side liquidity (individual participants can opt in/out of this interaction).[88] The two dark pools specialising in large orders only account for 6% of all volumes traded on European dark pools. Orders executed on Posit are substantially larger than those on other dark pools (see Table B2), but the venue does not trade exclusively in block orders. Most European dark pools process orders of any size and have very small average order sizes. These venues capture most dark pool trading in Europe, as shown in Chart 12. This pattern is similar in the United States, where the top five Alternative Trading Systems (dark pools) in terms of largest average trade size make up less than 3% of the total share volume executed in ATS.[89]

There may be a natural limit to the number of block-oriented dark pools, because a dark pool needs to amass a sufficient number of large orders in order to be able to match them; the more restrictive the minimum order size threshold, the fewer potential matches there are. In the past, there were more block-oriented dark pools, but some exited the market because they were unable to consolidate sufficient volumes. BlockCross was a block-oriented dark pool that was active between 2009 and 2012 and was closed by its owner ICAP, due to problems attracting sufficient liquidity from competitor Liquidnet (which offered similar block services). Pipeline was another dark pool which restricted trades to those above a minimum order size (in this case, 10,000, 25,000 or 100,000 shares, depending on the stock)[90], but it shut down in 2012.[91]

87 OECD (2016).

88 LiquidMetrix Guide to European Dark Pools, June 2016.

89 OECD (2016).

90 See Ready (2014).

91 Pipeline's US dark pool was accused of profiting ahead of orders that clients had placed at its dark pool. An investigation by the SEC into various abuses of Pipeline eventually led to the closure of Pipeline's dark pool operations. See article Pipeline Saga Comes to a Close.

Streaming liquidity pools, with low average trades, might attract a broader variety of orders and thus more liquidity by being less selective. However, owing to the very small average order size (the median order size on these venues is under EUR 5,000 as seen in Chart 10), it may be difficult to execute a larger order on these venues. Since there is no restriction on order size, HFT, which relies on placing many small orders to detect supply and demand, might operate in these venues; the small median order size and large volume traded could be an indication of the presence of HFT or other algorithmic trading. The largest European dark pools in terms of volume traded are streaming liquidity pools, including BATS, CXE, Instinet, Turquoise and UBS. The vast majority of orders on these venues are generally too small to qualify for the large-in-scale exemption in MiFID, which offers block orders pre-trade transparency regardless of venue. Consequently, these streaming liquidity venues could be most affected by restrictions on the use of the volume cap on using reference price waivers in MiFID II (see Box 1).

5.2 Matching process

Dark pools may also adopt and offer different mechanisms for crossing – or matching – orders. The large majority of dark pools are continuous crossing pools, meaning they match (or “cross”) demand and supply on a continuous basis as orders arrive. On the other hand, scheduled-crossing pools match orders at a scheduled time, gathering as much liquidity as possible before matching. The timing for crossing can be at specific or randomly determined intervals.

Scheduled (non-continuous) crossing can protect clients from predatory practices, particularly those of algorithms using high speed to gain information. Scheduled crossing introduces higher latency and makes it more difficult for HFT or predatory traders in the dark pool to get information and use their speed to take advantage of it.[92] For example, algorithms would not be able to efficiently use pinging to obtain a snapshot of demand and supply at a particular point in time as orders are not processed immediately but all at once at a later point.

In Europe, all dark pools offer continuous crossing. However, Turquoise and Posit also offer options for non-continuous crossing alongside options for continuous crossing. Turquoise offers the option of randomised period crossing (where matching is at random intervals), while the option Posit Match matches orders during a 30-second interval several times a day at pre-determined times. When it was active, Nomura NX also offered the option of periodic matching.[93] When offering continuous crossing, most dark pools prioritise orders based on the time they were submitted. However, Smartpool prioritises orders based on initial order size, and only executes orders submitted first where two orders of the same size are received.[94] This prioritisation may have effects similar to non-continuous crossing on the ability of HFT to use latency-based strategies effectively.

92 Vaananen (2015).

93 LiquidMetrix Guide to European Dark Pools, June 2012.

94 Smartpool rulebook.

5.3 Complexity of orders allowed on dark pools

Another means by which dark pools differentiate their operations and aim to attract different niches of clients is via the type of orders allowed. Some dark pools allow only the most basic buy or sell orders, while others allow for a range of more complex orders. Many dark pools allow clients to place minimum quantity restrictions for orders – specifying a minimum volume that must be filled for any volume of the order to be executed. Other dark pools allow traders to allow for time-in-force options through immediate-or-cancel or fill-or-kill orders. Different types of orders might be attractive to different types of clients; some orders may help reduce risk or avoid interaction with particular types of counterparties.

