House of Finance
Working Paper Series

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Paying for Market Liquidity: Competition and Incentives

SAFE Working Paper No. 247

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February 2019

ABSTRACT

Do competition and incentives offered to designated market makers (DMMs) improve market liquidity? Using data from NYSE Euronext Paris, we show that an exogenous increase in competition among DMMs leads to a significant decrease in quoted and effective spreads, mainly through a reduction in adverse selection costs. In contrast, changes in incentives, through small changes in rebates and requirements for DMMs, do not have any tangible effect on market liquidity. Our results are of relevance for designing optimal contracts between exchanges and DMMs and for regulatory market oversight.

JEL classification: G12, G14.

Key-words: High-Frequency Trading (HFT), Designated Market Makers (DMMs) Market Making, Adverse Selection, Liquidity Provision.

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1 Introduction

Over the past decade, technological innovation, faster computers with sophisticated execution algorithms, and new trading platforms have completely changed the landscape for equity trading around the world. A new class of electronic liquidity providers has emerged; the "old" class of specialists has almost disappeared, leaving room for a "modern" version of designated market makers (DMMs), who make extensive use of co-location facilities, high-speed connections, and fast computers.[1] In other words, modern market making is firmly in hands of high frequency traders (HFT).[2] Anecdotal evidence also confirms this view, e.g., on the NYSE, the DMMs' duties are, after January 2016, all managed by HFT firms.[3] Electronic market making is present all around the world today, and many major stock exchanges (among others, the New York Stock Exchange, Euronext, London Stock Exchange, and Deutsche Börse) have in place market-making agreements with electronic traders. The role of DMMs in exchanges, now largely played by HFTs, in influencing market liquidity is not well understood, and requires careful empirical examination to conclude whether competition between DMMs and incentives offered to them could influence liquidity. In this paper, we aim to cover this void and empirically investigate the role of competition and incentives enforced by exchanges in influencing market liquidity, particularly for HFTs who are willing to act as DMMs.[4] We attempt to disentangle the effects of competition from those of incentives to assess the effectiveness of each of these as policy instruments to improve market liquidity.

Stock exchanges have several instruments at their disposal to stimulate the market liquidity provided by DMMs. These can be classified into two broad categories: the competitive structure imposed on DMMs, and the incentives, both benefits offered to them and penalties

[1] Hasbrouck and Sofianos (1993) describe the role of the specialist on the NYSE; Venkataraman and Waisburd (2007) provides a historical overview of the "animateurs" in the French stock market.

[2] See Hagströmer and Norden (2013), Menkveld (2013), Budish, Cramton, and Shim (2015), Bongaerts and Van Achter (2016), and Menkveld and Zoican (2017) for both theoretical and empirical evidence on HFTs taking the role of de facto market makers.

[3] See "High-frequency traders in charge at NYSE," *Financial Times*, January 26, 2016.

[4] We use the term "designated market makers" in this context to emphasize the fact that such traders enter into a written agreement with the exchange, although their exact role in the market, and the details of such agreements may vary across time and across exchanges.

imposed on them through fees, rebates and market making requirements.[5] The competitive structure of the DMMs can be affected by the exchanges through the requirements imposed on them with regard to the number of stocks in which they are required to make markets, and the constraints imposed on potential new entrants. For instance, contract terms may assign only one or many DMMs to a particular stock, or restrict the number of stocks in which an individual DMM can operate. As for incentives, exchanges impose various obligations (sticks) but also grant advantages (carrots) to DMMs. The most typical contract for market making includes the following aspects. First, as compensation for their duties, DMMs enjoy a preferential maker/taker fee structure. For example, such traders pay a reduced fee when they execute an aggressive order (consume liquidity), and receive a rebate when they execute a passive order (provide liquidity). Second, DMMs agree to fulfill certain requirements such as an agreement with the exchange to be present in each assigned security for a minimum amount of time at the best bid-offer level, to quote or execute a minimum amount of shares, etc. In this paper, we isolate the effects of each aspect of the contract design on market liquidity: competition among DMMs from those of incentives, both positive and negative, imposed on them.

In order to analyze the role of different types of incentives on the behavior of DMMs, we use data from the NYSE Euronext Paris stock exchange, which includes flags that identify HFT and market-making activity. Our data are provided by the Base Européenne de Données Financières à Haute Fréquence (BEDOFIH). Each message (new order, modification, cancellation, and execution) is flagged as a message submitted by one of the three trader types: HFT, when submitted by a pure-play HFT (e.g., Getco or Virtu); MIXED, when submitted by an investment bank with HFT activity (e.g., Goldman Sachs, JP Morgan); or as NONHFT. In addition, data also include information on the account type used: market-making account (MM) and other account (OTHER) (e.g., proprietary trading, client orders, etc.).

The identification strategy used in the paper relies on the two events included in our sample period (March 1, 2013 till December 31, 2013). First, on June 3, 2013, NYSE

[5]Clearly, the level of competition that prevails in the market is also determined by the actions of other traders, besides DMMs, whose actions may be indirectly influenced by the exchanges.

Euronext Paris implemented several changes in the rules of the so-called Supplementary Liquidity Provider (SLP) program. More specifically, new SLP rules increased the rebate that DMMs receive for passive execution, tightened the requirements that they have to fulfill, and increased competition among them. Second, on November 1, 2013, NYSE Euronext Paris reversed the rebate that DMMs receive for passive execution to the pre-June level. These changes were accompanied by heterogeneity across stocks in the extent to which the requirements were binding. We are able to use the rebate-reversal event to isolate the effect of the carrots on the behavior of DMMs, while exploiting the heterogeneity in the impact across stocks to distinguish the effects of the two sticks: regulatory requirements and competition.

Our main findings can be summarized as follows. First, an exogenous increase in competition among DMMs is beneficial for market liquidity, both in statistical and economic terms. In particular, for traders active in the Cotation Assistée en Continu (CAC40) index stocks, the decrease in transaction costs due to the increased competition among market makers amounts to EUR 4.08 millions per year. Moreover, this decrease in transaction costs is not concentrated only among HFTs, since part of it is passed along to the NONHFT group. Second, the main driver of the improved liquidity is a decrease in adverse selection costs (the price impact of trades): with an increase in competition, each individual DMM is more likely to face another DMM, when initiating a transaction rather than adversely selecting slow uninformed traders (NONHFT). Third, small changes in rebates for DMMs (around 1% of the market-wide quoted spread) and requirements do not have any statistically and economically significant effect on market liquidity, as measured by quoted and effective spreads.

The outline of the paper is as follows. Section 2 places our paper in the context of the literature on DMMs. Section 3 provides a description of our database and presents some institutional detail about NYSE Euronext Paris, in particular with regard to changes in the competitive structure, and incentives, both fee rebates and regulatory requirements. The empirical implications of the policy changes under the SLP program and the testable hypotheses that they motivate are discussed in Section 4. Section 5 describes the methodology used in the paper. The empirical evidence is presented in Section 6. Our robustness analysis is presented in Section 7. Section 8 concludes.

2 Literature Review

Our first contribution to the literature is providing evidence on the importance of DMMs for market liquidity in the era of high frequency trading. The previous literature on the value of DMMs is largely based on voluntarily negotiated contracts between the DMM and firm itself. Bessembinder, Hao, and Zheng (2015) show in their model that a firm might hire a DMM prior to its initial public offering (IPO), in case of significant uncertainty about in its value accompanied by informational asymmetry. In other words, DMM contracts might be beneficial for small, growth firms that are about to enter the stock market. Skjeltorp and Ødegaard (2014) show empirically that the decision of a firm to hire a DMM is typically driven by the imminence of its interaction with the capital market such as through secondary equity offerings, share repurchases, etc. Venkataraman and Waisburd (2007), Anand, Tanggaard, and Weaver (2009), and Menkveld and Wang (2013) show that hiring a DMM improves market liquidity and price discovery. However, the afore-mentioned papers are likely to provide an upward-biased estimate of the DMM value, as only those firms for which hiring a DMM is beneficial choose to hire them. To the best of our knowledge, only Bessembinder, Hao, and Zheng (2017) and Clark-Joseph, Ye, and Zi (2017) provide causal evidence that the activity of DMMs has a positive effect on market liquidity. We contribute to this literature by pointing out not only the importance of DMMs for market liquidity, but also emphasizing the importance of their business organization for market liquidity. The unique feature of our database is the flag identifying the account type - market-making account or other account for each message, which allows us to establish a more direct connection between DMMs activity and market liquidity.

Our second contribution relates to the role of competition among DMMs. Remarkably, competition *among* DMMs is largely neglected in the empirical literature, although there is mention of competition in a broad sense in a few theoretical models. Although a couple of the existing models explicitly allow for different degrees of competition among market makers (Biais, Martimort, and Rochet (2000) and Aït-Sahalia and Sağlam (2017)), others often assume that the market making business is fully competitive.

The conventional wisdom is that, in modern markets, it is safe to assume that DMMs face enough competition from the voluntary liquidity providers; therefore it is enough to assign one DMM per stock. We challenge this view by providing evidence that competition among DMMs for the same stock is an important aspect of the contract design that exchanges ought to consider in their goal of improving market liquidity. To the best of our knowledge, we are the first to analyze the competition among DMMs (rather than competition between trading venues or competition among traders through a speed advantage, etc.) in an empirical setting.

The third feature of our paper is that it is the first one to study the relative importance of the different aspects of contract design between DMMs and exchanges, distinguishing between positive and negative incentives. While there are several studies on the role of maker/taker fees in encouraging liquidity provision (e.g., Colliard and Foucault (2012), Cardella, Hao, and Kalcheva (2015), Malinova and Park (2015), Clapham, Gomber, Lausen, and Panz (2017), Black (2018), El Euch, Mastrolia, Rosenbaum, and Touzi (2018), and Lin, Swan, and Harris (2018)) and regulatory requirements of DMMs (e.g., Bessembinder, Hao, and Zheng (2017)), these two aspects were studied *independently* of each other. Thus, it is not possible to draw conclusions about their relative effectiveness in providing the optimal incentives for DMMs to improve their liquidity provision. Besides, most of the prior studies regarding maker/taker fees focus on the case where such fees are applied uniformly to all market participants, across all stocks rather than specifically to DMMs to incentivize their liquidity provision. Our empirical setting is unique in that we are able to distinguish between the role of carrots (rebates) and sticks (competition and requirements), exploiting the impact of a policy change that had a differential impact across stocks.

3 Data and institutional details

3.1 Data

Our database is obtained from the Base Européenne de Données Financières à Haute Fréquence (BEDOFIH) and is based on data from the NYSE Euronext Paris exchange. Our sample spans the period from March 1, 2013 until December 31, 2013, and we focus our analysis on the 37 stocks that belong to the CAC40 Index.[6]. The BEDOFIH database provides quotes and trades timestamped in microseconds, covering the complete history of each order.

The data from NYSE Euronext Paris are complemented by a flag provided by the Autorité des Marchés Financiers (AMF), the French stock market regulator, that classifies each trader into one of three groups: HFT, MIXED (shortened to MIX), and NONHFT. HFT are pure-play HFT companies (e.g., Getco, Virtu), the MIX group covers the investment banks and large brokers, which could have substantial HFT activities (e.g., BNP Paribas, Goldman Sachs). The remaining companies are placed in the NONHFT category. This classification is revised once a year, and the three trader groups are mutually exclusive (see AMF (2017) for a detailed description of the methodology behind this classification).

NYSE Euronext Paris also provides information about the account type used to submit each order. For the purpose of our analysis, we distinguish between two account types: market-making account (MM) versus the other account (OTHER). The exchange confirms that the orders flagged for liquidity provision purposes are strictly monitored and verified by the exchange's compliance department. Please refer to Figure 1 for a schematic diagram of the trader-account types used in our analysis.

INSERT FIGURE 1 HERE

In Table 1, we present traders' characteristics and trading activity averaged across stock-days for the four trader-account types used in our analysis: HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT. We document that DMMs (HFT-MM and MIX-MM) are responsible for the majority of orders submitted to the market. They submit, on average, 65,549 and 51,409 orders, respectively, while NONHFT submit, on average, only 2,318 orders, per stock-day. HFT-MIX-OTHER are in the third place in terms of new order submissions. In line with stylized facts regarding fast traders acting as DMMs, HFT-MM and MIX-MM cancel more than 95% of the orders submitted, as opposed to NONHFT who cancel only 40% of the orders submitted. HFT-MIX-OTHER also cancel more than 90% of their orders. Another metric of HFT activity is how many times trader inventories cross zero. We

[6]Three component stocks of the CAC40 are not included in the database, since their main trading venues are Amsterdam (Arcelor Mittal and Gemalto) and Brussels (Solvay).

document that, as a group, HFT-MM's inventory crosses zero on average 16.42 times per stock-day. That is 2.78 times larger than the respective number for MIX-MM, 2.09 times larger than the respective number for HFT-MIX-OTHER, and 3.36 times larger than the respective number for NONHFT.

In terms of liquidity provision, HFT-MM contribute 31.08% to the total volume of passive execution, while MIX-MM contribute only 6.27%. The largest contribution to liquidity provision in NYSE Euronext Paris comes from voluntary liquidity provision by HFT-MIX-OTHER (47.79%). We note that all trader-account types use mixed strategies that involve both liquidity providing (limit) orders and liquidity consuming (market) orders. In net terms, HFT-MM are the largest contributors to liquidity: they provide 9.27% more than they consume.

INSERT TABLE 1 HERE

3.2 Institutional details

NYSE Euronext Paris is an order-driven market with an open limit order book. Therefore, any market participant can, in principle, act as a de facto liquidity provider by submitting limit orders to the market. However, in 2011, NYSE Euronext Paris introduced the Supplementary Liquidity Provider (SLP) program to enhance liquidity provision for blue-chip stocks, by licensing DMMs. The Flash News of January 13, 2011 (NYSE-Euronext (2011)) covers the details of the implementation of the program. According to the *Financial Times*, seven firms initially joined the program and became Designated Market Makers (DMMs).[7] In the remainder of this paper, we refer to SLP members as DMMs. In the next subsections, we discuss the sticks (competition and requirements) and carrots (rebates) that NYSE Euronext Paris uses to incentivize DMMs.

