JUILLET 2021

EFFECT OF SPEED BUMPS: ANALYSIS OF THE IMPACT OF THE IMPLEMENTATION OF EUREX'S PASSIVE LIQUIDITY PROTECTION ON FRENCH EQUITY OPTIONS

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This study was coordinated by the Research, Strategy and Risks Division and the Market Supervision Division. It is based on sources that are considered to be reliable but whose comprehensiveness and accuracy cannot be guaranteed. The views expressed in “Risk and Trend Mapping” are those of the authors; they do not necessarily reflect the position of the AMF.

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Effect of speed bumps: analysis of the impact of the implementation of EUREX's Passive Liquidity Protection on French equity options

Since the creation of the IEX regulated market in the United States in June 2016, the desire to "slow down the markets" has become popular with some US and European platforms. They have either already put in place or are planning to put in place mechanisms that diminish the comparative advantage of high-frequency traders. There is a lively academic debate on the benefits and costs of high-frequency trading, with some authors arguing that the increase in trading speed observed today is reaching the limits of increasing returns. A number of recent studies have highlighted the need to slow down markets in order to limit the "arms race" generated by technological competition, with the aim of replacing competition on speed with competition on price by limiting the comparative advantage of high-frequency traders.

In response to this debate, and more broadly as part of the strategy implemented by regulated markets to attract market-makers, some platforms are interested in experimenting with speed bumps, often on illiquid market segments, as a means of assessing their effectiveness before extending them to other market segments. The introduction of a speed bump on the Eurex platform provides an opportunity to assess the impact of this type of mechanism on the French equity options market.

The mechanism proposed by Eurex is asymmetrical and is motivated by the provision of "passive liquidity protection" (PLP), i.e. protection for market makers. This speed bump, by introducing a minimum delay between two orders, slows down only aggressive orders, and not passive orders, i.e. orders that cannot be immediately executed.
This mechanism targets latency arbitrage, practiced by some high-frequency players, as their technological superiority allows them to "overtake" market makers by a few microseconds before they have time to adjust their orders. If these liquidity providers integrate this possibility of being "outrun", this type of arbitrage leads to an increase in the cost of the liquidity provision and even to an exit from the order book by the latter, who are then encouraged to trade outside the order book (adverse selection phenomenon). Thus, with its passive liquidity protection mechanism, Eurex intends to generate a virtuous circle in which liquidity providers, no longer subject to latency arbitrage, would be encouraged to be more present in the order book rather than trading over-the-counter, thereby improving the liquidity level. This improvement in liquidity would ultimately enhance the attractiveness of the platform.

Initially implemented in June 2019 on French and German equity options for one year, this experiment was extended in August 2020 to all equity options traded on the platform and to options on the DAX index, i.e. more than 750 underlying equities from 10 countries. At the end of May 2021, the speed bump was also extended to options on the FTSE100 index and Eurex announced that it would cover all index options from February 2022.

Using a database containing all French equity option trades on Eurex and Euronext in 2019, the changes in liquidity on the two platforms are assessed through several econometric analyses that measure the impact on four liquidity indicators: the quoted spread, the effective spread, the market depth and traded volumes

The use of difference-in-difference method (to isolate the speed bump effect from other cyclical effects), confirms that speed bumps reduce adverse selection among passive market-makers present in the order book. A statistically significant decrease in quoted and effective
spreads is observed for options directly exposed to the mechanism (-10 and -3 basis points respectively). Market depth also increases but to a lesser extent (+€1.55). On the other hand, the effect of the speedbump is not statistically significant on the volumes traded on Eurex, a sign that this mechanism is primarily intended to impact the quality of liquidity and not necessarily to increase volumes. Moreover, options traded on both Euronext and Eurex benefited from a significant improvement in their spreads on both platforms, when compared with those traded only on Euronext. This is a sign of a possible shift of high-frequency speculators to the Paris platform, leading to an increase in competition between these players, or of a possible virtuous effect of the implementation of the

mechanism on Eurex, encouraging these same players to slow down the speed at which they place aggressive orders on Euronext. This beneficial effect of the mechanism on the liquidity of options on Euronext needs to be confirmed over time

Finally, a comparison of contracts that are only offered for trading on Eurex (which benefit from the mechanism) with those only offered on Euronext (which do not) shows that options traded exclusively on Eurex benefited only marginally from the improvement in liquidity. These options are nevertheless less liquid by their very nature, and the expected effect of attracting market-makers is consequently weaker.

