Stockholm University

Changing the Rules of the Game

A Market Microstructure Perspective on the Effects of Regulating Financial Markets

Ester Félez Viñas

Doctoral Thesis in Business Administration at Stockholm University, Sweden 2019

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Abstract

This dissertation contains four articles that examine the effects brought about by the implementation of new regulations and changes in the trading landscape on different facets of market quality and integrity.

Article I studies how the fragmentation of equity markets affects the speed of recovery of the market, both under normal market conditions and in times of stress. The results show that fragmentation increases the average ability of the market to converge towards its long-run liquidity levels by shortening the duration of liquidity deviations. In times of stress, fragmentation also speeds up the replenishment of the limit order book and its ability to recover from the moments of stress.

Article II examines the impact of introducing short selling restrictions on the speed of recovery of the market and commonality in liquidity. The findings indicate that short selling bans contribute to lowering the risk of financial contagion by decreasing the commonality in liquidity levels of banned securities. However, the restrictions also significantly hamper the ability of banned stocks to recover from transitory liquidity deviations.

Article III exploits the change in closing mechanism of 43 exchanges around the world to analyse the effects of batch facilities on liquidity, price efficiency, and market integrity. The results support the idea that batch facilities improve market quality, that auction design is important in explaining auction performance, and that the effects depend on the level of development of the market and the liquidity of the stock.

Article IV investigates whether volatility extensions in closing auctions improve the efficiency of closing prices. The findings confirm that the introduction of a volatility extension enhances price efficiency by reducing transitory closing price volatility. The results also suggest that the improvement in price efficiency is due to enhanced market integrity and to greater investor trust in the auction mechanism.

Keywords: *Market fragmentation, liquidity, resiliency, short selling ban, commonality in liquidity, financial contagion, call auction, market integrity, auction attractiveness, price efficiency.*

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To Alba and Carmen -
for your unconditional
love and support

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Ester Félez Viñas
Stockholm, April 2019.

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Introduction

Stock markets provide market participants with an environment in which they can transact and hence realise their latent demands for an asset. The area of finance concerned with the study of the trading mechanisms used to exchange securities is known as market microstructure. In this vein, O'Hara (2001, p. 1) defines market microstructure as the 'study of the process and outcomes of exchanging assets under a specific set of rules'.

The literature in market microstructure has experienced remarkable growth in the last decades. The increasing interest has been driven by recent regulatory changes, as well as the implementation of new trading protocols at the exchange level in an attempt to boost attractiveness and face the increased competition brought about by the fragmentation of equity markets. Moreover, market microstructure issues have been documented to have important implications for other areas of finance, such as asset pricing and corporate finance, contributing to the increasing interest in the field.

While market microstructure research covers a variety of topics, the studies contained in this dissertation are most closely related to the branch focusing on how market structure and design affect different facets of market quality. Security markets around the world differ in their trading protocols. Moreover, as a consequence of the implementation of new rules and regulations, the structure of the trading landscape is constantly changing. The trading mechanism in place determines the rules of the game that investors must follow to participate in the market. As discussed by Biais et al. (2005) and Foucault et al. (2013), this has important implications, since it affects the type of orders that can be placed, order-matching protocols, trading costs, and the amount of information provided to market

participants. A market's liquidity, its ability to generate efficient prices, its degree of integrity, and the gains realised by the different types of agents, are thus largely influenced by a market's specific structure and design.

An asset is considered to be liquid when large amounts of it can be traded without generating large price changes and when needed. Harris (2003) argues that liquidity is the most important aspect of a well-functioning market. Indeed, liquidity has become the cornerstone of market microstructure research and is the main attribute bridging market microstructure to other areas of finance. For instance, liquidity has been found to be relevant to asset pricing. Amihud and Mendelson (1986) indicate that returns include a compensation for illiquidity and Amihud et al. (1997) document a positive relation between liquidity gains and a stock's price appreciation. The existence of cross-stock co-movements in liquidity and returns is another interesting interface between market microstructure, asset pricing, and corporate finance. Anthonisz and Putniņš (2016) show that downside liquidity risk is associated with a return premium. Market participants dislike stocks that become illiquid with the market, requiring a return premium in compensation for holding them. A higher return premium can, in turn, increase a firm's cost of capital.

