Paying for Market Liquidity: Competition and Incentives

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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 the realized spread. 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, as well as for regulatory market oversight.

JEL classification: G12, G14.

Key-words: Designated Market Makers (DMMs), Liquidity Provision.

1 Introduction

Electronic market-making is present throughout the world today, and many major stock exchanges (among others, the New York Stock Exchange, Euronext, the London Stock Exchange, and Deutsche Börse) have market-making agreements in place with electronic traders. The role of Designated Market Makers (DMMs) in exchanges, now largely played by HFTs, and their influence on market quality, is not well understood and requires a careful empirical examination to conclude whether competition among DMMs, and the incentives offered to them, could have an impact on overall market liquidity.[1] The effect of competition among DMMs has been highlighted theoretically by, e.g., Aït-Sahalia and Sağlam (2017); however, to the best of our knowledge, there are no papers that have studied this aspect empirically. The previous literature tends to concentrate on either making/taking fees (e.g., among others Malinova and Park (2015)) or on a combination of making/taking fees and requirements (e.g., Bessembinder, Hao, and Zheng (2019)). In this paper, we aim to fill this void and empirically investigate the roles of competition versus incentives enforced by exchanges in influencing market liquidity, particularly for HFTs who are willing to act as DMMs. In particular, we attempt to disentangle the effects of competition from those of incentives and to assess the effectiveness of each of these aspects as policy instruments to improve market liquidity.

Stock exchanges have several instruments at their disposal to stimulate market liquidity provided by DMMs. These can be classified into two broad categories: (i) the competitive structure imposed on DMMs; and (ii) the incentives, in terms of benefits offered to, and penalties imposed on, them through fees, rebates, and market-making requirements.[2] The competitive structure of the DMMs can be affected by the exchanges through the re-

[1]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.

[2]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.

quirements imposed on them, for example with regard to the number of stocks in which (existing) participants are required to make markets, and the constraints imposed on potential new entrants. For instance, the 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. Concerning incentives, exchanges impose various obligations (sticks), but also grant advantages (carrots), to DMMs. The typical market-making contract 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 specific requirements, such as an agreement with the exchange to be present in each assigned security for a minimum period 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 on market liquidity of each such aspect of the contract design: competition among DMMs, and 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 on the Cotation Assistée en Continu (CAC40) index constituents (the main French stock market index), 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); MIX, 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 accounts (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 (that span from April 1, 2013, until December 31, 2013). First, on June

3, 2013, NYSE Euronext Paris implemented several changes in the rules of the so-called Supplementary Liquidity Provider (SLP) program. More specifically, the 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. The timeline for these changes is presented in Figure 1. 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": requirements and competition. In particular, we are able to capture the effect of competition because the new SLP rules caused an increase in the number of DMMs present in each stock. In order to establish the causal effect of DMMs' incentives and competition among DMMs on market liquidity, we employ a difference-in-difference methodology with the CAC40 index constituents used as a treatment group, and the Deutscher Aktienindex (DAX30) index constituents (the main German stock market index) used as a control group.

INSERT FIGURE 1 HERE

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 CAC40 index stocks, the decrease in transaction costs due to the increased competition among market-makers amounts to EUR 6.97 million 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 realized spreads (the revenue of liquidity providers net of adverse selection costs). Third, small changes in rebates for DMMs (of approximately 1% of the market-wide quoted spread) and, small changes in requirements, do not have any statistically and economically significant effect on market liquidity, as measured by quoted and effective spreads.

The remainder of this paper proceeds as follows. Section 2 places our paper in the context of the literature on DMMs. Section 3 provides the relevant institutional details about NYSE Euronext Paris, in particular with regard to changes in the competitive structure, and incentives, both fee rebates and requirements, and develops testable hypotheses. Section 4 describes the methodology and data used in the paper. The empirical evidence is presented in Section 5. Additional analysis is presented in Section 6. Section 7 concludes.

2 Literature Review

Our first contribution to the literature relates to the role of competition among DMMs. Remarkably, the issue of competition *among* DMMs is largely neglected in the empirical literature, even though competition in a broad sense is mentioned in a few theoretical models. Although a couple of the extant 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 voluntary liquidity providers; therefore, it is sufficient to assign one DMM per stock. We challenge this view by providing evidence that competition among DMMs for the same stock constitutes 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) in an empirical setting.

The second 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 several studies exist on the role of maker/taker fees in encouraging liquidity provision (e.g., Colliard and Foucault (2012), Malinova and Park (2015), Clapham, Gomber, Lausen, and Panz (2017), Cardella, Hao, and Kalcheva (2017), Black (2018), El Euch, Mastrolia, Rosenbaum, and Touzi (2018), and Lin, Swan, and Harris (2018)), most of them focus on the case in which such fees are applied uniformly to all market participants, across all stocks rather than specifically to DMMs to incentivize their liquidity provision. In a closely-related recent paper on this issue, Bessembinder, Hao, and Zheng (2019) study the effect of both making/taking fees that are specific to DMMs and requirements of DMMs. However, these two aspects were investigated simultaneously in their analysis and, thus, it is not possible for them to draw conclusions about their relative effectiveness in providing the optimal incentives for DMMs to improve their liquidity provision. In contrast to the analysis of Bessembinder, Hao, and Zheng (2019), 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.

Our third contribution to the literature is to provide evidence on the importance of DMMs for market liquidity in the era of high frequency trading. Over the past decade, technological innovation, faster computers with sophisticated execution algorithms, and new trading platforms have completely transformed the landscape for equity trading globally. A new class of electronic liquidity providers has emerged; the "old" class of specialists has almost disappeared, leaving room for a "modern" version of DMMs, who make extensive use of co-location facilities, high-speed connections, and fast computers.[3] In other words, modern market-making is firmly in the hands of high frequency traders (HFT).[4] The role

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

[4]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 on the role of *de facto* market-makers. Anecdotal evidence also confirms this view, e.g., on the NYSE, the DMMs' duties are, after January 2016, all managed by HFT firms (see "High-frequency traders

of DMM in the era of HFT in liquidity provision has been documented by Clark-Joseph, Ye, and Zi (2017) and Bessembinder, Hao, and Zheng (2019), who provide causal evidence that the activity of DMMs has a positive effect on market liquidity.[5] We contribute to this literature by pointing out not only the importance of DMMs for market liquidity, but also by emphasizing the importance of their business organization, and their response to incentives for market liquidity. The unique feature of our database is the flag identifying the account type – market-making account or other accounts for each message – which enables us to establish a more direct connection between DMMs activity and market liquidity.

3 Institutional Details and Hypotheses Development

Our analysis is based on a natural experiment in NYSE Euronext Paris, in which certain changes were made to the regime under which DMMs provide liquidity in blue-chip stocks. 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 (2011), seven firms initially joined the program and became DMMs. 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 employs to incentivize DMMs. We will focus our analysis and SLP program discussion on CAC40

in charge at NYSE," *Financial Times*, January 26, 2016).

[5]Other evidence on the value of DMMs is largely based on voluntarily negotiated contracts between the DMM and the firm itself (see Venkataraman and Waisburd (2007), Anand, Tanggaard, and Weaver (2009), Menkveld and Wang (2013), Skjeltorp and Ødegaard (2014), and Bessembinder, Hao, and Zheng (2015)). However, these studies are likely to provide an upward-biased estimate of the DMM's value, as only those firms for whom hiring a DMM is beneficial choose to hire them.

index constituents (the main French stock market index).

3.1 SLP Program: Competition and Requirements

The 2012 SLP program requires that each firm appointed as a DMM must (NYSE-Euronext (2011)):

A) Commit to be present in at least 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 on average across all stocks included in the basket."

  (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."

In the Flash News of May 9, 2013 (NYSE-Euronext (2013b)), the exchange announced several changes to the SLP program. 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 of the CAC40 components were placed in the same basket.[6] 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 all CAC40 index constituents. This change in basket composition is another source of increased competition among DMMs beyond the arrival of new entrants into the SLP program. According to AMF, there were

[6] Table A1 in Appendix A provides the details of the basket composition for CAC40 index constituents.

seven DMMs present in CAC40 index constituents in April and May 2013. Moreover, these seven DMMs were *not* present uniformly across baskets in April and May 2013. After the new SLP rules were implemented, these seven DMMs were present in all CAC40 index constituents, and one new DMM joined the SLP program.[7] Figure 2 shows that the number of DMMs present in each basket of stocks increased after the new SLP rules were implemented from five to eight, from six to eight, from five to eight, and from seven to eight in the four baskets, Baskets 1 to 4, respectively.

INSERT FIGURE 2 HERE

The key characteristics of the new 2013 SLP contract are (NYSE-Euronext (2013b)):

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,"

  (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."

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

[7] Megarbane, Saliba, Lehalle, and Rosenbaum (2017), using the same database enhanced with the ID of the traders, identify 13 firms as SLP members for the sample period from November 2015 until July 2016.

3.2 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 bps, and for each executed limit order (providing liquidity), the rebate for SLP members was -0.20 bps, until May 2013, which was increased to -0.22 bps 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 bps as of November 1, 2013. This attractive maker/taker fee structure applied only to those SLP members who fulfilled the exchange requirements. SLP members who did not fulfill the requirements were charged 0.55 bps per order execution, independent of whether they consumed or provided liquidity.

3.3 Hypotheses

The institutional setting, in particular the contract changes, suggest some clear implications for our empirical investigation. We will first summarize these 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, it was a binding requirement for DMMs, since these rules prescribed 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 indicate that competition increases with more players participating in each stock, which may have lead to an improvement in market liquidity. However, the increase in the number of stocks may have, at the same time, stretched the resources of DMMs, since their inventory and computational capacity had to be allocated across more stocks (tightened requirements). This may have, therefore, lead to the unintended consequence of the opposite result. i.e., a deterioration in market liquidity.

In order to analyze the potential effects of the tightened requirements through the need to be present in all baskets, we discuss five hypothetical cases for allocation of DMMs across baskets, before and after the new SLP rules were implemented (see Figure 3). We assume that each DMM has a capacity of one unit. Therefore, DMMs present only in one basket allocate their whole unit to that particular basket, and DMMs present in all four baskets allocate 0.25 units to each basket.

INSERT FIGURE 3 HERE

Case 1. Four DMMs were present in all baskets in the pre-SLP period. There was no change either in terms of competition among them, or in the total capacity allocated to each basket, after the new SLP rules were in place (no effect on market liquidity).

Case 2. Four DMMs were present in all baskets; in addition, in each basket, there were also four DMMs that were present. If all DMMs present in one basket decided to leave the market, as they were not able to fulfill the new requirements, then the competition among DMMs would have decreased, but so also would the total capacity allocated to each basket after the new SLP rules were in place (a decrease in market liquidity).

Case 3. Four DMMs were present in all baskets; in addition, in each basket, there were also four DMMs present. DMMs that were present only in Basket 2 and Basket 4 decided to leave the market. Then, the competition among DMMs increased (an increase in market liquidity), while the total capacity allocated to each of the baskets decreased after the new SLP rules were in place (a decrease in market liquidity).

Case 4. Four DMMs were present in all baskets; in addition, in each basket, four DMMs were present. If all DMMs that were present in only one basket decided to stay in the market, then the competition among DMMs would have increased (an increase in market liquidity), while total capacity allocated to each basket would have remained unchanged (no effect on market liquidity), after the new SLP rules were in place.

Case 5. Four DMMs were present in all baskets; in addition, in Baskets 1 and 3 four DMMs were present. If all DMMs that were present in only one basket decided to stay in the market, then the competition among DMMs would have increased (an increase in market liquidity), while the total capacity allocated to each basket would have increased for Baskets 2 and 4 (an increase in market liquidity), and decreased for Baskets 1 and 3 (a decrease in market liquidity).