The majority of European dark pools allow investors to impose a minimum quantity restriction; the exception is the dark pools that already have a minimum size requirement for accepting an order. For a buy order of 500 shares, a minimum quantity of 100 would imply that no amount would be matched until at least 100 shares were available to be matched (on the sell side). A minimum quantity restriction is intended to avoid a situation where only a small volume from an order is executed (through one or multiple small trades), while the rest of the volume remains on the dark pool. Such a situation might lead to information spreading in the market about the existence of supply or demand based on the order and to front running, leading to subsequent price movements that could harm investors' trading interests.[95] Moreover, a minimum quantity requirement might help prevent interaction with pinging by HFT or with other algorithms that rely on small orders. However, a higher minimum quantity threshold increases the risk of an order not being executed and the time it takes to find a matching opposite order that is sufficiently large. The low median trade size on most dark pools indicates the presence of many smaller orders, so that the use of this feature may substantially reduce the probability of finding a matching order. The overall benefit of using the minimum quantity restriction depends on the average order sizes on the venue and the popularity of the minimum order size: in certain circumstances, the use of this feature might increase costs by reducing execution probability and/or speed significantly.

Another category of special orders available on some dark pools are those which allow for time-in-force option – orders like fill-or-kill (FOK) or immediate-or-cancel (IOC); such order types allow traders to specify information about the timing of the execution of their order. Once FOK orders reach the order book, they are either executed in full or, if there is not sufficient liquidity available, they are cancelled in full. With IOC orders, as much volume as possible is executed from the available liquidity at the time the order reaches the order book and any remaining volumes are cancelled. These two types of orders are frequently used by HFT to get a "snapshot" of current liquidity in a venue[96]. Consequently, information leakage may be more likely on dark pools allowing IOC or FOK orders, because this may be an indicator of HFT presence. In Europe, most dark pools offer these types of orders. Exceptions are Posit, Liquidnet and SLS. Selecting non-continuous matching also means traders

95 Vaananen (2015).

96 Vaananen (2015).

avoid trading against IOC or FOK orders, which can only work on a continuous matching platform because they rely on timing.

Some dark pools – the two dark order books of BATS Europe, as well as Nomura prior to its exit from the market – allow special order types but charge higher fees for time-in-force orders.[97] This may serve to indirectly discourage HFT or algorithms looking to use a multitude of such orders to obtain information about the dark order book and act on it.

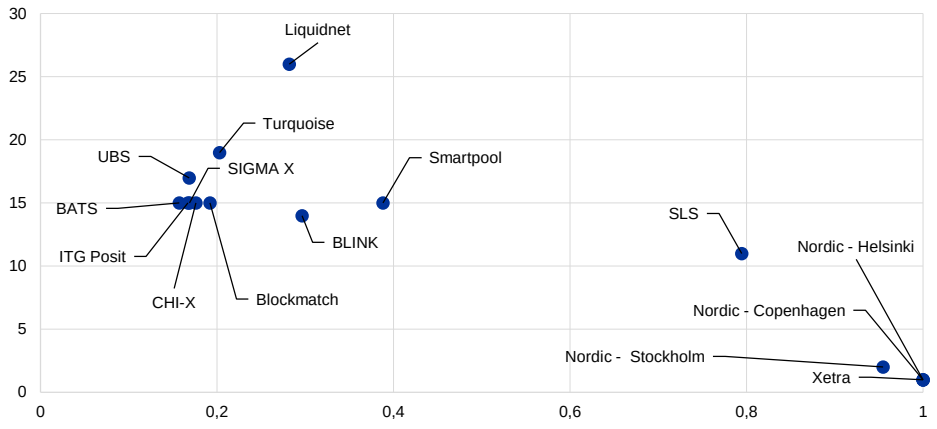
5.4 Diversity of products

Dark pools can increase market share by expanding trading to as many instruments as possible in order to attract clients with different preferences or complex portfolios. An alternative approach is to focus on the stocks of a particular country only (securities listed on a particular country's primary venue, such as the London Stock Exchange). Consolidating liquidity into a single subset of stocks may allow dark pools to attract a larger share of trading for these stocks. Venues with a narrow regional focus are usually located next to the primary exchange, which reduces traders' ability to use latency for arbitrage based on the reference price.

Chart 13

Number of markets (countries) in which a dark pool is active, and the concentration of dark pool trading in these markets, Q2 2016

(y-axis: number of markets active, x-axis: concentration of trade)



Sources: Based on dark pool guides and Liquidmetrix.
Note: The lower the concentration index number, the more evenly divided the trade.

Most dark pools in Europe trade in equities listed in a number of countries from a single order book in a single location, but a few have different business models (see Chart 13). The largest dark pools in Europe trade in equities from 14 or more European countries (stocks listed in a particular country's primary venue). A few dark pools in Europe trade only in the equities of one or a few countries, and locate their

[97] LiquidMetrix Guide to European Dark Pools, June 2016.

order book in these countries: the dark arm of Xetra, based in Frankfurt, is only active in German equities, while the Nordic@mid dark pools, with order books based in Stockholm, Copenhagen and Helsinki, are only active in Scandinavian equities. For dark pools operated by managers that also run lit order books, the number of instruments may depend on which stocks are traded in the lit order books. BATS Chi-X Europe runs large lit order books trading stocks from multiple countries, and, similarly, the dark pools trade a variety of stocks. On the other hand, Nordic@mid and Xetra are run by operators of primary exchanges (the Nasdaq Nordic exchanges and Xetra respectively), operating with a country-specific focus.