Although liquidity is a very important aspect of market quality, it is not the only one. Regulatory authorities and exchange officials have often motivated the introduction of new regulations and changes in trading mechanisms in an attempt to enhance price efficiency and market integrity. Prices are efficient when they reflect all available information about an asset. As discussed by Pagano et al. (2013), trading frictions that depend on microstructure features, such as order-matching protocols, transaction costs, or tick sizes, can lead to inefficient prices. Moreover, as evidenced by Kumar and Seppi (1992), Hillion and Suominen (2004), and Comerton-Forde and Putniņš (2011), some market participants could also have incentives to manipulate prices. When prices are inefficient, there is a mismatch between securities' prices and their fundamental value, which weakens investor trust in the market, disincentivises participation, harms liquidity, and hence, undermines market quality.

The trading protocols in place can also contribute to a well-functioning market by enhancing its quality. A majority of markets are organised as continuous trading systems. However, most exchanges have introduced opening and closing call auctions to determine prices in moments of especially high uncertainty or when prices are more susceptible to manipulation. In a call auction, traders indicate their trading interest during a non-trade order-entry phase also known as 'the batching period'. Orders are then simultaneously executed at a single equilibrium price at 'the uncross'. As discussed by Economides and Schwartz (1995), the aggregation of liquidity facilitates the absorption of order imbalances and reduces price impacts. A call auction also reduces the aggressiveness of liquidity demanders, since all trading takes place simultaneously, regardless of the time of order submission. Moreover, as argued by Schwartz (1995), the consolidation of orders should also translate into better price efficiency, given that the beliefs of many traders about a stock's fundamental value are brought together. A call auction is also likely to contribute to greater market integrity. By consolidating liquidity, the possibility of gaming the auction is reduced because a manipulator would need to submit larger orders. The profitability of manipulative strategies is also lower for a call auction due to the increased execution costs and risks to be faced by manipulators.

While most exchanges begin and end the trading day with a call auction, the call auction's specific design varies considerably across venues. The literature examining whether certain design features improve call auction performance is very limited (for an overview, see Biais et al., 1999; Domowitz and Madhavan, 2001; McCormick, 2001; Comerton-Forde and Rydge, 2006; Kandel et al., 2012). However, regulatory authorities and existing research emphasise the importance of call auction design in market quality. The call auction is a good mechanism for improving price efficiency, but having certain design features in place can either improve or diminish its performance. Exchange officials should consider call auction design in the search to improve the quality of their capital markets.

The regulation of financial markets is not an easy task. This is because implementing new regulations can have unintended side effects or lead to important

structural changes that greatly modify the trading landscape. The fragmentation of equity markets constitutes a clear example. The implementation of the Markets in Financial Instruments Directive (MiFID) in 2007 in the European Union, and of the Regulation-National Market System (Reg-NMS) in 2005 in the United States, led to the proliferation of alternative trading platforms and a boost in the participation of algorithmic traders. Market fragmentation has drastically changed the way trading takes place and has raised concerns about its consequences for the stability of financial markets. However, its effects and repercussions on the liquidity of security markets are not fully understood.

The fragmentation of equity markets has meant moving from a scenario in which liquidity was concentrated in a single exchange, to one where liquidity is scattered across trading platforms. The effects of market fragmentation on liquidity are difficult to predict. This is because, on the one hand, finding a counterparty is more difficult in fragmented markets, which increases execution risk and search costs. The higher complexity of the trading process can discourage participation, which is detrimental to liquidity. Moreover, fragmented markets depend heavily on the voluntary liquidity provision of cross-market algorithmic traders. If, as noted by Boehmer et al. (2015) and Anand and Venkataraman (2016), voluntary liquidity providers reduce their supply of liquidity when market conditions are unfavourable, the stability of financial markets could be especially at risk in times of stress.

