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Listing exchanges versus other lit venues: Price formation

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Executive summary

This paper is the second in a two-paper series evaluating order book quality and price formation in three European markets. This paper evaluates price formation on listing exchanges and the largest pan-European lit venues (Aquis, Cboe and Turquoise) trading stocks in the main indices in France, Germany, and the United Kingdom (U.K.).

Using data from [BMLL Technologies](#), we show that while listing exchanges and Cboe are similar in terms of their presence at the European Best Bid and Offer (EBBO), their performance significantly differs with respect to the frequency of EBBO improvements. Participants on Euronext Paris and the London Stock Exchange (LSE) set a new EBBO price substantially more frequently than participants on other lit venues. However, in Germany, Xetra improves the EBBO less frequently (20.1%) than Aquis (35.9%) and Cboe (29.5%). Cboe and the listing exchanges are individually at the EBBO alone a modest fraction of the trading day.

Employing the [Hasbrouck \(1995\)](#) Information Share (IS) method, commonly used in the academic literature to evaluate price discovery, we measure the relative contribution of each venue compared to the all other venues in the same country. Euronext and LSE contribute more to price discovery than other lit venues when IS is measured using both trades and quotes. In Germany, Xetra leads price discovery measured by trades but contributes less than the other lit venues when measured using quoted prices.

1. Introduction

This paper is the second in a two-part series that examines order book quality between listing exchanges and their most similar rival: the largest pan-European lit venues (Aquis, Cboe and Turquoise). In the [first paper](#) of this series, we analyse order book quality in terms of liquidity and order book dynamics across listing exchanges and other lit venues. In this second paper, we examine price formation. We document the contribution of listing exchanges and other lit venues to establishing the European Best Bid and Offer (EBBO) and to price discovery.

Price formation is the process through which the prices of assets are determined. It incorporates information into prices from public sources (e.g., macroeconomic news and order flow) and private sources (e.g., insights from fundamental research and data analytics). Market participants (e.g., liquidity providers and other traders) facilitate this process through their quoting and trading activities on lit venues. A well-functioning price formation process is essential as it enhances overall market efficiency and promotes efficient asset allocation.

In Europe, price formation occurs across both listing exchanges and other lit venues. Prices are disseminated by each venue almost instantaneously. How much do listing exchanges and other lit venues contribute to price formation? Are listing exchanges or other lit venues the primary setters of prices? Addressing these questions is important as it informs traders about which venue sets the best prices, helping them make routing decisions. Some market participants may only be connected to the listing exchange and/or a limited set of venues. These participants might not always interact with the best prices if the venues they are not connected to play a more important role in the price formation process than those to which they are connected. Understanding the role of each venue in the price formation process is also important for regulators to determine how each venue should be rewarded for its contribution.

Consistent with the [first paper](#) of the series, we use data from [BMLL Technologies](#) and focus on the activities of stocks from the main indices in France (CAC40), Germany (DAX30), and the U.K. (FTSE100) in the lit order book of listing exchanges and other lit venues. To streamline data processing, we select 12 stocks from each index in France and Germany, with three stocks randomly chosen from each market capitalisation quantile. For the U.K., we select 36 stocks, with nine stocks from each market capitalisation quantile within the FTSE 100. Trade and quote data are collected for the listing exchanges, Aquis, Cboe and Turquoise during January 2024.

2. Price formation

We employ several measures to evaluate the contribution of each venue to the EBBO and the price discovery process.

2.1 Contributions to the EBBO

We begin by measuring the fraction of time each venue is at the EBBO during a trading day, referred to as EBBO Presence. EBBO Presence reflects how consistently a venue is at the best prices on at least one side of the lit order book. A longer presence at the EBBO indicates stability and reliability for that venue to provide the best price.

Figure 1 displays the EBBO Presence of each venue in the three countries. Listing exchanges and Cboe dominate EBBO Presence. In France, Cboe is at the EBBO 93.9% of the time, statistically higher than the EBBO presence on Euronext at 90.1%. In Germany, Xetra and Cboe have the same EBBO Presence (89%). In the U.K., Cboe is at the EBBO 88.4% of the time, statistically higher compared to 86.1% for the LSE. In France and Germany, Aquis ranks third, followed by Turquoise. However, in the U.K., Turquoise (Aquis) has a lower (higher) EBBO Presence than Cboe BXE. There is also a notable difference between the EBBO Presence of Cboe and Cboe BXE (88.4% vs. 58.6%) in the U.K..