3.2.1 SLP program: Competition and Requirements

The 2012 SLP program requires that each firm appointed as a DMM must:

[7] "Euronext launches DMM-style programme in Europe *Financial Times*, April 17, 2011: NYSE Euronext started operating a similar scheme in Europe on April 1 with about seven firms signed up, according to Rollande Bellegarde, its head of European cash equities.

A) Commit to be present at least in one basket of stocks (CAC40 stocks are partitioned into *four* baskets). [Competition]

B) Satisfy the following three rules [Requirements]:

(1) Be present at least 95% of the time on both sides of the market during the continuous trading session;

(2) Display a minimum volume of at least EUR 5,000 at the best limit price.

(3) Deliver the presence time committed to by the applicant during the tender process at the Euronext best limit for each assigned basket of securities, with a minimum of 10% per each security included in the basket.

The composition of the 2012 SLP program members remained unchanged since the inception of the program until 2013, when in the Flash News of May 9, 2013 (NYSE-Euronext (2013b)) the exchange announced several changes to the SLP program, and opened it up to new members.[8] The new changes came into effect as of June 3, 2013. The main differences were related to basket composition (Rule A) and the proportion of time present at the best limit (Rule B3). CAC40 stocks were initially split into four different baskets, but starting on June 3, 2013, all the CAC40 components are placed in the same basket.[9] This change increased the number of DMMs present in each stock in the CAC40 index, since all of them were obliged to remain active in them. This change in basket composition is another source of increased competition among DMMs beyond the arrival of new entrants into the SLP program. The difference between the two contracts are:

A) Commit to be present in all stocks that belong to CAC40. [Competition]

B) Amendments to rule n. (3) [Requirements]:

(3.1) Minimum passive execution level of 0.70% in percentages of the aggregate monthly volume traded on Chi-X, BATs, Turquoise, and NYSE Euronext

(3.2) Minimum presence time of 25% at the NYSE Euronext best limit for each assigned basket, weight-averaged over the entire CAC40 basket and the calendar month,

[8] Megarbane, Saliba, Lehalle, and Rosenbaum (2017), using the same database enhanced with the ID of the traders, identify 20 firms as SLP members for the sample period from November 2015 until July 2016.

[9] Table IA.1 in the Internet Appendix provides the details of the basket composition.

(3.3) Minimum passive execution level of 0.10% and a minimum presence time of 10% at the NYSE Euronext best limit of the continuous trading session for each security, weight-averaged over the calendar month.

Overall, in June 2013, the market environment for DMMs was changed in two ways: a) competition between DMMs was increased through changes in the basket composition and the entry of new market makers into the SLP program, and b) the requirements of DMMs, in particular, those regarding the time presence at the best bid-offer level, were tightened.

3.2.2 SLP program: Benefits

NYSE Euronext Paris initially provided the following maker/taker scheme for SLP members: for each executed market order (consuming liquidity), the fee for SLP members was 0.30 basis points, and for each executed limit order (providing liquidity) the rebate for SLP members was -0.20 basis points, until May 2013, which was increased to -0.22 basis points as of June 3, 2013. However, the Flash News of October 1, 2013 (NYSE-Euronext (2013a)) announced that the rebate would revert to -0.20 basis points as of November 1, 2013. This attractive maker/taker fee structure applies only to those SLP members who fulfilled the requirements. SLP members who did not fulfill the requirements were charged 0.55 basis points per order execution, independent of whether they consumed or provided liquidity.

4 New SLP rules: empirical implications

The institutional setting, in particular the regulatory changes, suggest some clear implications for our empirical investigation. We will first summarize the implications, which will then be used to motivate the concrete hypotheses that we will subsequently test.

First, changes in Rule A create a backdrop for studying changes in the competitive environment for market making, but the presence requirement by itself does not lead to a quantitative prescription. However, when interpreted along with Rule B3, modified by Rule B3.3, has a binding requirement for DMMs, since these rules prescribes a 10% *minimum* presence at the best quotes for *each* security. According to the changed rule A, the number of stocks in which such a minimum market-making presence needs to be maintained was increased from 10 to 40 stocks, which would suggest that competition increases with more players participating in each stock, which may lead to an improvement in market liquidity. However, the increase in the number of stocks may, at the same time, stretch the resources of DMMs since their inventory and computational capacity has to be allocated across more stocks. This may, therefore, lead to the unintended consequence of the opposite result - a deterioration in market liquidity.

Second, Rule B3.2 is a new rule that requires a minimum *average* presence across stocks, which may again have two opposing effects on market liquidity. On the one hand, since DMMs are required to maintain best quotes in all stocks more often, market liquidity may improve. On the other hand, the resources constraints may be more binding with these increased requirements and hence, market liquidity may actually deteriorate.

Third, Rules B1 and B2 were not changed and are unlikely to be binding, in any case, as shown later on (see Section 6.4). Finally, the change in the maker/taker fee structure is small. Besides, the rebate increase (as of June 3, 2013) was shortly followed by a reversal (as of November 1, 2013). This suggests that changes in the maker/taker fee structure may have had a marginal impact, which will be verified in the robustness Section 7.1.

We also note that although the relevant basket of stocks has been defined by the NYSE Euronext Paris, traders decide themselves in which basket they want to be DMMs and, hence, in equilibrium their allocation should be optimal for the market. To ensure that the hypotheses we test include the possibility of rejection, we present them as if only one effect of the change in competition and requirements was dominant. Hence, the above empirical implications regarding market liquidity can be tested through the following formal hypotheses:

Hypothesis 1. *(Competition) An increase in competition between DMMs may improve market liquidity due to a larger number of market makers maintaining a minimum presence in each stock.*

Hypothesis 2. *(Requirements) More stringent requirements may lead to an improvement in market liquidity since there DMMs have to be present at the best bid-offer level more frequently under the changed regulations.*

5 Methodology

In this section, we discuss the methodology used in our paper. First, we define the variables that we use to measure market liquidity. Second, we describe our identification strategy to isolate the effect on market liquidity of the incentives imposed by the SLP program from that of competition among DMMS. We first define our market liquidity variables before outlining our methodology and identification strategy.

5.1 Market Liquidity Variables

We measure market liquidity by quoted and effective half-spreads, where the quoted spread measures the round-trip quoted cost of one share transaction, while the effective spread measures the round-trip cost of an actual transaction. Both spreads are computed at the time of t-th trade:

$$Quoted\ Spread_t = \frac{(Ask_t - Bid_t)}{2 * Midpoint_t} \tag{1}$$

$$Effective\ Spread_t = \frac{|P_t - Midpoint_t|}{Midpoint_t} \tag{2}$$

We then decompose the effective spreads into realized spreads (revenue for the liquidity provider, net of adverse selection costs) and price impact (adverse selection costs), where q_t equals 1 for a buyer-initiated trade and -1 for a seller-initiated trade and h is decomposition horizon in minutes:

$$Realized\ Spread_t = \frac{q_t * (P_t - Midpoint_{t+h})}{Midpoint_t} \tag{3}$$

$$Price\ Impact_t = \frac{q_t * (Midpoint_{t+h} - Midpoint_t)}{Midpoint_t} \tag{4}$$

We compute the liquidity variables for each trade in our sample and winsorize them at the 95% level, i.e., at 2.5% and 97.5%, for each stock j. Then, we compute the share-weighted average of these variables for each stock j, day d, and trader-account type k. We again winsorize them at the 95% level, across all stock-days for each trader-account types.

5.2 Identification strategy: Competition vs. Incentives

There are two events in our sample that affect different aspects of the contract between the exchange and the DMMs (see Figure 2 for the timeline of the events). The first event is the change in the SLP program that became effective as of June 3, 2013, and includes increased competition between DMMs, more stringent requirements, and increased rebates for liquidity provision by DMMs. The second one is the rebate reversal to the pre-June level that went into effect as of November 1, 2013.

INSERT FIGURE 2 HERE

We begin by examining the overall effect of the change in the SLP rules on market liquidity. We regress the different liquidity measures on the dummy variable, SLP_d, which is equal to one in the post-event period (from June 3, 2013 until July 31, 2013), and zero in the pre-event period (from March 1, 2013 until May 9, 2013) In all regressions, we control for stock and market volatility, trading volume, and market capitalization. The regressions are estimated with stock fixed effects and the standard errors are clustered by stock and by day as follows:

$$y_{j,d} = \alpha_i + \beta_1 SLP_d + \Gamma Controls + \epsilon_{j,d} \tag{5}$$

We then distinguish between stocks for which the changes in the requirements for DMMs imposed under the new SLP rules were or were not binding. We regress different liquidity measures on the dummy variable, SLP_d, which is equal to one in the post-event period (from June 3, 2013 until July 31, 2013), and zero in the pre-event period (from March 1, 2013 until May 9, 2013), and the interaction between SLP_d and a dummy variable, $NonBinding_j$, which is equal to one, for stocks that were not affected by the change in requirements, and zero otherwise. In all regressions, we control for stock and market volatility, trading volume, and market capitalization. The regressions are estimated with stock fixed effects and the standard errors are clustered by stock and by day as follows:

$$y_{j,d} = \alpha_i + \beta_1 SLP_d + \beta_2 SLP_d \times NonBinding_j + \Gamma Controls + \epsilon_{j,d} \tag{6}$$

We use the estimation results of equation (6) to disentangle the effect of tightened requirements from the effect of competition among DMMs. If β_1 and β_2 are both significant, then the pure effect of competition among DMMs on market liquidity is equal to $\beta_1 + \beta_2$, i.e., the effect of changes in the SLP rules for stocks with non-binding requirements. If β_2 is not significant, we conclude that changes in the SLP rules have the same effect on the stocks with binding as well as non-binding requirements and, thus, β_1 represents the effect that increased competition among DMMs has on market liquidity.

To support our conjecture that changes in the SLP rules increase competition for liquidity provision, we compute the normalized Herfindahl-Hirschman Index (HHI) based on the liquidity provision ratio (the number of shares executed passively by the trader-account type k relative to the total trading volume per stock j and day d) and test whether it changes significantly around the time of introduction of the new SLP rules.

$$HHI_{j,d} = \frac{\Sigma_{k=1}^{4}\left(\frac{Number\ of\ shares\ executed\ passively_{j,d,k}}{Total\ number\ of\ shares_{j,d}}\right)^2 - 1/4}{1 - 1/4} \tag{7}$$

In the robustness section (see Section 7.1), we also perform the analysis for the rebate reversal to ensure that small changes in rebates do not have any effect on the behavior of DMMs. We regress different liquidity measures on the dummy variable, $Rebate_d$, which is equal to one in the post-event period (from November 1, 2013 until December 31, 2013), and zero in the pre-event period (from August 1, 2013 until September 30, 2013). In all regressions, we control for stock and market volatility, trading volume, and market capitalization. Our regressions are estimated with stock fixed effects, with standard errors clustered by stock and by day, as follows:

$$y_{j,d} = \alpha_i + \delta_1 Rebate_d + \Gamma Controls + \epsilon_{j,d} \tag{8}$$

We use the results of equation (8) to quantify the effect of the rebate change (if any) that occurred on June 3, 2013 when the new SLP rules were implemented. In particular, if we observe a statistically significant δ_1, we adjust the effect of new SLP rules by $-\delta_1$.

6 Empirical results

In this section, we present our empirical results about the relative importance of incentives of DMMs and competition among DMMs for market liquidity. First, we provide summary statistics for market liquidity in our sample (see Section 6.1). Second, we examine the effect of the changes in the SLP rules on June 3, 2013 on market liquidity (see Section 6.2), competition (see Section 6.3), and the reaction of DMMs (see Section 6.4). Third, we empirically analyze the relative importance of DMMs' incentives and competition among DMMs (see Section 6.5). Finally, we examine the effect of the new SLP rules on the spread decomposition (Section 6.6).

6.1 Summary statistics

Figure 3 shows the dynamics of the weekly moving average of quoted (Panel A) and effective spreads (Panel B) during our sample period. We focus our attention on the two months before the announcement date, and two months after the implementation date of change in the SLP rules. The black line corresponds to the pre-SLP period (from March 1, 2013 until May 9, 2013), while the red line corresponds to the post-SLP period (from June 3, 2013 until July 31, 2013). The grey line show the dynamics of the spread between the announcement and implementation dates of the new SLP rules. It is clear from the figure that both the quoted and effective spreads are considerably higher at the beginning of our sample period as compared to the end of our sample period, with most of this change probably stemming from the changes in the SLP rules, though we note that the effect of the SLP rules was not immediate, i.e., DMMs require some time to set up their systems to operate under new SLP rules.

INSERT FIGURE 3 HERE

Table 2 shows the summary statistics for the two sub-samples: pre-SLP (Panel A) and post-SLP (Panel B). In particular, we provide evidence on the quoted and effective spreads for the market as a whole, as well as those faced by each trader-account type while initiating the transaction, averaged across stock-days. For example, during the pre-SLP period, the market-wide quoted (effective) spread is equal to 2.06 (2.13) basis points. HFT-MM face the smallest quoted and effective spreads of 1.85 and 1.87 basis points, while NONHFT face the largest quoted and effective spreads of 2.55 and 2.76 basis points, respectively. This pattern holds for the post-SLP sample as well.

INSERT TABLE 2 HERE

We also conduct a set of univariate t-tests with standard errors clustered by stock and by day for the difference in the means between the pre-SLP and the post-SLP market liquidity (see Panel C of Table 2). We observe a statistically significant decrease around the changes in the SLP rules in the market-wide quoted and effective spreads of -0.108 and -0.100 basis points, respectively. The quoted (-0.145 basis points) and effective (-0.087 basis points) spreads faced by NONHFT and quoted spread (-0.071 basis points) faced by HFT-MM also decreased significantly. Quoted and effective spreads faced by other trader categories do not experience statistically significant changes. Overall, the univariate tests provide preliminary evidence that the increase in incentives accompanied by the increase in competition induced by the changes in the SLP rules positively affected market liquidity.