On the other hand, fragmentation has increased exchange competition, which as discussed in Foucault and Menkveld (2008), reduces trading costs and hence encourages participation. Aitken et al. (2015) also note that fragmentation has boosted the participation of algorithmic traders who, according to Brogaard et al. (2018), commonly trade against extreme price movements, providing liquidity to the market in moments of stress. The greater participation due to cheap and diverse trading, the boost in liquidity supply, and the types of trading strategies conducted by algorithmic traders, could thus translate into markets with both more and better liquidity.

The increasing complexity of the trading process, the constant technological upgrades and innovations, the proliferation of sophisticated financial instruments, and the emergence of fast traders complicate the regulation of financial markets. As evidenced by the introduction of short selling and dark trading restrictions, new rules and regulations often have unintended side effects that are detrimental to the quality of financial markets. An educated understanding of the different effects that changes in the trading rules can generate is important to guarantee the quality and stability of today's capital markets.

Summary of the thesis

This dissertation contains four articles that examine the effects of new regulations and changes in the trading landscape on different facets of market quality. Article I studies how the fragmentation of equity markets affects the ability of the market to recover from liquidity deviations, both under normal market conditions and in times of stress. Article II examines the impact of introducing short selling restrictions on the speed of recovery of the market liquidity and on commonality in liquidity. Article III exploits the change in the closing mechanism of 43 exchanges around the world to analyse the effects of batch facilities on liquidity, price efficiency, and market integrity. Article IV investigates the impact of introducing a volatility extension in the closing call auction on transitory volatility, market integrity, and auction attractiveness.

Article I

Today's equity trading is fragmented. Stock markets have evolved from local, centralised exchanges to fragmented structures where trading takes place on a variety of alternative platforms. With fragmentation, liquidity is scattered across venues and provided voluntarily and the trading process is more complex. This has raised concerns among regulatory authorities, who worry about the quality of the liquidity of today's fragmented markets.

Liquidity is an ambiguous concept that, as discussed in Kyle (1985), needs to be evaluated by considering its three dimensions: tightness, depth, and resiliency. Tightness reflects the cost of trading, depth the quantities available, and resiliency the ability of the market to recover from deviations in liquidity. Whereas tightness and depth are well explored in the literature, resiliency has received little attention. Article I, 'Effects of market fragmentation on resiliency', studies the impact of fragmentation on liquidity, with a focus on resiliency.

Resiliency is important, since it determines the ability of traders to immediately and reliably execute orders when needed. If resiliency is low, traders either face execution risk as they wait for the market to absorb the deviations generated by liquidity shocks, or they incur losses from trading at unrepresentative prices. Resiliency is perhaps particularly relevant in moments of stress. Fragmented markets are interconnected and feed on the voluntary liquidity provision of cross-market participants. As noted by Anand and Venkataraman (2016), when conditions are unfavourable, voluntary liquidity providers are less likely to provide liquidity. The Flash Crash of 2010 provides evidence that the evaporation of liquidity provision in times of stress can compromise the stability of financial markets. Article I analyses the effects of fragmentation, both under normal market conditions and in times of stress.

This article analyses the effects of fragmentation on the liquidity of stocks belonging to the main Spanish index, the IBEX 35. The main finding is that fragmentation is beneficial for resiliency. Under normal conditions, fragmentation increases the ability of the market to converge towards its long-run liquidity levels by shortening the duration of spread deviations while not harming the recovery of the quantities available for trading. Fragmentation also has an overall positive effect on resiliency in instances of stress generated by large trades or large information asymmetries. Increasing levels of fragmentation not only narrow spreads and increase the quantities that are available for trading immediately after a large trade or when the level of information asymmetry is high, they also speed up the replenishment of the limit order book and its ability to revert to the nonstressed levels.