The EBBO represents the best available price across lit order books of the listing exchange and other venues. Therefore, multiple venues can be at the EBBO simultaneously if they offer the best price. Figure 2 shows the fraction of a trading day when only a single venue is at the EBBO on at least one side of its lit order book. The results show that a single venue is present at the EBBO alone, only a minority of the time. In France, Cboe offers unique, better-priced liquidity around 4.9% of the trading day, closely followed by Euronext at 3%. Like the EBBO Presence, in Germany, Cboe and Xetra are exclusively at the EBBO for almost equal duration (4.9% for Xetra and 5.0% for Cboe). In the U.K., Cboe is exclusively at the EBBO for a slightly longer duration than the LSE (4.4% vs. 3.8%).

Figure 1: EBBO Presence on listing exchanges and other lit venues

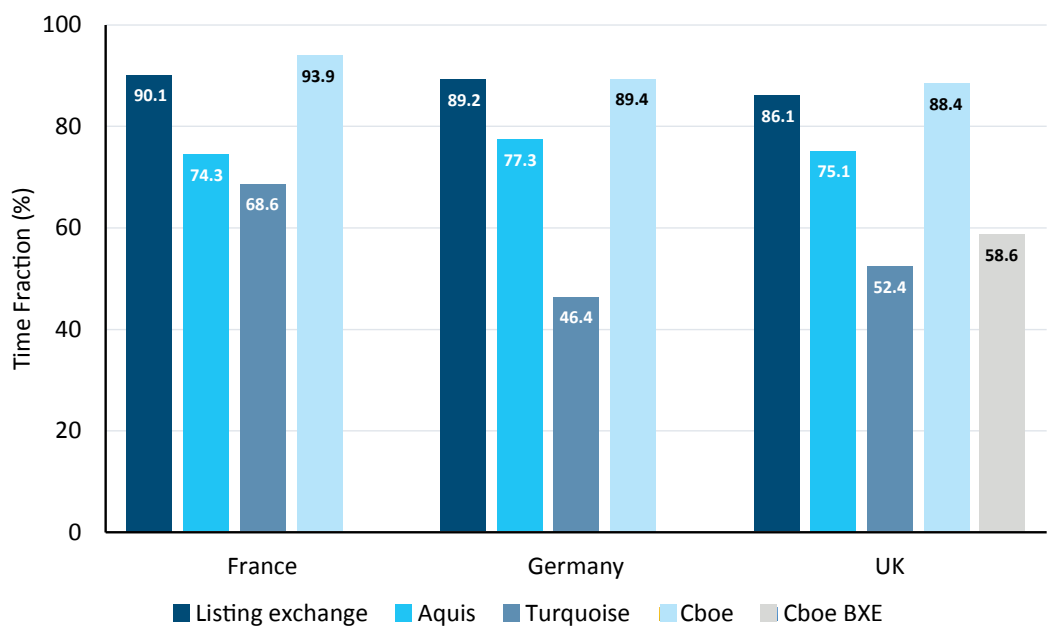
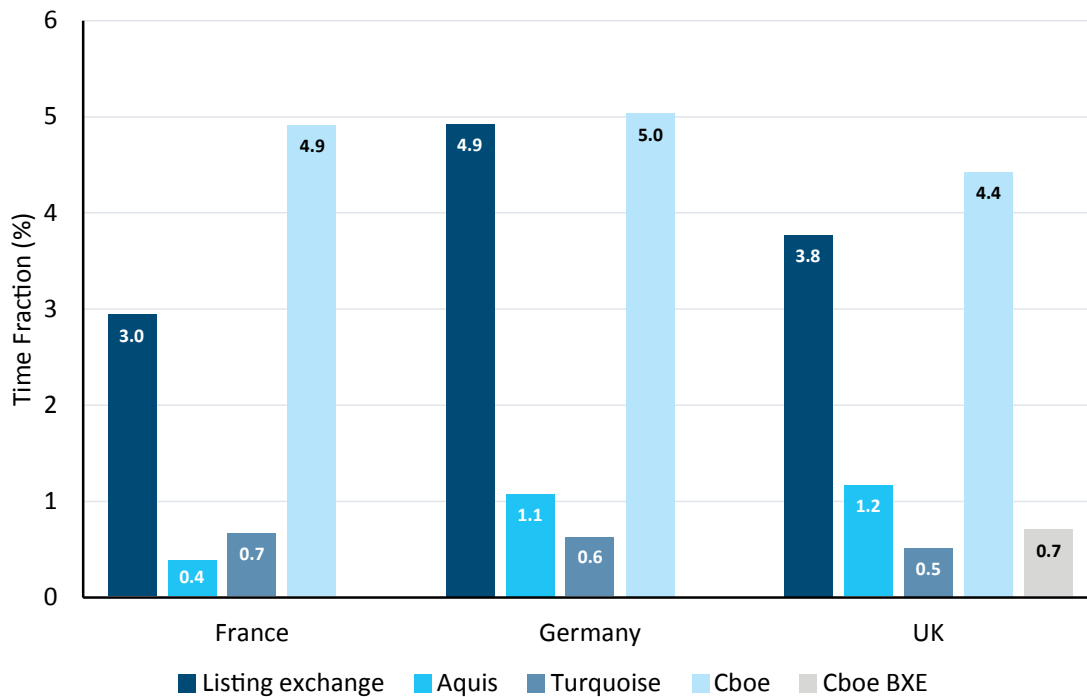


