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Market Lens

Why Do Most Markets Trade Continuously Rather Than In Auctions?

EXECUTIVE SUMMARY

Nearly all modern markets have evolved to trade on a continuous basis, whereby incoming orders are matched to resting orders as soon as they are received by the exchange. Most market observers believe that this type of continuous trading generates deeper liquidity, lower bid-ask spreads, and more accurate pricing. However, some commentators have suggested that "frequent batch auctions," which aggregate all orders for a defined time period before any executions can occur, may be preferable.

While there has been a robust theoretical debate on the topic, there have been limited opportunities to empirically assess the trade-offs between the two market structures because most of the world's largest exchanges utilize a continuous trading model. Furthermore, even when exchanges did use batch auctions, it was difficult to compare them to continuous trading markets because they were in different countries with different market structures. However, in March 2020, the world's largest discrete trading venue, the Taiwan Stock Exchange (TWSE), shifted from a frequent batch auction process to continuous trading. This change presented an ideal opportunity to test, in actual market conditions, which market structure generates better outcomes for investors.

Our analysis of the TWSE's transition clearly demonstrates the benefits of continuous trading, including:

- Better liquidity provision with order book depth more than doubling and, for the most liquid stocks increasing 4-5x
- Lower bid-ask spreads that reduce investor costs by \$550 million to \$1.36 billion TWD
- More stable prices and enhanced price discovery with volatility decreasing 18%
- 15% higher trading volumes

The combined benefits lower the cost of capital for companies raising money, thereby improving the real economy.

The following paper briefly evaluates each trading model, discusses the TWSE's move to continuous trading, and then assesses the impact that move had on volumes, liquidity and spreads, volatility, and price discovery using the most similar market to the TWSE (the Hong Kong Stock Exchange) to control for market dynamics other than the method of trading.

CONTINUOUS TRADING

Most markets operate using continuous trading during standard market hours (outside of those hours, they generally maintain an opening and a closing auction to identify starting and closing trading prices; some markets offer midday auctions as well).

Markets with continuous trading operate through a limit order book (LOB) that aggregates and matches orders as they arrive, typically based on "price-time priority," though other methods, such as "price-size" are also used. Under "price-time" priority, if two orders were to be received at the same price for the same security, the one received first would execute first. Similarly, if two orders were to be received at different prices, the better price (higher bid or lower offer) would execute first.

This competition improves price discovery as mispricings between similar sets of instruments are quickly resolved through the real-time arbitrage activities of market-makers and other market participants. However, some commentators have suggested that since speed is a factor in resolving mispricings, a continuously traded market may create advantages for faster traders. To address this, some economists have proposed that markets employ discrete time trading, specifically "frequent batch auctions."

FREQUENT BATCH AUCTIONS

Frequent batch auctions are a trading system in which all orders from a defined time period are aggregated, and an attempt to match as many as possible occurs at a single point in time. Orders that match the auction price are executed; those that do not match are not executed. If, however, there is an imbalance in orders, some of the volume priced at the execution price may not execute due to the discrete nature of the trading. Because they do not use the time an order comes in to allocate shares, frequent batch auctions require some alternative mechanism, such as the allocation of shares on a pro-rata basis. This introduces different incentives depending on the mechanism. For example, if shares are allocated on a pro-rata basis, it may incentivize sending larger orders to increase fill rates.

While there is no single standard for a frequent batch auction, economists suggest that an ideal frequent batch auction should last somewhere between a fraction of a second and a few seconds.¹ Because all orders are aggregated during this period and executed at once, there is less incentive to be faster than others to trade and costs may come down. However, the system has drawbacks. For one, there is no pretrade transparency to firm quotes and orders already resting on the exchange. This creates uncertainty in that a participant will not know whether or not an order it has submitted to the exchange will result in an execution. Instead the market participant must wait until the next batch auction is completed. In addition to the impact this may have on participants' abilities to quickly resolve market mispricing through arbitrage activities, economists have questioned whether volatility, the amount of liquidity on the exchange, volumes, and even the spreads between buyers and sellers (i.e. the cost of trading) could be adversely affected by the use of frequent batch auctions.