The results are consistent with the argument of Foucault and Menkveld (2008), that the increased competition brought about by fragmentation leads to cheaper trading. Cheap trading is likely to encourage participation, resulting in greater liquidity and a better ability to face moments of stress. The findings are also in line with the work of Brogaard et al. (2018), who find that algorithmic traders, whose presence has been boosted due to fragmentation, trade against large price movements and supply liquidity when market conditions are unfavourable.

This article contributes to the literature in the following ways. First, by examining the effects of fragmentation on all three dimensions of liquidity, including resiliency. And second, by evaluating the impact of fragmentation under normal market conditions, as well as in times of stress. Previous literature on fragmentation has only analysed its impact on the tightness and depth dimensions and has focused on examining its effects under normal market conditions (see Foucault and Menkveld, 2008; O'Hara and Ye, 2011; Degryse et al., 2015; Gresse, 2017). Although these studies provide relevant evidence of the effects of fragmentation on liquidity, they do not present a complete characterisation of its impact on all three dimensions, neither on whether the effects differ when liquidity is likely to matter the most, in times of stress. As for the limited literature on resiliency, so far previous research has neglected the current context of fragmented markets.

Article II

Short selling is the strategy of selling a stock without owning it, with the hope of profiting from a potential price decline. Academics and regulators have acknowledged the important role of short sellers in providing liquidity. However, in times of distorted markets, short sellers have been accused of spreading false rumours to profit from a market failure. Regulatory authorities have reacted to these episodes by restricting short selling activities with the aim of reducing systematic risk and, hence, the likelihood of financial contagion.

The increase in competition in liquidity provision brought about by short sellers has been documented to have beneficial effects on liquidity (e.g. Beber and Pagano,

2013; Boehmer et al., 2013). A short selling ban decreases the number of competing liquidity providers, which is likely to hinder the liquidity of the affected securities. Article II, 'Effects of short selling bans on resiliency and commonality in liquidity', studies the impact of introducing short selling restrictions on liquidity, with a focus on resiliency. Resiliency is important because it determines the ability to execute orders when needed. Securities with low resiliency take longer to recover from deviations originating from liquidity shocks.

Chordia et al. (2000), Hasbrouck and Seppi (2001), and Brockman et al. (2009) document the existence of cross-stock liquidity co-movement. As discussed by Karolyi et al. (2012) and Malceniece et al. (2018), commonality in liquidity is an important determinant of systematic risk and, hence, an indicator of the fragility of a market. The degree of commonality in liquidity affects the way liquidity shocks are propagated across securities (Cespa and Foucault, 2014). Regulatory authorities have motivated the introduction of short selling bans in an attempt to reduce the likelihood of financial contagion in times of financial instability. Article II analyses the effects of short selling restrictions on commonality in liquidity to examine whether such restrictions indeed decrease the possibility of illiquidity contagion.

On 12 August 2011, Belgium, France, and Italy imposed bans on the short selling of financials stocks. This article analyses the effects of the restriction by means of a quasi-natural experiment. The first main finding is that short selling restrictions are detrimental to the liquidity of the banned stocks. As documented in previous literature, the static dimensions of liquidity deteriorate following the implementation of the restrictions. Resiliency also decays. Given a liquidity shock that deviates the relative quoted spread and depth from their long-run values, a short selling ban increases the duration of the spread and depth deviations by 26% and 42%, respectively. The results are consistent with the claims of Boehmer et al. (2013) that a ban on short selling decreases competition in liquidity provision. Less competition is likely to hinder the ability of the affected stocks to recover from liquidity deviations.

The study also documents a decrease in commonality in liquidity in the banned stocks for all three dimensions of liquidity. The restriction reduces the exposure of such stocks to systematic risk and, hence, the likelihood of liquidity shocks propagating across securities. This result is consistent with the idea that short selling bans decrease the participation of agents with high monitoring capacity, resulting in less correlated trading strategies. The restriction also constrains the ability of short sellers to exploit mispricing opportunities across stocks, reducing the likelihood of liquidity spillovers. The decrease in commonality in liquidity for banned stocks comes with increased commonality levels for non-banned securities. This is because non-banned stocks are likely to attract some of the short sellers expelled from banned securities, thus facing increased monitoring and greater demand from market participants.