Figure 2: Presence of a single-venue at the EBBO



Aquis and Turquoise display different patterns in France and Germany. Turquoise is exclusively at the EBBO in France for a slightly longer fraction of time than Aquis (0.7% vs. 0.4%), whereas in Germany, the opposite is true. However, the levels are modest. In the U.K., Aquis offers unique liquidity 1.2% of the time, while for Cboe BXE and Turquoise, unique liquidity is offered 0.71% and 0.5% of the time, respectively.

In France, although Cboe offers more unique liquidity and its average EBBO Presence is higher than Euronext, the average bid-ask spread on Cboe is 4.6 bps compared to 3.5 bps on Euronext.¹ A similar pattern is evident in the U.K. This suggests that participants on Cboe are offering liquidity on one side of the market, whereas on Euronext there is tight liquidity offered on both sides of the market.

An alternative measure for evaluating the contribution a venue makes to the EBBO is how frequently a venue sets a new EBBO. A venue that improves the EBBO by providing the most competitive bid or offer can push the market toward a new price. Therefore, setting a new EBBO is related to price formation, and venues that set new EBBOs more frequently can be considered to make a larger contributor to price formation.

¹ See the [first paper](#) in our series for further details.

Figure 3: EBBO Setting on listing exchanges and other lit venues

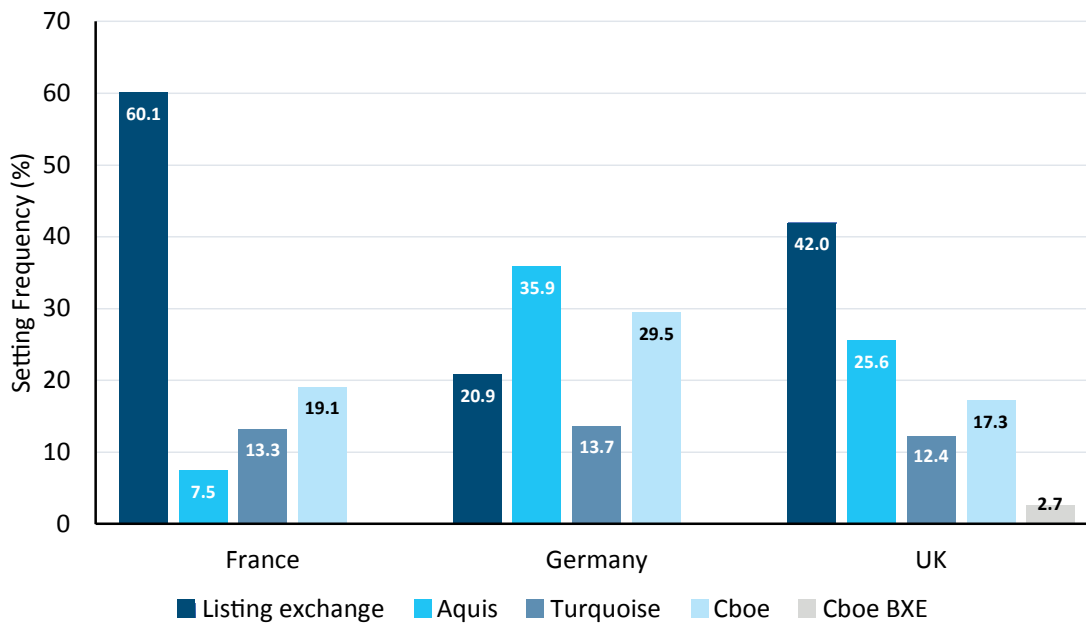


Figure 3 shows the frequency with which each venue improves the EBBO by setting a new best price, referred to as EBBO Setting. This is measured as the number of times each venue improves the EBBO on at least one side of its lit order book as a fraction of the total EBBO improvements on that side. The contributions made by venues differ from what is observed with the EBBO Presence.

