Post MiFID II Liquidity Dynamics Case Study: FTSE 100

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March 2018

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Executive Summary

As we settle into the MiFID II regulatory regime, there are many questions arising regarding what the impact on liquidity has been so far. We present in this report an analysis of how several liquidity characteristics have responded for the constituents of the FTSE 100 index on several trading venues. This will allow us to assess how the individual venues and securities have responded to the new regulatory regime.

We apply a technique where we first measure the change to a liquidity metric at the venue level and then aggregate the responses across a group of securities. This differs from the approach of first computing an average value for a liquidity metric for a group of securities and then comparing that average over two time periods. By measuring the responses of each security, we can analyze outliers and gain more detailed insight into how each security responded to the change.

We apply statistical significance tests to data comparing a period in late 2017 with a period in early 2018.

While we are interested in the impact of MiFID II, we also understand that this is not a controlled experiment and that there are many other factors that can impact the liquidity characteristics we are interested in. We note the heightened volatility that occurred in early February which will almost certainly impact liquidity measures.

We find the overall response to be neutral with the average spread decreasing for most but not all securities on all venues. The number of orders increased for most securities and all venues, and depth of book liquidity decreased for most securities on most venues. It does not appear the that MiFID II has lead to a significant deterioration of market quality for the group of securities measured despite what some participants had feared would happen.

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Introduction

How has the liquidity landscape changed? With the introduction of MiFID II, we expect that liquidity may shift as the new regulatory regime takes effect. The question we want to answer is: how has the liquidity adjusted?

LiquidMetrix computes many order book analytics using data from global venues. This allows us to analyze, at the venue and security level, how these statistics change over time as the market structure evolves. Examples of changes are volatility shocks and the introduction of new regulatory regimes. The analytics allow us to capture the information contained in the order book data and concentrate that information into analytics. The analytics can be further analyzed by computing descriptive statistics, modeling relationships, classifying events and many other use cases. This analysis then provides insights into business decisions.

In this paper, we illustrate a technique that considers how an individual security responds on each trading venue. We then can compare these responses across a group of securities, such as the constituents of an index. We believe this approach to be superior to other common approaches that first aggregate across groups of securities and then measure the responses because each security has its own liquidity characteristics. As we will show, not all securities in a group react in the same way. This may not be surprising since each security represents a different company and has its own unique liquidity characteristics.

Using this technique, we can avoid combining liquidity characteristics such as spread across different securities and instead look at the changes in each of the liquidity characteristics we are interested in prior to aggregation. Another benefit is we can attribute the overall performance to sub-groups and/or individual securities.

We also need to be clear here that while we are trying to assess the impact of a specific event, there are many other factors that can impact the liquidity metrics we are analyzing. One such factor could be an increase in market volatility due to macro-economic and/or political issues. We did observe an increase in volatility beginning February 5, 2018 which coincides with our measurement post period. We can use the same toolset that we use for studying the impact of MiFID II implementation to analyze the impact of the volatility event that began in early February.

We recognize that the markets are driven by many factors, and trying to isolate one in isolation will always be difficult and so we need to keep this in mind as we interpret our results. While we recognize this difficulty, we will still view it as a useful exercise to proceed with our analysis.

From a practical perspective, we would like to have as much data as possible but we also need to try and isolate specific events which may limit the data we use so as not to include other events that may affect the metrics we are measuring. Analyzing market quality is not a controlled experiment and so is more like astronomy where we can make many passive observations than it is like particle physics where we can have fine control over the environment and repeat experiments multiple times.

The paper is structured as follows. The methodology is described in the next section. We then show some sample calculations for a single security to illustrate the approach. Results are then presented after aggregating the responses across our group of securities. We then present an analysis of the results. Finally, we discuss our conclusions.

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Methodology

We define two distinct time periods. The first is prior to the implementation of MiFID II. The second period represents the period immediately following implementation of MiFID II.

We also define a set of securities to be analyzed. This allows us to group securities across geographies and by general liquidity characteristics, such as market cap. In the following analysis, we use the components of the FTSE 100, however we could just as easily look at any other group of securities that we are interested in, such as other index components, ETFs or small-cap securities.

For each group of securities, we analyze the changes in liquidity metrics as follows:

- For each individual security, we observe the daily values of a specific liquidity metric in each multi-day period. Specifically, we examine the average daily top of book spread, number of booked orders and average liquidity looking 100 bps into the order book.
- We analyze long term secular trends and optionally remove them.
- We then compute the distributional characteristics of these observations: mean and standard deviation for each security, for each period.
- The changes in the characteristics of the distributions in each period can then be computed. We have one distribution per security per venue per period.
- We apply a statistical test, called a t-test (Welch's t-test), to determine whether the differences in the mean (average) of each security is significant, i.e. we compute the mean for period one and the mean for period two and then apply the t-test to determine if the difference between the two means is significantly different from zero.
- We record the change of the mean.
- If the difference is not significantly different from zero, we replace the difference with a value of 0 to indicate the lack of significant difference.
- We also apply a statistical test, called an F-test, to determine whether the change in the variances of each security's distribution between periods is statistically different from zero.
- We record the change in the variance.
- We set the differences in variances that are not statistically significant to zero.
- We aggregate the results to show the distribution of changes across the group of securities we are analyzing for each liquidity metric of interest. We do this for both the changes in the means and changes in the variance.

We can further inspect attributes of the securities as a function of the amplitude of the change, i.e. do we see that securities from one sector have larger responses than securities from other sectors? Do some types of securities increase their spreads while others decrease their spreads?

By computing the response of each individual security in the group before aggregation, we can get more precise measurements.