This article contributes to the literature in the following ways. First, by examining the effects of short selling bans on all three dimensions of liquidity, including resiliency. Previous literature has analysed the effects of such restrictions on the static dimensions of liquidity. However, liquidity has an evident dynamic nature and not considering its dynamic properties gives an incomplete characterisation of the impact of the bans on liquidity. The second contribution of this article is its evaluation of the impact of short selling bans on commonality in liquidity. This is especially relevant because regulators have motivated the introduction of such restrictions in an attempt to decrease systematic risk. The literature focuses solely on the liquidity impact at the individual security level, bypassing the existence of common determinants that cause cross-stock liquidity variation.

Article III

Closing prices are often adopted as the reference price for the settlement of derivatives contracts, for the performance evaluation of brokers and funds, to determine the inclusion of a stock in an index, and to compute portfolio returns. The importance and widespread use of closing prices require guaranteeing that they reflect the stock's fundamental value. Closing prices have traditionally been tied to the price

of the last trade of the continuous trading session. However, concerns about the ability of last-trade mechanisms to generate closing prices that are efficient and resilient to manipulation have led many exchanges to replace them in favour of batch facilities.

In a batch facility, liquidity is aggregated during a non-trade batching phase in which market participants indicate their trading interests. Orders are then simultaneously executed at a single equilibrium price at the uncross. Batch facilities differ in design. There are four design features that are common in batch mechanisms: *flexibility* to submit, cancel, or modify orders during the batching period; *randomisation* of the time to uncross; use of *price stabilisation systems* to curb volatility, and *transparency* of the order book during the batching phase. Article III, 'Closing time: Effects of closing mechanism and design on market quality', evaluates the effects of closing batch facilities on market liquidity, price efficiency, and integrity and whether certain design features improve their performance. This article is written jointly with Professor Talis Putniņš, Senior Lecturer Sean Foley, and Nicholas Cordi.

The article analyses the change in the closing mechanism of 43 exchanges worldwide from 1999 to 2013 and finds that batch facilities generally improve market quality relative to last-trade mechanisms. For the broad market, batch facilities are associated with better liquidity and price efficiency. They also contribute to greater integrity by reducing the variability of closing price distortions and by increasing synchronicity with the market. The study further provides evidence of the importance of auction design in ensuring a well-functioning batch mechanism. In this vein, the findings indicate that a randomised closing time and the use of stabilisation systems largely improve market quality. Transparency and flexibility are mostly detrimental in this regard.

The heterogeneity of the sample allows one to extract specific lessons for developed and emerging markets and about liquid versus illiquid stocks. Developed markets benefit from the introduction of batch facilities, especially when it comes to liquid stocks. While illiquid securities experience a general improvement in liquidity and price efficiency, liquid stocks additionally experience a decrease in the probability

of manipulation, greater synchronicity with the market, and lower idiosyncratic volatility. Transparency is largely detrimental to developed markets but flexibility mostly has a positive effect, which supports the idea that giving traders the opportunity to act upon the arrival of new information is beneficial in markets where securities regulation is highly enforced. Liquid stocks also benefit from the use of stabilisation systems.

The introduction of batch facilities is mostly detrimental to emerging markets, which likely are unable to attract sufficient order flow for a well-functioning auction. These results suggest that enhanced regulation and an appropriate auction design are needed in these markets to attract sufficient order flow and fight closing price manipulation. The results show that transparency and flexibility are strongly detrimental to emerging markets. However, a majority of emerging markets include transparency and flexibility within their design features. In contrast, whereas emerging markets especially benefit from randomised closing times and the use of stabilisation systems, only about half of the sample has these design features in place.