Overall, Cases 1 to 4 suggest that tightened requirements could not have lead to an improvement in liquidity, while only Case 5 allows for liquidity improvement in some baskets at the expense of the other baskets, through a reallocation of the DMMs capacity to provide liquidity. We also note that, although the relevant basket of stocks was defined by the NYSE Euronext Paris, traders themselves decided in which basket they wanted to participate as DMMs and, hence, in equilibrium, their allocation should be optimal for them (i.e., DMMs optimally decide which of Cases 1 to 5 is realized). We also note, that in terms of the SLP rules, one can define the DMMs capacity to provide liquidity in terms of their time presence at the best bid-offer level, as this is the only requirement that is applied at the individual stock level. According to AMF, seven DMMs were not present in a uniform manner across baskets; therefore, Case 5 is the most likely scenario of the actual effect of capacity reallocation. We also note that none of these cases includes new entrants, as we believe that the effect of the new entrants is purely attributed to the increase in competition among DMMs, rather than to capacity reallocation as a consequence of the tightened requirements.

Second, Rule B1, Rule B2, and the newly introduced Rule B3.2, were not binding for DMMs in the pre-SLP period (see Section 5.3) and, thus, should not have resulted in a change in market liquidity after the new SLP rules were in place. Finally, the change in the maker/taker fee structure is small in absolute terms. 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 only a marginal impact, which will be verified in Section 6.4, in which we discuss the robustness of our results.

Overall, we conclude that only Rule A combined with Rule B3.3 is likely to have had an effect on market liquidity. To ensure that the hypotheses that we test allow for 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) The requirement on DMMs to deliver a minimum time presence for a larger number of stocks may lead to:*

- *an improvement in market liquidity in baskets of stocks for which the time presence of the DMMs increased.*
- *a deterioration in market liquidity in baskets of stocks for which the time presence of the DMMs decreased.*

4 Methodology and Data

We use two natural experiments based on changes that affect different aspects of the contract between the exchange and the DMMs (we refer to Figure 1 for the timeline of the events accompanying these changes). The first event is the change in the SLP program that became effective as of June 3, 2013, and includes: (i) increased competition between DMMs; (ii) more stringent requirements; and (iii) 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. We use a difference-in-difference setting to examine the effect of competition among DMMs and the incentives of DMMs on market liquidity.

In the following sections, we describe the treatment and control groups used for our analysis, define market liquidity variables, and discuss our identification strategy.

4.1 Treatment Group

We focus our attention in this paper on the index constituents of the CAC40 index (the main French stock market index). 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. We concentrate our analysis on the 36 stocks that belong to the CAC40 Index.[8] The BEDOFIH database provides quotes and trades time-stamped in microseconds, covering the complete history of each order.

The 2012 SLP program (NYSE-Euronext (2012)) covers 90 stocks that are split into six baskets (15 stocks in each basket). Baskets 1 to 4 are predominantly composed of French stocks, while Baskets 5 and 6 are composed of non-French ones. The BEDOFIH database includes only French stocks that have NYSE Euronext Paris as their main trading venue: therefore, our database contains only data for Baskets 1 to 4. These baskets are largely composed of CAC40 index constituents (the main French stock market index) and CAC20Next index constituents (the main candidates to be included in CAC40). The BEDOFIH database includes 52 SLP stocks, with 36 of them being CAC40 index constituents and 15 of them being CAC20Next index constituents (the next tier). Table 1 shows that SLP stocks that do not belong to CAC40 are much smaller (in terms of market capitalization) than CAC40 constituents (EUR 6.66 billion vs. EUR 27.53 billion). Given that stock market liquidity, which constitutes the main dependent variable of our analysis, is strongly related to size, we focus on CAC40 index constituents only to avoid the possibility that our results are driven by the most illiquid stocks in the SLP program.

[8] Four component stocks of the CAC40 are not included in the database, since their main trading venue is not NYSE Euronext Paris: ArcelorMittal, Gemalto, Solvay, and Unibail-Rodamco.

INSERT TABLE 1 HERE

The data from NYSE Euronext Paris are complemented by a flag provided by the Autorité des Marchés Financiers (AMF), the French stock market regulator, which 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), and the MIX group covers 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 annually, 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: the market-making account (MM); and 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. Figure 4 provides a schematic diagram of the trader-account types used in our analysis. Appendix B contains a summary of the traders' characteristics.

INSERT FIGURE 4 HERE

4.2 Control Group

We start by examining whether non-SLP stocks available in the BEDOFIH database might serve as a reasonable control group for CAC40 stocks. In particular, we look at the French stocks with a market capitalization above EUR 1 billion as of February 2013, which leaves us with 45 stocks as a potential control group. However, these stocks have an average market capitalization of EUR 8.31 billion, as opposed to EUR 27.53 billion of those stocks that belong to CAC40 (see Table 1). Given that market liquidity is strongly related to company size proxied by market capitalization, we conclude that non-SLP stocks are not a suitable control group for the purpose of our analysis.

Therefore, we decide to use stocks that belong to DAX30 (the main German stock market index) as our control group. The average market capitalization of the DAX30 constituents is comparable to those of the CAC40 (EUR 27.43 billion vs. EUR 27.53 billion). We use the Thomson Reuters Tick History (TRTH) database to obtain data on trades and best bid-offer quotes for the DAX30 index constituents, time-stamped to the millisecond level from Xetra. We note that the data provided by TRTH are much less granular than those provided by BEDOFIH, and do not distinguish between different trader types.

4.3 Market Liquidity Variables

We measure market liquidity by quoted and effective half-spreads, in which 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:

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

$$\textit{Effective Spread}_t = \frac{|P_t - Midpoint_t|}{Midpoint_t} \tag{2}$$

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:

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

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

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 type.

4.4 Identification Strategy: Competition vs. Incentives

We start by examining the first natural experiment: implementation of the new SLP rules on June 3, 2013. We focus our attention on the two months surrounding the implementation date of the new SLP rules (from April 1, 2013 until July 31, 2013). 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 April 1, 2013 until June 3, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to CAC40 index and zero if stock j belongs to DAX30 index, and the interaction term between $CAC40_j$ and SLP_d. In all regressions, we control for stock and market volatility, trading volume, and market capitalization. We estimate alternative specifications without fixed effects, with stock fixed effects, and with both stock and day fixed effects. In all of our regressions, we cluster standard errors by stock and day.

$$Liquidity_{j,d} = \alpha + \beta_1 SLP_d + \beta_2 CAC40_j + \beta_3 CAC40_j \times SLP_d + \Gamma Controls + \epsilon_{j,d} \qquad (5)$$

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. First, we examine whether the reallocation of the DMMs' capacity occurred across baskets. We use the time presence at the best bid-offer level as a measure of the DMMs' capacity (jointly for HFT-MM and MIX-MM). We regress the capacity measure 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 April 1, 2013 until June 3, 2013), for each of the four baskets of stocks as defined in the pre-SLP period (we refer to Appendix A for the basket composition). We note that, due to our data restrictions, the DMMs' capacity can only be estimated for CAC40 stocks (as the BEDOFIH database provides relevant identification flags, while TRTH does not). We estimate all of our regressions with stock fixed effects, and cluster standard errors by stock and day.

$$Capacity_{j,d} = \alpha_j + \beta_1 SLP_d + \Gamma Controls + \epsilon_{j,d} \tag{6}$$

We define baskets of stocks that have positive and significant β_1 coefficient as baskets for which the new requirements were previously binding and, thus, the DMMs had to reallocate their capacity to them. We then 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 April 1, 2013 until June 3, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, on the dummy variable, $NonBinding_j$, which is equal to one, if stock j belongs to a non-binding basket of stocks, on the interaction term between $CAC40_j$ and SLP_d and on the interaction term between $NonBinding_j$ and SLP_d. Again, in all regressions, we control for stock and market volatility, trading volume, and market capitalization. We estimate all specifications without fixed effects, with stock fixed effects, and with both stock and day fixed effects. In all of our regressions, we cluster the standard errors by stock and day.

$$\begin{aligned} Liquidity_{j,d} = & \alpha + \beta_1 SLP_d + \beta_2 CAC40_j + \beta_3 NonBinding_j + \beta_4 CAC40_j \times SLP_d + \\ & \beta_5 NonBinding_j \times SLP_d + \Gamma Controls + \epsilon_{j,d} \end{aligned} \tag{7}$$

We use the estimation results of equation (7) to disentangle the effect of tightened requirements from the effect of competition among DMMs based on the following argument. If β_4 and β_5 are both significant, then the pure effect of competition among DMMs on market liquidity is equal to $\beta_4 + \beta_5$, i.e., the effect of changes in the SLP rules for stocks with nonbinding requirements. If β_5 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_4 represents the effect that increased competition among DMMs has on market liquidity.

In the robustness section (see Section 6.4), we also perform an analysis for the rebate reversal which took place on November 1, 2013, to ensure that small changes in rebates do not have any effect on the behavior of DMMs. We focus our attention on the two months surrounding the implementation date of the rebate reversal (from September 1, 2013 until December 31, 2013). We regress the 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 September 1, 2013 until October 31, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to CAC40 index, and zero if stock j belongs to DAX30 index, and on the interaction term between $CAC40_j$ and $Rebate_d$. As previously, in all regressions, we control for stock and market volatility, trading volume, and market capitalization. We estimate the specifications without fixed effects, with stock fixed effects, and with both stock and day fixed effects. In all of our regressions, we cluster standard errors by stock and day.

$$Liquidity_{j,d} = \alpha + \delta_1 Rebate_d + \delta_2 CAC40_j + \delta_3 CAC40_j \times Rebate_d + \Gamma Controls + \epsilon_{j,d} \quad (8)$$

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_3, we adjust the effect of new SLP rules by $-\delta_3$.

5 Empirical Results

In this section, we present our empirical results about the relative importance of incentives of DMMs, versus competition among DMMs, for market liquidity using the natural experiment conducted in NYSE Paris Euronext, i.e., the implementation of the new SLP rules. First, we provide summary statistics of our sample (see Section 5.1). Second, we examine market liquidity around the implementation of the new SLP rules (see Section 5.2). Third, we examine the reaction of DMMs to the new SLP rules (see Section 5.3). Finally, we empirically analyze the relative importance of the DMMs' incentives versus competition among the DMMs for market liquidity (see Section 5.4).

5.1 Summary Statistics

Table 2 shows the summary statistics during our sample period for CAC40 and DAX30 index constituents. We focus our attention on the two months before (the pre-SLP period, Panel A) and two months after (the post-SLP period, Panel B) the implementation date of the new SLP rules – June 3, 2013.

INSERT TABLE 2 HERE

In particular, we provide evidence on the market-wide quoted and effective spreads for the market for both CAC40 and DAX30 index constituents, averaged across stock-days. For example, during the pre-SLP period, the market-wide quoted (effective) spread of CAC40 index constituents is equal to 2.02 (2.09) bps, with the respective number of 2.07 (2.11) bps for DAX30 index constituents. However, in the post-SLP period, the quoted and effective spreads for CAC40 and DAX30 deviate from each other. In particular, in the post-SLP period, the quoted (effective) spread for the CAC40 is equal to 1.92 (1.99) bps, while that for the DAX30 it is equal to 2.15 (2.20) bps.

Panel C of Table 2 reports the results of the univariate t-tests for the pre- and post-SLP mean comparison. The tests confirm, that for CAC40 index constituents, market liquidity improves significantly in the post-SLP period, as compared to the pre-SLP period; whereas, for DAX30 index constituents, market liquidity significantly deteriorates. This divergence of market liquidity measures for treatment and control groups in the post-SLP period constitutes preliminary evidence that the new SLP rules improve stock market liquidity.

Then, for CAC40 index constituents, we also provide information on the quoted and effective spreads faced by each trader-account type while initiating the transaction, averaged across stock-days. HFT-MM activity faces the smallest quoted and effective spreads of 1.82 bps and 1.83 bps, while NONHFT traders face the largest quoted and effective spreads of 2.51 bps and 2.72 bps, respectively. This pattern holds for the post-SLP period, as well.

Figure 5 depicts the weekly moving average of the quoted (Panel A) and effective spreads (Panel B) during our sample period for CAC40 (solid black line) and the DAX30 index constituents (solid grey line). The dashed horizontal lines represent the pre-SLP (from April 1, 2013 until June 3, 2013) and post-SLP (from June 3,2013 until July 31, 2013) averages (for ease of comparison, we subtract the pre-SLP average from both time-series). The vertical dashed-dotted lines represent the announcement and implementation dates. We note that the quoted and effective spreads for CAC40 and DAX30 co-move during the pre-SLP period and deviate in the post-SLP period.