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Results

We analyzed the constituents of the FTSE 100 as our group of interest. For the first period, we took data from October 2, 2017 – December 15, 2017. For the second period, we took data from January 3, 2018 – February 27, 2018. We looked at the following liquidity analytics:

- average daily top of book spread
- number of orders
- average liquidity within 100 bps of the top of book

The daily liquidity analytics are time-weighted averages throughout continuous trading hours and are available on a per security per venue basis. These metrics and many others are available for multiple regions.

We begin by showing sample calculations for one security to illustrate the approach.

The daily liquidity analytics are time-weighted averages throughout continuous trading hours and are available on a per security per venue basis.

Sample Calculations

In Figure 1a below, we show time series plots for the number of orders for a specific security. We can see in this chart that there appears to be a secular trend in place in the period October – December, i.e. the value of this metric is increasing over time before the event we are investigating—the implementation of MiFID II—so we may expect that trend to continue. The increase we observe may be due to something other than the event we are analyzing.

We can fit a model to the first period and then project the trend forward into the second period, i.e. after MiFID has been implemented. We show in Figure 1b a linear model that was fit using only the October – December data. We extend the model into the January – February period. In Figure 1c, we show the result of removing this trend from the data. Figure 1d is the same as Figure 1c except we are showing the results for a different venue.

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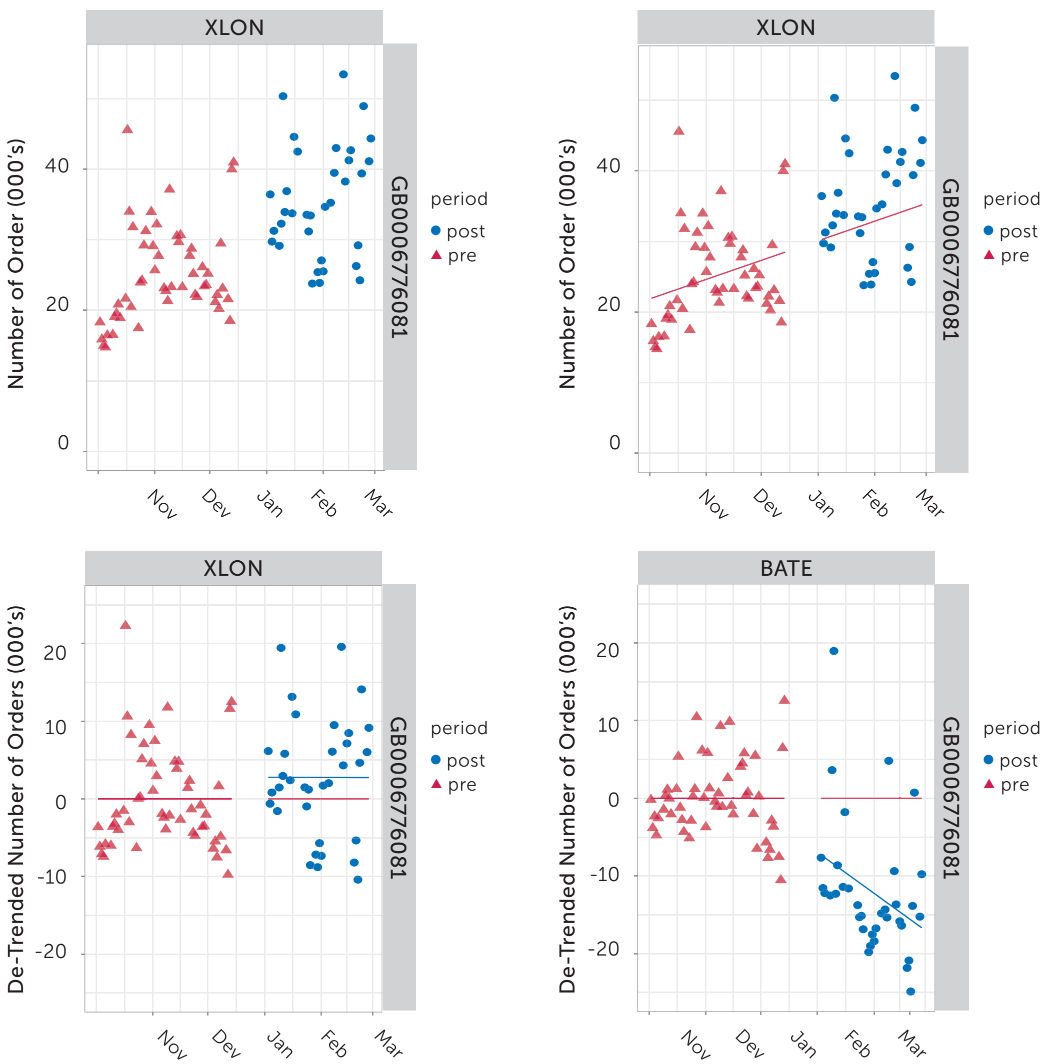
FIGURE 1. In the top left figure, we see the daily measurements for the Number of Orders, for a single security on the LSE. The red triangles represent the period before MiFID II is implemented and the blue circles represent the period after implementation. In the top right figure, we fit a linear regression model to the population of red triangles and extend it into the post period. The blue circles are not used to fit the model, but we use the model to adjust the values. In the lower left chart, we see the result of subtracting the linear model from both populations. We also fit a linear regression to the blue circles so we can see the difference between the projected trend and the adjusted observations. The lower right chart is the same as the lower left chart, but for a different venue (BATS).

After optionally de-trending the data we next investigate the distributional characteristics.



After removing the linear trend, we then analyze any changes to the overall distribution of the adjusted metric. Note that we must apply some judgement when extrapolating as we have done here, which is why we plot the data first. Clearly metrics like number of orders or spread should never go below zero.

We see that on LSE (XLON), the de-trended number of orders is roughly constant (blue line) following the implementation but on BATE we see a steady decrease following implementation of MiFID II (blue line that is decreasing from January – February).