Given that there are other factors at play that are not controlled for in these univariate tests, such as stock and market volatility, trading volume, market capitalization, we provide the results of the multivariate analysis for the changes in SLP rules, which explicitly control for these factors in the following sections.

6.2 New SLP rules: Market liquidity

We start by analyzing the overall effect of the new SLP rules (see equation (5)) on market liquidity. Table 3 presents the results of the regression estimation of the quoted spread (Panel A) and the effective spread (Panel B) as dependent variables. In each of the regressions we control for stock fixed effects, stock and market volatility, trading volume, and market capitalization of the stock and cluster standard errors by stock and day.

INSERT TABLE 3 HERE

We observe that the new SLP rules decreased the quoted and effective spreads for the market as a whole as well as spreads faced by different trader categories, as manifested by the negative and significant coefficients for the post-SLP dummy variables, SLP_d, except for the effective spread of the HFT-MIX-OTHER group. In particular, the market-wide quoted spread decreases by 0.113 basis points, which is 5.5% of the pre-SLP level, and the market-wide effective spread decreases by 0.103 basis points which is 4.8% of the pre-SLP level. HFT-MIX-OTHER do not experience significant changes in the effective spread, while HFT-MM face an effective spread that is 0.077 basis points (4.1% of the pre-SLP level) lower than in the pre-SLP period; MIX-MM face an effective spread that is 0.073 basis points (3.6% of the pre-SLP level) lower than in the pre-SLP period, and NONHFT face an effective spread that is 0.106 basis points (3.8% of the pre-SLP level) lower than in the pre-SLP period. These results suggest that the new SLP rules had a positive effect on market liquidity. In the following sections, we discuss the effect that the new SLP rules had on competition for liquidity provision, and on the trading and quoting behavior of DMMs.

6.3 New SLP rules: Competition for liquidity provision

In Section 4, we discussed how the new SLP rules (Rules A and B3.3, in particular) might translate into an increase in competition among DMMs. To support our intuition, we evaluate the ex-post effect of the new SLP rules using as a proxy for competition in liquidity provision the HHI Index (see equation (7)), which is based on the liquidity provision ratio (the number of shares executed passively by the trader-account type relative to the total trading volume per stock-day) of all four trader-account types, both DMMs and voluntarily liquidity providers.

INSERT FIGURE 4 HERE

Figure 4 shows the dynamics of the HHI two months before the announcement of the new SLP rules and two months after their implementation. We observe that the HHI drops after the new SLP rules were implemented. We document that in the pre-SLP period the average HHI is 22.07%, while in the post-SLP period the average HHI is 14.81%, with the difference of 7.26% being highly statistically significant. Therefore, we conclude that the implementation of the new SLP rules is associated with increased competition for liquidity provision, in line with Hypothesis 1.

6.4 New SLP rules: Changes in DMMs' quoting and trading behavior

In this section, we explore the potential heterogeneity across stocks in the changes in DMMs' quoting and trading behavior in response to the new SLP rules. To do so, we compute several variables that reflect the requirements that DMMs have to fulfill. In particular, these requirements involve restrictions on the minimum presence by DMMs at the best bid-offer level, the minimum presence on both sides of the market, the minimum order value in EUR displayed at the best bid-offer level, and the liquidity provision ratio (the number of shares executed passively by the trader-account type relative to the total trading volume per stock-day). Table 4 shows the average of these measures for all stocks in the CAC40 index, and for each of the baskets of stocks that DMMs could choose from prior to June 3, 2013, for the pre-SLP (Panel A) and post-SLP (Panel B) periods, separately for HFT-MM and MIX-MM. (We refer to Table IA.1 in the Internet Appendix for details of the basket composition.) Unfortunately, we cannot track the behavior of individual DMMs and, thus, can only confirm whether or not they fulfill the requirements as a group.

INSERT TABLE 4 HERE

We show that the liquidity provision ratio improves in the post-SLP period for both HFT-MM and MIX-MM groups, for CAC40 stocks as a whole, and for each of the four baskets of stocks. In particular, at the market level, we observe an increase in liquidity provision by HFT-MM from 22.10% to 35.28%, and by MIX-MM from 5.24% to 6.76%. This suggests that the new SLP rules shifted the liquidity provision business from voluntarily liquidity providers to DMMs.

The time presence at the first 5 best prices of the limit order book levels increased slightly for both HFT-MM and MIX-MM, and is above 99% in the post-SLP period for the CAC40 index and for each basket of stocks. Time presence at the best bid offer level increased for MIX-MM (from 23.52% to 28.37% for CAC40) and decreased for HFT-MM (from 60.23% to 57.20% for CAC40), with a similar pattern present for the displayed quantity at the best bid-offer level. We interpret this effect as MIX-MM substituting for HFT-MM, due to the binding requirements of minimum time presence at the best bid offer level for the MIX-MM.

In particular, we note that in the pre-SLP and post-SLP periods, HFT-MM and MIX-MM, as a group, largely comply with the new SLP rules (including those that remained unchanged). In particular, the time presence at the first 5 best prices is either above or close to 95%, the displayed order value at the best price is far above 5,000 EUR and the liquidity provision is above 0.1% of the total passive execution volume. However, the new rule B3.2 requires that DMMs are, on average, present for at least 25% of the time, at the best level of the limit order book. Only HFT-MM comply with this requirement, on average, across all baskets of stocks in the pre-SLP period. On the contrary, MIX-MM deviate a lot from the new requirement of the minimum time presence at the best bid offer level of 25% for the stocks in Basket 1 and Basket 3 for which MIX-MM are present only 14.87% and 18.22%, respectively. We also note that for the stocks in Basket 2 and Basket 4, MIX-MM fulfill the new requirement in the pre-SLP period and are present at the best bid-offer level at 29.02% and 30.22%, respectively. In the post-SLP period, we observe that MIX-MM comply with the new requirements across all baskets of stocks. Therefore, we conclude that new requirements were binding for stocks in Baskets 1 and 3 and were not binding for stocks in Baskets 2 and 4.[10] This heterogeneity across baskets of stocks allows us to empirically disentangle the role of changes in incentives and competition due to the implementation of the new SLP rules on June 3, 2013.

6.5 New SLP rules: Competition vs. incentives

In Sections 6.2 – 6.4, we show that new SLP rules led to an increase in market liquidity, as measured by quoted and effective spreads, an increase in competition for liquidity provision, and a change in the quoting and trading behavior of DMMs following the tightened requirements. In this section, we empirically distinguish between the effects of competition and incentives used by NYSE Euronext Paris to encourage DMMs to provide liquidity and examine their relative empirical importance. In order to disentangle these two effects, we use a difference-in-difference methodology to compare the effect of the new SLP rules for baskets of stocks for which the new requirements were binding (Baskets 1 and 3) and baskets of

[10]Table IA.2 in the Internet Appendix provides evidence on the changes in the time presence at the best bid offer level by stock, separately for HFT-MM and MIX-MM.

stocks for which the new requirements were not binding (Baskets 2 and 4), before and after new SLP rules were implemented. In particular, we regress market liquidity measures on the dummy variable, SLP_d, which equals one in the post-SLP period (from June 3, 2013 till July 31, 2013) and zero in the pre-SLP period (from March 1, 2013 till May 9, 2013) and an interaction term between the post-SLP dummy variable, SLP_d, and the dummy variable for Baskets 2 and 4 for which the change in the requirements was not binding, $NonBinding_j$.[11]

INSERT TABLE 5 HERE

Table 5 presents the results of the regression estimation for the quoted spread (Panel A) and the effective spread (Panel B) as dependent variables. In each of the regressions we control for stock fixed effects, stock and market volatility, trading volume, and market capitalization of the stock and cluster standard errors by stock and day.

We observe that the new SLP rules decreased the quoted and effective spreads for the market as a whole, as well as the spreads faced by all trader categories, except the effective spread for HFT-MIX-OTHER, as demonstrated by the negative and significant coefficients for the post-SLP dummy variables, SLP_d. We also document that the two groups of stocks for which requirements were binding, and the two for which they were not binding, experience no difference in the effect of the new SLP rules, as in all cases the coefficients of the interaction term are not significantly different from zero. This leads us to the conclusion that the effect of the new SLP rules on market liquidity was solely driven by the increased competition among the DMMs and that DMMs could easily adjust their algorithms in order to formally comply with the changed requirements without any de facto improvement in liquidity provision.

Our result is at odds with the findings of Bessembinder, Hao, and Zheng (2017) who document that the tightened requirements of DMMs improve market liquidity. There are several potential explanations for this divergence in results. First, the empirical setup of Bessembinder, Hao, and Zheng (2017) does not include the *simultaneous* increase in competition among DMMs. Second, Bessembinder, Hao, and Zheng (2017) looks at the dynamic contract of DMMs, when requirements would be loosened again if trading volume increased

[11] Figure IA.1 in the Internet Appendix provides a graphical justification of the "parallel trend" assumption in the market liquidity variables for Baskets 1 and 3 and Baskets 2 and 4.

above the specified threshold; therefore, in their context, DMMs had a direct incentive to fulfill such requirements not only de jure but also de facto, given the regulatory response.

In particular, in our case, competition between DMMs led to a decrease in the market-wide quoted spread of 0.126 basis points, which is 6.1% of the pre-SLP level, and a decrease in the market-wide effective spread of 0.118 basis points, which is 5.5% of the pre-SLP level. HFT-MIX-OTHER traders do not experience better market liquidity when initiating a transaction, while HFT-MM, MIX-MM, and NONHFT traders face tighter spreads when initiating a transaction. Specifically, HFT-MM traders face an effective spread that is 0.104 basis points (5.6% of the pre-SLP level) lower than in the pre-SLP period, MIX-MM face an effective spread that is 0.110 basis points (5.5% of the pre-SLP level) lower than in the pre-SLP period, and NONHFT face an effective spread that is 0.136 basis points (4.9% of the pre-SLP level) lower than in the pre-SLP period. On average, trading volume per day for all CAC40 stocks is EUR 1,372.03 millions; hence, in economic terms, the decrease in effective spread of 0.118 basis points corresponds to a decrease in transaction costs of EUR 4.08 million per year. For HFT-MM traders that are active in all CAC40 stocks, the respective number is equal to EUR 1.21 million, while for NONHFT traders the respective number is equal to EUR 0.63 million.

These results highlight that the increase in competition among DMMs significantly improves the trading conditions both in statistical and economic terms, not only for the DMMs themselves, but also for the slow traders, namely, NONHFT.

6.6 New SLP rules: Spread decomposition

In this section, we analyze the effect of the new SLP rules on the decomposition of the spreads. In particular, we address the question whether the increase in competition among DMMs affected the revenues of liquidity providers as measured by realized spreads (see equation (3)) and adverse selection costs, as measured by the price impact (see equation (4)).

INSERT TABLE 6 HERE

Table 6 provides summary statistics for the effective spread decomposition into realized spread and price impact components based on one-second, 10-seconds, one-minute and 5-minutes horizons for the pre-SLP (from March 1, 2013 until May 9, 2013) and post-SLP (from June 3, 2013 until July 31, 2013) periods. During the pre-SLP period (see Panel A of Table 6), the market-wide realized spread is negative, ranging between -0.08 to -0.36 basis points, depending on the horizon under consideration. Negative realized spreads signal that there is a severe adverse selection problem and that, on average, the revenue of liquidity providers, net of adverse selection costs, is negative. Market-wide adverse selection costs are captured by the price impact of the trade, and range between 2.25 to 2.54 basis points during pre-SLP period. Splitting the sample based on the type of trader initiating the transaction yields interesting results. In particular, liquidity providers lose to HFT-MM, MIX-MM, and HFT-MIX-OTHER, while making profits on NONHFT trades. For instance, for a 10-seconds decomposition horizon, liquidity providers lose 0.96 basis points, if HFT-MM initiate a transaction, and the price impact of such a transaction is 2.86 basis points. At the same time, liquidity providers make profits of 0.84 basis points, if NONHFT initiate a transaction, and the price impact of such a transaction is 2.04 basis points. We observe similar patterns for the post-SLP period (see Panel B of Table 6). This finding is in line with classical adverse selection models such as (Kyle (1985) and Glosten and Milgrom (1985)), in which liquidity providers lose to informed agents (HFT-MM) and profit from uninformed agents (NONHFT). This finding also highlights the fact that DMMs in modern markets can be viewed as the most informed agents from an intraday perspective, given their superior knowledge of order flow.

We also conduct a set of univariate t-tests with standard errors clustered by stock and by day for the difference in the means between the pre-SLP and the post-SLP realized spreads, and the price impact components of the effective spread (see Panel C of Table 6). At the market level, we observe a slight increase in realized spreads at a 5-minutes horizon. We also observe that realized spreads (price impact) increased (decreased) significantly for transactions initiated by HFT-MM, MIX-MM, and HFT-MIX-OTHER at the one-second and 10-seconds horizons, indicating that with an increase in competition between DMMs, each individual DMM is more likely to face another market maker when initiating the transaction, rather than adversely selecting NONHFT. Nevertheless, realized spreads remain mainly negative for all transactions in the post-SLP period, except for those initiated by NONHFT. Realized spreads faced by NONHFT when initiating the transactions remain unchanged, while the price impact has decreased significantly at the 10-seconds and one-minute horizons. Overall, this constitutes preliminary evidence that the realized spread increased for HFT-MM, MIX-MM, and HFT-MIX-OTHER traders under the new SLP rules, while the price impact decreased for all trader-account types.

We now move to multivariate tests and estimate equation (6) with realized spread and price impact components of the effective spreads as dependent variables. Table 7 presents the results of the regression estimation. In particular, we regress the realized spreads and the price impact components of the effective spread on a dummy variable, SLP_d, which equals one in the post-SLP period (from June 3, 2013 till July 31, 2013), and zero in the pre-SLP period (from March 1, 2013 till May 9, 2013) and and an interaction term between the post-SLP dummy variable, SLP_d, and the dummy variable for Baskets 2 and 4 for which the change in the requirements was not binding, $NonBinding_j$. In each of the regressions we control for stock fixed effects, stock and market volatility, trading volume, and market capitalization of the stock and cluster standard errors by stock and day. For brevity, we report only the coefficients of SLP_d and $SLP_d \times NonBinding_j$.