INSERT FIGURE 5 HERE

We also conduct a formal test for the "parallel trends" assumption between CAC40 and DAX30 quoted and effective spreads. Figure 6 depicts the coefficient estimates and confidence intervals from the regression, with stock and day fixed effects of market liquidity on the interaction between the time (biweekly) dummies and a dummy variable, $CAC40_j$, which is equal to one, if the stock belongs to the CAC40 index, and zero, if the stock belongs to the DAX30 index. We note that the parallel trend assumption is satisfied, which makes the DAX30 an appropriate control group for analyzing the effect of the new SLP rules on the market liquidity of CAC40 stocks.

INSERT FIGURE 6 HERE

In the following sections, we perform a difference-in-difference analysis to estimate the effect of the new SLP rules on market liquidity and separate effects that arise from the competition among DMMs from those that stem from the tightened requirements.

5.2 New SLP Rules: Market Liquidity

We start by analyzing the overall effect of the new SLP rules (see equation (5)) on market liquidity. In particular, 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 April 1, 2013 until June 3, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, and the interaction term between $CAC40_j$ and SLP_d. Table 3 presents the results of the regression estimation with the quoted spread (Panel A) and the effective spread (Panel B) as dependent variables. In each case, we estimate three specifications: without fixed effects, with stock fixed effects, and with stock and day fixed effects. In each of the regressions, we control for 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 market-wide quoted and effective spreads for CAC40 index constituents, relative to those for the DAX30 index constituents across all three specifications, as manifested by the negative and significant interaction coefficients associated with $SLP_d \times CAC40_j$. We focus our discussion on the most conservative specification with stock and day fixed effects. The market-wide quoted (effective) spread following the implementation of the new SLP rules decreases for the CAC40 index constituents by 0.191 (0.181) bps, which is 9.5% (8.7%) relative to the pre-SLP level.

INSERT TABLE 4 HERE

Table 4 shows the overall effect of the new SLP rules (see equation (5)) on the spreads faced by different trader categories. For brevity, we report only the estimation results of the most conservative specification with stock and day fixed effects. We document that all four trader categories experienced a decrease in both quoted and effective spreads after the implementation of the new SLP rules. In particular, HFT-MM traders face effective spreads that are 0.158 bps lower than in the pre-SLP period (8.6% of the pre-SLP level); MIX-MM traders face effective spreads that are 0.135 bps lower than in the pre-SLP period (7.0% of the pre-SLP level); HFT-MIX-OTHER traders face effective spreads that are 0.137 bps lower than in the pre-SLP period (6.6% of the pre-SLP level); and NONHFT traders face effective spreads that are 0.187 bps lower than in the pre-SLP period (6.9% of the pre-SLP level).[9]

These results indicate that the new SLP rules had a positive effect on market liquidity. In the following section, we discuss the effect that the new SLP rules had on the behavior of DMMs.

5.3 New SLP Rules: Capacity of DMMs

In this section, we explore the effect of potential heterogeneity across stocks in the changes in the DMMs' behavior in response to the new SLP rules on market liquidity. To do so, we first compute several variables that reflect the requirements that DMMs have to fulfill, and then check whether the new requirements introduced by the new SLP rules were binding.

INSERT TABLE 5 HERE

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 1,000 displayed at the best bid-offer level, and the liquidity provision ratio (the

[9]Unreported tests show that the improvement in the effective spread for NONHFT is statistically insignificantly different from the improvement in the effective spread for HFT-MM at the usual significance levels (10%, 5%, and 1%), and statistically larger than the improvement in effective spreads for MIX-MM (at the 10% level) and HFT-MIX-OTHER (at the 1% level).

number of shares executed passively by the trader-account type relative to the total trading volume per stock-day). Table 5 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 Appendix A for details of the basket composition before and after that date). Unfortunately, we cannot track the behavior of individual DMMs and, thus, can only confirm whether or not they fulfill the requirements as a group.

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 24.2% to 35.5%, and by MIX-MM from 7.2% to 8.1%. This suggests that the new SLP rules shifted the liquidity provision activity from voluntary liquidity providers to DMMs.

The time presence at the first five 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. The time presence at the best bid offer level increased slightly for MIX-MM (from 27.2% to 27.9% for CAC40), and decreased for HFT-MM (from 69.3% to 56.7% for CAC40), with a similar pattern present for the displayed quantity at the best bid-offer level. The displayed order value at the best bid-offer level increased for MIX-MM (from 14.36 to 16.02 thousand of EUR), and decreased for HFT-MM (from 34.82 to 23.27 thousand of EUR).

We note that, in the pre-SLP and post-SLP periods, HFT-MM and MIX-MM, as a group, comply with the new SLP rules (including those that remained unchanged). In particular, the time presence at the first five best prices is above 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. The newly introduced rule B3.2 requires that DMMs are, on average, across all CAC40 stocks, present at least 25% of the time at the best level of the limit order book. Both HFT-MM and MIX-MM traders comply with this requirement, as well.

Therefore, we conclude that none of the afore-mentioned requirements was binding for the DMMs as a group.[10] However, Rule A combined with Rule B3.3 requires that DMMs have to be present at the best bid-offer level in all CAC40 stocks for at least 10% of the time. These two rules, while increasing the competition, also lead to a reallocation of the DMMs' capacity across baskets. We measure the DMMs' capacity to provide liquidity in terms of the time presence at the best bid-offer level, as this is the only requirement that is applied at the individual stock level. We also note that, for market liquidity, it matters whether the aggregate capacity to provide liquidity was reallocated from one basket to another rather than to which type of DMMs' it belongs; hence, we analyze changes in the aggregate capacity measure estimated for both HFT-MM and MIX-MM.

Table 6 presents the reallocation of the DMMs' capacity across baskets, following the implementation of the new SLP rules (see equation (6)). 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 6 HERE

We find that the only basket that experienced a statistically significant increase of 2.6% of the duration of the continuous trading session in the presence of the DMMs is Basket 3, while all other baskets did not experience a significant change in the time presence of the DMMs. Therefore, we conclude that DMMs reallocate their capacity from Baskets 1, 2, and 4 to Basket 3 in the post-SLP period, to fulfill the new requirement to be present at least 10% of the time at the best bid-offer level in each of the CAC40 index constituents. This heterogeneity across baskets of stocks allows us to empirically differentiate the role of

[10] We note that this conclusion is true, on average, across stock-days for HFT-MM and MIX-MM as a group. We implicitly assume that each individual DMM complies with the requirements, as well.

changes in incentives versus competition, following the implementation of the new SLP rules on June 3, 2013.

5.4 New SLP Rules: Competition vs. Incentives

In Sections 5.2 – 5.3, we show that the new SLP rules led to an increase in market liquidity, as measured by quoted and effective spreads, and reallocation of the DMMs capacity across baskets following the tightened requirements. In this section, we empirically distinguish between the effects of competition versus incentives used by NYSE Euronext Paris to encourage DMMs to provide liquidity, and examine their relative empirical importance.

In order to discern these two effects, we use a triple difference-in-difference methodology to compare the effect of the new SLP rules for baskets of stocks for which the new requirements were binding (Basket 3) relative to baskets of stocks for which the new requirements were not binding (Baskets 1, 2, and 4), before and after the new SLP rules were implemented using DAX30 as a control group. In particular, 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 April 1, 2013 until June 3, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, on the dummy variable, $NonBinding_j$, which is equal to one, if stock j belongs to a non-binding basket of stocks (Baskets 1, 2, and 4), on the interaction term between $CAC40_j$ and SLP_d, and on the interaction term between $NonBinding_j$ and SLP_d.[11]

INSERT TABLE 7 HERE

Table 7 presents the results of the regression estimation for the quoted spread (Panel A) and the effective spread (Panel B) as dependent variables. In all regressions, we control for

[11] We note that all stocks for which requirements were not binding belong to the CAC40 index. Consequently, the triple difference-in-difference term $SLP_d \times CAC40_j \times NonBinding_j$ is exactly the same as the interaction term $SLP_d \times NonBinding_j$, and is omitted from the regression estimation due to multicollinearity.

stock and market volatility, trading volume, and market capitalization, and cluster standard errors by stock and day. We estimate specifications without fixed effects, with stock fixed effects, and with both stock and day fixed effects. Our findings are consistent across all specifications. In the discussion of the results, we focus on the most conservative specification that includes both stock and day fixed effects.

We observe that the new SLP rules decreased market-wide quoted and effective spreads, as demonstrated by the negative and significant coefficients for the interaction term $SLP_d \times CAC40_j$. In particular, we show that the quoted (effective) spread decreased by 0.205 (0.200) bps or 10.1% (9.6%) of the pre-SLP level. We also document that the coefficient of the interaction term $SLP_d \times NonBinding_j$, which represents the differential effect of the new SLP rules across baskets of stocks *from* which DMMs' capacity was reallocated (Baskets 1, 2, and 4) as opposed to the baskets of stocks *to* which DMMs' capacity was reallocated (Basket 3), is not statistically significant in any of our specifications. 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 highlights the fact that small static changes in the requirements for DMMs do not lead to an improvement in market liquidity and, thus, complements the findings of Bessembinder, Hao, and Zheng (2019), who report that the tightened requirements of DMMs, together with an increased rebate for liquidity provision, did improve market liquidity. There are several potential explanations for this divergence in the two sets of results. First, the empirical setup of Bessembinder, Hao, and Zheng (2019) does not include the *simultaneous* increase in competition among DMMs as in our analysis (for example, in Baskets 1 and 3 number of DMMs increased from five to eight DMMs as shown in Figure 2). Second, Bessembinder, Hao, and Zheng (2019) looks at the dynamic contract of DMMs, when requirements would be loosened again if the trading volume increased above a 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 exchange response. Third, the ultimate effect of the change in the requirements depends on the original level and tightness of the requirements already in place, and the magnitude of the imposed changes.

Interestingly, the size of liquidity improvement is comparable for the rebate that DMMs receive for passive execution (0.22 bps in the post-SLP period). This suggests that with only one DMM present per stock, DMMs capitalize on the rebate and quote the same spread as any voluntary liquidity provider. However, in the presence of competitors, DMMs are willing to undercut each other's quotes, up to the size of the rebate received.

INSERT TABLE 8 HERE

Table 8 shows the overall effect of the new SLP rules (see equation (7)) on spreads faced by different trader categories. For brevity, we report only the estimation results of the most conservative specification with stock and day fixed effects. We document that all four trader categories experienced a decrease in both quoted and effective spreads, after implementation of the new SLP rules, as documented by a negative and significant coefficient of $SLP_d \times CAC40_j$. We also note that the requirements of DMMs are not shown to be an important determinant for the spreads faced by all four trader categories, as documented by an insignificant coefficient of $SLP_d \times NonBinding_j$. Thus, our analysis by trader-type confirms the results of the analysis performed at the market-wide level. In particular, competition between DMMs results in an improvement in the effective spread faced by HFT-MM of 0.174 bps (9.5% of the pre-SLP level). The respective improvement for MIX-MM is 0.151 bps (7.8% of the pre-SLP level); for HFT-MIX-OTHER is 0.141 bps (6.8% of the pre-SLP level); and for NONHFT is 0.211 bps (7.8% of the pre-SLP level).[12]

[12] Unreported tests show that the improvement in the effective spread for NONHFT is statistically insignificantly different from the improvement in the effective spread for HFT-MM, MIX-MM, and HFT-MIX-OTHER at the usual significance levels (10%, 5%, and 1%).

On average, the trading volume per day for all CAC40 stocks is EUR 1,384 million; hence, in economic terms, the decrease in the effective spread of 0.200 bps corresponds to a decrease in transaction costs of EUR 6.97 million per year. For HFT-MM traders that are active in all CAC40 stocks, the respective number is equal to EUR 1.93 million, while for NONHFT traders the respective number is equal to EUR 0.90 million. These findings highlight the key result 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, i.e., NONHFT; whereas, small changes in the requirements that DMMs have to fulfill do not translate into meaningful changes in market liquidity.