In France, Euronext improves the EBBO and sets a new best price more frequently than all other lit venues combined. Euronext captures 60% of the total EBBO improvements, substantially higher than its nearest competitor, Cboe, improving the EBBO 19% of the time. This is in contrast to the EBBO Presence measure, where Cboe is present at the EBBO around 4% more than Euronext (90% for Euronext and 94% for Cboe). Turquoise and Aquis set the EBBO 13.3% and 7.5% of the time, respectively.

Even though Xetra and Cboe both achieve an 89% EBBO Presence in Germany, Xetra sets the EBBO less often than both Aquis and Cboe. Aquis and Cboe set the EBBO 35.9% and 29.5% of the time, respectively, compared to Xetra at 20.9%. Similar to France, in the U.K., while Cboe is at the EBBO slightly more often than the LSE, the LSE dominates the EBBO Setting with 42%. Aquis also sets the EBBO more frequently than Cboe.

Liquidity providers and fundamental investors are key players in the price formation process. They move prices toward a stock's true value by incorporating information into prices. Liquidity providers learn from order flow, news, and announcements, adjusting their order prices accordingly. Fundamental investors incorporate information from research or data analytics into prices. Overall, our results show that market participants on Cboe are at the EBBO statistically than the participants on the listing exchanges in France and the U.K., but economically the differences are small. However, participants on Euronext and the LSE set the EBBO statistically and economically more frequently than the participants on other

venues. The opposite holds in Germany. Participants on Xetra and Cboe have similar EBBO Presence, but participants on Aquis and Cboe contribute significantly more to EBBO Setting. Arguably the EBBO Setting is more important for price formation.

2.2 Contributions to price discovery

So far, we have used simple descriptive measures to capture the contribution of each venue to price formation by either being present or setting the EBBO. Next, we employ an econometric method, widely used in academic literature, as an alternative approach to examine the extent to which different venues contribute to price discovery.

We use the [Hasbrouck \(1995\)](#) information share (IS) measure to determine the relative contribution of each venue to price discovery compared to all other venues. The Hasbrouck IS assesses the price discovery contribution of two venues relative to each other. Given the presence of multiple venues in each market and the computational intensity involved, we measure the IS for each venue relative to all other venues in our sample combined.

The Hasbrouck IS method estimates which venue has the most influence in setting the "true" value of an asset when it is traded on multiple venues. It analyses price movements across different venues by assuming there is a "true" price that all venues aim to reflect, even though their individual prices might vary. By examining price changes on each venue, this method determines how much each venue contributes to uncovering this "true" price relative to others. It then assigns a percentage to each venue to indicate its contribution to price discovery. This percentage ranges from zero to 100%, representing no contribution to full contribution to price discovery, respectively.

The Hasbrouck IS method is frequently used in academic literature to compare price discovery between trades and mid-quotes (i.e. the midpoint of the bid and ask price), different trade types (e.g., lit vs. dark), and various order types. Academic literature documents that mid-quotes contribute more to price discovery than trades (e.g., [Benos and Sagade \(2016\)](#); [Brogaard, Hendershott, and Riordan \(2019\)](#); [Hasbrouck \(2021\)](#); [Hagströmer and Menkveld \(2023\)](#)) show that lit markets capture the bulk of price discovery and the contribution of dark venues, systematic internalisers, and periodic auctions is negligible.

Figure 4 shows the IS of lit trades on each venue relative to all other venues. For instance, the percentage displayed for the *Listing exchange* represents its contribution to price discovery compared to the contribution of other venues combined. Similarly, the Cboe percentage indicates its contribution to price discovery compared to other venues, including the listing exchange, Aquis, and Turquoise.