While a narrow focus reduces the potential client base, dark pools specialised in the stocks of a single country are usually located near the primary venue, gaining an advantage in latency; this advantage can help protect against the negative impact of HFT. Most other dark pools are located in London, and therefore far from primary trading venues for non-UK stocks. Consequently, the time taken for information on the new reference price to travel from the primary exchange to the dark pool is longer for these venues; for reference prices from Nordic exchanges the travel time to London can be as much as 10 milliseconds.[98] The fastest HFT algorithms might detect price updates on primary exchanges before the updated prices are reflected in the London-based dark pools, and react by placing orders on the dark pool to take advantage of this arbitrage opportunity. This may cause losses for their counterparties in the dark pool, as they would be trading at outdated prices. The Nordic@mid dark pools of Nasdaq and Xetra may protect traders from this possibility because they are located next to the primary venue. SLS, operated by the Swiss stock exchange and located in Zurich, can also be considered in this category as most volumes traded are in Swiss stocks.

In most other European dark pools, volumes traded are distributed among stocks from different countries rather than concentrated in one or two markets.[99] A concentration index assesses the extent to which volumes traded in a dark pool are divided proportionately among different countries (taking the sum of squared proportions) – with one symbolising complete specialisation in the stocks of a single country, and lower numbers symbolising more diversification among countries. Most of the larger dark pools – including UBS, Turquoise, Chi-X and BATS – have a low measure of concentration, as illustrated on the x-axis of Chart 13. An exception is Liquidnet, which has a relatively high concentration due to disproportionately large trading in less liquid markets, specifically Lisbon, Vienna and Dublin. Venues offering liquidity in a broader selection of stocks are more suited to clients with diversified pan-European portfolios and more complex trading strategies.

98 Liquidmetrix (2013a).

99 In this section, countries are understood to be the country of the venue of primary listing.

5.5 Implications of horizontal differentiation for client protection

The previous sections show that few European dark pools employ one of the two trading and matching features that restrict trading to orders least likely to be derived from HFT strategies: high minimum order size requirements or employing non-continuous matching (see Table 3). Instead, most venues accept small orders and offer continuous matching and execution, as well as offering clients the possibility of using time-in-force options (often used under HFT strategies). In this latter setting, some HFTs could use their latency advantage to place and cancel small orders on dark pools to obtain information about the market or take advantage of arbitrage opportunities from the latency in changes to reference prices.

Some dark pools offer participants trading options that may decrease the likelihood of interacting with HFT counterparties, such as options for a minimum quantity restriction for the execution of an order; however, it is not clear whether this option is sufficiently popular to substantially reduce the probability of execution with such counterparties. Traders must weigh the benefits (reduced risk of interaction with certain counterparties or of information leakage) against the cost of slower execution or no execution, which is higher the less popular the feature (as there are fewer potential counterparties to match with).

Moreover, dark pool operators have incentives to allow HFT counterparties to trade on their platforms in order to increase volumes traded and to appear more liquid to clients. Since there is no observable evidence to quantify the prevalence of HFT or other predatory trading on any dark venue, clients looking for protection may prefer dark pools with order placement and matching mechanisms that remove or decrease the likelihood of interacting with such counterparties.[100]

In order to assess the degree of additional protection from information leakage and trading with HFT implied by various features offered by different dark pools, a simple additive indicator based on the availability of the features described in the previous sections has been constructed. The analysis then considers trends in the market shares of dark pools offering more or fewer additional protective features. The features relate to the size and type of orders accepted and the timing of the matching process. The features are categorised by whether they imply direct or indirect means of protection from information leakage or from trading against HFT. The number of points allocated for a feature in the construction of the indicator depends on the category and thus the degree of protection:

- (3) points for trading restrictions which limit access to the platform to investors making block trades or investors who are patient (block order venues with minimum order size or venues with the option to select non-continuous matching) only; such restrictions would allow traders to avoid counterparties that use certain algorithmic practices such as pinging or that use latency to obtain information about orders

[100] Vaananen (2015).

in the order book and profit from it. A single venue offers at most one of these features.

- (2) points for offering features that decrease the likelihood that clients will encounter counterparties that employ algorithms to obtain information and engage in predatory practices, but that do not fully eliminate flows from these traders/algorithms. This includes the option for block traders to use a minimum quantity restriction for their orders in the absence of a venue-wide minimum order size requirement. It also includes dark pools that have continuous matching but that do not offer the option to place IOC or FOK orders, which are frequently employed under HFT strategies (thus reducing the prevalence of some but not all HFT participants). [101] It further includes platforms that offer volume-time priority (rather than time priority first).

- (1) points for features that increase the costs of trading for participants seeking to use latency to obtain information, but do not directly restrict the placement or execution of orders likely to be derived from HFT strategies. These include charging higher fees for time-in-force orders, and being located near the primary venue for the equities where the dark pool specialises.