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FIGURE 2. We show 5 venues together along with the linear regression model fit to the first period. The plots are all for the same security.

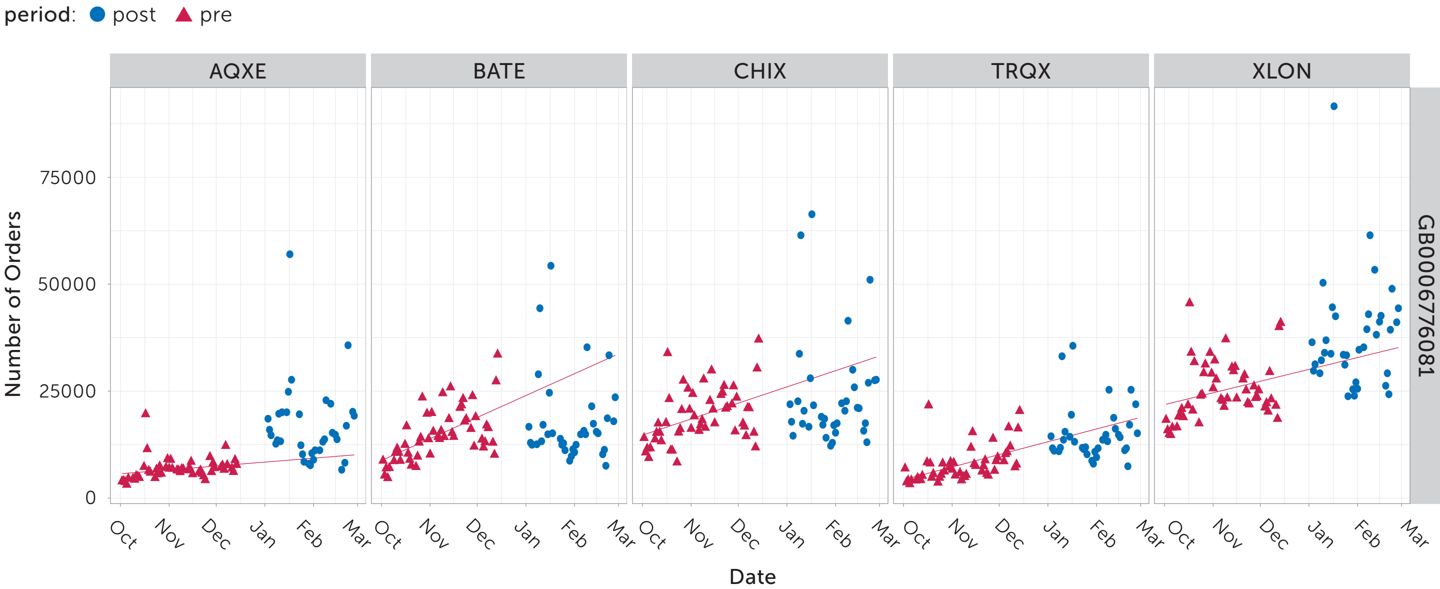

Figure 2 shows five venues for the same security, along with a model for each venue fit to the observations before the event of interest, i.e. the values of the number of orders metric in 2017. The red line is the model and we project it forward to the 2018 data. We can adjust the two sets of data by subtracting the model from the data, removing the trend.

We next investigate the distributional characteristics. The set of charts in Figure 3 below shows the distributions for the daily average top of book spread. Five lit venues in the two periods for a single instrument are shown.

We use these distributions as inputs to a statistical test, called a t.test, that tells us whether the mean (average) value between the pre-MiFID II distribution and the post -MiFID II distribution is likely to be the same. Specifically, the test measures the probability that the two distributions are drawn from the same "parent" distribution (see side bar: The T-Test). If the distributions are consistent with being drawn from the same parent, then the true means are interpreted as being the same, i.e. we cannot conclude that there is a statistically significant difference between the means.

We can run another test, called an F-test, to measure whether the widths (variances) of the distributions are the same.

In the charts below, we show sample results for a single security trading on five different venues. We have applied the statistical tests to measure which venues have significant differences in their mean values and variances. For each distribution, the mean and standard deviation (square root of the variance) are shown in each panel as the mean +/- the standard deviation.