TAIWAN STOCK EXCHANGE'S CONVERSION FROM DISCRETE TO CONTINUOUS TRADING

While economists and market commentators have engaged in a robust theoretical debate about which market structure is preferable, there have been limited opportunities to test the theories in actual markets because most markets traded continuously. In fact, prior to March 23, 2020, 19 of the world's 20 largest markets did so.² There also had not been any recent moves between the two market structures, and making comparisons across markets is challenging because each market has a different structure in terms of volume, price levels, types and proportions of investors, and the like.

However, on March 23, 2020, the Taiwan Stock Exchange, the world's 15th largest exchange, shifted trading from a frequent batch auction mechanism to a continuous matching mechanism, providing an opportunity to assess both forms of trading on a single exchange. Before the move, all stocks traded on the Taiwan Stock Exchange by frequent batch auctions with a duration of 5 to 5.2 seconds.³ Beginning on March 23, 2020, all stocks could be traded continuously between the opening and closing auctions.

Because the global COVID-19 pandemic resulted in a substantial increase in trading volumes around the world as this shift took place, this paper assesses the impact of the shift in comparison with the stock of the Hong Kong Stock Exchange (HKEX).

Reviewing the shift from discrete time trading to continuous trading shows that continuous trading results in higher trading volume, increased liquidity provision, lower bid-ask spreads, more stable prices, and enhanced price discovery. These effects not only benefit investors, but also improve the real economy through lower costs of capital.

^{1.} Fricke and Gerig. "Too fast or too slow? Determining the optimal speed of financial markets"

^{2.} Indriawan, Pascual, Shkilko. "On the Effects of Continuous Trading"

^{3.} According to Roberto Ricco and Kai Wang in their paper "Frequent Batch Auctions vs. Continuous Trading: Evidence from Taiwan," the TWSE's auction "design is very close to the one proposed by Budish et al." in the 2015 paper "The High-Frequency Trading Arms Race: Frequent Batch Auctions as a Market Design Response"

The move to continuous trading also resulted in the addition of several key order types that gave investors options that they were unable to utilize under the previous system. Prior to the conversion to continuous trading, for example, all orders sent into the Taiwan Stock Exchange were limit orders.

The following sections review the impact of the shift to continuous trading on volumes, liquidity and spreads, volatility, and price discovery.

VOLUMES

March 2020 was an extraordinary time in the global economy, and stock markets around the globe experienced significant volatility. In the US, for example, share volumes averaged nearly 16 billion shares a day, an increase of ~80% over the previous month. Even against this backdrop, the change in volume that the TWSE experienced was substantial and it has been enduring.

Volumes on the TWSE were just over \$4 billion (USD) per day before the shift to continuous trading. After the move, volumes doubled to roughly \$8 billion (USD) per day.

TWSE Daily Notional Volume

January 2019-March 2021



However, volume alone does not tell the full story, given the increase in volumes across multiple venues. When looking at the volumes for the TWSE relative to the Hong Kong Stock Exchange to normalize the impact of the COVID-19 pandemic, it is clear that volumes increased to a greater extent for the TWSE than the HKEX. From January 2019 until the move to continuous trading in March 2020, the volumes for the TWSE and the HKEX indices relative to their March 2020 volumes tracked each other closely.

In the year prior to the shift to continuous trading, the TWSE traded \$4.1 billion (USD) each day while the HKEX traded \$9.3

billion (USD). In the year after the move to continuous trading, both exchanges increased volume substantially, but the TWSE experienced a greater increase. The TWSE rose by 95% over the previous year (to \$8 billion (USD) per day), while the HKEX increased 80% (to \$16.7 billion (USD)). After adjusting for the increase in volumes driven by the pandemic and other factors, the TWSE still increased by an additional 15%.