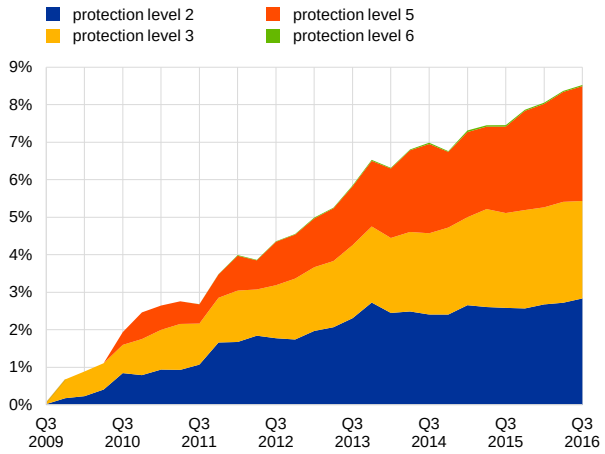
An assessment was made of the availability of these attributes on each dark pool based on information from the monthly LiquidMetrix Guides to European Dark Pools and own research into the published guidelines and rules of each venue. The score of each dark pool was constructed by allocating the relevant points when a feature in one of the above categories above was present. Information is only compiled on the most common features, although it is possible that these dark pools offer additional measures to offer clients protection from HFT counterparties that are not public. Implicitly all the features discussed offer benefits in addition to the reduced pre-trade transparency, which is common to all dark pools.

[101] If a dark pool offered a non-continuous matching option, no further points were added for not providing the option to use time-in-force options with trades, or for charging higher fees for time-in-force options. This is because time-in-force options cannot be used under a non-continuous matching process, so the protective features cannot be considered additive.

Chart 14

Share in European equities trading on dark pools offering different additional features of investor protection

(y-axis volume traded as % of total percentage of total volume traded on dark and lit venues; x-axis: time)



Sources: Bats Global Markets, Intelligent Financial Systems Ltd and authors' calculations.
Note: higher score means higher protection.

Chart 14 shows European stock trading market shares (volume traded as % of total) for European dark pools with different levels of additional protection between 2009 and 2016. Aggregating the points across the three attributes generates a final score; for the dark pools in our sample, this score ranges between two and six, as all venues in the sample have at least one of the features listed above. The sample of dark pools where data are available can be grouped into four categories based on the final score calculated from the points system above: lowest additional protection (2 points), lower additional protection (3 points), high additional protection (5 points), highest additional protection (6 points). With the exception of Turquoise, which implemented the option to use randomised matching in 2012, the scores of individual dark pools in this sample remained the same throughout the period.

Most dark pool trading in Europe occurs on venues with few additional features for protection (scores of 2 or 3). The BATS Chi-X Europe and Nordic@mid pools all offer low levels of protection, as did the now-inactive BlockCross and Pipeline (score of 3). UBS, Smartpool, Instinet and Turquoise before 2012 all offer the lowest levels of protective features. The dark pools that are categorised as offering lower additional protection feature (scores 2 or 3) account for 5.4% of equities trading volumes, persistently capturing a majority of the dark pool market share. Only SLS offers a trading restriction in addition to allowing clients to decrease the likelihood of interacting with HFT and a feature that increases costs for implementing HFT strategies, resulting in the highest level of additional protection (a score of 6). However, trading on this dark pool accounts for less than 0.05% of equity volumes traded on European markets (see Chart 1). The market share of venues with more options for additional protection (5 points), which offer both a trading restriction and a feature that decreases in another way the likelihood of traders interacting with HFT strategies, has increased more quickly recently, reaching 2.9% in Q2 2016. The dark pools in this category are Posit, Liquidnet, Nomura (before exiting the market in 2012) and Turquoise (after 2012).

The results suggest that patient investors seeking the highest levels of protection when placing block orders or looking for other additional options to avoid information leakage might form only a part of the demand for dark pools. The venues with fewer additional features to reduce the likelihood of trading against HFT have higher market shares than those with more such features. Moreover, it cannot be ruled out that at least some of the recent growth in the market pool of dark pools is driven by the increased presence of HFT on dark venues; HFT strategies may be more easily implemented on venues without restrictions on minimum order size, where average trades are very small. A potential reduction in dark pool usage after the implementation of MiFID II might disproportionately affect the dark pools with fewer additional protective features where smaller trades are more prevalent due to the

restriction placed on the volumes traded under the reference and negotiated price waivers (see Box 1). However, to the extent that some of the traders impacted are algorithms trading for profit rather than due to business needs, the economic effect might be small.

6 Dark pools and implications for the market

The aggregate implications of dark pools on market functioning are the subject of continued debate among regulators and researchers. Generally, competition between multiple trading venues may reduce trading costs: O'Hara and Ye (2011) find that fragmentation in trading between exchanges reduces transaction costs and increases execution speed for US stocks. However, fragmentation between lit and dark order books results in changes to market structure and dynamics, which may have implications for financial stability and market efficiency. Two of the principal channels through which dark pool trading could have negative effects on market stability and efficiency, identified by the International Organization of Securities Commissions (IOSCO) in 2010, are liquidity fragmentation and price formation.

6.1 Liquidity fragmentation and dark pools

The implications of dark pools for the efficiency and stability of financial markets stem in part from the way dark pools segment information and order flow in the market. Dark pools affect the composition of investors found on both lit and dark venues.