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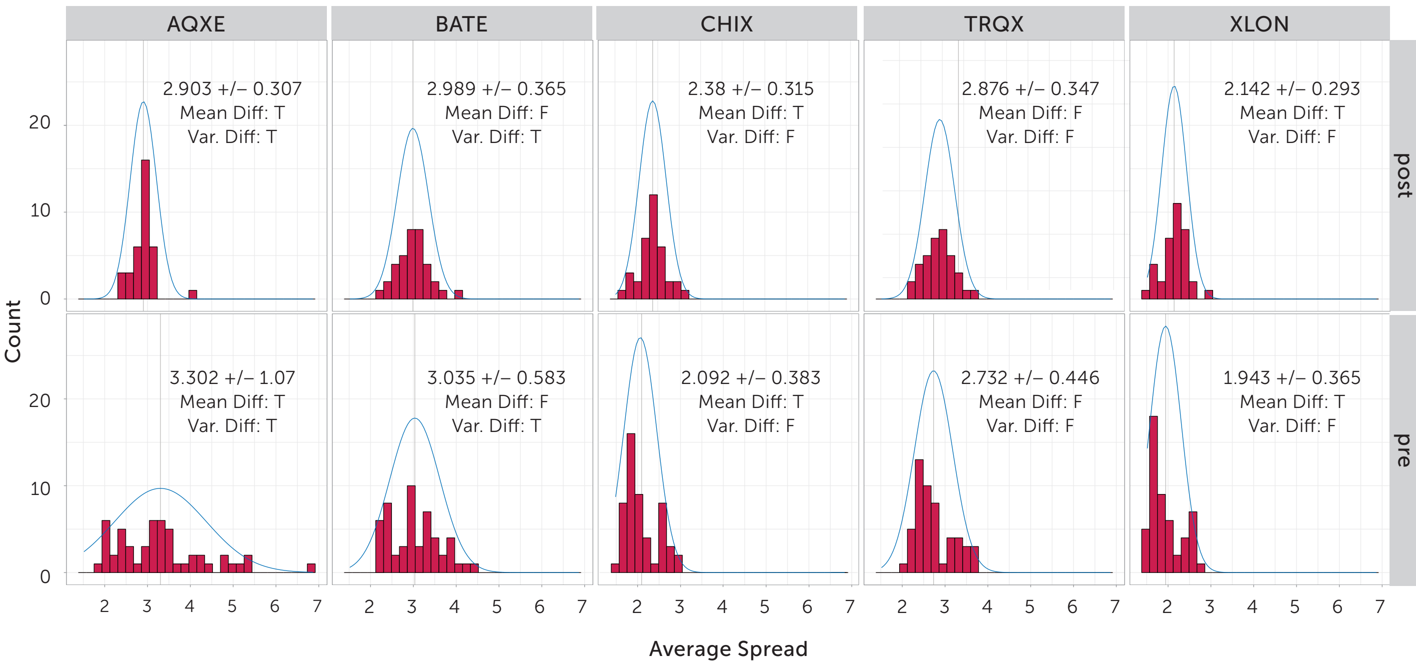
FIGURE 3. Sample calculations showing the distributions for a security in two periods for five venues. We also show the mean and standard deviation as a label on each chart along with the results of the tests to determine if the mean from the top row is equal to the bottom row and if the width of the distribution in the top row is equal to the width in the bottom row.



In addition, for each venue, we show the results of comparing the distributions along the top row, which represents the period after the implementation of MiFID II with the corresponding distribution in the bottom row which represents the period prior to the implementation of MiFID II. If the statistical test shows that the two distributions' means are not statistically different from each other, we indicate that by stating the Mean Diff is false (F), otherwise we indicate on the chart that it is true (T). The T indicates there is a statistically significant change in the mean. We do the same for the variance.

We can see that three of the venues in this example showed a change with a statistically significant difference: even though none of the means of the top distributions are exactly equal to the means of the bottom distribution, only the means from AQXE, CHIX and XLON are different enough that we can say they are significantly different.

The charts in Figure 3 show that only BATE and AQXE had significant changes in the variance for the average daily top of book spread metric.

We cannot conclude, based on the characteristics of the distributions that the mean changed on BATE or TRQX. Nor can we conclude that the variance changed on CHIX, TRQX or LSE. We are not concluding that they are the same, only that we can't say that they are different enough to be significantly different. We are concluding that we can't tell if there was a change.

It is worth pointing out that the statistical tests used here depend on the number of observations in each period and the typical variation in the data. Having more data allows us to determine smaller changes in the mean or variance as being significant. Similarly, data sets with smaller variations allow us to measure smaller changes in the mean than we could for distributions with larger variations (see sidebar: The T-Test for more details).

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The T Test

The t-test, also known as Student's t-test was first developed by a chemist named William Gosset who published his results anonymously under the pseudonym "Student". Gosset was interested in monitoring the quality control of beer produced by the Guinness brewery where he worked.

There are many uses for the t-test. The use we are most interested in here is the comparison of the means of two samples. We are using a form of the t-test called Welch's test.

While the language of statistics can be somewhat tortuous, what we are doing when employing the test is to decide whether there is a significant difference in the means of two groups of data.

Why don't we just measure the means and look to see if they are different? We do this, but since we are taking a statistical approach, we want to understand whether the difference we measure is "significant". Therefore, we employ the test, because the test will allow us to measure the level of significance

An example can help. Imagine that we have a "fair" coin. By fair we mean that the "true" probability of flipping heads is 50%. Now imagine that we flip the coin a number of times to estimate whether the coin is fair or not. Our estimate for the probability of flipping heads will be the number of times we observe heads from a coin flip divided by the number of times we flipped the coin.

Consider an experiment where we flip a fair coin an odd number of times. We will never estimate the true value to be 50% with an odd number of coin flips, because the estimated probability can't be 50% with an odd number of flips. The more times we flip the coin—the more observations we have—the closer our estimate is likely to be to 50%, the true value.

We could interpret our result from this experiment as indicating the coin is not exactly fair, but if we apply a statistical test like a t-test, then we can realize that the difference we are seeing between our estimate and the true value is not significant, so we can't conclude coin is unfair.

Overall Results

For each security, we compute the statistics shown above in the sample calculation. We then determine, for each instrument, whether the mean and standard deviation for each venue changed significantly between our two periods of interest (in this case the periods are before and after the implementation of MiFID II). We then tabulate the results.

For each security, we compute the statistics shown above in the sample calculation

Average Top of Book Spreads

Table 1 shows a summary of mean changes for the average top of book spread. We can also plot a histogram showing how many instruments have a significant change in their mean values.

Figure 4 below shows a histogram of the changes of the mean value of the average top of book spread. There are 101 securities in our sample, and we measure the change in mean for each one on each of the five venues shown. The securities that did not have a significant change all have their change in the mean set to zero and are shown in red. The blue bars indicate the securities where a significant change was measured using the t.test. We see that some securities had negative changes and others had positive changes. Results are summarized in Table 1. We know the identities of these securities and can use this information for further analysis to see if certain types of securities group together in terms of their responses.

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FIGURE 4 . The difference daily in average top of book spread for all instruments having significant changes (non-significant differences removed) for the FTSE 100 constituents as a function of venue, comparing the periods Oct 1, 2017 – Dec 15, 2017 with Jan 2, 2018 – Feb 27, 2018. Each difference is between the mean of the spreads in each period for a single instrument. The distribution shows all instruments that had a significant difference between their mean in the period Oct 1, 2017 – Dec 15, 2017 as compared with Jan 3, 2018 – Feb 27, 2018.