INSERT TABLE 7 HERE

Panel A of Table 7 shows that the market wide realized spread increased significantly for one-second (by 0.078 basis points), one-minute (by 0.116) and 5-minutes (by 0.160 basis points) horizons, but only for the baskets of stocks for which requirements were not binding. Realized spreads also increased significantly for at least one of the decomposition horizons under consideration faced by every trader category except NONHFTs. Occasionally we also document that the observed effect is stronger for the baskets of stocks for which requirements were not binding, however there is no consistent pattern across different decomposition horizons and trader types. Realized spreads faced by NONHFT decreased at one-second decomposition horizon by 0.133 basis points and remained unchanged for other decomposition horizon. Besides that, there is no evidence that degree to which requirements are binding has any effect on the realized spreads faced by NONHFT.

Panel B of Table 7 also shows that the price impact component of the effective spread has decreased significantly for every trader-account types with the new SLP rules for the 10-seconds decomposition horizon ranging from -0.112 basis points (NONHFT) to -0.265 basis points (MIX-MM). At longer decomposition horizon of 5-minutes price impact decreases significantly for all trader categories except HFT-MM, while at shorter decomposition horizon of one-second price impact decreases for all trader categories except NONHFT. We note that consistently for all decomposition horizons and trader categories we document no effect on price impact component of the degree to which requirement are binding across different baskets of stock. At the market-wide level, the price impact of transactions decreased by -0.146 basis points for the 10-seconds horizon (5.8% of the pre-SLP level).

To conclude, at the market-wide level, the decrease in the price impact component of the effective spread is the main driver of the decrease in effective spread and this result is driven by the increased competition among DMMs, rather than tightened requirements. From the perspective of NONHFT, the increase in competition among DMMs not only decreased adverse selection costs, but also their revenues from transactions with NONHFT (based on the one-second effective spread decomposition), in line with theoretical predictions of Aït-Sahalia and Sağlam (2017).

7 Robustness checks

In this section,we perform several robustness checks. First, we show that small changes in rebates for DMMs indeed do not have any effect on market liquidity (see Section 7.1). Second, we repeat the analysis of the new SLP rules for the different transaction sizes (see Section 7.2). Third, we analyze whether implementation of the new SLP rules has a spillover effect on alternative trading venues, namely, Chi-X (see Section 7.3). Finally, we repeat the analysis of the effect of new SLP rules on market liquidity using a different announcement date as determined by a structural break in the DMM's behavior (see Section 7.4).

7.1 Rebate reversal

NYSE Euronext Paris increased the rebate for DMMs' passive execution from 0.20 basis points to 0.22 basis points when implementing new SLP rules on June 3, 2013, however, on November 1, 2013 the rebate reverted to the pre-June level. Ex-ante, we would expect that such small changes (around 1% of quoted spread in the pre-SLP period) in rebate should have, at best, a marginal effect on market liquidity, especially given that the reversal took place several months after the rebate was initially increased. We focus our attention on the two months before the announcement date and two months after the implementation date of the rebate reversal. Table 8 shows the summary statistics for the two sub-samples: pre-rebate (from August 1, 2013 until September 30, 2013), and post-rebate (from November 1, 2013 until December 31, 2013). In particular, we provide evidence on the quoted and effective spreads for the market as a whole as well as those faced by each trader-account type while initiating the transaction, averaged across stock-days.

During the pre-rebate period, the market-wide quoted (effective) spread is equal to 1.90 (1.98) basis points. We note that the respective numbers for the pre-SLP period are 2.06 (2.13) basis points. This indicates that the improvement in market liquidity caused by the new SLP rules did not have merely a temporary effect but prevailed over the long term. In line with the summary statistics for the period surrounding the implementation of the new SLP rules (see Table 2), HFT-MM (NONHFT) face the smallest (largest) change in the quoted and effective spreads.

INSERT TABLE 8 HERE

Univariate *t*-tests for the difference in the means between the pre-rebate and post-rebate samples show that only the NONHFT category experiences statistically significant changes in both quoted (-0.070) and effective (-0.092) spreads. This contradicts our ex-ante expectation that small changes in spread should have no effect on market liquidity; moreover, the decrease in the rebate should negatively affect market liquidity, if anything, while we observe the opposite effect. However, these univariate tests do not take into account other factors that might concurrently affect market liquidity, which we next control for.

INSERT TABLE 9 HERE

In Table 9, we provide the regression results (see equation (8)) for the changes in market liquidity that occur around the rebate reversal to the pre-SLP level from -0.22 basis points to -0.20 basis points, which took place on November 1, 2013. We note that this rebate applies only for passive execution by DMMs only. We look at the period from August 1, 2013 till December 31, 2013, and exclude the time interval between the announcement and implementation dates from October 1, 2013 till November 1, 2013 in this analysis. Panel A of Table 9 reports the regression results with the quoted spread as the dependent variable, while Panel B of Table 9 reports the regression results with effective spread as the dependent variable. In each of the regressions we control for stock fixed effects, stock and market volatility, trading volume, and market capitalization of the stock and cluster standard errors by stock and day. We observe that none of the coefficients for the dummy variable for post-rebate period, $Rebate_d$, is statistically significant for both the quoted and effective spreads.

To conclude, our findings confirm our ex-ante expectations that small changes in rebate (0.02 basis points which is around 1% of the quoted spreads in the pre-SLP period) do not materially affect market liquidity. We emphasize that there is no effect of the decrease in rebate for all categories of market participants, contrary to the univariate tests from which we got the counter-intuitive effect of decreasing spreads faced by NONHFT. Given that the change in the rebate that occurred on November 1, 2013 exactly offsets the change in rebate that occurred on June 3, 2013 (at the same time as the change in SLP rules) we argue that any affect observed around change in SLP rules is attributable to other sources than the change in the maker/taker fee structure.

7.2 New SLP rules: Different transaction size

In this section, we examine whether observed improvement in market liquidity after implementation of the new SLP rules is observed across different transaction sizes or is concentrated among smallest transactions only. In order to do so, we split all the aggressive transactions for each stock into quintiles based on the number of shares traded using the data for the whole 2013. Panel A of Table 10 reports the average number of aggressive transaction and their size in shares for each quintile. Quintile 1 contains aggressive transaction with the average size of 43.65 shares, while Quintile 5 contains transactions with the average size of 1,575.84 shares. Interestingly, amount of aggressive transactions decreases for both HFT-MM and NONHFT while moving from Quintile 1 to Quintile 5, while HFT-MIX-OTHER exhibit the opposite pattern.

INSERT TABLE 10

Panel B of Table 10 shows the results of the regression estimation (see equation (6)). In particular, we regress effective spreads on a dummy variable, SLP_d, which equals one in the post-SLP period (from June 3, 2013 till July 31, 2013), and zero in the pre-SLP period (from March 1, 2013 till May 9, 2013) and and an interaction term between the post-SLP dummy variable, SLP_d, and the dummy variable for Baskets 2 and 4 for which the change in the requirements was not binding, $NonBinding_j$. In each of the regressions we control for stock fixed effects, stock and market volatility, trading volume, and market capitalization of the stock and cluster standard errors by stock and day. For brevity, we report only coefficients of SLP_d and $SLP_d \times NonBinding_j$.

First, we note that in line with the main analysis there is no difference between stocks for which requirements were binding and for which they were not binding as manifested by insignificant coefficient of $SLP_d \times NonBinding_j$ across all quintiles. Therefore, coefficient of SLP_d can be interpreted as a pure effect of the increased competition among DMMs.

Second, effective spread has decreased for a market as a whole across all quintiles. The effect is decreasing while moving from small transactions (-0.191 basis points) to the large transactions (-0.096 basis points). Zooming into effective spreads faced by each individual trader type, we observe that for the first three quintiles effective spread has improved for all trader types, while for quintile 4 only HFT-MM and NONHFT benefit from the spread improvement. For the largest transaction size (quintile 5) only MIX-MM benefit from the spread improvement. Overall, we document that competition among DMMs has the largest effect for the smallest transactions, nevertheless, increased competition among DMMs still decreases significantly transaction costs for larger transactions as well (though only marginally for the largest transactions).

7.3 New SLP rules: Euronext vs. Chi-X

In this section, we discuss whether new SLP rules have any spillover effects to alternative trading venues. In particular, we examine whether market wide quoted and effective spreads observed in Chi-X reacted to the new SLP rules. We note that NYSE Euronext Paris holds around 72% of total trading volume in CAC40 and Chi-X is the second largest trading venue with around 14% of total trading volume in CAC40 in 2013.[12] We also note that all 37 stocks used in this paper are traded on Chi-X. Data on transactions and best bid-offer quotes for Chi-X comes from Thomson Reuters Tick History (TRTH) database. The two markets differ substantially in terms of trading hours (Chi-X market is open from 8 a.m. to 4 p.m., while NYSE Euronext Paris is open from 9 a.m. ti 5.30 p.m.) and maker-taker fees, where a trader receives a rebate of 0.15 basis points, when providing liquidity (limit order), and pays 0.30 basis points when consuming liquidity (market order), which valid for all traders (not only for DMMs as in NYSE Euronext Paris).[13]

INSERT FIGURE 5

Figure 5 depicts the dynamics of quoted (Panel A) and effective spreads (Panel B) for the NYSE Euronext Paris and Chi-X. We include only those stock-days for which the data are available for both NYSE Euronext Paris and Chi-X. We document that spreads on NYSE Euronext Paris and Chi-X move in line with each other. We also note that spreads on Chi-X are smaller than on NYSE Euronext Paris, which is likely to be explained by the different marker/taker scheme.

Table 11 presents the results of the regression estimation (see equation (6)). In particular, we regress quoted and effective spreads on a dummy variable, SLP_d, which equals one in the post-SLP period (from June 3, 2013 till July 31, 2013), and zero in the pre-SLP period (from March 1, 2013 till May 9, 2013) and and an interaction term between the post-SLP dummy variable, SLP_d, and the dummy variable for Baskets 2 and 4 for which the change in the requirements was not binding, $NonBinding_j$. In each of the regressions we control for stock fixed effects, stock and market volatility, trading volume, and market capitalization of

[12]Data on market share (based on the number of shares traded) are from Bloomberg.

[13]The Chi-X fee structure for the 2013 is available at http://cdn.batstrading.com/resources/press_releases/BATS_Chi-X_2013_Pricing_FINAL.pdf

the stock and cluster standard errors by stock and day. For comparison purposes, we also report results for the NYSE Euronext Paris for only those stock and days for which data are available for both NYSE Euronext Paris and Chi-X.

INSERT TABLE 11

We document that new SLP rules significantly affect quoted and effective spreads on Chi-X, though to a lesser extent than on NYSE Euronext Paris. In particular, both quoted and effective spreads on Chi-X decrease by 0.103 basis points, while quoted and effective spreads on NYSE Euronext Paris decrease by 0.151 basis points and 0.143 basis points, respectively. We also note that the effect of the new SLP rules on Chi-X spreads does not depend on degree to which new requirements were binding. Put differently, the decrease in spreads on Chi-X as well as on NYSE Euronext Paris is driven by increased competition among DMMs on NYSE Euronext Paris. Bessembinder, Hao, and Zheng (2017) document similar improvement in liquidity on other trading venues due to changes in contract requirements of DMMs on NYSE. They argue that this result stems from strategic complimentary of the NYSE and other trading venues. In other words, liquidity providers on other trading venues are likely to quote lower spreads because they always have an outside option to unload any undesired inventory to DMM on the main trading venue.

7.4 Effective announcement date of the new SLP rules

In Section 6.4, we document that one of the requirements introduced by the new SLP rules were binding for MIX-MM, namely, a minimum time presence at the best bid-offer level of 25% on average across CAC40 stocks. One might expect that it takes some time to adjust to the new requirements; therefore, the effective date when the new SLP rules came into play might be different from the actual announcement date.

INSERT FIGURE 6 HERE

Figure 6 shows the dynamics of the time presence at the best bid-offer level during the pre-SLP and post-SLP periods separately for HFT-MM and MIX-MM. We confirm the result reported in Table 4 that this change in the requirements is not binding for HFT-MM, while it is binding for MIX-MM. Surprisingly, the sharp increase in the presence of MIX-MM traders at the best bid-offer level occurred well before the announcment date of the new SLP rules. This suggests that before announcing the change in the SLP program, NYSE Euronext Paris discussed it with current SLP members. Therefore, we conduct a structural break test in order to determine the effective date of the SLP announcement to be used in further analysis. The structural break test pinpoints April 2, 2013 instead of the actual announcement date, May 9, 2013 (Flash News release date), as the effective date of the announcement. Therefore, we repeat our analysis on the effect of the new SLP rules on market liquidity that separates the role of DMMs' incentives and competition among DMMs (see Table 5) using a different pre-SLP sample from March 1, 2013 till March 31, 2013 (instead of March 1, 2013 till May 9, 2013).

INSERT TABLE 12 HERE

Table 12 presents the results of the regression estimation (see equation (6)) for the quoted spread (Panel A) and the effective spread (Panel B) as dependent variables. In each of the regressions we control for stock fixed effects, stock and market volatility, trading volume, and market capitalization of the stock and cluster standard errors by stock and day. In line with the base-case results, we observe that the new SLP rules decreased the quoted and effective spreads for the market as a whole, and those faced by individual trader-account types, except HFT-MIX-OTHER, as illustrated by the negative and statistically significant coefficients of the post-SLP dummy variable, SLP_d. In particular, the market-wide quoted (effective) spread decreases by 0.120 (0.116) basis points as compared to 0.126 (0.118) basis points as reported in Table 5 in Section 6.5. The interaction coefficient between the post-SLP dummy variable and the dummy variable for baskets of stocks with nonbinding requirements is statistically insignificant, thus, confirming our conclusion that the main improvement in market liquidity due to the new SLP rules is a result of increased competition among DMMs.