The chart on the following page shows the change in volumes, normalized to each exchange's March 2020 average volume.

TWSE vs. Hong Kong Daily Notional Volume

% Difference vs. March 2020 | January 2019–March 2021



LIQUIDITY AND SPREADS

Similar to the increase in volume, the shift to continuous trading improved liquidity provision and decreased spreads. In a continuously traded market, market makers can manage risk better and provide more efficient arbitrage. This enables market makers to post narrower quotes and provide more liquidity.

The conceptual improvement is born out in the data. By looking at the volume of posted shares on the TWSE at each level away from midpoint (for continuous trading) or from the executed price (for discrete trading), we can assess the amount of liquidity available. This analysis looks at the top five levels of liquidity offered away from midpoint (the TWSE only published the top five losing bids and offers prior to the conversion to continuous trading). The analysis then aggregates the total shares bid or offered for each of those top five levels of liquidity. For example, if midpoint is \$100 and there were an offer for 200 shares at \$100.10 and two offers for 400 shares each at \$100.20, then the analysis would reflect that there were 200 shares on offer 10bps away from the midpoint and a total of 1,000 shares within 20bps of the midpoint.

To create as similar a comparison as possible, after the shift to continuous trading, the analysis looks at time-sliced samples of

the order book every five seconds (to match the duration of the auctions). The assessment looked at top five levels of bid and offered liquidity away from the midpoint to correspond with the data available before March 2020.

This analysis shows improved liquidity at each point in continuous trading relative to discrete trading.

As the chart on the following page clearly shows, at each point beyond the top of book bid and offer, substantially more liquidity is available in continuous trading than in discrete trading. The average number of shares on offer in the top five levels away from the midpoint, for example, is ~600,000 before continuous trading. After the move to continuous trading, there are approximately 1.3 million shares, or more than double the depth.^{4,5}

Comparing the spread from before and after the conversion to continuous trading is challenging because there is no publicly quoted spread in auction markets. However, by leveraging an approach from the fixed income markets, we can approximate the spread by the short-term volatility because the price changes up or down over a short time period will equate to the differences in price between the bid and ask.

4. Before continuous trading refers to the one-year period leading up to March 23, 2020 and after continuous trading refers to the one-year following March 23, 2020.

5. Using arithmetic / unweighted depth. Using volume weighted depth increases the improvement, making it similar to the Top 30 stocks traded chart which follows

(the top 30 stocks account for ~80% of volume).

Taiwan Average Cumulative Depth vs. Distance From Mid Price

All Taiwan Listed Stocks - Before and After Continuous Trading



Assessing the two-minute volatility before the shift to continuous trading shows the volatility is 0.0147%. After the move to continuous trading the volatility is 0.0139%. This means that volatility decreased by 0.0008%. Using this as a proxy for spreads—and given 1.3 trillion shares traded per year with an average share price of \$53 TWD—these narrower spreads and additional liquidity saved investors approximately \$550 million TWD in a single year. This benefit will continue to accrue annually to investors, improving investor returns and reducing the cost of capital in support of the real economy.

Even this significant savings underestimates the impact of the change because it does not account for the increased depth provided in continuous markets. As shown in the chart above, the improvement seen in continuous trading increases as the distance from mid-point does. Many orders trade more shares than the available shares at the best available price, which only increases the benefits of continuous trading given the deeper liquidity seen in the above charts. To estimate this, we can look at how deep into the order book a trader would need to go in order to access an average sized trade.

On average, the order size for TWSE stocks was approximately 6,000 shares. The spread after the shift to continuous trading is 0.2bps narrower than before continuous trading. Given 1.3 trillion shares traded per year and a weighted average stock price of \$53, these narrower spreads and additional liquidity saved investors \$1.4 billion TWD in one year. This means that investors are saving between \$550 million and \$1.36 billion TWD in a single year.