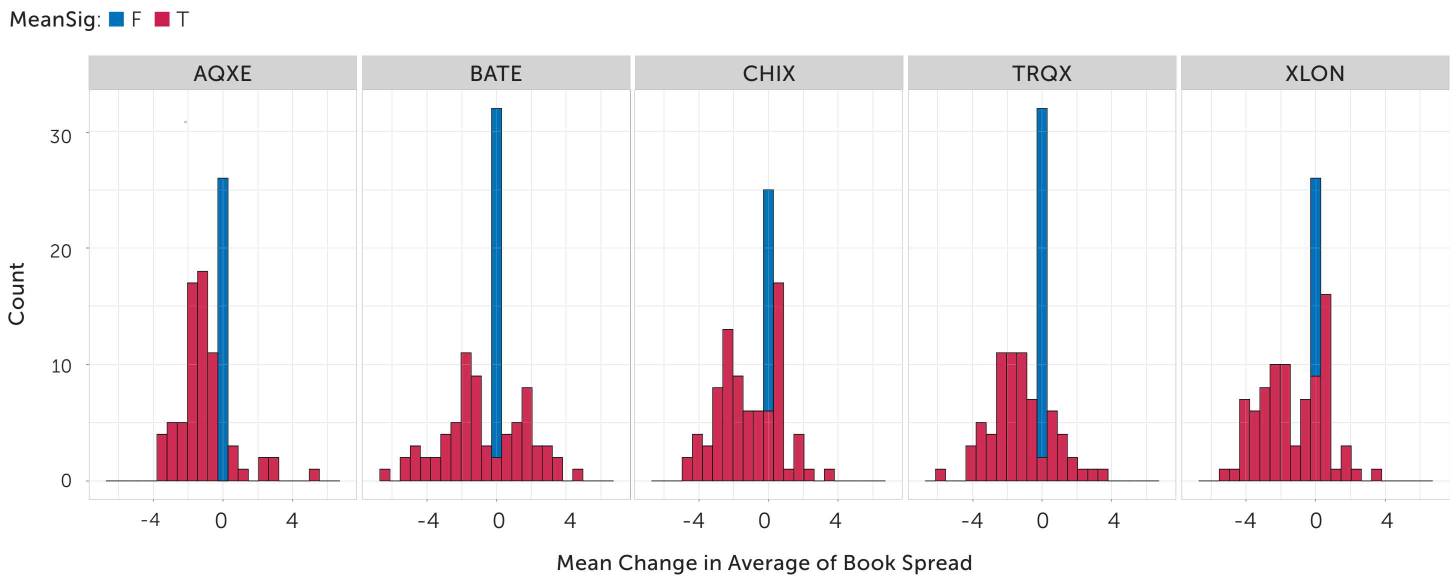

FIGURE 5. Variance changes for the same set of securities and period as shown in Figure 5. Here we show changes in the variances. We note that in most cases the variance increased after MiFID II was implemented. LSE showed the most stability with 54 securities not changing and the smallest average of the securities that did change, both positively and negatively.

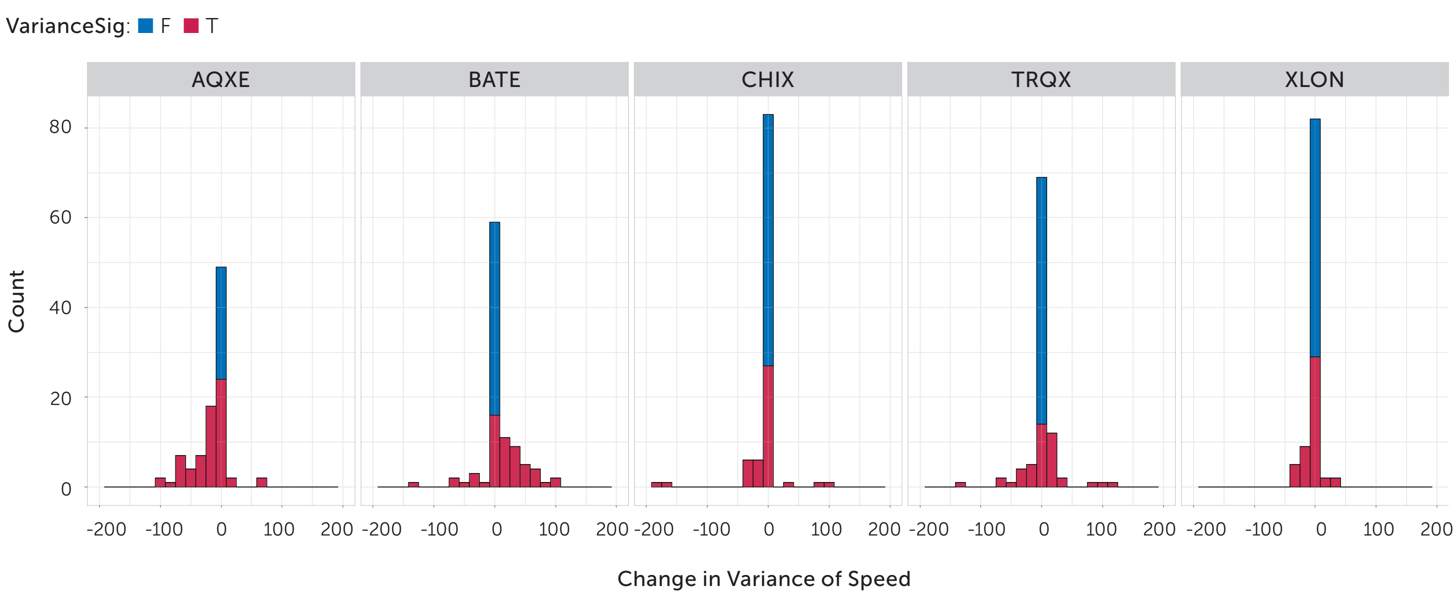

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TABLE 1. Summary results for FTSE 100 components mean change in daily average top of book spread for the periods Nov 1, 2017 – Dec 15, 2017 compared with Jan 2, 2018 – Feb 27, 2018.