This article contributes to the literature in the following ways. First, by examining the change of the closing mechanism in a comprehensive sample of 43 exchanges around the world for stocks of different liquidity levels. This setup enables conclusions to be drawn about the general effects of different closing mechanisms on market quality, and the extraction of lessons for developed and emerging markets and about liquid versus illiquid stocks. Existing research has instead examined the impact of introducing a batch mechanism in a particular exchange and has mostly focused on developed markets and liquid stocks (e.g. Pagano and Schwartz, 2003, 2005; Barclay et al., 2008; Kandel et al., 2012). The second contribution of this article is its analysis of the relative effects that the most common auction design features have on liquidity, closing price efficiency, and market integrity. The limited research emphasising the importance of auction design has focused only on a single design feature (see Biais et al., 1999; Domowitz and Madhavan, 2001; Hauser et al., 2012). Moreover, the effects of some of the features have, so far, not been empirically documented in the literature.

Article IV

As addressed in Article III, efficient closing prices are important since they function as reference prices for derivatives and index calculations, and are commonly used to benchmark the performance of portfolio managers and brokers. Given the relevance of closing prices, it is necessary to guarantee that they reflect the stock's fundamental value. To this end, most exchanges around the world have incorporated call auctions to end the trading day. This is because, as discussed by Madhavan (1992), Economides and Schwartz (1995), Schwartz (2001), and Pagano and Schwartz (2003), closing call auctions can help to improve the efficiency of closing prices and overcome order imbalances and information asymmetries at the end of the trading day.

Although the use of a call auction facilitates the achievement of efficient prices, Madhavan and Panchapagesan (2000) show that closing prices can still be distorted and Hillion and Suominen (2004) note that appropriate safeguards need to be in place in order to guarantee reliable prices. Comerton-Forde and Rydge (2006) show that auction design is important in improving the ability of a call auction to generate efficient prices. Article IV, 'Call Auction Volatility Extensions', analyses the effects of introducing a volatility extension in a closing call auction. This article is written jointly with Associate Professor Björn Hagströmer.

A volatility extension is designed to mitigate transitory volatility in call auction prices. A call auction consists of two phases: the *batching period*, where orders are entered but no trading takes place, and the *uncross*, where orders are simultaneously executed at a single equilibrium price. When a call auction operates with a volatility extension, large price swings can trigger an extension of the order entry phase. The extension signals to investors that volatility is unusually high and allows them to reconsider their orders.

On 1 December 2014, Nasdaq Stockholm introduced a volatility extension to its closing call auction. Article IV analyses the impact of the volatility extension on closing price efficiency, finding strong evidence of an improvement. After the event,

the incidence of extraordinary closing price volatility is reduced for both small-cap and mid-cap stocks. The study also finds that not only there are fewer instances of extraordinary volatility, but also daily transitory volatility undergoes a significant reduction. When the sample is split into volatile and non-volatile stocks, the results show that the reduction in transitory volatility is not isolated to the most volatile securities.

To understand the channels underlying the improvement in closing price efficiency, Article IV zooms in on the quoting activity in the batching period to evaluate the effects that the volatility extension has on market integrity and auction attractiveness. The findings indicate that market integrity improves. Market participants cancel significantly fewer orders in the final seconds of the auction and the order imbalance shortly before market closure is reduced. The results also provide evidence consistent with an improvement in market participant trust in the auction mechanism. Investors allocate higher trading volumes to the closing call auction, orders are submitted earlier in the batching period and they are of greater volume, and the indicative price volatility is reduced. This evidence suggests that investors are less wary of auction manipulation and have greater trust in the auction mechanism when a volatility extension is in place.

This article contributes to the literature in the following ways. First, by analysing how volatility extensions influence the quality of the auction mechanism and by introducing new measures to evaluate the quality of the batching phase. Most of the literature has focused on examining whether ending the trading day with a call auction is beneficial for price efficiency. The literature emphasising the importance of auction design in achieving efficient prices is very limited and, so far, it has not examined the effects of volatility extensions. The article's second contribution is its examination of the effects of volatility curbs on trading behaviour. Previous studies focus mainly on the magnet effect of circuit breakers described by Subrahmanyam (1994). Article IV analyses instead whether volatility extensions increase market integrity and investor trust in the auction mechanism.

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