6 Additional Analysis

In this section, we perform several additional robustness tests. First, we show the effect of the new SLP rules on the components of the effective spread: realized spread and price impact (see Section 6.1). Second, we repeat the analysis of the new SLP rules for the different transaction sizes (see Section 6.2). Third, we analyze whether the implementation of the new SLP rules exerts a spillover effect on alternative trading venues, i.e., Chi-X (see Section 6.3). Finally, we demonstrate that small changes in rebates for DMMs indeed do not have any effect on market liquidity (see Section 6.4).

6.1 New SLP Rules: Spread Decomposition

In this section, we analyze the effect of the new SLP rules on the decomposition of the effective spread. In particular, we address the question of 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 9 HERE

Table 9 provides the 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 April 1, 2013 until June 3, 2013) and post-SLP (from June 3, 2013 until July 31, 2013) periods. During the pre-SLP period (see Panel A of Table 9), the market-wide realized spread for the CAC40 index constituents is negative, ranging between -0.09 to -0.33 bps, depending on the horizon under consideration. The realized spread for the DAX30 index constituents is also negative, ranging from -0.04 to -0.20 bps, with the only exception being the realized spread at the 1-second horizon (0.27 bps) in the pre-SLP period. The negative realized spreads signal that a severe adverse selection problem exists 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 2.21 to 2.44 bps during the pre-SLP period for CAC40 index constituents. The price impact for the DAX30 index constituents is of comparable magnitude, ranging from 1.89 to 2.36 bps in the pre-SLP period.

For the CAC40 index constituents, we can further split the sample based on the type of trader initiating the transaction. We document that 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 0.91 bps if HFT-MM traders initiate a transaction, and the price impact of such a transaction is 2.76 bps. At the same time, liquidity providers make profits of 0.84 bps if NONHFTs initiate a transaction, and the price impact of such a transaction is 1.97 bps. We observe similar patterns for the post-SLP period (see Panel B of Table 9). 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 now move to a formal test of the effect of the new SLP rules on effective spread decomposition, and estimate equation (7) with realized spread and price impact components of the effective spreads as dependent variables. In particular, 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 April 1, 2013 until June 3, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to CAC40 index and zero, if stock j belongs to DAX30 index, on the dummy variable, $NonBinding_j$, which is equal to one, of stock j belongs to a non-binding basket of stocks (Basket 1, 2, and 4), on the interaction term between $CAC40_j$ and SLP_d, and on the interaction term between $NonBinding_j$ and SLP_d. Table 10 presents the results of the regression estimation. We estimate three specifications: without fixed effects, with stock fixed effects, and with stock and day fixed effects. In each of the regressions, we control for 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 $SLP_d \times CAC40_j$ and $SLP_d \times NonBinding_j$ for the specification that includes both stock and day fixed effects.

INSERT TABLE 10 HERE

We note that, in line with the main analysis, there is no differential effect between the baskets of stocks *from* which DMMs' capacity was reallocated (Baskets 1, 2, and 4) and baskets of stocks *to* which DMMs' capacity was reallocated (Basket 3), as manifested by an insignificant coefficient of $SLP_d \times NonBinding_j$ for realized spread and price impact alike.[13] Therefore, we can interpret the coefficient of $SLP_d \times CAC40_j$ as a pure effect of increased competition among DMMs. Table 10 shows that the market-wide realized spread

[13] Occasionally, we find that the observed effect is different for the baskets of stocks for which the requirements were not binding. However, no consistent pattern exists across different decomposition horizons and trader categories.

decreased significantly for the 1-second, 10-seconds, and the 1-minute decomposition horizons by 0.117 bps, 0.106 bps, and 0.182 bps, respectively. The decrease in the realized spread, which is frequently interpreted as a revenue of the liquidity provider (net of adverse selection costs), is in line with what one might expect with an increase in competition among DMMs. Splitting our sample by trader categories, we show that HFT-MM and NONHFT experience a significant decrease in realized spreads over different decomposition horizons. Table 10 also reveals that the price impact component of the effective spread decreased significantly at the 10-second decomposition horizon at the market-wide level, and for HFT-MM, HFT-MIX-OTHER, and NONHFT by 0.096 bps, 0.167 bps, 0.158 bps, and 0.107 bps, respectively, in line with theoretical predictions of Aït-Sahalia and Sağlam (2017). However, the price impact component remained largely unchanged for other decomposition horizons.

To conclude, at the market-wide level, the decrease in the realized spread component of the effective spread is the main driver of the decrease in the effective spread, and this result derives from the increased competition among DMMs, rather than tightened requirements.

6.2 New SLP Rules: Different Transaction Sizes

In this section, we examine whether the observed improvement in market liquidity after the implementation of the new SLP rules is observed across different transaction sizes or is concentrated only among the smallest transactions. In order to do so, we split all of the aggressive transactions for the sample stocks into quintiles based on the number of shares traded using the data for the whole 2013, with quintile 1 (quintile 5) including the smallest (largest) transactions.

INSERT TABLE 11

Table 11 shows the results of the regression estimation (see equation (7)) for different transaction size quintiles. In particular, 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 April 1, 2013 until June 3, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, on the dummy variable, $NonBinding_j$, which is equal to one, if stock j belongs to a non-binding basket of stocks (Baskets 1, 2, and 4), on the interaction term between $CAC40_j$ and SLP_d, and on the interaction term between $NonBinding_j$ and SLP_d. We estimate three specifications: without fixed effects, with stock fixed effects, and with stock and day fixed effects. In each of the regressions, we control for 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 $SLP_d \times CAC40_j$ and $SLP_d \times NonBinding_j$, for the specification that includes both stock and day fixed effects.

First, we note that, in line with the main analysis, there is no difference between stocks for which requirements were binding and those for which they were not binding, as manifested by the insignificant coefficient of $SLP_d \times NonBinding_j$ across all quintiles. Therefore, the coefficient of $SLP_d \times CAC40_j$ can be interpreted as a pure effect of the increased competition among DMMs. Second, market-wide effective spread significantly decreased across all quintiles. Moreover, the effect is decreasing while moving from small transactions to large transactions. In particular, market-wide effective spread decreased by 0.260 bps for the smallest transactions and by 0.188 bps for the largest transactions. By examining the effective spreads faced by each individual trader category, we observe that the effective spread improved for all trader categories in quintiles 1, 2, and 5; whereas, for quintiles 3 and 4, MIX-MM traders do not 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 significantly decreases transaction costs for larger transactions, as well.

6.3 New SLP Rules: Euronext vs. Chi-X

In this section, we discuss whether the new SLP rules have any spillover effects into alternative trading venues. In particular, we examine whether the market-wide quoted and effective spreads observed in Chi-X reacted to the new SLP rules of NYSE Euronext Paris. We note that NYSE Euronext Paris holds approximately 72% of total trading volume in CAC40, while Chi-X is the second-largest trading venue with approximately 14% of total trading volume in CAC40 in 2013.[14] We also note that all 36 stocks used in the analysis are also traded on Chi-X. Data on the transactions and best bid-offer quotes for Chi-X come from the Thomson Reuters Tick History (TRTH) database. The two markets differ substantially in terms of maker-taker fees: on Chi-X, a trader receives a rebate of 0.15 bps, when providing liquidity (limit order), and pays 0.30 bps when consuming liquidity (market order), and this maker/taker scheme is valid for all traders (not only for DMMs, as in NYSE Euronext Paris).[15]

Table 12 presents the results of the regression estimation (see equation (7)) using data for Chi-X, instead of the data for NYSE Euronext Paris. In particular, 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 April 1, 2013 until June 3, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, on the dummy variable, $NonBinding_j$, which is equal to one, if stock j belongs to a non-binding basket of stocks (Baskets 1, 2, and 4), on the interaction term between $CAC40_j$ and SLP_d, and on the interaction term between $NonBinding_j$ and SLP_d. We estimate three specifications: without fixed effects, with stock fixed effects, and with stock and day fixed effects. In each of the regressions, we control for stock and market volatility, trading volume, and market

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

[15]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

capitalization of the stock and cluster standard errors by stock and day.

INSERT TABLE 12

We find that new SLP rules significantly affect quoted and effective spreads on Chi-X. In particular, both the quoted and effective spreads on Chi-X decrease by 0.219 bps and 0.220 bps, respectively (focusing on the most conservative specification with both stock and day fixed effects). We also note that, in line with the main analysis, there is no differential effect between the baskets of stocks *from* which DMMs' capacity was reallocated (Baskets 1, 2, and 4) and baskets of stocks *to* which DMMs' capacity was reallocated (Basket 3), as manifested by the insignificant coefficient of $SLP_d \times NonBinding_j$. In other words, the decreases in spreads on Chi-X, as well as on NYSE Euronext Paris, are driven by the increased competition among DMMs on NYSE Euronext Paris. Bessembinder, Hao, and Zheng (2019) report a similar improvement in liquidity on other trading venues stemming from the changes in contract requirements of DMMs on NYSE. They argue that this result stems from strategic complementariness of the NYSE and other trading venues. Indeed, liquidity providers on other trading venues are likely to also quote lower spreads because they always have an outside option to unload any undesired inventory to DMMs on the main trading venue.

6.4 Rebate Reversal: Market Liquidity

NYSE Euronext Paris increased the rebate for DMMs' passive execution from 0.20 bps to 0.22 bps, 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 (approximately 1% of the 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, and after, the implementation date of the rebate reversal – November 1, 2013.

INSERT TABLES 13 and 14 HERE

In Table 13, 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 bps to -0.20 bps, which occurred on November 1, 2013. In particular, we regress the 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 September 1, 2013 until October 31, 2013), on the dummy variable, $CAC40_j$, which is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, and the interaction term between $CAC40_j$ and $Rebate_d$. In each case, we estimate three specifications: without fixed effects, with stock fixed effects, and with stock and day fixed effects. In each of the regressions, we control for 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 of the interaction term, $CAC40_j \times Rebate_d$, is statistically significant for both the quoted and the effective spreads across all specifications. Table 14 provides the regression estimation results (see equation (8)) for each trader category. To conserve space, we report only the results of the specification with both stock and day fixed effects. Furthermore, in this case, none of the coefficients of the interaction term, $CAC40_j \times Rebate_d$, is statistically significant, for both the quoted and the effective spreads across all trader categories.

To conclude, our findings confirm our *ex-ante* expectations that small changes in the DMMS rebate (0.02 bps, which is approximately 1% of the quoted spreads in the pre-SLP period) do not materially affect market liquidity. Given that the change in the rebate that occurred on November 1, 2013 exactly offset the change in rebate that occurred on June 3, 2013 (at the same time as the change in SLP rules), we argue that any effect observed around the change in SLP rules is attributable to other sources than the change in the maker/taker fee structure. We note that our analysis does not offer any conclusion on large changes in the rebate, which may well have a material impact on market liquidity.

7 Conclusion

The evolution of the trading environment has 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, such as the "flash crash" in the U.S. 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, particularly in terms of market stress. Thus, it is not surprising that high-frequency market-making has drawn close scrutiny by regulators to ensure continuous participation of traders in market-making. For example, the recently implemented MiFID II regulation has explicitly focused on 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 will not lead to the best possible outcome 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 size of the transaction. These conclusions are likely to be of interest to 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 Data Description

This table shows the number of stocks and the respective market capitalization in EUR billion as of February 2013. For the French stocks, we report the respective numbers for SLP stocks available in the BEDOFIH database (separately for stocks that belong to the CAC40 index and the SLP stocks that do not belong to the CAC40 index) and Non-SLP stocks. For German stocks, we report the respective numbers for the stocks that belong to the DAX30 index based on data from the TRTH database. Data on stock market capitalization come from Datastream.