Venue	Positive Change	Average Positive Change	Negative Change	Average Negative Change	Zero Change	Overall Change
AQXE	9	2.01	65	-8.55	26	-5.45
XLON	27	1.78	44	-2.58	30	-0.62
BATE	27	0.90	55	-2.28	19	-0.99
CHIX	16	1.29	55	-2.27	30	-1.02
TRQX	29	0.78	55	-2.35	17	-1.07

TABLE 2. Summary results for FTSE 100 components variance change in daily average top of book spread for the periods Nov 1, 2017 – Dec 15, 2017 compared with Jan 2, 2018 – Feb 27, 2018.

Venue	Positive Change	Average Positive Change	Negative Change	Average Negative Change	Zero Change	Overall Change
AQXE	15	13.1	59	-4743.5	25	-2825.5
BATE	44	30.6	14	-84.8	43	1.9
CHIX	25	11.2	20	-54.1	56	-8.5
TRQX	29	19.5	17	-118.2	55	-14.8
XLON	24	6.0	23	-14.0	53	-2.1

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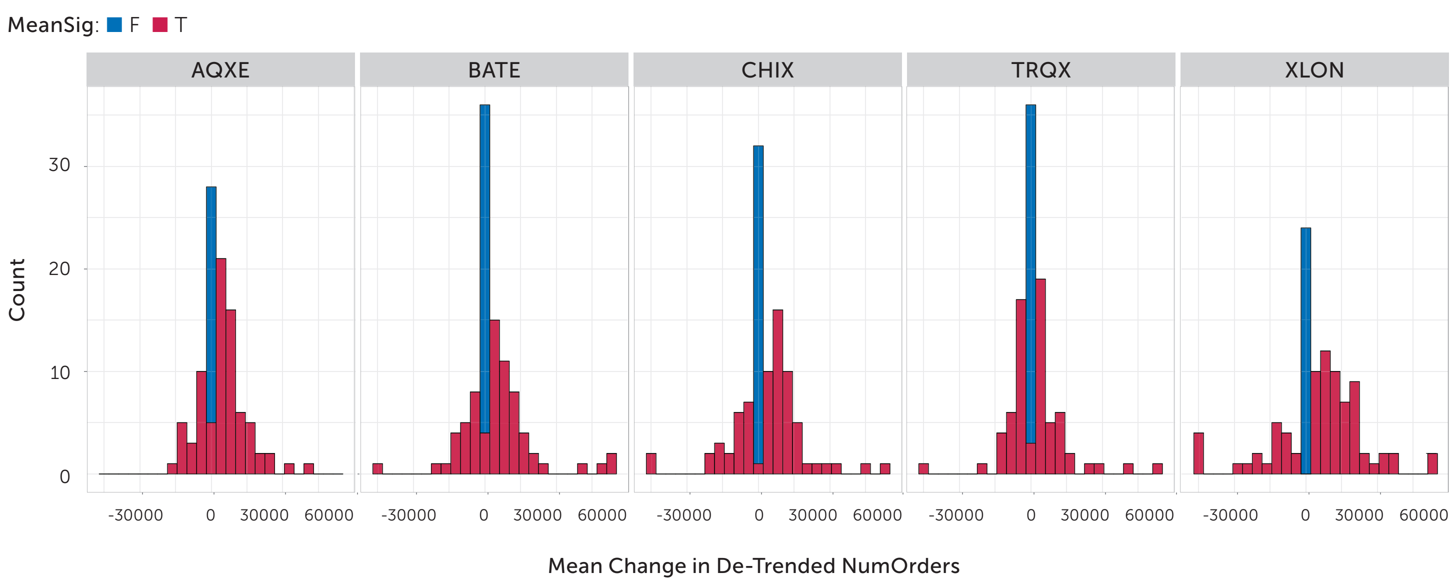
Number of Orders

We can apply the same analysis to the number of orders, but in this case, we choose to de-trend the observations as it is apparent that there is a secular trend prior to MiFID II implementation.

FIGURE 6 Changes in the mean for the de-trended number of orders metric. We observe more positive changes than negative changes, with LSE showing the greatest increase and TRQX the smallest increase. Table 4 summarizes the results.

We notice some outliers in Figure 6. We can winsorize the data by replacing the outliers by a smaller tolerance value—here we replace any observation that is more than 3 standard deviations from the mean with the value equal to 3 standard deviations from the mean. The result of removing the outliers is shown in Figure 7.

FIGURE 7 These charts are the same as shown in Figure 6, but we have replaced outlier values.



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We can also identifier the outliers. For the data above we identify the following outliers. Table 3 shows the symbol, isin, venue and change in the number of orders between periods. We also show the result of winsorizing the data. Note that AQXE has no outliers and is not impacted by winsorization.

TABLE 3. Outliers for the change in number of orders.