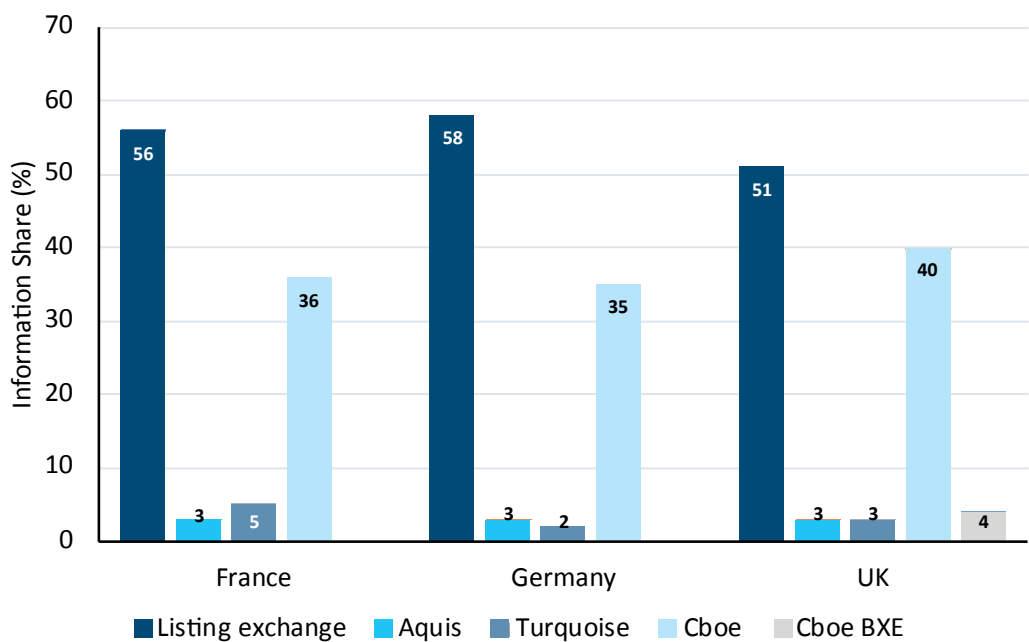
In all three countries, trades on the listing exchange contribute more to price discovery than trades on all other lit venues combined. In France, Euronext trades account for 56% of the price discovery contribution, while the other venues collectively contribute the remaining 44%. Cboe is the next major contributor to price discovery, with an IS of 36%. Turquoise and Aquis have the

lowest price discovery contributions, with IS values of 5% and 3%, respectively.

Germany and the UK show similar patterns. In Germany, trades on Xetra contribute 58% to price discovery. Trades on Cboe capture 35% of price discovery relative to the contribution of all trades on Xetra, Turquoise, and Aquis combined. In the U.K., the LSE captures the majority of price discovery relative to trades on all other venues, with a 51% contribution, followed by Cboe CXE with 40%.

When contrasting the information share to the market shares presented in the [first paper](#) in the series, it is noteworthy that in France and the U.K., the listing exchanges contribute more to price discovery (56% and 51%, respectively) than they do to trading activity (46.5% and 41.6%, respectively). This is also true for Cboe in Germany and the U.K. Cboe accounts for 35% (40%) of price discovery in Germany (U.K.) and only 28% (32%) of market share. These results highlight the importance of these venues to the price discovery process. Except for Cboe in France, where information shares and market shares are approximately equal, in all other cases market share understates the importance of the venue to price discovery.

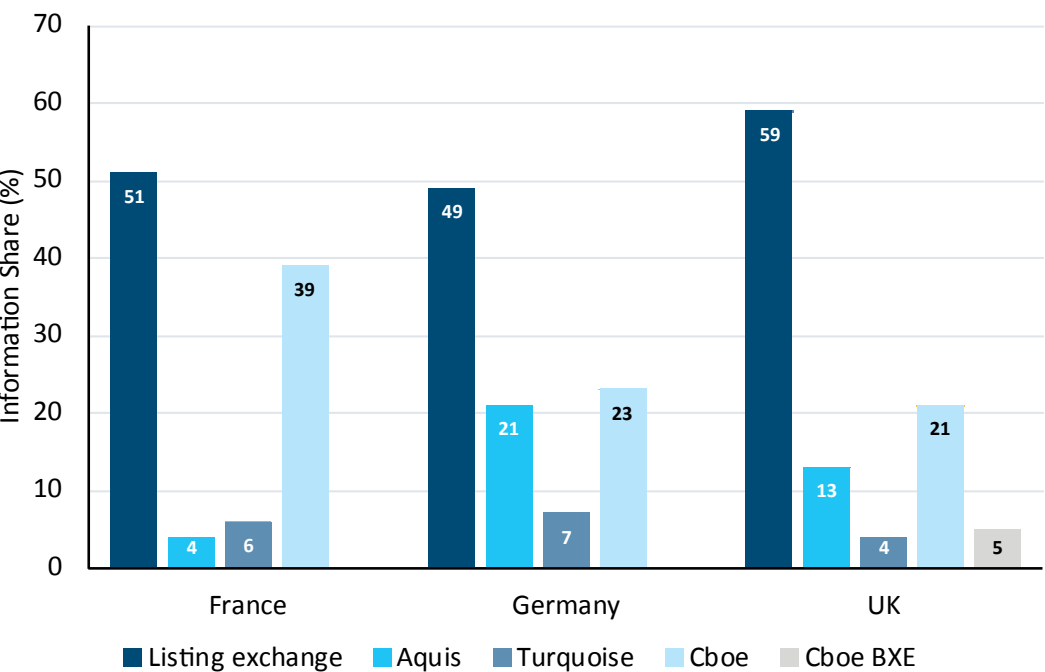
Figure 4: Hasbrouck (95) Information Share - Trades