		# of stocks	MCAP, EUR billion
	French stocks		
SLP			
	CAC40	36	27.53
	Not CAC40	16	6.66
Non-SLP	>1 billion EUR	45	8.31
	German stocks		
DAX30		30	27.43

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 bps 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 implementation of the new SLP rules (from April 1, 2013 until June 3, 2013). Panel B reports the summary statistics for the two months after the implementation of the new SLP rules (from June 3, 2013 until 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 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	French stocks					German stocks
	CAC40	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT	DAX30
	Panel A: Pre-SLP period					
Quoted Spread	2.02	1.82	1.90	2.01	2.51	2.07
Effective Spread	2.09	1.83	1.94	2.07	2.72	2.11
	Panel B: Post-SLP period					
Quoted Spread	1.92	1.75	1.86	1.95	2.36	2.15
Effective Spread	1.99	1.76	1.90	2.02	2.62	2.20
	Panel C: Difference					
Quoted Spread	-0.107***	-0.074*	-0.043	-0.066*	-0.149***	0.089**
Effective Spread	-0.099***	-0.069*	-0.045	-0.048	-0.097**	0.090***

Table 3 New SLP Rules: Market-Wide Liquidity

This table shows the results of SLP regression estimation (see equation (5)). We regress the 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 until July 31, 2013), and zero otherwise (from April 1, 2013 until June 3, 2013), on a dummy variable $CAC40_j$, that is equal to one, if stock j belongs to the CAC40 index, and zero, if stock j belongs to the DAX30 index, and on the interaction term between $CAC40_j$, and SLP_d. In all regressions, we control for stock and market volatility, trading volume, and market capitalization. Standard errors are clustered by stock and by day. Spreads are measured in bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	Panel A: Quoted spread			**Panel B: Effective spread**		
	(1)	(2)	(3)	(1)	(2)	(3)
$SLP_d \times CAC40_j$	-0.169***	-0.161***	-0.191***	-0.162***	-0.153***	-0.181***
	(-3.95)	(-3.37)	(-4.04)	(-3.88)	(-3.26)	(-3.91)
SLP_d	0.068*	0.046		0.073**	0.047	
	(1.82)	(1.22)		(1.98)	(1.28)	
$CAC40_j$	-0.129			-0.108		
	(-1.59)			(-1.33)		
$Realized\ volatility_{j,d}$	0.156***	0.109***	0.089***	0.163***	0.112***	0.092***
	(6.49)	(9.54)	(7.46)	(6.85)	(10.01)	(8.03)
$Trading\ volume_{j,d}$	-0.040***	-0.041***	-0.041***	-0.039***	-0.040***	-0.040***
	(-2.69)	(-6.20)	(-6.44)	(-2.65)	(-5.88)	(-6.34)
$Market\ capitalization_{j,d}$	-0.009***	-0.013**	-0.016***	-0.010***	-0.011**	-0.015**
	(-3.81)	(-2.22)	(-2.62)	(-3.94)	(-1.96)	(-2.40)
$Market\ volatility_d$	0.016***	0.026***		0.014**	0.025***	
	(2.76)	(5.02)		(2.44)	(4.85)	
$Constant$	1.849***	1.526***	2.086***	1.911***	1.526***	2.066***
	(17.21)	(7.63)	(9.41)	(17.75)	(7.58)	(9.28)
Observations	5,613	5,613	5,613	5,613	5,613	5,613
R^2	0.382	0.839	0.855	0.389	0.840	0.856
Stock FE	No	Yes	Yes	No	Yes	Yes
Day FE	No	No	Yes	No	No	Yes
Clustered SE	By Stock and Day			By Stock and Day		

Table 4 New SLP Rules: Liquidity by Trader Type

This table shows the results of SLP regression estimation (see equation (5)) for each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) that initiates the transaction. We regress the quoted (Panel A) and effective (Panel B) spreads for stock j on day d on the interaction between 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 until July 31, 2013), and zero otherwise (from April 1, 2013 until June 3, 2013), and the dummy variable $CAC40_j$, that is equal to one if stock j belongs to the CAC40 index and zero if stock j belongs to the DAX30 index. In all regressions, we control for stock volatility, trading volume, and market capitalization. For brevity, we report only specifications with both stock and day fixed effects. Standard errors are clustered by stock and by day. Spreads are measured in bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	Panel A: Quoted spread				**Panel B: Effective spread**			
	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT
$SLP_d \times CAC40_j$	-0.164***	-0.133**	-0.155***	-0.240***	-0.158***	-0.135**	-0.137**	-0.187***
	(-2.80)	(-2.23)	(-2.74)	(-3.84)	(-2.73)	(-2.22)	(-2.46)	(-3.07)
$Realized\ volatility_{j,d}$	0.078***	0.072***	0.087***	0.098***	0.081***	0.076***	0.090***	0.102***
	(6.28)	(5.40)	(7.45)	(6.70)	(6.46)	(5.36)	(7.88)	(7.31)
$Trading\ volume_{j,d}$	-0.037***	-0.038***	-0.039***	-0.056***	-0.038***	-0.037***	-0.038***	-0.053***
	(-4.99)	(-4.62)	(-5.31)	(-6.11)	(-5.07)	(-4.23)	(-5.30)	(-6.05)
$Market\ capitalization_{j,d}$	-0.013*	-0.012*	-0.018**	-0.018**	-0.012	-0.011	-0.017**	-0.014*
	(-1.79)	(-1.70)	(-2.43)	(-2.47)	(-1.63)	(-1.54)	(-2.33)	(-1.91)
$Constant$	1.979***	1.974***	2.106***	2.222***	1.988***	1.960***	2.114***	2.094***
	(7.70)	(7.64)	(8.13)	(8.43)	(7.66)	(7.47)	(8.12)	(8.15)
Observations	5,613	5,613	5,613	5,613	5,613	5,613	5,613	5,613
R^2	0.857	0.810	0.839	0.836	0.859	0.804	0.840	0.853
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Clustered SE	By Stock and Day				By Stock and Day			

Table 5 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 five best price levels (amount of seconds present at the best bid-offer level or at the first five best price levels relative to the total amount of seconds during a 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 Appendix A for the details of basket composition). The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. The period under consideration is from April 1, 2013 until June 3, 2013 (Panel A: pre-SLP period) and from June 3, 2013 until July 31, 2013 (Panel B: post-SLP period). Data for the French stocks come from the BEDOFIH database.

	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 (%)	24.2%	23.7%	22.7%	22.0%	29.1%	6.4%	7.2%	6.7%	6.2%	5.4%
Displayed order at value at BBO	34.82	35.88	33.87	37.94	31.55	14.36	12.13	14.31	13.96	17.10
Time Presence 5 Best Prices	99.3%	99.4%	99.2%	99.3%	99.4%	99.7%	99.4%	99.8%	99.5%	99.8%
Time Presence at BBO	59.3%	58.8%	56.1%	61.5%	61.5%	27.2%	19.8%	30.8%	23.9%	33.6%
	Panel B: Post-SLP period									
Gross Liquidity Provision (%)	35.5%	37.5%	35.3%	34.2%	35.1%	6.9%	8.1%	6.8%	6.5%	6.5%
Displayed order at value at BBO	23.27	24.52	19.43	28.77	21.10	16.02	14.56	13.25	18.78	18.20
Time Presence 5 Best Prices	99.6%	99.7%	99.4%	99.7%	99.6%	99.8%	99.7%	99.8%	99.8%	99.8%
Time Presence at BBO	56.7%	55.5%	50.7%	62.8%	59.1%	27.9%	27.0%	25.4%	29.6%	30.5%

Table 6 New SLP Rules: DMMs' Capacity

This table shows the results of DMMs' capacity (jointly for HFT-MM and MIX-MM) reallocation regression, (see equation (6)) for each of the four baskets of stocks that were in place in the pre-SLP period (see Appendix A for details of basket composition). We regress the time presence at the best bid-offer level (amount of seconds present at the best bid-offer level during a continuous trading session) 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 until July 31, 2013), and zero otherwise (from April 1, 2013 until June 3, 2013). In all regressions, we control for stock and market volatility, trading volume, and market capitalization. All of our regressions are estimated with stock fixed effects. Standard errors are clustered by stock and by day. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. Data for the French stocks come from the BEDOFIH database.

	Basket 1	Basket 2	Basket 3	Basket 4
SLP_d	0.013	-0.008	0.026***	-0.005
	(0.97)	(-0.38)	(3.04)	(-0.33)
$Realized\ volatility_{j,d}$	0.010***	0.012*	0.003	0.003
	(3.26)	(1.81)	(1.07)	(0.73)
$Trading\ volume_{j,d}$	-0.013***	-0.026***	-0.013***	-0.012***
	(-3.01)	(-3.50)	(-3.19)	(-2.83)
$Market\ capitalization_{j,d}$	-0.009**	-0.014*	-0.008***	-0.008*
	(-2.41)	(-1.79)	(-2.63)	(-1.72)
$Market\ volatility_d$	0.003	0.003	0.002	0.003**
	(1.58)	(1.27)	(0.60)	(2.30)
$Constant$	1.522***	1.025***	1.386***	0.785***
	(4.64)	(6.86)	(6.19)	(9.10)
Observations	680	935	765	680
R^2	0.215	0.250	0.678	0.563
Stock FE	Yes	Yes	Yes	Yes
Day FE	No	No	No	No
Clustered SE	By Stock and Day			

Table 7 New SLP Rules: Market-wide Effect of Competition vs. Incentives

This table shows the results of the SLP regression estimation (see equation (7)). We regress the quoted (Panel A) and the 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 until July 31, 2013) and zero otherwise (from April 1, 2013 until June 3, 2013), on dummy variable $CAC40_j$, that is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, on the dummy variable $NonBinding_j$, that is equal to one, if stock j belongs to Baskets 1, 2, and 4 in the pre-SLP period and zero otherwise (see Appendix A for details of basket composition), on interaction terms between $CAC40_j$, and SLP_d and between $NonBinding_j$, and SLP_d. In all regressions, we control for stock and market volatility, trading volume, and market capitalization. Standard errors are clustered by stock and by day. Spreads are measured in bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	Panel A: Quoted spread			**Panel B: Effective spread**		
	(1)	(2)	(3)	(1)	(2)	(3)
$SLP_d \times CAC40_j$	-0.178***	-0.174***	-0.205***	-0.175***	-0.169***	-0.200***
	(-3.10)	(-2.62)	(-3.07)	(-3.09)	(-2.58)	(-3.02)
$SLP_d \times NonBinding_j$	0.012	0.017	0.019	0.017	0.022	0.024
	(0.24)	(0.27)	(0.31)	(0.36)	(0.37)	(0.40)
SLP_d	0.067*	0.046		0.072*	0.047	
	(1.80)	(1.22)		(1.96)	(1.28)	
$CAC40_j$	-0.075			-0.055		
	(-0.55)			(-0.40)		
$NonBinding_j$	-0.071			-0.070		
	(-0.50)			(-0.49)		
$Realized\ volatility_{j,d}$	0.155***	0.109***	0.089***	0.162***	0.112***	0.092***
	(6.22)	(9.49)	(7.40)	(6.57)	(9.96)	(7.96)
$Trading\ volume_{j,d}$	-0.040***	-0.041***	-0.041***	-0.038**	-0.040***	-0.039***
	(-2.61)	(-6.19)	(-6.44)	(-2.57)	(-5.88)	(-6.34)
$Market\ capitalization_{j,d}$	-0.009***	-0.013**	-0.016***	-0.010***	-0.011**	-0.015**
	(-3.85)	(-2.23)	(-2.63)	(-3.98)	(-1.98)	(-2.42)
$Market\ volatility_d$	0.016***	0.026***		0.014**	0.025***	
	(2.76)	(5.02)		(2.45)	(4.85)	
$Constant$	1.847***	1.529***	2.090***	1.910***	1.530***	2.071***
	(17.18)	(7.65)	(9.41)	(17.71)	(7.59)	(9.28)
Observations	5,613	5,613	5,613	5,613	5,613	5,613
R^2	0.384	0.839	0.855	0.390	0.840	0.856
Stock FE	No	Yes	Yes	No	Yes	Yes
Day FE	No	No	Yes	No	No	Yes
Clustered SE	By Stock and Day			By Stock and Day		