8 Conclusion

The evolution of the trading environment reshaped the market making business in global equity markets. Traditional market makers were crowded out by algorithmic liquidity providers often operating voluntarily, without any obligations for maintaining stable markets. Episodes like the "flash crash" in the US market on May 6, 2010, raised serious doubts about the efficacy of voluntary liquidity provision by algorithmic traders (and especially its subset of high-frequency traders) in modern financial markets, especially in terms of market stress. Thus, it is not surprising that high-frequency market-making has drawn close scrutiny by regulators, to ensure the continuous participation of traders in market-making. For example, the recently implemented MiFID II regulation has explicitly focused on the requirements for such market makers and made it mandatory to have written contracts between high frequency market makers and stock exchanges. In this paper, we empirically address the issue of such an optimal contract design between DMMs and stock exchanges to facilitate better liquidity provision.

Our findings allow us to conclude that specifying the requirements that DMMs have to fulfill, and providing them with an attractive fee structure, might improve liquidity provision on equity markets, but it will not lead to the best outcome possible unless exchanges explicitly introduce competition among them for providing liquidity for the same stock. This broad conclusion is robust to controlling for several other effects, including the composition of the baskets, the fee rebates offered and the effective date of implementation of new regulations. These conclusions are likely to be of interest for security market regulators and exchanges who seek to improve liquidity provision in the face of rapid changes in trading technology and execution speed.

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Table 1 Traders' characteristics

This table shows the average across stock-days of the number of new orders, the cancellation ratio (number of cancelled orders relative to the total number of new orders submitted by the trader-account type), the number of times inventory crosses zero, liquidity provision (the number of shares executed passively by the trader-account type relative to the total trading volume per stock-day) and liquidity consumption (the number of shares executed aggressively by the trader-account type relative to the total trading volume per stock-day) ratios for the four trader-account types (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT). The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. The period under consideration is from March 1, 2013 till December 31, 2013. Order flow data with trader and account flags are from BEDOFIH.

	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT
# of new orders	65,549.18	51,409.85	48,138.58	2,318.13
Cancellation ratio	95.95%	97.48%	91.50%	40.93%
# of times inventory crosses zero	16.42	5.91	7.86	4.88
Liquidity provision	31.08%	6.27%	47.79%	14.62%
Liquidity consumption	21.81%	14.41%	45.69%	17.94%

Table 2 Summary statistics: Spreads around new SLP rules

This table shows the average across stock-days of quoted (see equation (1)) and effective (see equation (2)) spreads in basis points for the market as a whole as well as those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction. Panel A reports summary statistics for the two months before the announcement of the new SLP rules (from March 1, 2013 till May 9, 2013). Panel B reports summary statistics for the two months after the implementation of the new SLP rules (from June 3, 2013 till July 31, 2013). Panel C provides a univariate *t*-test with standard errors clustered by stock and by day for the mean difference between pre-SLP and post-SLP periods. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	Market	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT
	Panel A: Pre-SLP period				
Quoted Spread	2.06	1.85	1.96	2.05	2.55
Effective Spread	2.13	1.87	2.01	2.11	2.76
	Panel B: Post-SLP period				
Quoted Spread	1.96	1.78	1.90	1.99	2.41
Effective Spread	2.03	1.80	1.94	2.06	2.68
	Panel C: Difference				
Quoted Spread	-0.108***	-0.071*	-0.062	-0.063	-0.145***
Effective Spread	-0.100**	-0.067	-0.066	-0.044	-0.087*

Table 3 New SLP rules: Market liquidity

This table shows the results of SLP regression estimation (see equation (5)). We regress quoted (Panel A) and effective (Panel B) spreads for stock j on day d on the dummy variable, SLP_d, that is equal to one in the period after the implementation of the new SLP rules (from June 3, 2013 till July 31, 2013) and zero otherwise (from March 1, 2013 till May 9, 2013). In all regressions, we control for stock and market volatility, trading volume, and market capitalization. All our regressions are estimated with stock fixed effects. Standard errors are clustered by stock and by day. We perform our analysis for the market as a whole as well as for those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction. Spreads are measured in basis points. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	Panel A: Quoted spread					**Panel B: Effective spread**				
	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT
SLP_d	-0.113***	-0.081**	-0.072*	-0.067*	-0.162***	-0.103**	-0.077*	-0.073*	-0.047	-0.106**
	(-2.81)	(-2.00)	(-1.72)	(-1.69)	(-3.18)	(-2.56)	(-1.87)	(-1.67)	(-1.19)	(-2.11)
$Realized\ volatility_{j,d}$	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.42)	(0.41)	(0.29)	(0.46)	(0.47)	(0.47)	(0.42)	(0.40)	(0.47)	(0.69)
$Trading\ volume_{j,d}$	-0.002	-0.007***	-0.000	-0.002	-0.010***	-0.000	-0.006***	0.003	-0.000	-0.010***
	(-0.77)	(-2.72)	(-0.04)	(-0.63)	(-2.99)	(-0.16)	(-2.61)	(0.76)	(-0.16)	(-3.44)
$Market\ capitalization_{j,d}$	-0.004	-0.001	0.004	-0.004	-0.001	-0.003	-0.002	0.005	-0.004	0.004
	(-0.75)	(-0.30)	(0.70)	(-0.81)	(-0.19)	(-0.71)	(-0.38)	(0.94)	(-0.77)	(0.66)
$Volatility\ of\ CAC40_d$	0.049***	0.050***	0.045***	0.048***	0.072***	0.048***	0.051***	0.044***	0.047***	0.070***
	(7.37)	(7.34)	(5.67)	(7.48)	(8.26)	(7.16)	(7.44)	(4.93)	(7.39)	(7.91)
$Constant$	1.566***	1.228***	1.693***	1.573***	1.962***	1.661***	1.214***	1.798***	1.646***	2.275***
	(10.46)	(9.19)	(9.03)	(10.49)	(10.01)	(11.25)	(8.92)	(9.31)	(11.38)	(12.32)
Stock FE	Yes									
Clustered SE	By stock and day									
# of observations	3,216	3,216	3,214	3,216	3,216	3,216	3,216	3,214	3,216	3,216
R^2	0.811	0.803	0.724	0.799	0.798	0.819	0.799	0.719	0.805	0.816

Table 4 New SLP rules: DMMs' behavior

This table shows the average across stock-days requirements of the DMMs. In particular, we show the average time presence at the best bid-offer level and at the first 5 best price levels (amount of seconds present at the best bid-offer level or at the first 5 best price levels relative to the total amount of second during continuous trading session), order value in EUR displayed at the best bid-offer level, and liquidity provision (number of shares executed passively by the trader-account type relative to the total trading volume per stock-day) separately for HFT-MM and MIX-MM. We report the results for all stocks in CAC40 and also separately for each basket of stocks as defined in the pre-SLP period (we refer to Table IA.1 in Internet Appendix for the details of basket composition). The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. The period under consideration is from March 1, 2013 till May 9, 2013 (Panel A: pre-SLP period) and from June 3, 2013 until July 31, 2013 (Panel B: post-SLP period). Order flow data with trader and account flags are from BEDOFIH.

	HFT-MM					MIX-MM				
	CAC40	Basket 1	Basket 2	Basket 3	Basket 4	CAC40	Basket 1	Basket 2	Basket 3	Basket 4
	Panel A: Pre-SLP period									
Gross Liquidity Provision (%)	22.10%	21.86%	19.75%	20.64%	26.66%	5.24%	6.16%	5.40%	5.38%	4.07%
Displayed order at value at BBO	34,326.27	36,332.97	34,521.32	37,207.28	29,178.26	13,293.31	11,527.75	13,193.55	13,017.53	15,368.14
Time Presence 5 Best Prices	99.16%	99.51%	98.89%	98.95%	99.38%	96.54%	92.77%	98.79%	94.66%	99.07%
Time Presence at BBO	60.23%	59.74%	57.99%	61.34%	62.39%	23.53%	14.87%	29.02%	18.22%	30.22%
	Panel B: Post-SLP period									
Gross Liquidity Provision (%)	35.28%	37.28%	35.31%	34.22%	34.49%	6.76%	8.05%	6.77%	6.47%	5.84%
Displayed order at value at BBO	23,282.59	24,586.28	19,618.93	29,027.96	20,835.75	16,332.29	14,639.91	13,260.14	19,478.07	18,485.93
Time Presence 5 Best Prices	99.62%	99.67%	99.46%	99.70%	99.67%	99.77%	99.70%	99.76%	99.77%	99.85%
Time Presence at BBO	57.20%	55.95%	50.85%	63.56%	59.76%	28.37%	27.30%	25.54%	29.85%	31.35%

Table 5 New SLP rules: Competition vs. Incentives

This table shows the results of SLP regression estimation (see equation (6)). We regress quoted (Panel A) and effective (Panel B) spreads for stock j on day d on the dummy variable, SLP_d, that is equal to one in the period after the implementation of the new SLP rules (from June 3, 2013 till July 31, 2013) and zero otherwise (from March 1, 2013 till May 9, 2013) and the interaction between SLP_d and dummy variable for stock baskets 2 and 4 for which the change in requirements was not binding, $NonBinding_j$ (we refer to Table IA.1 in Internet Appendix for the details of basket composition). In all regressions, we control for stock and market volatility, trading volume, and market capitalization. All our regressions are estimated with stock fixed effects. Standard errors are clustered by stock and by day. We perform our analysis for the market as a whole as well as for those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction. Spreads are measured in basis points. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	Panel A: Quoted spread					**Panel B: Effective spread**				
	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT
SLP_d	-0.126***	-0.110**	-0.108**	-0.075*	-0.180***	-0.118***	-0.104**	-0.110**	-0.057	-0.136**
	(-2.81)	(-2.35)	(-2.14)	(-1.66)	(-3.02)	(-2.61)	(-2.16)	(-2.05)	(-1.25)	(-2.20)
$SLP_d \times NonBinding_j$	0.026	0.054	0.069	0.017	0.034	0.029	0.051	0.071	0.020	0.056
	(0.38)	(0.81)	(1.05)	(0.24)	(0.39)	(0.42)	(0.75)	(1.05)	(0.29)	(0.66)
$Realized\ volatility_{j,d}$	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.41)	(0.40)	(0.27)	(0.46)	(0.47)	(0.46)	(0.41)	(0.37)	(0.47)	(0.67)
$Trading\ volume_{j,d}$	-0.002	-0.006***	0.000	-0.002	-0.010***	-0.000	-0.006***	0.004	-0.000	-0.010***
	(-0.74)	(-2.73)	(0.06)	(-0.61)	(-2.96)	(-0.10)	(-2.63)	(0.84)	(-0.12)	(-3.39)
$Market\ capitalization_{j,d}$	-0.004	-0.001	0.004	-0.004	-0.001	-0.003	-0.002	0.005	-0.004	0.004
	(-0.78)	(-0.35)	(0.76)	(-0.83)	(-0.21)	(-0.75)	(-0.44)	(1.04)	(-0.80)	(0.68)
$Volatility\ of\ CAC40_d$	0.049***	0.050***	0.045***	0.048***	0.072***	0.048***	0.051***	0.044***	0.047***	0.070***
	(7.41)	(7.37)	(5.67)	(7.51)	(8.28)	(7.19)	(7.47)	(4.93)	(7.42)	(7.94)
$Constant$	1.560***	1.215***	1.676***	1.569***	1.954***	1.654***	1.202***	1.781***	1.641***	2.262***
	(10.24)	(9.03)	(9.16)	(10.26)	(9.83)	(11.06)	(8.77)	(9.43)	(11.17)	(12.23)
Stock FE	Yes									
Clustered SE	By stock and day									
# of observations	3,216	3,216	3,214	3,216	3,216	3,216	3,216	3,214	3,216	3,216
R^2	0.811	0.803	0.725	0.799	0.798	0.819	0.800	0.720	0.805	0.816

Table 6 Summary statistics: spread decomposition

This table shows the average across stock-days of the realized spread (see equation (3)) and the price impact (see equation (4)) components of the effective spread in basis points for the market as a whole as well as those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction for one-second, 10-seconds, one-minute, and 5-minutes horizons. Panel A reports summary statistics for the two months before the announcement of the new SLP rules (from March 1, 2013 till May 9, 2013). Panel B reports summary statistics for the two months after the implementation of the new SLP rules (from June 3, 2013 till July 31, 2013). Panel C provides a univariate *t*-test with standard errors clustered by stock and by day for the mean difference between pre-SLP and post-SLP periods. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	Market	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT
			Panel A: Pre-SLP period		
Realized spread 1 sec	-0.08	-0.73	-0.58	0.00	1.10
Realized spread 10 sec	-0.33	-0.96	-0.79	-0.27	0.84
Realized spread 1 min	-0.36	-0.85	-0.64	-0.37	0.78
Realized spread 5 min	-0.24	-0.63	-0.26	-0.32	0.87
Price impact 1 sec	2.25	2.63	2.60	2.13	1.77
Price impact 10 sec	2.51	2.86	2.80	2.40	2.04
Price impact 1 min	2.54	2.75	2.67	2.51	2.12
Price impact 5 min	2.42	2.53	2.29	2.48	2.05
			Panel B: Post-SLP period		
Realized spread 1 sec	-0.12	-0.61	-0.49	0.08	1.03
Realized spread 10 sec	-0.30	-0.81	-0.63	-0.10	0.87
Realized spread 5 min	-0.30	-0.78	-0.44	-0.15	0.86
Realized spread 1 min	-0.16	-0.56	0.20	-0.12	0.89
Price impact 1 sec	2.19	2.44	2.45	2.02	1.75
Price impact 10 sec	2.37	2.63	2.58	2.20	1.92
Price impact 1 min	2.38	2.61	2.41	2.25	1.95
Price impact 5 min	2.24	2.38	1.76	2.23	1.92
			Panel C: Difference		
Realized spread 1 sec	-0.041	0.121***	0.091*	0.079***	-0.068
Realized spread 10 sec	0.030	0.157***	0.165***	0.168***	0.024
Realized spread 1 min	0.063	0.066	0.200**	0.224***	0.079
Realized spread 5 min	0.086*	0.071	0.463***	0.204***	0.024
Price impact 1 sec	-0.060	-0.193***	-0.150**	-0.117***	-0.025
Price impact 10 sec	-0.131**	-0.230***	-0.221***	-0.204***	-0.116**
Price impact 1 min	-0.162**	-0.140*	-0.263***	-0.263***	-0.175***
Price impact 5 min	-0.189***	-0.142*	-0.535***	-0.252***	-0.123