Trading without pre-trade transparency might be especially attractive to uninformed traders who look to benefit from price improvements (and avoid the risks of trading against HFT on a lit venue). Hendershott and Mendelson (2000) argue that, when dark pools are available, lit exchanges are used primarily for informed order flow looking for fast and certain execution, being seen as only a market of last resort by other trader types. Zhu (2014) argues that informed traders prefer lit venues offering faster execution; informed traders are also more likely to be on the same side of the market and thus less likely to obtain execution in dark pools. Consequently, if informed traders predominantly use lit venues, while uninformed traders go to dark pools, the risk of adverse selection for uninformed traders and the costs of trading on lit venues increase. This increases incentives for uninformed traders to use dark pools. The availability of dark pools consequently leads to a concentration of informed traders on lit exchanges.

Empirical evidence generally supports the hypothesis that the relative information level of traders on dark venues is lower than the level of traders on lit venues. Comerton-Forde and Putniņš (2015) find that traders on dark venues are less informed that those on lit exchanges. Meanwhile Nimalendran and Ray (2011) find that there are some informed traders on dark pools, and the level of information is highest for trades involving illiquid stocks and placed using algorithmic strategies.

Fragmentation in trading resulting from the emergence of new venues may affect the costs of trading through spreads and liquidity, and thus affect welfare. Iyer et al.

(2015) find that in a model with different levels of information, there is an equilibrium with traders segmented by information level: less informed traders engage in dark pools, resulting in higher spreads in lit order books due to increased adverse selection. However, these welfare losses may be counterbalanced by welfare gains resulting from increasing the volume of uninformed traders who have access to the market as dark pools provide an additional venue with lower adverse selection. On the other hand, while fragmentation among lit exchanges was found to have an overall positive effect on liquidity across venues, the relationship between dark trading and aggregated liquidity has been found to be negative.[102] Liquidity providers on lit venues usually offset their losses from trading against informed traders with gains from trading against the uninformed.[103] Fewer uninformed investors trading on lit markets could be associated with significantly lower returns for liquidity provision, and thus lower market maker activity; this could lead to lower levels of liquidity overall, and higher transaction costs.[104]

6.2 Price formation and dark pools

By removing liquidity from primary venues and other lit order books, trading in dark pools may have potential implications for price formation and, consequently, volatility and the market's ability to absorb shocks. The European Commission (2010) has expressed concern that "[an] increased use of dark pools […] may ultimately affect the quality of the price discovery mechanism on the 'lit' markets." If such effects are strong during periods of instability, dark pools may contribute to amplifying volatility and illiquidity. Moreover, in market shocks, liquidity and volatility can have feedback effects on each other.[105] Investigating the relationship between dark trading on market stability is especially relevant given the recent high volatility events (flash crashes) in financial markets.

If the orders traded in dark pools are orders that might otherwise have been publicly displayed and contributed to price formation, then the development of dark pools and use of dark orders could inhibit price discovery.[106] As prices in dark pools are not determined by internal demand and supply but are based on external reference points, they do not contribute to pre-trade price formation.[107] By removing order flow from lit venues, dark pools reduce the information contained in lit order books where prices are formed; prices can only react to trades conducted "in the dark" after the trades are executed. Reducing the amount of information incorporated in price formation could lead to more volatile prices.

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102 Degryse et al. (2015).

103 Glosten and Milgrom (1985).

104 Zhu (2014).

105 Cespa and Foucault (2014).

106 IOSCO (2010).

107 Moreover, most orders in dark pools are too small to qualify for the large-in-scale transparency waiver, so most dark pool orders would otherwise be part of the displayed depth in lit order books.

On the other hand, theoretical models hold that because dark pools segment the market between the informed and uninformed, their presence may reduce price volatility; in this setting, orders from informed traders concentrate on lit venues where price formation occurs, while the noise from orders of uninformed traders is removed as these orders move to dark venues.[108] Comerton-Forde and Putniņš (2015) find that as the share of dark trading increases, quotes from liquidity providers become more important relative to trade prices in discounting new information in market prices; this is consistent with the view that liquidity providers in the lit market become more informed as uninformed traders move to dark pools. In such a setting, greater use of dark pools could imply lower volatility as more uninformed flow is removed from price formation. Moreover, under such fragmentation based on information, there may be a lower market share of dark pool trading when there is high volatility due to a lower proportion of uninformed traders active in the market. This may occur either because uninformed traders observe volatility and are reluctant to trade due to the risk of adverse selection, or because volatility indicates more information in the market and more traders are informed.

The link between volatility and the use of dark pools has been explored empirically in the United States, but analysis has been more limited in Europe due to data availability. For US stocks, Ready (2014) finds that orders of stocks with more price volatility are more likely to be routed to dark pools. In contrast, Buti et al. (2010) find that, for a single stock, dark pool market share is higher on days with lower volatility.