Table 8 New SLP Rules: Effect of Competition vs. Incentives by Trader Type

This table shows the results of the SLP regression estimation (see equation (7)) for each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) that initiates the transaction. We regress the quoted (Panel A) and the effective (Panel B) spreads for stock j on day d on the interaction between dummy variable, SLP_d, that is equal to one in the period after the implementation of the new SLP rules (from June 3, 2013 until July 31, 2013), and zero otherwise (from April 1, 2013 until June 3, 2013), on dummy variable $CAC40_j$, that is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, and the interaction between the dummy variable $NonBinding_j$, that is equal to one, if stock j belongs to Baskets 1, 2, and 4 in the pre-SLP period and zero otherwise (see Appendix A for details of basket composition) and SLP_d. In all of the regressions, we control for stock volatility, trading volume, and market capitalization. For brevity, we report only the specifications with both stock and day fixed effects. Standard errors are clustered by stock and by day. Spreads are measured in bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	Panel A: Quoted spread				Panel B: Effective spread			
	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT
$SLP_d \times CAC40_j$	-0.179**	-0.147*	-0.161**	-0.253***	-0.174**	-0.151*	-0.141**	-0.211**
	(-2.42)	(-1.71)	(-2.23)	(-2.73)	(-2.35)	(-1.71)	(-1.97)	(-2.33)
$SLP_d \times NonBinding_j$	0.021	0.018	0.008	0.018	0.021	0.021	0.006	0.032
	(0.33)	(0.24)	(0.13)	(0.21)	(0.34)	(0.28)	(0.10)	(0.39)
$Realized\ volatility_{j,d}$	0.078***	0.072***	0.087***	0.098***	0.081***	0.076***	0.090***	0.102***
	(6.22)	(5.36)	(7.41)	(6.66)	(6.40)	(5.31)	(7.85)	(7.28)
$Trading\ volume_{j,d}$	-0.037***	-0.038***	-0.039***	-0.056***	-0.038***	-0.037***	-0.038***	-0.053***
	(-4.98)	(-4.62)	(-5.31)	(-6.11)	(-5.06)	(-4.23)	(-5.30)	(-6.05)
$Market\ capitalization_{j,d}$	-0.013*	-0.012*	-0.018**	-0.018**	-0.012*	-0.011	-0.017**	-0.014*
	(-1.81)	(-1.72)	(-2.44)	(-2.47)	(-1.65)	(-1.56)	(-2.34)	(-1.93)
$Constant$	1.983***	1.977***	2.108***	2.225***	1.992***	1.964***	2.115***	2.099***
	(7.73)	(7.66)	(8.13)	(8.41)	(7.68)	(7.50)	(8.13)	(8.14)
Observations	5,613	5,613	5,613	5,613	5,613	5,613	5,613	5,613
R^2	0.857	0.810	0.840	0.836	0.859	0.804	0.840	0.853
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	By Stock and Day				By Stock and Day			

Table 9 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 bps for the market as a whole as well as the spreads faced by each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) while initiating the transaction for the one-second, 10-seconds, one-minute and five-minutes horizons. Panel A reports the summary statistics for the two months before the announcement of the new SLP rules (from April 1, 2013 until June 3, 2013). Panel B reports the summary statistics for the two months after the implementation of the new SLP rules (from June 3, 2013 until July 31, 2013). The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	French stocks					German stocks
	CAC40	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT	DAX30
Panel A: Pre-SLP period						
Realized spread 1 sec	-0.09	-0.71	-0.52	0.01	1.06	0.27
Realized spread 10 sec	-0.31	-0.91	-0.67	-0.22	0.84	-0.04
Realized spread 1 min	-0.33	-0.81	-0.51	-0.30	0.80	-0.20
Realized spread 5 min	-0.21	-0.60	-0.19	-0.26	0.89	-0.07
Price impact 1 sec	2.21	2.56	2.47	2.09	1.74	1.89
Price impact 10 sec	2.42	2.76	2.61	2.31	1.97	2.19
Price impact 1 min	2.44	2.67	2.47	2.40	2.02	2.36
Price impact 5 min	2.33	2.46	2.15	2.36	1.93	2.25
Panel B: Post-SLP period						
Realized spread 1 sec	-0.12	-0.61	-0.50	0.08	1.01	0.32
Realized spread 10 sec	-0.30	-0.79	-0.61	-0.10	0.85	0.06
Realized spread 5 min	-0.29	-0.75	-0.41	-0.14	0.84	-0.05
Realized spread 1 min	-0.14	-0.53	0.24	-0.12	0.87	0.04
Price impact 1 sec	2.14	2.39	2.42	1.96	1.68	1.92
Price impact 10 sec	2.31	2.57	2.52	2.14	1.84	2.18
Price impact 1 min	2.30	2.53	2.32	2.18	1.86	2.31
Price impact 5 min	2.16	2.31	1.67	2.16	1.83	2.24

Table 10 New SLP Rules: Spread Decomposition

This table shows the results of the SLP regression estimation for the spread (see equation (3)) and the price impact (see equation (4)) components of the effective spread (see equation (7)). We regress the realized spread and price impact components of the effective spread for stock j on day d on the interaction between dummy variable, SLP_d, that is equal to one, in the period after the implementation of the new SLP rules (from June 3, 2013 until July 31, 2013) and zero otherwise (from April 1, 2013 until June 3, 2013), on dummy variable $CAC40_j$, that is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, and interaction between dummy variable $NonBinding_j$, that is equal to one, if stock j belongs to Baskets 1, 2, and 4 in the pre-SLP period and zero otherwise (see Appendix A for details of basket composition) and SLP_d. In all regressions, we control for stock volatility, trading volume, and market capitalization. For brevity, we report only the coefficients for the interaction terms, relative to the specifications with both stock and day fixed effects. Standard errors are clustered by stock and by day. We perform the 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 bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	$SLP_d \times CAC40_j$					$SLP_d \times NonBinding_j$				
	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT
Realized spread 1 sec	-0.117**	0.006	-0.060	0.013	-0.156*	0.038	0.041	0.014	-0.010	0.052
	(-2.06)	(0.10)	(-0.76)	(0.18)	(-1.83)	(0.75)	(0.69)	(0.23)	(-0.15)	(0.70)
Realized spread 10 sec	-0.106**	0.007	-0.013	0.024	-0.125	0.004	-0.006	-0.065	-0.018	0.024
	(-2.49)	(0.15)	(-0.19)	(0.36)	(-1.56)	(0.13)	(-0.17)	(-1.25)	(-0.30)	(0.35)
Realized spread 1 min	-0.182***	-0.141*	-0.037	-0.070	-0.128	0.075	0.051	-0.038	0.108*	0.015
	(-3.16)	(-1.90)	(-0.32)	(-1.10)	(-1.27)	(1.52)	(0.74)	(-0.36)	(1.84)	(0.15)
Realized spread 5 min	-0.130	-0.137*	0.416**	-0.039	-0.292***	0.102	0.117*	-0.130	0.087	0.203
	(-1.49)	(-1.67)	(2.16)	(-0.34)	(-3.18)	(1.41)	(1.74)	(-0.67)	(0.80)	(1.63)
Price impact 1 sec	-0.079	-0.170***	-0.071	-0.151***	-0.075	-0.017	-0.037	0.008	0.011	-0.001
	(-1.45)	(-2.68)	(-0.71)	(-2.68)	(-1.29)	(-0.37)	(-0.57)	(0.09)	(0.22)	(-0.03)
Price impact 10 sec	-0.096*	-0.167**	-0.112	-0.158***	-0.107*	0.019	0.011	0.086	0.019	0.029
	(-1.84)	(-2.48)	(-1.13)	(-3.08)	(-1.83)	(0.40)	(0.16)	(0.93)	(0.41)	(0.61)
Price impact 1 min	-0.038	-0.028	-0.134	-0.060	-0.103	-0.046	-0.041	0.084	-0.111**	0.029
	(-0.50)	(-0.24)	(-0.96)	(-1.03)	(-1.46)	(-0.65)	(-0.37)	(0.61)	(-2.31)	(0.47)
Price impact 5 min	-0.075	-0.032	-0.563**	-0.089	0.046	-0.088	-0.104	0.152	-0.101	-0.141
	(-0.89)	(-0.32)	(-2.54)	(-0.96)	(0.55)	(-1.22)	(-1.12)	(0.68)	(-1.15)	(-1.31)
Controls	Yes									
Stock FE	Yes									
Day FE	Yes									
Clustered SE	By Stock and Dday									

Table 11 New SLP Rules: Liquidity by Transaction Sizes

This table shows the results of the SLP regression estimation (see equation (7)) for different transaction size quintiles (based on the transaction in 2013). We regress the effective spread for stock j on day d on the interaction between dummy variable, SLP_d, that is equal to one, in the period after the implementation of the new SLP rules (from June 3, 2013 until July 31, 2013) and zero otherwise (from April 1, 2013 until June 3, 2013), on dummy variable $CAC40_j$, that is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, and interaction between dummy variable $NonBinding_j$, that is equal to one if stock j belongs to Baskets 1, 2, and 4 in the pre-SLP period and zero otherwise (see Appendix A for details of basket composition) and SLP_d. In all of the regressions, we control for stock volatility, trading volume, and market capitalization. For brevity, we report only the coefficients for the interaction terms relative to the specifications with both stock and day fixed effects. Standard errors are clustered by stock and by day. We perform the 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 bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	$SLP_d \times CAC40_j$					$SLP_d \times NonBinding_j$				
	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT	Market	HFT-MM	MIX-MM	HFT-MIX-OTH	NONHFT
Quintile 1 (small transactions)	-0.260***	-0.302***	-0.209***	-0.204***	-0.251***	0.019	0.053	0.010	0.016	-0.011
	(-3.79)	(-4.20)	(-2.82)	(-2.92)	(-2.75)	(0.30)	(0.86)	(0.16)	(0.27)	(-0.13)
Quintile 2	-0.247***	-0.284***	-0.146*	-0.196***	-0.237***	0.037	0.060	0.030	0.032	0.015
	(-3.73)	(-3.94)	(-1.90)	(-2.63)	(-2.62)	(0.61)	(1.04)	(0.48)	(0.54)	(0.18)
Quintile 3	-0.218***	-0.217***	-0.102	-0.170**	-0.253***	0.027	0.028	-0.002	0.013	0.039
	(-3.24)	(-2.87)	(-1.21)	(-2.33)	(-2.84)	(0.43)	(0.43)	(-0.02)	(0.21)	(0.50)
Quintile 4	-0.186***	-0.179**	-0.100	-0.144**	-0.238***	0.042	0.046	0.029	0.031	0.058
	(-2.84)	(-2.27)	(-1.19)	(-2.02)	(-2.59)	(0.68)	(0.67)	(0.41)	(0.55)	(0.71)
Quintile 5 (large transactions)	-0.188***	-0.135*	-0.170*	-0.132*	-0.162*	0.024	0.003	0.031	-0.001	0.058
	(-2.71)	(-1.80)	(-1.82)	(-1.78)	(-1.83)	(0.39)	(0.05)	(0.38)	(-0.02)	(0.73)
Controls	Yes									
Stock FE	Yes									
Day FE	Yes									
Clustered SE	By Stock and Day									

Table 12 New SLP Rules: Chi-X

This table shows the results of the SLP regression estimation (see equation (5)) for Chi-X. We regress the quoted (Panel A) and the 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 until July 31, 2013) and zero otherwise (from April 1, 2013 until June 3, 2013), on dummy variable $CAC40_j$, that is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, and on interaction term between $CAC40_j$, and SLP_d. In all regressions, we control for stock and market volatility, trading volume, and market capitalization. Standard errors are clustered by stock and by day. Spreads are measured in bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris and Chi-X that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data come from the TRTH database.