Symbol	isin	venue	MetricChange
BLT	GB0000566504	BATE	95212.44
BLT	GB0000566504	CHIX	89026.41
BLT	GB0000566504	TRQX	71138.89
BLT	GB0000566504	XLON	171269.4
STAN	GB0004082847	XLON	-77130.6
BP	GB0007980591	BATE	63938.1
AZN	GB0009895292	BATE	-68081.9
AZN	GB0009895292	CHIX	-77292.4
AAM	GB00B1XZS820	XLON	55352.11

TABLE 4. Summary of mean changes for the number of orders metric including outliers

Venue	Positive Change	Average Pos. Change	Negative Change	Average Neg. Change	Zero Change	Overall Change
AQXE	56	9420.394	22	-6703.74	23	3776.921
BATE	47	13642.95	22	-10118	32	4494.474
CHIX	47	13063.77	23	-14030.7	31	2849.675
TRQX	37	10322.09	31	-7236.78	33	1370.093
XLON	57	17734.97	20	-21582.8	24	5329.761

TABLE 5 Same as Table 4, but with outliers winsorized. Note that only the values for venues with outliers changes between this Table and Table 4.

Venue	Positive Change	Average Pos. Change	Negative Change	Average Neg. Change	Zero Change	Overall Change
AQXE	56	9420.394	22	-6703.74	23	3776.921
BATE	47	12458.39	22	-9135.71	32	4157.211
CHIX	47	12270.4	23	-12690.7	31	2785.646
TRQX	37	9797.739	31	-7236.78	33	1178.005
XLON	57	15574.52	20	-19814.2	24	4460.719

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Average 100 Bps Liquidity

We also de-trend the average 100 bps liquidity metric to remove secular trends prior to implementation of MiFID II. We note, but don't report for brevity, that all the outliers are on XLON.

FIGURE 8 Change in means for the de-trended and winsorized average 100 bps liquidity metric. We observe that LSE appears to have the widest range of changes on both the positive and negative sides. Turquoise shows the most stable distribution with the fewest positive changes. While it had more negative changes than any other venue, the average size of the negative changes is smallest. All venues show a decrease in the average 100 bps liquidity metric which measures depth of book liquidity. The Table below summarizes the results.

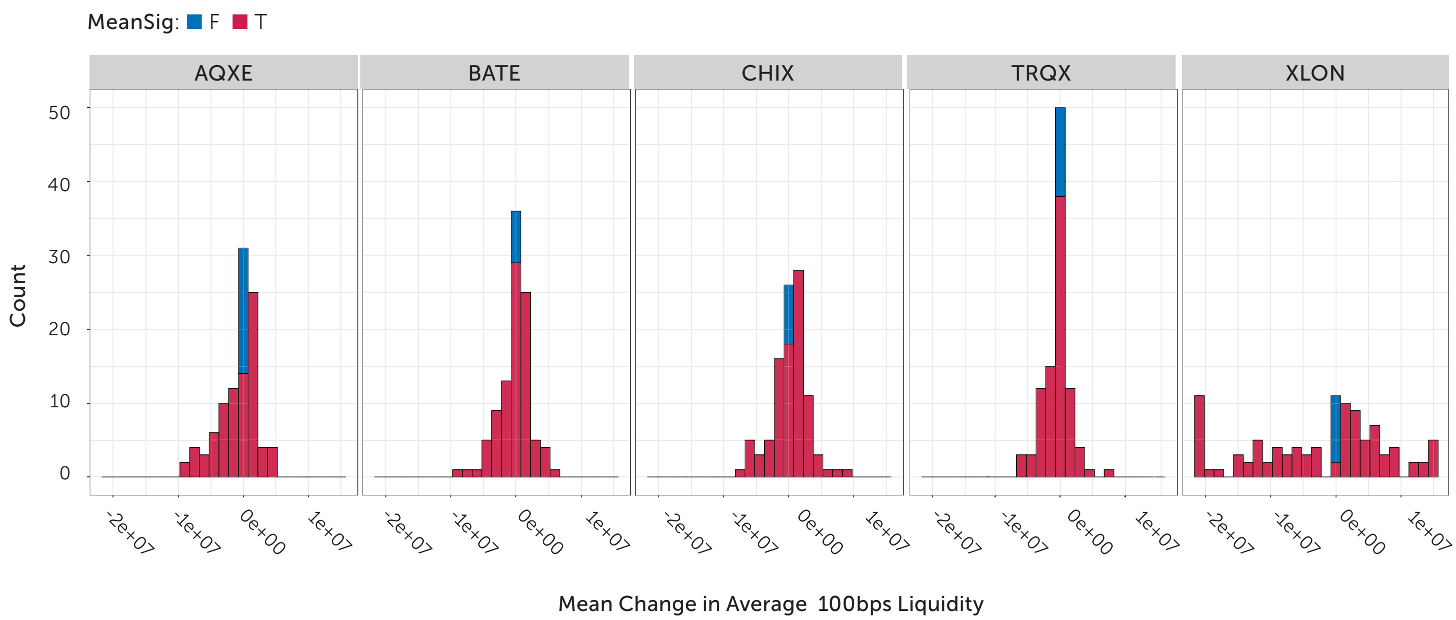

TABLE 6. Winsorized results summarizing the changes in the means for the average 100 bps depth metric.

Venue	Positive Change	Average Pos. Change	Negative Change	Average Neg. Change	Zero Change	Overall change
AQXE	40	1676961	44	-3313602	17	-761836
BATE	55	1573180	39	-2415862	7	-71166.9
CHIX	59	1871610	34	-2750420	8	161932.6
TRQX	42	1264265	47	-1998063	12	-391382
XLON	49	6056572	43	-1.2E+07	9	-2107484

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Analysis

We first check to see what the impact of the volatility shock to the market is on the metrics of interest here. We plot the results for the period Jan 3 – Feb 27, 2018 for each of the metrics on each venue.

To check if we need to control for volatility, we observe, for spreads, an increase following Feb 6, 2018 when the volatility started. We observed an increase in spreads, but for the other metrics, we didn't see a noticeable change around the time of the volatility shock. Based on empirical inspection of these charts, we decide not to control for volatility in this analysis. In future, we may want to repeat the analysis where we adjust for volatility.