Petrescu, Wedow and Lari (2016) find evidence that dark pool trading share has explanatory power in predicting volatility; consistent with a theory that the existence of dark pools removes noise from price formation on lit venues, they find that increased use of dark pools is associated with lower price volatility. Such a result suggests dark pools may not be significantly detrimental to market stability in times of stress. The results are also consistent with a setting where, under very high volatility, orders are no longer routed to dark pools because prices are constantly changing and slower execution or outdated reference pricing can lead to larger losses for investors. Lower dark pool trading in periods of higher volatility are also consistent with a hypothesis that HFT – which is more active in periods of moderate volatility as it can benefit from more arbitrage opportunities – is less prevalent on dark pools than on other venues.

The relationship between volatility and market share for individual dark pools is further considered below; it is found that the relationship differs significantly across venues in both direction and magnitude. The dataset from Petrescu, Wedow and Lari (2016) is used, which consists of a panel reflecting the market share of 18 individual dark pools for trading in FTSE100 stocks from October 2009 to October 2015. Table 4 shows the venue-specific coefficients for the relationship between a (change in) daily realised volatility in the FTSE 100 price index and a (change in) the market share of each venue. For most of the dark pools with substantial trading volumes in FTSE100, the correlation between own market share and price volatility is negative; the strongest negative correlation is with the volatility of Liquidnet, which restricts

[108] Zhu (2014).

orders to block trades only. The correlation between the market share of BlockCross – another block trading platform – and volatility is also negative. Block trading venues might be most likely to host uninformed traders and least likely to host informed traders or HFT;[109] the negative correlation between block trading venues and volatility is thus consistent with a setting where dark pools fragment liquidity by information level. By removing some information on the larger orders of uninformed traders from the pre-trade price formation, these venues might remove substantial amounts of noise; on the other hand, uninformed investors might not place large block orders when they observe substantial or rapid price changes to avoid the risk of trading at a bad price for a large volume.

Table 4

Relationship between daily market share in FTSE 100 trading and equity price volatility for individual dark pools

Venue	Coefficient for effect of daily price volatility on market share of the venue	Total FTSE volumes traded in EUR million (daily average for active period)	Block trading only?	Primary focus in non-FTSE100 equities?	Inactive?
Liquidnet	-0.028***	34	Y		
ICAP BlockCross	-0.018***	2	Y		Y
Turquoise	-0.016***	90			
CXE Book	-0.012***	123			
BXE Book	-0.008***	77			
Nomura NX	-0.007***	19	Y		Y
Instinet Blockmatch	-0.004***	44			
UBS MTF	-0.002	103			
ITG Posit	0.002**	74			
NEURO	0.002*	6			Y
Smartpool	0.003**	9			
SIGMA X MTF	0.004***	63			
BLINK MTF	0.006***	1			
SLS	0.006***	0		Y	

Source: regression analysis based on data from Petrescu, Wedow and Lari (2016).

For some venues, there is a positive correlation between the market share and price volatility. One of these venues specialises in stocks from another country (SLS); and only trades very small volumes in FTSE100 stocks. It is possible that clients of this venue do not focus on FTSE stocks and do not have high levels of information about these stocks. Most other dark pools where the correlation between market share and volatility is positive are venues with smaller average daily trading volumes in FTSE100. While it is not possible to draw conclusions regarding the link between their business models and the correlation with market volatility, it is possible that these venues did not attract many uninformed clients and had a higher proportion of informed clients, resulting in a positive rather than negative correlation between

[109] Informed traders looking to profit from their information and trying to use dark pools would be happy selling smaller volume orders.

market share and volatility.[110] Such a dark pool with a larger proportion of informed traders might not be able to gain large volumes from uninformed traders when there is high volatility because uninformed clients would be reluctant to use the venue due to adverse selection risks.

[110] Orders from informed traders would remove information from price formation leading to more volatility, while the proportion of informed traders might grow during periods of high volatility.

7 Conclusion: the future of dark pools

Dark pools have grown rapidly in Europe in recent years and several of them have gained substantial market shares in trading equity products across multiple countries. The market for dark pools appears more competitive than that for lit order books as there are multiple dark pools with stable market shares in Europe, with no one venue dominant in all or a subset of instruments. Dark pools compete both in price and in offering different order placement and execution services; horizontal differentiation results from venues offering various additional services to clients to protect them from various counterparty and trading risks.

Dark pools are likely to continue to be important players in financial markets when MiFID II comes into force in Europe in 2018. The market share of dark pools has stabilised in recent years around the level of the volume cap (8%), so it is unlikely that the new MIFID II restrictions will dramatically reduce their aggregate market presence. However, the impact on trading in some instruments where dark pools are more often used – particularly stocks listed in London – may be more substantial given that the level of trading is more likely to exceed the volume cap (see Box 1). The effect of this regulation will likely be different across dark pools, as venues focusing on large orders may be able to continue offering "dark" trading to clients through large-in-scale waivers even if the cap limit is hit.

Dark pools are currently seeking to expand beyond equity markets to other instruments, including fixed income. As MiFID II/MiFIR introduces pre-trade transparency requirements for liquid bonds, some dark pools may expand their business lines to these instruments.[111] Understanding the impact of dark pools on market functioning in equity markets may help anticipate the effect of such structural changes in secondary fixed income markets; the latter have been identified as particularly vulnerable to liquidity shocks. The review of the scant literature on this topic suggests that there is limited evidence for a detrimental impact of dark pool trading on price formation and volatility in equity markets. This finding may not be transferable to fixed income markets due to the differing characteristics of the instruments and the trading behaviour., Dark pools may be better able to cater to fixed-income instrument trading given the large ticket size and infrequent trading that typically characterises the fixed-income space. At the same time, the continued coexistence of many dark pools in the equity space could suggest that dark pools may also cement market fragmentation for fixed income, affecting the price discovery process and, thus, market liquidity.