Table 7 New SLP rules: Spread decomposition

This table shows the results of the SLP regression estimation for the realized spread (see equation (3)) and the price impact (see equation (4)) components of the effective spread (see equation (6)). We regress the realized spread and price impact components of the effective spread for stock j on day d on the dummy variable, SLP_d, that is equal to one in the period after the implementation of the new SLP rules (from June 3, 2013 till July 31, 2013) and zero otherwise (from March 1, 2013 till May 9, 2013) and the interaction between SLP_d and dummy variable for stock baskets 2 and 4 for which the change in requirements was not binding, $NonBinding_j$ (we refer to Table IA.1 in Internet Appendix for the details of basket composition). In all regressions we control for stock and market volatility, trading volume, and market capitalization. All our regressions are estimated with stock fixed effects. Standard errors are clustered by stock and by day. We perform our analysis for the market as a whole as well as for those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction. Spreads are measured in basis points. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. For brevity, we report only coefficents of SLP_d and $SLP_d \times NonBinding_j$. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	SLP_d					$SLP_d \times NonBinding_j$				
	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT
Realized spread 1 sec	-0.060	0.071*	0.079	0.095**	-0.133***	0.078*	0.137***	0.080	0.007	0.095
Realized spread 10 sec	0.031	0.153***	0.171**	0.188***	-0.044	0.032	0.043	0.011	-0.006	0.083
Realized spread 1 min	0.001	0.028	0.110	0.166***	-0.039	0.116*	0.081	0.137	0.110*	0.125
Realized spread 5 min	-0.012	0.013	0.214	0.113*	-0.142	0.160**	0.095	0.343**	0.158*	0.204
Price impact 1 sec	-0.053	-0.162**	-0.171**	-0.146***	-0.022	-0.055	-0.106	-0.018	0.022	-0.015
Price impact 10 sec	-0.146**	-0.251***	-0.265**	-0.237***	-0.112*	-0.005	-0.002	0.055	0.034	-0.003
Price impact 1 min	-0.119	-0.126	-0.218**	-0.216***	-0.129*	-0.078	-0.046	-0.058	-0.086	-0.034
Price impact 5 min	-0.114*	-0.111	-0.320**	-0.171***	-0.017	-0.114	-0.052	-0.287	-0.135	-0.135
Controls	Yes									
Stock FE	Yes									
Clustered SE	By stock and day									

Table 8 Summary statistics: Spreads around rebate reversal

This table shows the average across stock-days of quoted (see equation (1)) and effective (see equation (2)) spreads in basis points for the market as a whole as well as those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction. Panel A reports summary statistics for the two months before the announcement of the rebate reversal (from August 1, 2013 till September 20, 2013). Panel B reports summary statistics for the two months after the implementation of the rebate reversal (November 1, 2013 till December 31, 2013). Panel C provides a univariate t-test with standard errors clustered by stock and by day for the mean difference between pre-rebate and post-rebate periods. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	Market	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT
	Panel A: Pre-rebate period				
Quoted Spread	1.90	1.75	1.82	1.91	2.29
Effective Spread	1.98	1.76	1.86	1.99	2.55
	Panel B: Post-rebate period				
Quoted Spread	1.86	1.71	1.79	1.88	2.22
Effective Spread	1.95	1.72	1.85	1.98	2.46
	Panel C: Difference				
Quoted Spread	-0.039	-0.040	-0.034	-0.031	-0.070*
Effective Spread	-0.032	-0.040	-0.009	-0.012	-0.092**

Table 9 Rebate reversal: Market liquidity

This table shows the results of rebate reversal regression estimation (see equation (8)). We regress quoted (Panel A) and effective (Panel B) spreads for stock j on day d on the dummy variable, $Rebate_d$, that is equal to one in the period after the implementation of the rebate reversal (from November 1, 2013 till December 31, 2013) and zero otherwise (from August 1, 2013 till September 30, 2013). In all regressions, we control for stock and market volatility, trading volume, and market capitalization. All our regressions are estimated with stock fixed effects. Standard errors are clustered by stock and by day. We perform our analysis for the market as a whole as well as for those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction. Spreads are measured in basis points. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	Panel A: Quoted spread					**Panel B: Effective spread**				
	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT
$Rebate_d$	-0.000	0.009	-0.001	0.006	-0.024	0.003	0.012	0.015	0.021	-0.050
	(-0.01)	(0.24)	(-0.02)	(0.16)	(-0.46)	(0.07)	(0.29)	(0.37)	(0.52)	(-0.90)
$Realized\ volatility_{j,d}$	0.000	0.000	-0.001	0.000	-0.000	0.000	0.000	-0.001	0.001	0.000
	(0.18)	(0.09)	(-1.11)	(0.21)	(-0.24)	(0.44)	(0.13)	(-1.08)	(0.75)	(0.00)
$Trading\ volume_{j,d}$	-0.005	-0.009**	-0.008	-0.005	-0.018***	-0.003	-0.009**	-0.008	-0.003	-0.018***
	(-1.18)	(-2.20)	(-1.18)	(-0.99)	(-3.70)	(-0.67)	(-2.09)	(-1.11)	(-0.52)	(-3.70)
$Market\ capitalization_{j,d}$	0.004	0.001	0.013	0.002	0.005	0.005	0.001	0.023***	0.001	0.006
	(0.31)	(0.12)	(1.28)	(0.13)	(0.34)	(0.40)	(0.09)	(2.68)	(0.05)	(0.37)
$Volatility\ of\ CAC40_d$	0.030***	0.036***	0.030***	0.028***	0.036***	0.028***	0.037***	0.030***	0.024***	0.033***
	(3.38)	(3.99)	(2.91)	(3.26)	(3.38)	(3.07)	(4.06)	(2.86)	(2.77)	(3.07)
$Constant$	1.487***	1.342***	1.378***	1.430***	1.978***	1.622***	1.346***	1.452***	1.582***	2.458***
	(6.57)	(5.95)	(6.36)	(6.32)	(7.10)	(7.47)	(6.02)	(6.93)	(7.28)	(9.22)
Stock FE	Yes									
Clustered SE	By stock and day									
# of observations	2,975	2,973	2,971	2,973	2,975	2,975	2,973	2,971	2,973	2,975
R^2	0.830	0.821	0.722	0.813	0.803	0.834	0.817	0.711	0.812	0.810

Table 10 New SLP rules: Different transaction size

This table shows the effect of the new SLP rules on the market liquidity for the different transaction sizes. In particular, we split all the aggressive transactions into quintiles based on the number of shares traded for each stock. Panel A reports average number of aggressive transactions and their size in shares for the market as a whole as well as for each trader-account types (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) averaged across stock-days. Panel B shows the results of SLP regression estimation (see equation (6)). We regress effective spreads for stock j on day d on the dummy variable, SLP_d, that is equal to one in the period after the implementation of the new SLP rules (from June 3, 2013 till July 31, 2013) and zero otherwise (from March 1, 2013 till May 9, 2013) and the interaction between SLP_d and dummy variable for stock baskets 2 and 4 for which the change in requirements was not binding, $NonBinding_j$ (we refer to Table IA.1 in Internet Appendix for the details of basket composition) separately for each transaction size quintile. In all regressions, we control for stock and market volatility, trading volume, and market capitalization. All our regressions are estimated with stock fixed effects. Standard errors are clustered by stock and by day. We perform our analysis for the market as a whole as well as for those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction. Spreads are measured in basis points. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. For brevity, we report only coefficents of SLP_d and $SLP_d \times NonBinding_j$. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	Panel A: Aggressive transactions						**Panel B: New SLP rules and Effective spread**				
	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT		Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT
Quintile 1: Small transaction											
# of aggressive transactions	626.12	255.44	21.24	187.31	162.70	SLP_d	-0.191***	-0.229***	-0.213***	-0.139***	-0.186***
Size of aggressive transactions	43.65	43.39	54.28	43.36	42.73	$SLP_d \times NonBinding_j$	0.036	0.102	0.061	0.025	-0.026
Quintile 2											
# of aggressive transactions	639.55	276.88	41.77	210.40	110.82	SLP_d	-0.192***	-0.214***	-0.147***	-0.144***	-0.198***
Size of aggressive transactions	161.83	160.72	149.63	162.06	160.05	$SLP_d \times NonBinding_j$	0.052	0.090	0.105	0.046	0.020
Quintile 3											
# of aggressive transactions	628.53	275.08	42.47	233.35	77.87	SLP_d	-0.146***	-0.161***	-0.091*	-0.098**	-0.171***
Size of aggressive transactions	314.63	311.78	280.73	313.87	318.91	$SLP_d \times NonBinding_j$	0.048	0.087	0.064	0.031	0.037
Quintile 4											
# of aggressive transactions	626.50	257.30	42.52	260.33	66.59	SLP_d	-0.106**	-0.116**	-0.074	-0.056	-0.154**
Size of aggressive transactions	573.43	569.81	500.61	569.95	582.56	$SLP_d \times NonBinding_j$	0.047	0.080	0.089	0.034	0.061
Quintile 5: Large transaction											
# of aggressive transactions	608.19	190.14	41.58	303.24	73.76	SLP_d	-0.096**	-0.062	-0.103*	-0.038	-0.058
Size of aggressive transactions	1575.84	1381.40	1198.05	1627.79	1810.74	$SLP_d \times NonBinding_j$	0.028	0.028	0.068	0.019	0.086
						Controls			Yes		
						Stock FE			Yes		
						Clustered SE			By stock and day		

Table 11 New SLP rules: Euronext vs. Chi-X

This table shows the results of SLP regression estimation (see equation (6)). We regress quoted (Panel A) and effective (Panel B) spreads for stock j on day d on the dummy variable, SLP_d, that is equal to one in the period after the implementation of the new SLP rules (from June 3, 2013 till July 31, 2013) and zero otherwise (from March 1, 2013 till May 9, 2013) and the interaction between SLP_d and dummy variable for stock baskets 2 and 4 for which the change in requirements was not binding, $NonBinding_j$ (we refer to Table IA.1 in Internet Appendix for the details of basket composition). In all regressions, we control for stock and market volatility, trading volume, and market capitalization. All our regressions are estimated with stock fixed effects. Standard errors are clustered by stock and by day. We perform our analysis for the NYSE Euronext Paris and Chi-X. Spreads are measured in basis points. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data for NYSE Euronext Paris with trader and account flags are from BEDOFIH. Trades and best bid-offer quotes are from TRTH. We include only those stock-days that are present in both databases.

	Panel A: Quoted spread		**Panel B: Effective spread**	
	Euronext	Chi-X	Euronext	Chi-X
SLP_d	-0.151***	-0.103***	-0.143***	-0.103***
	(-3.84)	(-3.63)	(-3.57)	(-3.64)
$SLP_d \times NonBinding_j$	0.043	0.086	0.046	0.087
	(0.66)	(1.54)	(0.71)	(1.54)
$Realized\ volatility_{j,d}$	0.001	22.517***	0.001	22.519***
	(0.81)	(8.77)	(0.86)	(8.75)
$Trading\ volume_{j,d}$	-0.001	-0.178***	0.001	-0.177***
	(-0.55)	(-3.93)	(0.28)	(-3.91)
$Market\ capitalization_{j,d}$	-0.002	-0.009**	-0.002	-0.009**
	(-0.46)	(-1.99)	(-0.43)	(-1.98)
$Volatility\ of\ CAC40_d$	0.050***	0.028***	0.048***	0.028***
	(7.37)	(3.89)	(7.14)	(3.90)
$Constant$	1.521***	1.594***	1.618***	1.594***
	(10.52)	(10.27)	(11.40)	(10.24)
Stock FE	Yes			
Clustered SE	By stock and day			
# of observations	3,147	3,147	3,147	3,147
R^2	0.819	0.851	0.826	0.851

Table 12 New SLP rules: Effective announcment date

This table shows the results of SLP regression estimation (see equation (6)) for an effective announcment date (April 2, 2013) instead of the official news release date (May 9, 2013). We regress quoted (Panel A) and effective (Panel B) spreads for stock j on day d on the dummy variable, SLP_d, that is equal to one in the period after the implementation of the new SLP rules (from June 3, 2013 till July 31, 2013) and zero otherwise (from March 1, 2013 till March 31, 2013) and the interaction between SLP_d and dummy variable for stock baskets 2 and 4 for which the change in requirements was not binding, $NonBinding_j$ (we refer to Table IA.1 in Internet Appendix for the details of basket composition). In all regressions, we control for stock and market volatility, trading volume, and market capitalization. All our regressions are estimated with stock fixed effects. Standard errors are clustered by stock and by day. We perform our analysis for the market as a whole as well as for those spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction. Spreads are measured in basis points. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

	Panel A: Quoted spread					**Panel B: Effective spread**				
	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT
SLP_d	-0.120***	-0.090**	-0.181***	-0.066	-0.182***	-0.116***	-0.086*	-0.186***	-0.049	-0.145**
	(-2.76)	(-2.00)	(-3.46)	(-1.49)	(-3.06)	(-2.65)	(-1.83)	(-3.38)	(-1.10)	(-2.41)
$SLP_d \times NonBinding_j$	0.008	0.044	0.088	0.002	0.015	0.017	0.042	0.093	0.009	0.053
	(0.11)	(0.62)	(1.24)	(0.03)	(0.15)	(0.22)	(0.59)	(1.29)	(0.12)	(0.55)
$Realized\ volatility_{j,d}$	-0.000	-0.001*	-0.000	-0.000	0.000	-0.000	-0.001*	-0.000	-0.000	0.000
	(-0.51)	(-1.83)	(-0.50)	(-0.15)	(0.34)	(-0.50)	(-1.90)	(-0.54)	(-0.21)	(0.68)
$Trading\ volume_{j,d}$	-0.006**	-0.010***	-0.007	-0.006**	-0.015***	-0.004	-0.009***	-0.002	-0.004	-0.015***
	(-2.00)	(-4.26)	(-1.63)	(-2.01)	(-3.98)	(-1.28)	(-4.28)	(-0.36)	(-1.47)	(-4.39)
$Market\ capitalization_{j,d}$	-0.007	-0.005	0.002	-0.007	-0.005	-0.007	-0.006	0.003	-0.007	0.001
	(-1.52)	(-1.26)	(0.55)	(-1.51)	(-0.83)	(-1.46)	(-1.33)	(0.74)	(-1.41)	(0.13)
$Volatility\ of\ CAC40_d$	0.054***	0.055***	0.053***	0.052***	0.079***	0.053***	0.057***	0.051***	0.050***	0.076***
	(8.44)	(8.65)	(6.58)	(8.57)	(9.50)	(8.21)	(8.71)	(5.54)	(8.57)	(8.99)
$Constant$	1.519***	1.177***	1.568***	1.535***	1.894***	1.610***	1.161***	1.696***	1.603***	2.198***
	(9.63)	(8.22)	(8.79)	(9.90)	(9.53)	(10.36)	(7.92)	(8.83)	(10.77)	(11.65)
Stock FE	Yes									
Clustered SE	By stock and day									
# of observations	2,261	2,261	2,259	2,261	2,261	2,261	2,261	2,259	2,261	2,261
R^2	0.826	0.831	0.742	0.813	0.814	0.833	0.827	0.736	0.819	0.828

Figure 1. Trader-account types

This figure shows the trader-account types used in this paper as provided by the BEDOFIH database.