	Panel A: Quoted spread			**Panel B: Effective spread**		
	(1)	(2)	(3)	(1)	(2)	(3)
$SLP_d \times CAC40_j$	-0.114	-0.181***	-0.219***	-0.116	-0.182***	-0.220***
	(-1.30)	(-2.67)	(-3.14)	(-1.33)	(-2.71)	(-3.17)
$SLP_d \times NonBinding_j$	0.009	0.084	0.087	0.009	0.084	0.086
	(0.11)	(1.42)	(1.40)	(0.11)	(1.41)	(1.39)
SLP_d	0.067	0.039		0.070	0.040	
	(1.49)	(0.88)		(1.58)	(0.91)	
$CAC40_j$	-0.141			-0.174		
	(-0.97)			(-1.20)		
$NonBinding_j$	-0.112			-0.112		
	(-0.77)			(-0.77)		
$Realized\ volatility_{j,d}$	0.217***	0.149***	0.119***	0.222***	0.152***	0.122***
	(6.88)	(8.65)	(6.48)	(7.06)	(8.83)	(6.62)
$Trading\ volume_{j,d}$	-0.058***	-0.044***	-0.045***	-0.058***	-0.046***	-0.046***
	(-3.54)	(-3.68)	(-3.26)	(-3.60)	(-3.99)	(-3.51)
$Market\ capitalization_{j,d}$	-0.011***	-0.010	-0.015*	-0.011***	-0.010	-0.014*
	(-4.46)	(-1.44)	(-1.89)	(-4.49)	(-1.41)	(-1.86)
$Market\ volatility_d$	0.019***	0.030***		0.019***	0.030***	
	(3.24)	(5.69)		(3.16)	(5.60)	
$Constant$	1.783***	1.281***	1.960***	1.826***	1.326***	1.999***
	(15.75)	(5.29)	(7.49)	(16.00)	(5.50)	(7.64)
Observations	5,548	5,548	5,548	5,548	5,548	5,548
R^2	0.427	0.828	0.842	0.441	0.831	0.845
Stock FE	No	Yes	Yes	No	Yes	Yes
Day FE	No	No	Yes	No	No	Yes
Clustered SE		By Stock and Day			By Stock and Day	

Table 13 Rebate reversal: Market-Wide Liquidity

This table shows the results of the rebate reversal regression estimation (see equation (8)). We regress the quoted (Panel A) and the 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 rules (from November 1, 2013 until December 31, 2013) and zero otherwise (from September 1, 2013 until October 31, 2013), on dummy variable $CAC40_j$, that is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index, and on interaction term between $CAC40_j$, and $Rebate_d$. In all regressions, we control for stock and market volatility, trading volume, and market capitalization. Standard errors are clustered by stock and by day. Spreads are measured in bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	Panel A: Quoted spread			**Panel B: Effective spread**		
	(1)	(2)	(3)	(1)	(2)	(3)
$Rebate_d \times CAC40_j$	0.051	0.066	0.086	0.053	0.070	0.088
	(0.86)	(1.05)	(1.32)	(0.88)	(1.09)	(1.32)
$Rebate_d$	0.007	-0.017		0.002	-0.024	
	(0.12)	(-0.27)		(0.03)	(-0.37)	
$CAC40_j$	-0.233**			-0.191*		
	(-2.17)			(-1.77)		
$Realized\ volatility_{j,d}$	0.178***	0.128***	0.110***	0.191***	0.135***	0.119***
	(3.99)	(8.16)	(6.76)	(4.25)	(8.59)	(7.32)
$Trading\ volume_{j,d}$	-0.020	-0.044***	-0.052***	-0.020	-0.044***	-0.052***
	(-1.04)	(-4.15)	(-5.04)	(-1.05)	(-4.00)	(-5.02)
$Market\ capitalization_{j,d}$	-0.010***	0.001	0.005	-0.010***	0.002	0.005
	(-4.35)	(0.12)	(0.61)	(-4.50)	(0.22)	(0.65)
$Market\ volatility_d$	0.021***	0.025***		0.018***	0.024***	
	(3.16)	(3.03)		(2.82)	(2.85)	
$Constant$	1.762***	1.042***	1.484***	1.821***	1.058***	1.482***
	(11.64)	(3.91)	(5.25)	(12.06)	(4.01)	(5.31)
Observations	5,475	5,475	5,475	5,475	5,475	5,475
R^2	0.294	0.802	0.816	0.300	0.802	0.816
Stock FE	No	Yes	Yes	No	Yes	Yes
Day FE	No	No	Yes	No	No	Yes
Clustered SE		By Stock and Day			By Stock and Day	

Table 14 Rebate Reversal: Liquidity by Trader Type

This table shows the results of the rebate reversal regression estimation (see equation (8)) for each trader-account type (HFT-MM, MIX-MM, HFT-MIX-OTHER, and NONHFT) that initiates the transaction. We regress the quoted (Panel A) and the effective (Panel B) spreads for stock j on day d on the interaction between dummy variable, $Rebate_d$, that is equal to one in the period after the implementation of the rebate reversal (from November 1, 2013 until December 31, 2013) and zero otherwise (from September 1, 2013 until October 31, 2013), on dummy variable $CAC40_j$, that is equal to one, if stock j belongs to the CAC40 index and zero, if stock j belongs to the DAX30 index. In all regressions, we control for stock volatility, trading volume, and market capitalization. For brevity, we report only specifications with both stock and day fixed effects. Standard errors are clustered by stock and by day. Spreads are measured in bps. t-statistics are reported in parentheses. ***, **, * corresponds to statistical significance at 1%, 5%, and 10%, respectively. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

	Panel A: Quoted spread				**Panel B: Effective spread**			
	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT
$Rebate_d \times CAC40_j$	0.078	0.099	0.094	0.095	0.081	0.117	0.104	0.071
	(1.04)	(1.34)	(1.26)	(1.24)	(1.08)	(1.57)	(1.40)	(0.93)
$Realized\ volatility_{j,d}$	0.104***	0.097***	0.119***	0.122***	0.107***	0.103***	0.128***	0.136***
	(5.87)	(4.97)	(6.82)	(6.46)	(6.05)	(5.28)	(7.39)	(7.24)
$Trading\ volume_{j,d}$	-0.054***	-0.057***	-0.054***	-0.068***	-0.054***	-0.057***	-0.054***	-0.071***
	(-4.44)	(-4.43)	(-4.54)	(-5.48)	(-4.49)	(-4.45)	(-4.58)	(-5.70)
$Market\ capitalization_{j,d}$	0.006	0.007	0.005	0.008	0.006	0.008	0.005	0.008
	(0.68)	(0.80)	(0.57)	(0.92)	(0.69)	(0.94)	(0.59)	(0.98)
$Constant$	1.480***	1.526***	1.503***	1.500***	1.506***	1.500***	1.502***	1.499***
	(5.00)	(4.94)	(5.00)	(4.93)	(5.12)	(4.86)	(5.05)	(4.91)
Observations	5,473	5,471	5,473	5,475	5,473	5,471	5,473	5,475
R^2	0.814	0.775	0.800	0.801	0.817	0.770	0.798	0.815
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	By Stock and Day				By Stock and Day			

Figure 1. Timeline

This figure shows the timeline of the events used in this paper. The sample period is from April 1, 2013 until December 31, 2013.

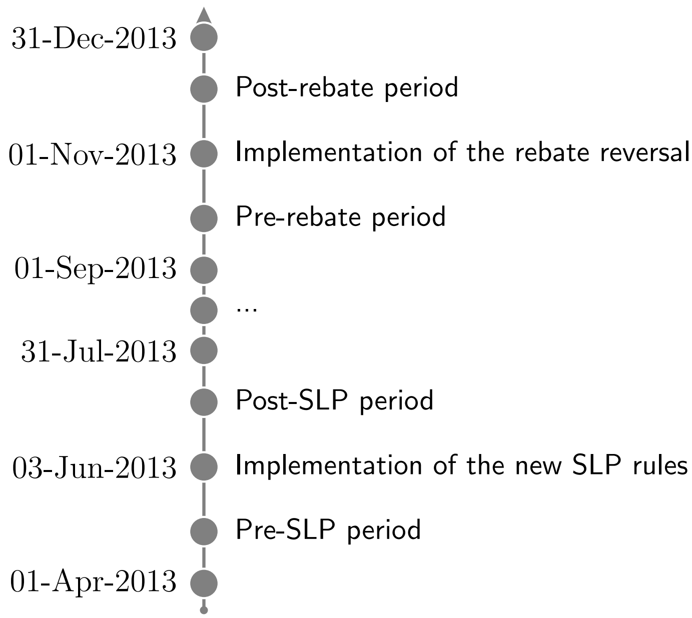


Figure 2. Number of DMMs by basket around the implementation of the new SLP rules

This figure shows the number of DMMs present in each of the four baskets of stocks in the pre-SLP period (from April 1, 2013 until June 3, 2013) and post-SLP period (from June 3, 2013 until July 31, 2013). We refer to Appendix A for the basket composition. We note that in the pre-SLP period there were seven DMMs active in the CAC40 index constituents; in the post-SLP period one new DMM joined the SLP program. Data on number of DMMs per basket is provided by AMF.

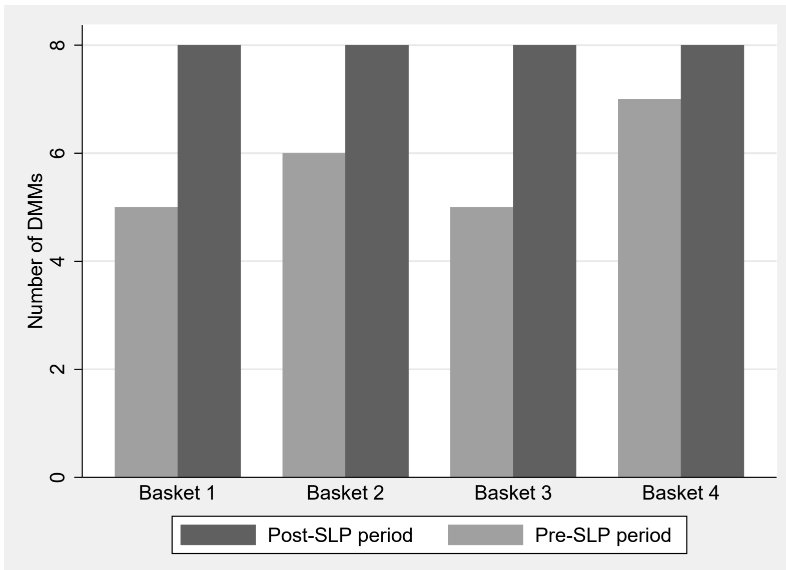


Figure 3. New SLP Rules and Capacity of DMMs

This figure shows five possible cases of changes in DMMs' capacity to provide liquidity in four baskets of stocks as a result of the new SLP rules' implementation. Cases are different from each other in terms of how many DMMs were present in all baskets or one basket only in the pre-SLP period and how many of them decide to stay/leave after the new SLP rules were implemented. We assume that all DMMs have the same total capacity to provide liquidity that is equal to one unit.

	Pre-SLP					Post-SLP			
	Basket 1	Basket 2	Basket 3	Basket 4		Basket 1	Basket 2	Basket 3	Basket 4
	Case 1 (**all DMMs** are present in **all baskets** in the pre-SLP period)								
# of DMMs present in one basket	0	0	0	0		0			
# of DMMs present in all baskets	4				⟹	4			
Total capacity	1	1	1	1		1	1	1	1
	Case 2 (**all DMMs** that were not present in all baskets in the pre-SLP period **decide to leave**)								
# of DMMs present in one basket	4	4	4	4		0			
# of DMMs present in all baskets	4				⟹	4			
Total capacity	5	5	5	5		1	1	1	1
	Case 3 (**some DMMs** that were not present in all baskets in the pre-SLP period **decide to leave**)								
# of DMMs present in one basket	4	4	4	4		8			
# of DMMs present in all baskets	4				⟹	4			
Total capacity	5	5	5	5		3	3	3	3
	Case 4 (**all DMMs** that were not present in all baskets in the pre-SLP period **decide to stay**)								
# of DMMs present in one basket	4	4	4	4		16			
# of DMMs present in all baskets	4				⟹	4			
Total capacity	5	5	5	5		5	5	5	5
	Case 5 (**all DMMs** that were not present in all baskets in the pre-SLP period **decide to stay**)								
# of DMMs present in one basket	4	0	4	0		8			
# of DMMs present in all baskets	4				⟹	4			
Total capacity	5	1	5	1		3	3	3	3