The growth of dark pools raises important questions regarding the appropriate regulatory approach. Dark pools developed in response to client demand as a result of changing market conditions. New regulation under MiFID II/MiFIR is likely to affect dark pools directly by setting limits on the volumes traded on dark pools and, indirectly, through regulation on predatory practices, especially those of algorithmic

[111] Liquidnet has already launched such a venue; see Liquidnet Launches Fixed Income Dark Pool

trading or HFT. Individual countries have already passed laws addressing algorithmic trading in different ways. MiFID II/MiFIR aim to regulate algorithmic trading and HFT, but primarily through measures to avoid flash crashes when liquidity for this type of trading disappears.[112] MiFID II/MiFIR include requirements for system controls of algorithms and storing sequenced records of the actions of algorithmic trading systems, as well as obligations that algorithms engaged in market making do so on a continuous basis.[113] The aim of these requirements is to ensure the resilience of trading systems, to avoid the sending of erroneous orders and to provide supervisors with information on the activities of algorithmic trading.

[112] For example, the High-Frequency Trading Act in Germany, passed in 2013, defines authorisation and organisational requirements for investment firms using HFT, and outlines obligations regarding trading on trading venues (Gomber 2016).

[113] See Mifid II, Directive 2014/65/EU, Article 17.

References

Aguilar, L. (2015), “Shedding light on dark pools. Securities and Exchange Commission Public Statement”, available at sec.gov/news/statement

Buti, S., Rindi, B. and Werner, I.M. (2017), “Dark pool trading strategies, market quality and welfare”, *Journal of Financial Economics*, Vol. 124, No 2, pp. 244-265.

Cespa, G. and Foucoult, T. (2014), “Illiquidity Contagion and Liquidity Crashes”, *Review of Financial Studies*, Vol. 27, No 6, pp. 1615-1660.

Clarke, T. (2014), “High frequency trading and dark pools: sharks never sleep”, *Law and Financial Markets Review*, Vol. 8, No 4, pp. 342-351.

Cohen, K.J., Maier, S.F., Schwartz, R.A. and Whitcomb, D.K. (1981), “Transaction costs, order placement strategy, and existence of the bid-ask spread”, *Journal of Political Economy*, Vol. 89, No 2, pp. 287-305.

Comerton-Forde, C. and Putniņš, T.J. (2015), “Dark trading and price discovery”, *Journal of Financial Economics*, Vol. 118, No 1, pp. 70-92.

Degryse, H., de Jong, F. and van Kervel, V. (2015), “The impact of dark trading and visible fragmentation on market quality”, *Review of Finance*, Vol. 19, No 4, pp. 1587-1622.

Degryse, H. and Ongena. S. (2007), “The impact of competition on bank orientation”, *Journal of Financial Intermediation*, Vol. 16, No 3, pp. 399-424.

Deutsche Bank Research (2016), “High frequency trading: Reaching the limits”, Research Briefing: Global financial markets.

Eng, E.M., Frank, R. and Lyn, E.O (2013), “Finding Best Execution in the Dark: Market Fragmentation and the Rise of Dark Pools”, *Journal of International Business and Law*, Vol. 12, No 1, pp. 39-50.

European Commission (2010), “Review of the Markets in Financial Instruments Directive (MiFID)”. Public Consultation, European Commission, 8 December.

Financial Conduct Authority (2016), “UK equity market dark pools – Role, promotion and oversight in wholesale markets”, *Thematic Review*, TR16/5.

Fioravanti, S.F. and Gentile, M. (2011), “The impact of market fragmentation on European stock markets”, *CONSOB Working Paper*, No 69, July.

Garvey, R., Huang, T. and Wu, F. (2016), “Why do traders choose dark markets?”, *Journal of Banking & Finance*, Vol. 68, July, pp. 12-28.

Glosten, L.R. and Milgrom, R. (1985), “Bid, ask and transaction prices in a specialist market with heterogeneously informed traders”, *Journal of Financial Economics*, Vol. 14, No 1, pp. 71-100.

Gomber, P. (2016), “The German equity trading landscape”, Goethe University Frankfurt, Research Center SAFE-Sustainable Architecture for Finance in Europe, *White Paper*, No 34.

Gomber, P., Arndt, B., Lutat, M. and Uhle, T. (2011), “High frequency trading”, available at SSRN 1858626.

Gomber, P., Sagade, S., Theissen, E., Weber, M.C. and Westheide, C. (2015), “The State of Play in European Over-the-Counter Equities Trading”, *Journal of Trading*, Vol. 10, No 2, pp. 23-32.

Gomber, P., Sagade, S., Theissen, E., Weber, M.C. and Westheide, C. (2016), “Competition Between Equity Markets: A Review of the Consolidation Versus Fragmentation Debate”, *Journal of Economic Surveys*, forthcoming.