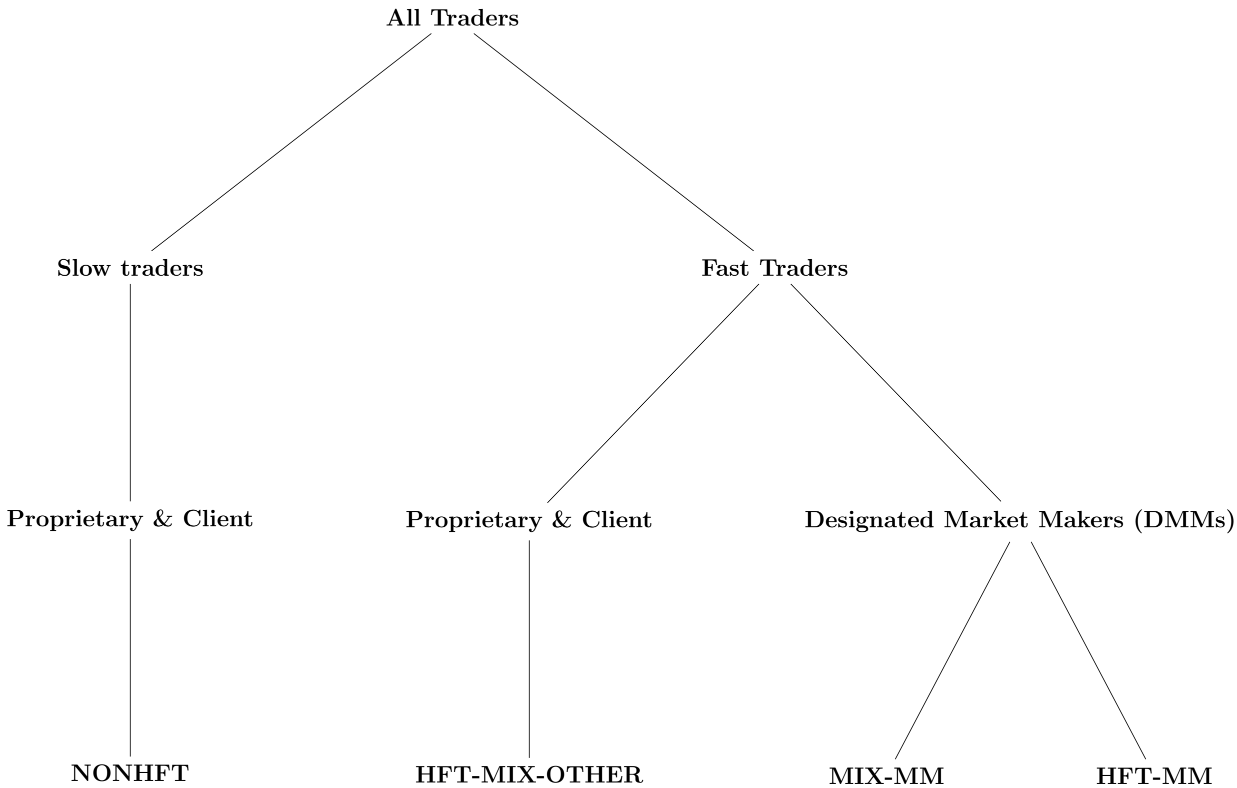


Figure 2. Timeline

This figure shows the timeline of the events used in this paper. Sample period is from March 1, 2013 till December 31, 2013.

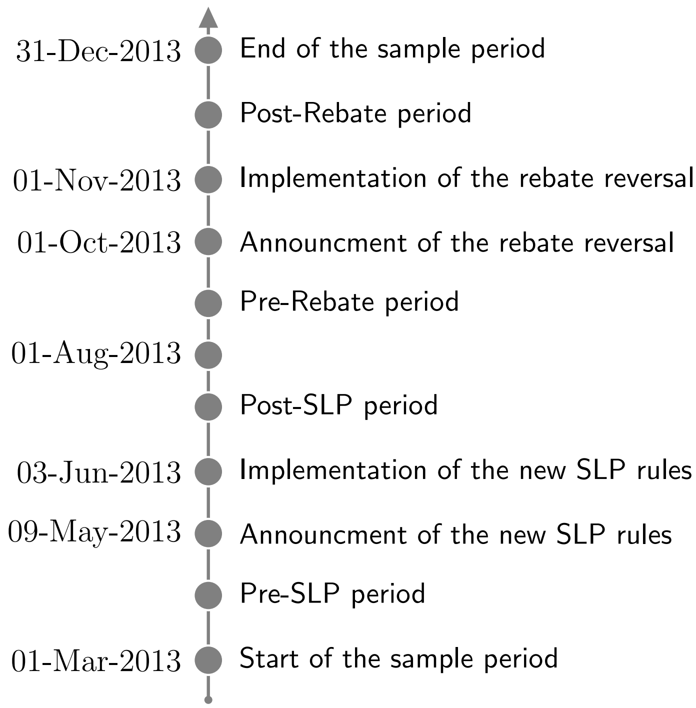
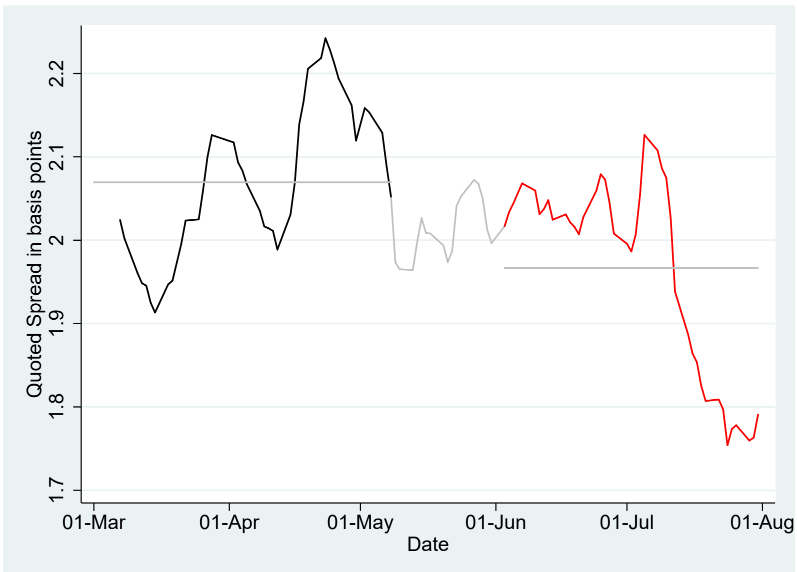


Figure 3. Quoted and effective spreads

This figure shows the weekly moving average of the market-wide share-weighted quoted (see equation (1)) and effective (see equation (2)) spreads in basis points. Black line shows spread dynamics during pre-SLP period (from March 1, 2013 till May 9, 2013), while red line shows spread dynamics during post-SLP period (from June 3, 2013 till July 31, 2013). Grey line shows spreads dynamics between announcement and implementation dates for the new SLP rules. Horizontal grey lines corresponds to the pre-SLP and post-SLP averages of the spreads. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. The period under consideration is from March 1, 2013 till July 31, 2013. Order flow data with trader and account flags are from BEDOFIH.

Panel A: Quoted spread



Panel B: Effective spread

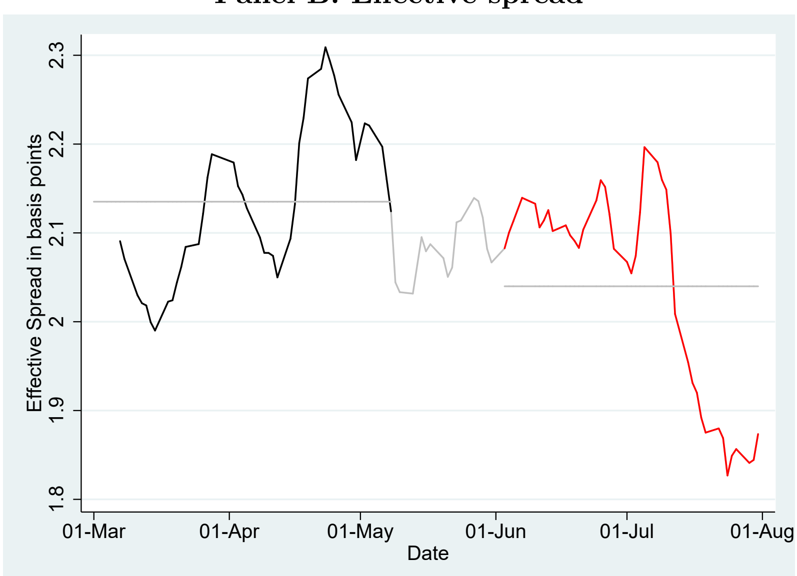


Figure 4. Competition for liquidity provision

This figure shows the average competition for liquidity provision (the number of shares executed passively by the trader-account type k relative to the total trading volume per stock j and day d) as measured by Herfindahl-Hirschman Index (HHI) (see equation (7)). Black line shows HHI dynamics in the pre-SLP period (from March 1, 2013 till May 9, 2013). Red line shows HHI dynamics in the post-SLP period (from June 3, 2013 till July 31, 2013). Grey line shows spreads dynamics between announcement and implementation dates for the new SLP rules. Horizontal grey lines corresponds to the pre-SLP and post-SLP averages of the HHI. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

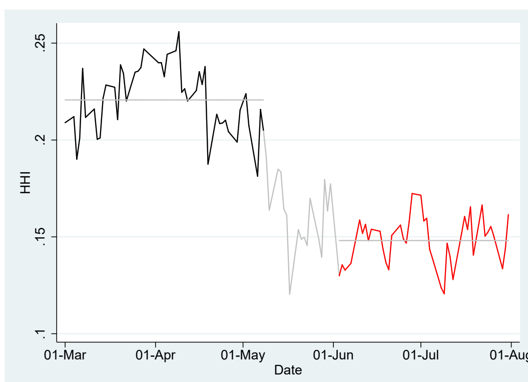
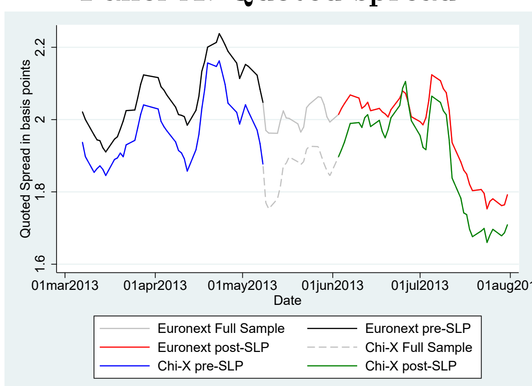


Figure 5. Quoted and effective spreads: NYSE Euronext Paris vs. Chi-X

This figure shows the weekly moving average of the market-wide share-weighted quoted (see equation (1)) and effective (see equation (2)) spreads in basis points for NYSE Euronext Paris and Chi-X. Black (blue) line shows spread dynamics in the pre-SLP period (from March 1, 2013 till May 9, 2013) for NYSE Euronext Paris (Chi-X) . Red (green) line shows spread dynamics in the post-SLP period (from June 3, 2013 till July 31, 2013) for NYSE Euronext Paris (Chi-X). Grey solid (dotted) line shows spreads dynamics between announcment and implementation dates of the new SLP rules for NYSE Euronext Paris (Chi-X). The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data for NYSE Euronext Paris with trader and account flags are from BEDOFIH. Trades and best bid-offer quotes are from TRTH. We include only those stock-days that are present in both databases.