Given that the Eurex mechanism is an asymmetric speed bump, this study is not comparable to the existing literature. However, its results are of the same order of magnitude as those highlighted by the empirical literature analysing the effect of symmetric speed bumps. It is also consistent with some of the current theoretical literature, which emphasises the cost of high-frequency speculators' speed bumps for slower investors.

1. CHALLENGES AND LITERATURE REVIEW

Since the creation of the IEX regulated market in June 2016, the desire to "slow down the markets" has become popular with some US and European platforms. Consequently, they have either already put in place or are planning to put in place mechanisms that diminish the comparative advantage of high-frequency traders and/or are designed to protect the liquidity offered by market makers, such as a speed bump.

Speed bumps are designed to slow down the entry of an order into the matching engine. They can take several forms:

- Symmetrical speed bumps, where the minimum delay between two orders is the same for all order types and market participants. This mechanism was implemented on the American IEX platform and is mainly used in the United States to slow down the speed of trading.
- Asymmetric speed bumps, which may or may not apply a delay depending on the type of order. The objective of these mechanisms used in Europe is to protect liquidity providers by explicitly targeting high-frequency arbitrage strategies.
- Random speed bumps, which are designed to prevent market participants from anticipating the effect of the slowdown. This particular mechanism, which can encourage duplicate orders but also reduce market participation, has only been implemented on foreign exchange markets. It is not covered in this study.

Since only traders for whom just a few microseconds can make a difference are concerned, an asymmetric speed bump mainly targets market participants who practice latency arbitrage, which involves "overtaking" or getting ahead of changes to passive orders. For example, if new information about the price of an instrument comes to light, the passive participant in the order book may wish to adjust their order to reflect this change, by cancelling their initial order and replacing it with a new one reflecting the new value of the instrument. At the same time, however, other market participants with a comparative speed advantage may try to "overtake" this order by buying (selling) the security at the old (stale) price, before the liquidity provider makes its adjustment, a strategy known as "quote sniping". This type of arbitrage is sometimes referred to as "toxic" because it leads to an increase in the cost of liquidity provision if liquidity providers include the possibility of being outrun on the bid and ask prices offered (Foucault et al., 2017). It can also lead to endless competition between market participants to invest in faster technology to update their prices. Finally, this type of arbitrage may also, for liquidity providers unable to protect themselves against this adverse selection, prompt them to widen their price ranges and provide less liquidity or even exit the market.

An ability to narrow the bid-ask spread by arbitraging markets at very high speeds can nevertheless be seen in a positive light. The benefit to the market is that it integrates information more quickly into prices and thus promotes market efficiency (Pagnotat and Philippon, 2018). Some analyses even argue that in the optimal market ecosystem, high-frequency traders (HFTs) and slower operators should coexist (Biais et al., 2015).

In Europe, the first speed bump implemented by a regulated platform is the speed bump introduced by Eurex, the German derivatives exchange, on French and German equity options (see Box 1). Launched in June 2019, the reason for introducing this asymmetric mechanism is to provide "Passive Liquidity Protection" (PLP), i.e. protection for market-makers. This speed bump only slows down aggressive orders.[1] It does not slow down passive orders (those that cannot be executed immediately). This indirectly provides additional time for liquidity providers, in particular market-makers, to update their prices by modifying or cancelling their orders to avoid the quote sniping phenomenon described above. The slowdown is 1 millisecond for options on German underlying equities and 3 milliseconds for options on French underlying equities. Since August 2020, PLP has been extended to all equity options traded on the platform and to options on the DAX index, i.e. more than 750 underlying equities from 10 countries. At the end of May 2021, the speed bump was also extended to options on the FTSE100 index and Eurex announced that it would cover all index options from February 2022[2]. Box 1 provides details of the Eurex PLP and the speed bumps in place or planned on other markets around the world.