While volumes increased across all markets in March 2020, the same is not true for liquidity. Again, looking at the HKEX as

a comparison, it is clear that there is no substantial change in liquidity on offer during this period.



Hong Kong Average Cumulative Depth vs. Distance From Mid Price

All Hang Seng Index Stocks - Before and After Continuous Trading

After Continuous

While there is little substantive difference in Hong Kong, if anything, slightly wider spreads are required to reach the same number of shares bid or offered in the year after March 2020. This indicates that the increase in liquidity for TWSE is due to the shift to continuous trading, rather than temporal effects. The effect of the move to continuous trading in Taiwan is even more pronounced if one looks at the most liquid stocks. Limiting the sample to the top 30 stocks, which collectively account for ~80% of total shares traded on the TWSE, the available liquidity is 4-5 times more after continuous trading than it was prior to the shift.

Taiwan Average Cumulative Depth vs. Distance From Mid Price

Top 30 Stocks by Shares Traded - Before and After Continuous Trading



After Continuous

At the same time, it is clear that spreads on these liquid names also improve. Looking at the top of book shares (the shares available that are closest to the midpoint price for continuous trading or executed price for discrete trading), the spreads decline ~8% for each of the bids and asks to get the same number of available shares as before the shift to continuous trading. Clearly, this decline in spreads, as well as the increased liquidity available at any given level of pricing, benefits investors in the form of lower transaction costs. The magnitude of the improvement for the top 30 stocks does, however, point to a consideration for continuous trading: continuous trading works best for the most liquid stocks. As shown in the chart on the following page, while liquidity improved for the non-top 30 stocks as well, the magnitude was smaller (slightly less than 2x across the top five liquidity levels vs. the 4-5x seen above for the most liquid names).

Therefore, stocks with lower demand may benefit from liquidity programs that further incentivize liquidity provision.

Taiwan Average Cumulative Depth vs. Distance From Mid Price

TWSE Stocks Outside of Top 30 - Before and After Continuous Trading



Programs to incentivize trading in these less liquid names can extend some of the greater benefits experienced by the more liquid stocks.

Taiwan Daily 2-Minute Volatility

March 2019 – March 2021



VOLATILITY AND PRICE DISCOVERY

In the year up to March 23, 2020, the TWSE's two-minute volatility was 0.0147%. In the year after the conversion to continuous trading, volatility decreased to 0.0139%. This was a decline of ~5.5% from its starting point.

However, this is only part of the story. With the market conditions caused by COVID-19, volatility changed globally and needs to be normalized to make an accurate comparison.

Normalizing the TWSE's volatility by comparing it with the HKEX's shows that volatility for the TWSE did, indeed, decrease idiosyncratically for the TWSE. Volatility for Hong Kong actually increased (from a lower base). Two-minute volatility in Hong Kong was 0.00281% in the year prior to the TWSE's transition to continuous trading. That increased to 0.00316% in the following year, an increase of 12.5%.



March 2019-March 2021



Based on this normalization, the shift to continuous trading actually resulted in an idiosyncratic decline of ~18% (assuming that the TWSE's volatility would have mirrored Hong Kong's without the transition to continuous trading).

The lower volatility clearly points to more stable prices for the TWSE's investors.

The decline in volatility also indicates improved price discovery. Order imbalances in an auction market can cause prices to fluctuate, thereby increasing volatility, because market makers are less able to bridge supply and demand imbalances. In a continuous market, market makers are better able to supply liquidity. As a result, volatility will decline and prices will more accurately reflect the value of the security. Thus, the lower volatility also indicates enhanced price discovery.

CONCLUSION

The Taiwan Stock Exchange's transition from an auction process to continuous trading demonstrates the benefits continuous trading provides to both retail and institutional investors. The shift to continuous trading led to increased liquidity provision, lower bid-ask spreads, more stable prices, enhanced price discovery, and more volume. This resulted in a net annual benefit of \$550 million to \$1.36 billion TWD to investors, which lowered the cost of capital and improved the real economy.