Do trades and mid-quotes have the same role in price discovery? Figure 5 shows the relative contribution of mid-quotes on each venue to price discovery compared to the other venues in our sample. Directionally the results are the same. The listing exchanges continue to be the main contributors to price discovery relative to the other lit venues. However, there are some interesting differences in the magnitudes. LSE contributes more to price discovery when it is measured with mid-quotes rather than trades, while for Euronext and Xetra the opposite is true. For Cboe, its contribution to price discovery is greater when it is measured with trades rather than mid-quotes, in both Germany and the U.K., while its contribution is fairly consistent across trades and mid-quotes in France.

Perhaps most interesting is that while the contribution Aquis makes is trivial when measured with trades, its contributions to price discovery is considerably larger when measured with mid-quotes. In Germany, it accounts for 21% and in the U.K. 13%. These results are consistent with the relatively high levels of EBBO Setting observed for Aquis in the U.K. and Germany. Taken together, these results suggest that active liquidity providers on Aquis play an important role in its contributions to price discovery.

Figure 5: Hasbrouck (95) Information Share - Quotes



Conclusions and policy recommendations

A well-functioning price formation process and plentiful liquidity are crucial for ensuring market efficiency. Informative prices reflect all available information about the true value of a stock, aiding market participants in making informed trading decisions. A liquid market also allows investors to move in and out of stocks at low transactions costs.

In this paper, and our prior paper on liquidity, we show that there is substantial variation in how much different venues contribute to price discovery and liquidity. Our findings in this paper indicate that only the listing exchanges and Cboe consistently offer the EBBO for over 80% of a trading day in France, Germany, and the U.K.. Notably, Cboe is at the EBBO for longer duration than the listing exchange in France and the U.K., and for the same duration as Xetra in Germany. We also show that there are times when venues other than the listing exchanges set the EBBO or are exclusively at the EBBO. The findings in our [first paper](#) show that there is also variation in liquidity and order book dynamics across the different venues.

Currently, the public cannot observe the EBBO or how venues are contributing to it without subscribing to expensive proprietary data feeds. This problem can be solved by a consolidated tape. The European Union (EU) and the U.K. are slowly moving towards adopting such a tape. The current EU proposal for a tape mandates the reporting of an EBBO, but it will be anonymous and not report which venues are setting or displaying the EBBO. While knowing the post-trade EBBO aids the public in evaluating their execution quality after a trade, it does not allow traders to understand which venues consistently set and offer the EBBO, nor which venues systematically offer the tightest spreads and greatest depth. Better understanding of how venues contribute to liquidity and price discovery would allow smaller brokers to make more informed choices about connectivity. It would also allow customers to ask questions of their brokers if they see the broker is not connected to a venue that offers valuable liquidity and better prices.

The current EU proposal for [distributing tape revenue](#) to venues is based on three criteria: small trading venues; young instruments and pre-trade transparent trading volume. The first two criteria ensure a disproportionate share of revenue is provided to small venues and to more recently listed instruments by assigning these venues and instruments higher weights in the allocation model. All transparent trading venues will receive revenue in proportion to its share of pre-trade transparent trading.

Our analysis shows that the share of pre-trade transparent trading volume is not perfectly correlated with liquidity and price discovery. To enhance market quality, regulation and market structure should incentivise market participants and venues to contribute to the most important attributes of the market: liquidity and price discovery. Therefore, the tape revenue model should reward venues for delivering these features, as well as, or perhaps instead of trading volume. If it is too late for the EU, we encourage the U.K. to consider it before finalising their consolidated tape proposal.

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