[1] An order is said to be "aggressive" when it triggers a trade. It is therefore the last order entered in the order book before the trade, it encounters one or more passive orders and then triggers one or more trades.
[2] It will be applicable from September 2021 on index options except Eurostoxx options which will be concerned only in February 2022.

Box 1: Overview of current and future speed bump programmes

A speed bump is part of the strategy adopted by regulated markets to attract market-makers, traders and investors, not only through the implementation of market-making programmes that encourage the provision of liquidity and commercial proposals (such as lower transaction fees or clearing costs[3]), but also, for the derivatives market in particular, by modulating the size of possible off-book transactions. While some newer platforms use speed bumps as an argument to increase their uniqueness and market share, other more mature platforms seem to want to test this type of mechanism on segments of their market with lower volumes, before extending it to other segments. Lastly, calibrating the time delay appropriately seems important, as it is clearly defined by the time it takes to send and receive orders. The time delay must also be proportionate to the tick size in force on the market in question.

Eurex – Passive Liquidity Protection (PLP)

Mechanism: Aggressive orders, i.e. orders that would trigger a transaction if they entered the order book, are set aside for 1 or 3 milliseconds before being integrated into the order book. Passive orders, i.e. orders that are not immediately executable, are not affected. They are entered directly into the order book and can be processed immediately. The time delay is 1 millisecond (= 0.001 seconds) for German equity options and 3 milliseconds for French equity options.[4] The order response from the platform informs the participant whether their order is subject to the delay or not.

Scope: All French and German equity options (single underlying equity), including weekly options traded on the Eurex platform.[5]

Start of experiment: 03/06/2019 for options (another experiment was also launched on 27/05/2019 for foreign exchange products).

Duration: Initially announced as an experiment lasting a minimum of six months, Eurex announced that it would continue the experiment, and then in May 2020 extended it to all equity options traded on the platform (French, German, but also Swiss, Dutch and Italian), i.e. more than 750 options from 10 countries. In addition, option trading on the DAX index, the main German stock market, has also had an asymmetric speed bump of 1.5 milliseconds since 24 August 2020.[6] Eurex also announced, at the end of May 2021, that the speed bump was extended to options on the FTSE100 index and that it will cover all index options from February 2022.

Objective: According to Eurex, the mechanism's objective is not to slow down market trading but to increase fairness in the price discovery mechanism and to improve market functioning. Eurex considers that liquidity providers on its platform are disadvantaged by the speed of updates to their orders in the event of underlying movements, and therefore do not display their best prices in the order book. For the platform, this means wide spreads in its order book and clients who may prefer to trade off-book. With PLP, Eurex intends to generate a virtuous circle that will encourage liquidity providers to be more active in the order book (rather than trading over-the-counter), thereby increasing the average depth of the order book and narrowing the average spreads, which is an attractive factor for clients. The aim is to increase the number of clients on the order book, with the initial objective of having more liquidity offered by the market-makers.

TSX Alpha Exchange

Mechanism: An asymmetric speed bump implemented in September 2015 imposing a random delay of 1 to 3 milliseconds for orders likely to consume liquidity. However, it is possible for participants not to be affected by the mechanism by paying an additional fee.

Scope: TSX Alpha operates in the Canadian equity market.

The platform's stated goal is to attract "slow" (i.e. non-HFT) liquidity providers.

An analysis published by TSX, in December 2019[7], shows that the implementation of this mechanism allows the Exchange, compared to other platforms, to position itself in first place with the highest rate of presence at the NBBO (national best bid and offer), the largest average trade size, and the greatest share of posted volume at the NBBO. In addition, the mechanism would allow greater interaction between retail and institutional orders.

[3] Both platforms offer an integrated model where clearing is done by their associated clearing houses (Eurex Clearing and LCH SA respectively). Having multiple clearing houses clearing similar products increases the cost of clearing, as traders bringing liquidity to multiple platforms cannot "net" their positions and must use multiple clearing houses (Benos et al., 2019).