Panel A: Quoted spread



Panel B: Effective spread

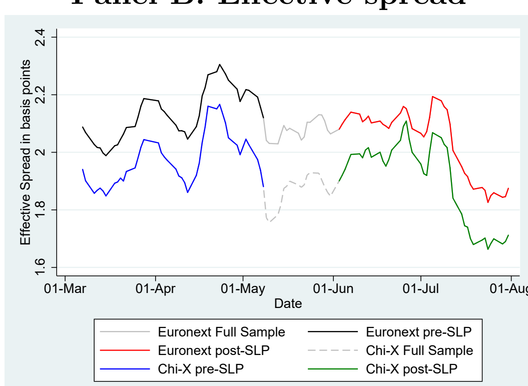
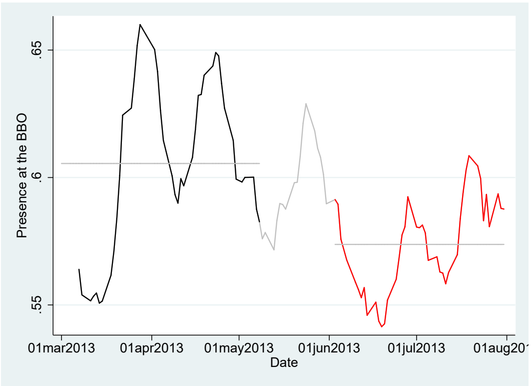


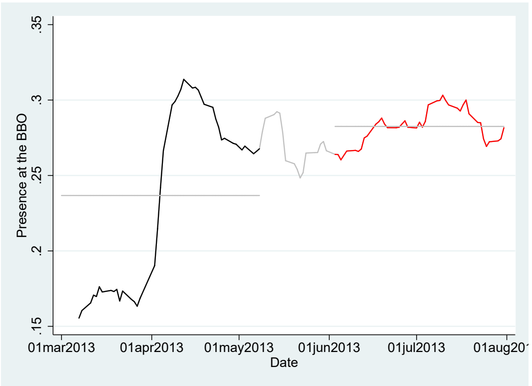
Figure 6. Time presence of DMMs at the best bid offer level

This figure shows the weekly moving average of the time presence at the best bid offer level (amount of seconds present at the best bid-offer level relative to the total amount of second during continuous trading session), separately for HFT-MM and MIX-MM. Black line shows time presence dynamics in the pre-SLP period (from March 1, 2013 till May 9, 2013). Red line shows time presence dynamics in the post-SLP period (from June 3, 2013 till July 31, 2013). Horizontal grey lines corresponds to the pre-SLP and post-SLP averages of the time presence at the best bid offer level. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data with trader and account flags are from BEDOFIH.

Panel A: HFT-MM



Panel B: MIX-MM



Internet Appendix for

"Paying for Market Liquidity: Competition and Incentives"

MARIO BELLIA, LORIANA PELIZZON, MARTI G. SUBRAHMANYAM,
JUN UNO and DARYA YUFEROVA

This supplemental appendix presents additional details on the sample composition, further statistics on changes in DMMs' behavior around introduction of the new SLP rules, and parallel trend test for the difference-in-difference analysis: competition vs. incentives.

Contents

A. Sample Composition

Our sample consists of the components of CAC40 in 2013 (see Tabel IA.1). Out the 40 components of the CAC40 Index, three are not included since their main trading venues are Amsterdam (Arcelor Mittal and Gemalto) and Bruxelles (Solvay).

Table IA.1: Sample composition

This table shows the components of the CAC40 that we use for our analysis together with ISIN, the basket to which each stock belongs to, as defined by the SLP rules in place before June 3, 2013, the industry, average market capitalization in EUR millions, average daily trading volume in millions of shares, and average daily realized volatility based on one-minute midpoint returns in percentages over pre-SLP (from March 1, 2013 till May 9, 2013) and post-SLP (from June 3, 2013 till July 31, 2013) periods. Market capitalization data are from Bloomberg.

Name	ISIN	Industry	MCAP	Trading volume	Realized volatility	Basket 2012
Total	FR0000120271	Energy	113,320	8.78	1.17	1
Accor	FR0000120404	Consumer Discr.	6,120	1.80	0.58	1
Sanofi	FR0000120578	Healt Care	101,323	5.34	2.27	1
Michelin	FR0000121261	Consumer Discr.	12,935	1.33	2.90	1
Schneider	FR0000121972	Industrials	30,837	2.87	1.43	1
Saint-Gobain	FR0000125007	Industrials	16,688	3.38	1.74	1
BNP	FR0000131104	Financials	53,891	7.98	3.50	1
STMicroelectronics	NL0000226223	Information Tech.	7,526	6.71	1.73	1
Credit Agricole	FR0000045072	Financials	17,068	10.00	0.92	2
Safran	FR0000073272	Industrials	15,504	1.56	1.16	2
Air Liquide	FR0000120073	Materials	29,507	1.30	2.01	2
Lafarge	FR0000120537	Materials	13,847	1.54	2.88	2
Danone	FR0000120644	Consumer Staples	32,175	3.22	1.44	2
Pernod Ricard	FR0000120693	Consumer Staples	22,780	1.08	1.14	2
Veolia Environ.	FR0000124141	Utilities	4,664	6.21	0.87	2
Publicis Groupe SA	FR0000130577	Consumer Discr.	10,115	1.38	2.93	2
Technip	FR0000131708	Energy	9,255	0.90	1.51	2
EDF	FR0010242511	Utilities	30,238	3.33	1.43	2
Legrand	FR0010307819	Industrials	9,541	1.24	1.16	2
Lvmh Moet Henessy	FR0000121014	Consumer Discr.	65,045	1.55	2.29	3
Kering	FR0000121485	Consumer Discr.	18,962	0.59	5.76	3
Essilor International	FR0000121667	Healt Care	16,739	1.10	4.67	3
Vinci	FR0000125486	Industrials	20,616	3.12	2.03	3
Societe Generale	FR0000130809	Financials	22,697	10.07	1.73	3
Renault	FR0000131906	Consumer Discr.	13,843	2.09	1.17	3
ENGIE	FR0010208488	Utilities	36,460	9.28	0.59	3
Alstom	FR0010220475	Industrials	9,182	2.75	0.88	3
EADS	NL0000235190	Industrials	33,497	5.03	2.35	3
Carrefour	FR0000120172	Consumer Staples	14,235	4.97	0.89	4
L'Oreal	FR0000120321	Consumer Staples	70,567	1.16	5.80	4
Vallourec	FR0000120354	Energy	5,002	1.18	0.92	4
Bouygues	FR0000120503	Industrials	7,061	2.37	0.88	4
Axa	FR0000120628	Financials	34,464	12.96	2.32	4
Cap Gemini	FR0000125338	Information Tech.	5,699	1.45	2.03	4
Vivendi Universal	FR0000127771	Consumer Discr.	21,026	8.71	2.84	4
Alcatel	FR0000130007	Information Tech.	3,187	33.24	2.96	4
Orange	FR0000133308	Tellecommunication	20,186	19.26	1.45	4

B. New SLP rules: DMMs' behavior by stock

In the main body of the paper, we examine changes in DMMs' behavior around implementation of the new SLP rules at CAC40 level and per baskets of stocks. Table IA.2 focuses on the only binding requirement for DMMs, namely, average time presence at the best bid-offer level of 25%. For each stock we compute the time presence at the best bid-offer level separately for HFT-MM and MIX-MM. We note that this requirement is not binding for HFT-MM, while it is binding for MIX-MM for stocks in Basket 1 and Basket 3. We also note that MIX-MM consistently increase their presence at the best bid-offer level in the stocks for which the requirement was binding.

Table IA.2: New SLP rules: Presence at the BBO by stock

This table shows the average time presence at the best bid-offer level (amount of seconds present at the best bid-offer level relative to the total amount of second during continuous trading session) separately for HFT-MM and MIX-MM for each individual stock in CAC40. The period under consideration is from March 1, 2013 till May 9, 2013 (pre-SLP period) and from June 3, 2013 until July 31, 2013 (post-SLP period). Order flow data with trader and account flags are from BEDOFIH. The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index.

Name	ISIN	Basket 2012	HFT-MM		MIX-MM	
			Pre-SLP	Post-SLP	Pre-SLP	Post-SLP
Total	FR0000120271	1	66%	60%	16%	29%
Accor	FR0000120404	1	53%	50%	15%	31%
Sanofi	FR0000120578	1	57%	61%	15%	28%
Michelin	FR0000121261	1	56%	51%	16%	26%
Schneider	FR0000121972	1	62%	63%	19%	29%
Saint-Gobain	FR0000125007	1	60%	53%	16%	27%
BNP	FR0000131104	1	61%	54%	11%	23%
STMicroelectronics	NL0000226223	1	63%	56%	9%	24%
Credit Agricole	FR0000045072	2	59%	50%	24%	23%
Safran	FR0000073272	2	47%	38%	27%	23%
Air Liquide	FR0000120073	2	70%	54%	24%	23%
Lafarge	FR0000120537	2	55%	45%	32%	26%
Danone	FR0000120644	2	59%	69%	34%	29%
Pernod Ricard	FR0000120693	2	54%	59%	26%	23%
Veolia Environ.	FR0000124141	2	63%	40%	30%	23%
Publicis Groupe SA	FR0000130577	2	63%	55%	28%	28%
Technip	FR0000131708	2	45%	44%	25%	24%
EDF	FR0010242511	2	64%	54%	37%	28%
Legrand	FR0010307819	2	59%	49%	32%	32%
Lvmh Moet Henessy	FR0000121014	3	83%	87%	26%	44%
Kering	FR0000121485	3	64%	71%	26%	39%
Essilor International	FR0000121667	3	50%	55%	18%	25%
Vinci	FR0000125486	3	62%	56%	14%	26%
Societe Generale	FR0000130809	3	58%	66%	15%	27%
Renault	FR0000131906	3	48%	54%	16%	21%
ENGIE	FR0010208488	3	81%	82%	21%	39%
Alstom	FR0010220475	3	57%	62%	12%	28%
EADS	NL0000235190	3	48%	39%	11%	20%
Carrefour	FR0000120172	4	58%	51%	32%	29%
L'Oreal	FR0000120321	4	77%	82%	44%	45%
Vallourec	FR0000120354	4	56%	51%	21%	26%
Bouygues	FR0000120503	4	55%	59%	27%	29%
Axa	FR0000120628	4	71%	73%	32%	31%
Cap Gemini	FR0000125338	4	51%	39%	24%	25%
Vivendi Universal	FR0000127771	4	66%	71%	33%	35%
Alcatel	FR0000130007	4	76%	61%	42%	37%
Orange	FR0000133308	4	56%	50%	22%	24%

C. New SLP rules: parallel trends assumption

In the main body of the paper, we distinguish between the effect of tightened requirements and the effect of increased competition among DMMs by performing a difference-in-difference analysis around new SLP rules implementation where we use stocks for which new requirements were not binding (baskets 2 and 4) as control group and stocks for which new requirements were binding (baskets 1 and 3) as treatment group. We perform parallel trends assumption test as follows:

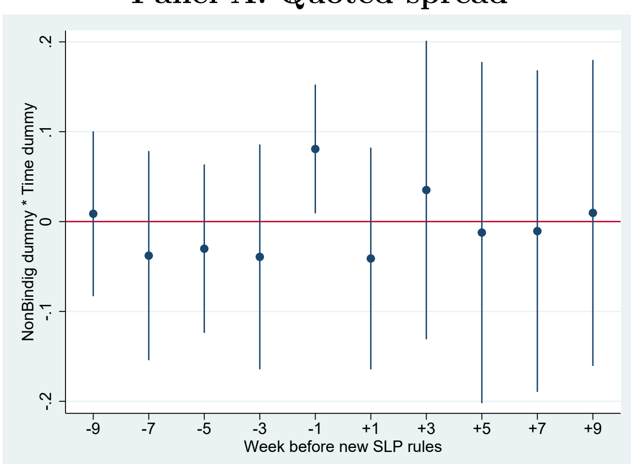
$$y_{j,d} = \alpha_i + \Sigma_k \beta_k TD_k + \Sigma_k \gamma_k TD_k \times NonBinding_j + \Gamma Controls + \epsilon_{j,d} \quad \text{(IA.1)}$$

where $y_{j,d}$ is a market liquidity measure for stock j and day d, TD_k is time dummy variable (at biweekly frequency), $NonBinding_j$ is a dummy variable which equals one if for stock j new requirements were not binding. In all regressions, we control for stock and market volatility, trading volume, and market capitalization. The regressions are estimated with stock fixed effects and the standard errors are clustered by stock and by day. Base case is weeks 10 and 11 before the announcement of the new SLP rules. We focus on the period from March 1, 2013 till May 9, 2013 (pre-SLP period) and from June 3, 2103 till July 31, 2013 (post-SLP period). Figure IA.1 depicts γ_k with 95% confidence intervals. We observe that before SLP announcement γ_k is insignificantly different from zero at 5% significance level, with the only exception of one week before the announcement day, for quoted and effective spreads alike. Hence, parallel trend assumption holds. We also note that there is no difference between treatment and control group after new SLP rules were implemented in line with the analysis performed in the main body of the paper.

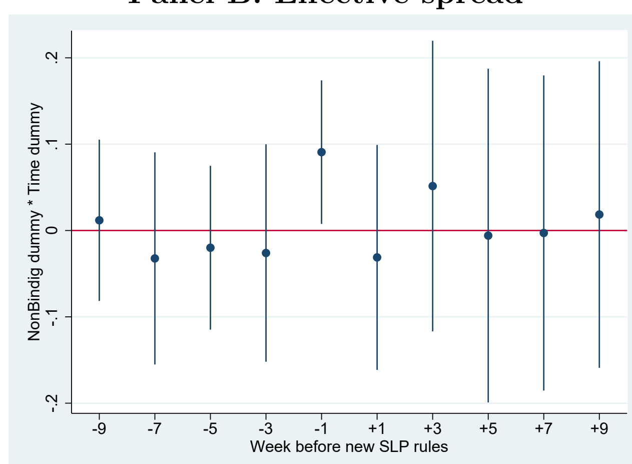
Figure IA.1: New SLP rules: parallel trends

This figure shows test for the parallel trend assumption (see equation (IA.1)) with quoted and effective spreads as dependent variable. In particular, we report coefficient estimates together with 95% confidence intervals of the interaction between biweekly time dummies (TD_k) and dummy variable for stock baskets 2 and 4 for which the change in requirements was not binding, $NonBinding_j$ (we refer to Table IA.1 for the details of basket composition). Spreads are measured in basis points. Sample period under consideration is from March 1, 2013 till May 9, 2013 (pre-SLP period) and from June 3, 2013 till July 31, 2013 (post-SLP period). The sample is composed of 37 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Order flow data for NYSE Euronext Paris with trader and account flags are from BEDOFIH.

Panel A: Quoted spread



Panel B: Effective spread



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