Grant, J. (2011), “Pipeline to launch Europe ‘dark pool’ next month”, *Financial Times*, retrieved from financial times, 10 April.

Grant, J. and Wilson, J. (2008), “Deutsche Börse to launch hybrid ‘dark pool’ facility”, *Financial Times*, retrieved from financial times, 20 November.

Hendershott, T. and Mendelson, H. (2000), “Crossing Networks and Dealer Markets: Competition and Performance”, *Journal of Finance*, Vol. 55, No 5, pp. 2017-2115.

IOSCO (2010), “Issues raised by Dark Liquidity”, Consultation Report, CR05/10, IOSCO Technical Committee.

Iyer, K., Johari, R. and Moallemi, C.C. (2015), “Welfare analysis of dark pools”, available at SSRN 2040959, 12 May.

LiquidMetrix (2013a), “Bid Offer Dark Pools – A Free Lunch?”, *White Paper*, No WP003.

LiquidMetrix (2013b), “Comparing Nordic Dark Pools”, Short Article LM0012.

LiquidMetrix (2012-2016), “LiquidMetrix Guide to European Dark Pools”, Monthly, retrieved from liquidmetrix.

Madhavan, A. (1995), “Consolidation, fragmentation, and the disclosure of trading information”, *Review of Financial Studies*, Vol. 8, No 3, pp. 579-603.

Nasdaq OMX (2010), “Nasdaq OMX to close its pan-European equity MTF Nasdaq OMX Europe”, Nasdaq news release, retrieved from nasdaq, 28 April.

Nimalendran, M. and Ray, S. (2011), “Informed trading in dark pools”, SSRN eLibrary.

O'Hara, M. and Ye, M. (2011), “Is market fragmentation harming market quality?”, *Journal of Financial Economics*, Vol. 100, No 3, pp. 459-474.

OECD (2016), *OECD Business and Finance Outlook 2016,* OECD Publishing, Paris.

Pagano, M. (1989), “Trading volume and asset liquidity”, *Quarterly Journal of Economics*, Vol. 104, No 2, pp. 255-274.

Petrescu, M., Wedow, M. and Lari, N. (2016), “Do dark pools amplify volatility in times of stress?”, *Applied Economics Letters*, Vol. 24, No 1, pp. 1-5.

Puaar, A. (2012), “Nomura plots NX closure ahead of Instinet integration”, *The Trade*, retrieved from tradenews, 20 November.

Ready, M. J. (2014), “Determinants of volume in dark pool crossing networks”, AFA 2010 Atlanta Meetings Paper, August.

Securities and Exchange Commission (2010), “Concept Release on Equity Market Structure”, Release No 34-61358; File No S7-02-10.

Securities and Exchange Commission (2011), File 3-14600: In the Matter of Pipeline Trading Systems LLC, Fred J. Federspiel and Alfred R. Berkeley III, “Order instituting administrative and cease-and-desist proceedings, pursuant to 8a of the securities act of 1933, and sections 15(b) and 21c of the securities exchange act of 1934, making findings and imposing remedial sanctions and a cease-and-desist order”, available at sec.gov/litigation

Securities and Exchange Commission (2015a), In the Matter of UBS Securities LLC, “Order instituting administrative and cease-and-desist proceedings, pursuant to 8a of the securities act of 1933, and sections 15(b) and 21c of the securities exchange act of 1934, making findings and imposing remedial sanctions and a cease-and-desist order”, File 3-16338, available at sec.gov/litigation.

Securities and Exchange Commission (2015b).In the Matter of ITG Inc. and Alternet Securities Inc, “Order instituting administrative and cease-and-desist proceedings, pursuant to 8a of the securities act of 1933, and sections 15(b) and 21c of the securities exchange act of 1934, making findings and imposing remedial sanctions and a cease-and-desist order”, File 3-16742, available at sec.gov/litigation.

Shorter, G. and Miller, R.S. (2014), “Dark Pools in Equity Trading: Policy Concerns and Recent Developments”, Congressional Research Service, Vol. 1, No 5, 26 September.

Stafford, P. (2016), “Dark pool operator Liquidnet Europe enjoys record trading year”, *Financial Times*, 18 January, retrieved from financial times.

Vaananen, J. (2015), *Dark Pools and High Frequency Trading for Dummies*, West Sussex, UK: John Wiley & Sons.

Zhu, H. (2014), “Do dark pools harm price discovery?”, *Review of Financial Studies*, Vol. 27, No 3, pp. 747-789

Abbreviations

CESR	Committee of European Securities Regulators
ESMA	European Securities and Markets Authority
EVBBO	Effective volume-weighted best bid and offer
FCA	Financial Conduct Authority
FOK	Fill-or-kill order
HFT	High-frequency trading
IOC	Immediate-or-cancel order
IOSCO	International Organization of Securities Commissions
MiFID/R	Markets in Financial Instruments Directive/Regulation
MTF	Multilateral Trading Facility
NBBO	National Best Bid and Offer
SEC	US Securities and Exchange Commission

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