We observed a reduction in spreads for most securities

Average Top of Book Spread

We observe that all five venues analyzed show a reduction in spread following the implementation of MiFID II. While AQXE had the largest reduction, we note that the size of the change is due to a handful of outliers that had very large spreads prior to 2018. AQXE had the largest number of securities that showed a reduction in spread with 65 securities tightening. AQXE also had the fewest securities that increased their spread with 9 securities increasing on average 2 bps. Removing the outliers changed the overall spread change from -5.45 bps to -2.55.

The LSE (XLON) had the next largest reduction in spreads with an overall reduction of 1.07 bps. LSE also had the largest number of securities that increased their spreads with 29 but the average of the increases was only .78 bps, i.e. while more securities on LSE increased their spreads, they were small increases. LSE had the fewest securities that did not show any significant change. LSE had 55 securities that decreased their spread with the average decrease for these 55 securities being -2.35 bps.

TRQX and BATE each had 30 securities with no significant change in spread. BATE had the smallest overall decrease in spread. While 44 securities decreased their spreads by an average of 2.58 bps, there were 27 securities that increased their spreads by an average of 1.78 bps.

We note that based on Figure 10, it appears that the spreads increased in the post-MiFID period following the onset of volatility. We expect have seen larger decreases if we had excluded this period or adjusted for the volatility.

Overall, we see that in the period following MiFID II, we observed a reduction in spreads for most securities and the average size of the reductions was larger than the average size of spread increases. Given that tighter spreads are a sign of better market quality, we conclude that MiFID II did not have a negative impact on market quality.

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Number Of Orders

We de-trended the number of orders because visual inspection showed a secular trend of increasing number of orders for the 2017 population (Oct 2 – Dec 15, 2017).

We observe that LSE had the largest increase in the average number of orders with an overall change of over 5,000. LSE had 57 securities that increased their number of orders which was more than any other venue, and they also had the fewest securities that reduced the number of orders, with 20.

Turquoise (TRQX) had the smallest change in number of orders with 1370. Turquoise also had the fewest securities that showed an increase in the number of orders as well as the largest number of securities that decreased their number of orders.

CHIX had 23 securities decrease their number of orders, but these decreased on average by 14,000 orders which was the largest reduction across the venues. CHIX also had 47 securities that increased their number of orders—inspection of Figure 6 shows that this was driven in large part by outliers.

Across all venues, we see an increase in the number of orders. This is a positive for market quality since more orders represents a more diverse order book. We see that after implementation of MiFID II we have a positive change in this market quality measure.

Average 100 Bps Liquidity

For the depth of liquidity metric, we also de-trended the data.

We can see from Figure 7 that LSE had the widest range of outcomes, with 49 securities increasing on average 6.6 million which was the largest across all venues, but also had 43 securities decrease their depth of book liquidity with an average reduction of 14 million. LSE also showed the largest decrease overall.

CHIX was the only venue to increase its liquidity on a de-trended basis with 59 securities increasing and 34 decreasing. The average decrease was much higher than the average decrease.

BATE was the most stable of the venues even though they had the fewest number of securities that were unchanged. The 55 securities that increased their depth liquidity was balanced by 39 securities that increased leading to BATE having the smallest overall change which was slightly negative.

Overall, we would hope to see this metric increase, however on a de-trended basis we see the opposite. So, we have in general more orders but less depth within 100 bps of the top of the book.

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Venue Ranking

We can rank the venues based on the observed changes. We rank spread change based on which venues had the largest reduction. For number of orders and depth we rank more orders as better. We then rank the venues in terms of the differences in the two periods, so we show rank venues based on their response rather than the absolute value of their metrics, i.e. we are ranking based on which venues had the most positive change in liquidity metrics following the implementation of MiFID II.

Venue	Spread		Orders		Depth		Average Rank	Overall Rank
AQXE	-5.45037	1	3777	3	-761836	4	2.67	1
XLON	-1.06911	2	5330	1	-2922821	5	2.67	1
BATE	-0.61616	5	4494	2	-71166.9	2	3.00	3
CHIX	-0.98974	4	2850	4	161932.6	1	3.00	3
TRQX	-1.01994	3	1370	5	-391382	3	3.67	5

We see that AQXE and LSE had the most positive changes based on how the averages of the metrics changed following the implementation of MiFID II.

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Conclusion

We have analyzed the impact of the implementation on several liquidity metrics that are derived from the order book data that LiquidMetrix has acquired. We analyze at the security level before aggregating results into a group. Here we have presented results for the FTSE 100 for three liquidity metrics: spread, number of orders and average 100 bps depth.

We have de-trended two of the metrics that show strong secular trends in the period prior to the implementation of MiFID II. We then applied statistical tests to assess whether changes in either the mean or variance are statistically different from zero.

Based on the analysis we can assess the impact of MiFID II on the liquidity metrics we have analyzed. We observe that spreads have tightened, the trend-adjusted number of orders has remained steady on some venues but gone down on others and that trend-adjusted depth of liquidity has decreased.

We conclude that the implementation of MiFID II on liquidity has been neutral overall so far. We do note that there was a period of increasing volatility in February that likely impacted the liquidity metrics we are measuring, making it difficult to fully attribute the observed changes entirely to the implementation of MiFID II. Equally we can conclude that MiFID II did not have a negative impact on liquidity. Spreads are tighter and while there is less depth and the number of orders in the book increased for most securities on most venues.

We can continue to monitor the impacts to liquidity using the same approach. As more observations (more days) become available to analyze, it will strengthen the statistical tests that we have used. The more data we can analyze, the more confident we can be in the results.

At LiquidMetrix we have created interactive tools to analyze and visualize the venue statistics to address questions regarding how the statistics change dynamically through time. Combined with our global order book coverage, we can provide insights into how various events may have impacted overall market quality.

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