Figure 4. Trader-account types

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

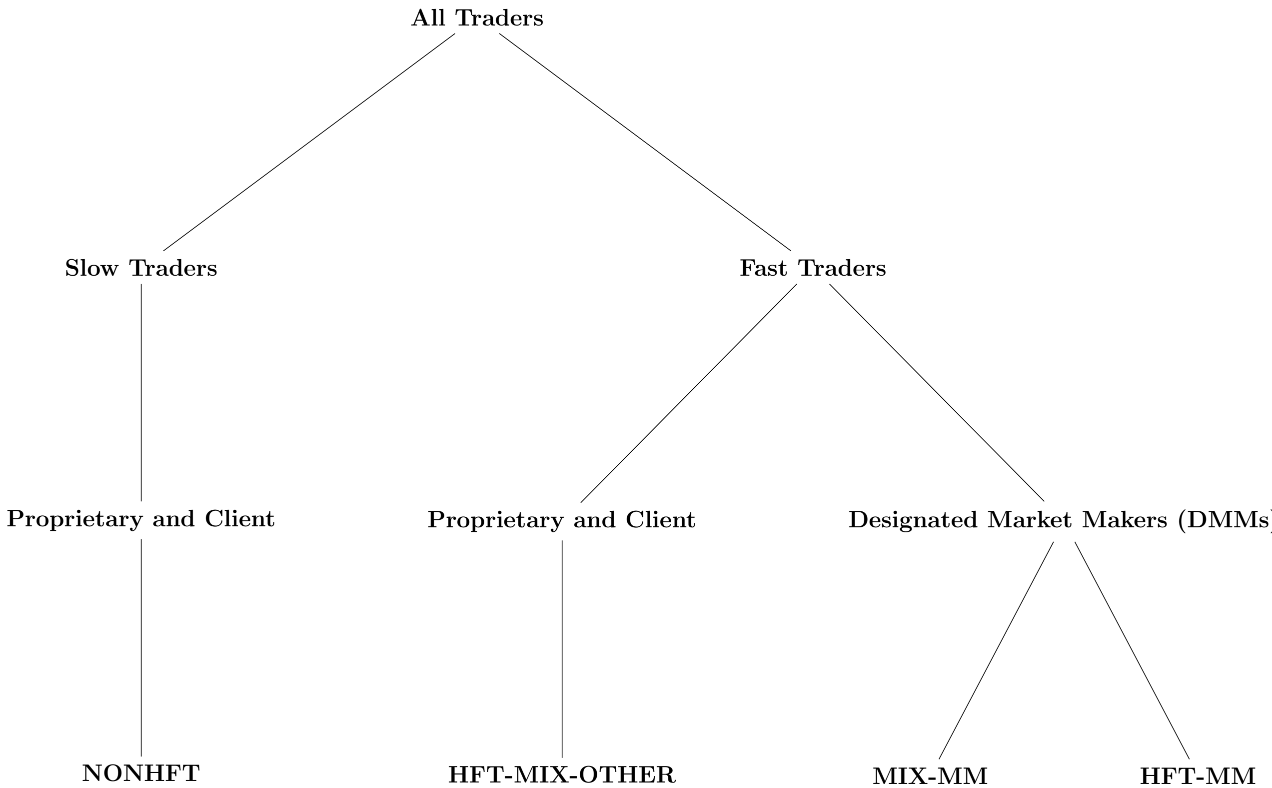
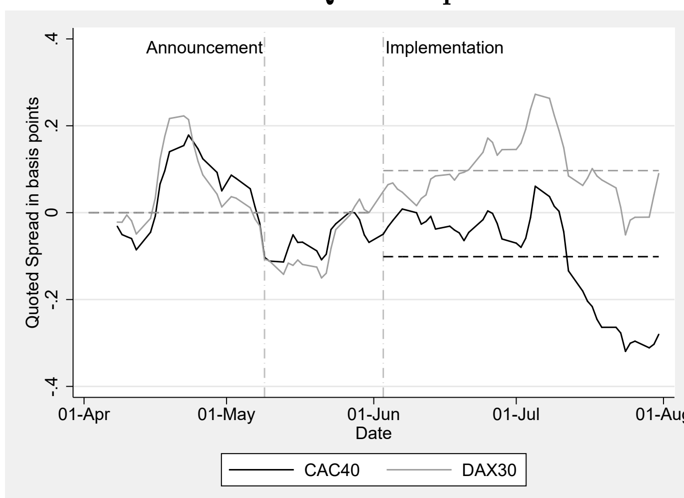


Figure 5. Quoted and effective spreads

This figure shows the weekly moving average of the market-wide share-weighted quoted (see equation (1)) and effective (see equation (2)) spreads in bps. The solid black (gray) line shows the spread dynamics for the stocks that belong to the CAC40 (DAX30). For readability, we subtract the pre-SLP average (April 1, 2013 until June 3, 2013) from both time-series. The horizontal dashed lines correspond to the pre-SLP and post-SLP averages of the spreads. The vertical dashed-dotted lines show the announcement and implementation dates of the new SLP rules. The period under consideration is from April 1, 2013 until July 31, 2013. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

Panel A: Quoted spread



Panel B: Effective spread

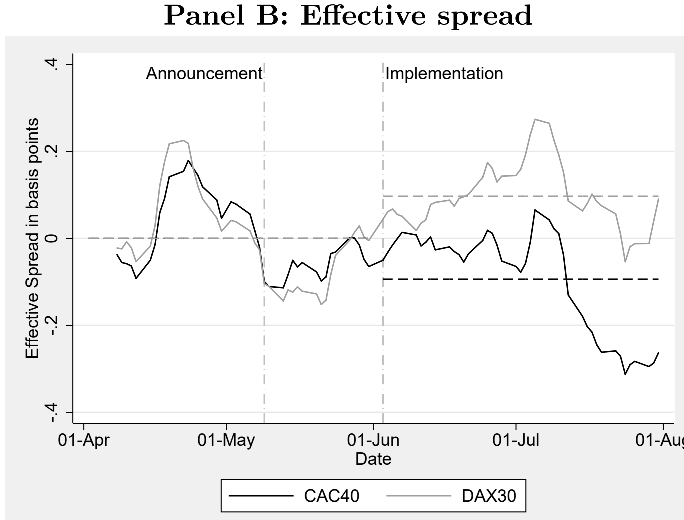
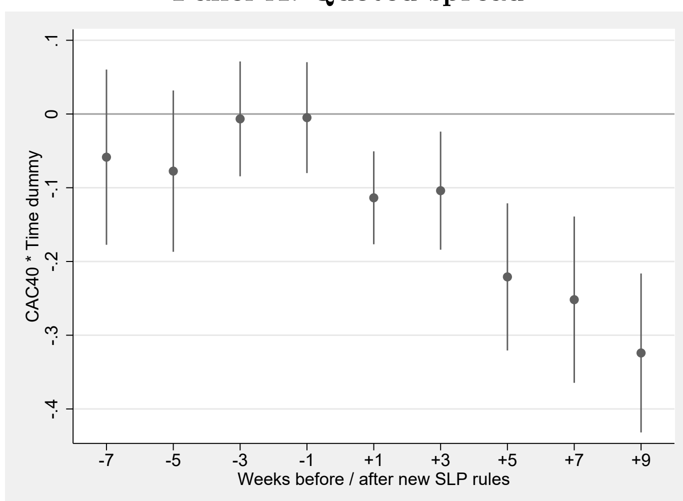


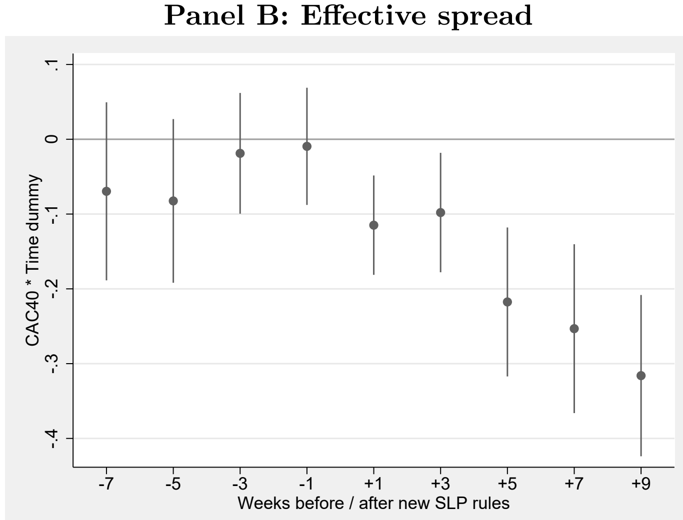
Figure 6. Parallel trends in market liquidity

This figure depicts the coefficient estimates and the confidence intervals from the regression with stock and day fixed effects of market liquidity, on the interaction between the (biweekly) time dummies and a dummy variable, $CAC40_j$, which is equal to one, if stocks belong to the CAC40 index, and zero, if stocks belong to the DAX30 index. The period under consideration is from April 1, 2013 until July 31, 2013. The sample is composed of 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index and 30 stocks that belong to the DAX30 index. Data for the French stocks come from the BEDOFIH database. Data for the German stocks come from the TRTH database.

Panel A: Quoted spread



Panel B: Effective spread



Appendix A Basket composition

In this section, we report the details of the basket composition according to the old and new SLP rules, focusing on CAC40 index constituents.

Table A1 Basket Composition

This table shows the components of the CAC40 that were used in our analysis, together with ISIN, industry, and the basket to which each stock belongs, as defined by the SLP rules in place before June 3, 2013 (Basket 2012) and after June 2013 (Basket 2013).

Name	ISIN	Industry	Basket 2012	Basket 2013
Total	FR0000120271	Energy	1	C
Accor	FR0000120404	Consumer Discr.	1	C
Sanofi	FR0000120578	Healt Care	1	C
Michelin	FR0000121261	Consumer Discr.	1	C
Schneider	FR0000121972	Industrials	1	C
Saint-Gobain	FR0000125007	Industrials	1	C
BNP	FR0000131104	Financials	1	C
STMicroelectronics	NL0000226223	Information Tech.	1	C
Credit Agricole	FR0000045072	Financials	2	C
Safran	FR0000073272	Industrials	2	C
Air Liquide	FR0000120073	Materials	2	C
Lafarge	FR0000120537	Materials	2	C
Danone	FR0000120644	Consumer Staples	2	C
Pernod Ricard	FR0000120693	Consumer Staples	2	C
Veolia Environ.	FR0000124141	Utilities	2	C
Publicis Groupe SA	FR0000130577	Consumer Discr.	2	C
Technip	FR0000131708	Energy	2	C
EDF	FR0010242511	Utilities	2	C
Legrand	FR0010307819	Industrials	2	C
Lvmh Moet Henessy	FR0000121014	Consumer Discr.	3	C
Kering	FR0000121485	Consumer Discr.	3	C
Essilor International	FR0000121667	Healt Care	3	C
Vinci	FR0000125486	Industrials	3	C
Societe Generale	FR0000130809	Financials	3	C
Renault	FR0000131906	Consumer Discr.	3	C
ENGIE	FR0010208488	Utilities	3	C
Alstom	FR0010220475	Industrials	3	C
EADS	NL0000235190	Industrials	3	C
Carrefour	FR0000120172	Consumer Staples	4	C
L'Oreal	FR0000120321	Consumer Staples	4	C
Vallourec	FR0000120354	Energy	4	C
Bouygues	FR0000120503	Industrials	4	C
Axa	FR0000120628	Financials	4	C
Cap Gemini	FR0000125338	Information Tech.	4	C
Vivendi Universal	FR0000127771	Consumer Discr.	4	C
Orange	FR0000133308	Tellecommunication	4	C

Appendix B Traders' Characteristics

In Table B1, we present the traders' characteristics and the 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. 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 26.6% of the orders submitted. Another metric of HFT activity is how many times trader inventories cross zero. We document that, as a group, HFT-MM's inventory crosses zero, on average, 20 times per stock-day. This is four times larger than the respective number for NONHFT. In terms of liquidity provision, HFT-MM contribute 29.8% to the total volume of passive execution, while MIX-MM contribute only 6.7%. The largest contribution to liquidity provision comes from voluntary liquidity provision by HFT-MIX-OTHER (50.1%). 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 7.1% more than they consume.

Table B1 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 36 stocks traded on NYSE Euronext Paris that belong to the CAC40 index. The period under consideration is from April 1, 2013 till July 31, 2013. Data for the French stocks come from the BEDOFIH database.

	French stocks			
	HFT-MM	MIX-MM	HFT-MIX-OTHER	NONHFT
# of new orders	74,496	59,608	28,967	3,675
Cancellation ratio	96.2%	97.8%	86.8%	26.6%
# of times inventory crosses zero	20	6	8	5
Liquidity provision	29.8%	6.7%	50.1%	13.3%
Liquidity consumption	22.7%	13.9%	45.9%	17.4%