[4] Eurex explains the reason for the time difference between the two as the result of examining the reaction time and the time required for market participants' transactions to pass through its matching engine. This is related to the greater geographical distance of the underlying equity market (infrastructure located near London for French equities traded on Euronext) compared with Eurex, causing higher latency in adjusting option prices based on French equity prices.

[5] For more technical details on PLP, see the dedicated pages on the Eurex website.

[6] DAX options accounted for 33.5 million trades during 2019, or 8% of index options trading on the platform.

[7] https://www.tsx.com/resource/en/2167/tsx-alpha-market-quality-statistics-2019-12-20

IEX (Investors' Exchange LLC)
Mechanism: A symmetrical speed bump imposing a 350-microsecond (= 0.00035 seconds) delay between the request and the execution of all incoming orders on the platform, since the approval of the mechanism by the Securities and Exchange Commission (SEC), in June 2016.
Scope: IEX is a national platform and therefore allows all US stocks and ETFs to be traded in the same way as the NYSE or Nasdaq. According to the platform, its market share of US equity trading volumes was 2.15% in December 2020.

The SEC's approval was permitted by a new interpretation of Rule 611 of the National Market System regulation, which governs best execution and ensures that there is a single best bid or offer at the national level – the National Best Bid and Offer (or NBBO). It stipulates that brokers must place orders on the platform at the best price, thus ensuring that market participants have "immediate" access to the best execution. IEX therefore relies on an open understanding of Rule 611, because the SEC interprets that an intentional time delay of less than one millisecond "*may be at a* de minimis *level [...] consistent with the goals of Rule 611 [...] because such delays are within the geographic and technological latencies experienced by market participants today.*"[8] Nevertheless, the SEC is careful not to give blanket approval to such mechanisms and confirms that they must be subject to assessment by the regulator and must be "fairly applied", potentially closing the door to asymmetric speed bumps, as illustrated by the ban on the asymmetric speed bump proposed by the CBOE (see below).

London Metal Exchange (LME):
Mechanism: A symmetrical speed bump applying an 8-millisecond delay to all new incoming orders, but not applying to cancellation messages for existing orders.[9] The mechanism was introduced on 9 March 2020 for a one-year trial period.
Scope: Gold and silver futures contracts (LME Precious Metals).
Objective: Considering itself a market where liquidity is still being built, LME wishes to attract new liquidity providers, encourage market participation, increase liquidity and improve the quality of spreads.

Programmes completed, not implemented or under discussion:

NYSE American (the New York Stock Exchange's segment for small and medium-sized enterprises): Had implemented a 350-microsecond symmetric speed bump for all orders on 1 July 2017. Designed to benefit passive orders, NYSE hoped it would encourage more trading from institutional investors at the mid-price. However, NYSE's assessments proved disappointing: market share decreased by 0.6% in its segment and average daily volumes decreased by 8%. More importantly, the speed bump did not have the desired effect: average spreads increased by 40%. The platform therefore removed it on 18 November 2019.[10]

Chicago Board Options Exchange (CBOE)
Mechanism: The CBOE proposed the implementation of a 4-millisecond (= 0.004 seconds, i.e. more than 10 times that of IEX) asymmetric speed bump for the first time in the United States on its EDGA Equities platform, which in April 2020 accounted for 1.6% of volumes traded in US equities. As with Eurex, the mechanism delays orders that would be executed immediately, allowing orders that cannot be executed immediately to be added to the book without a time delay.
Opposition: The public consultation that opened in 2019[11] provided an opportunity for many market participants and competitors to publicly oppose the mechanism, and in particular its asymmetrical nature, calling into question the fairness of market participants, the right to innovation and adding complexity to the market.
The SEC rejected the proposed mechanism in February 2020,[12] finding that CBOE had not provided sufficient evidence that its speed bump "would not unfairly discriminate" against high-frequency traders' orders. It also found that the platform had not demonstrated that the proposal was sufficiently tailored to its stated purpose of improving displayed liquidity by reducing the risk of adverse selection for liquidity providers.

[8] Quote from the new interpretation of Rule 611, the "order protection rule" issued in 2016 by the SEC, allowing the approval of intentional "*de minimis*" delays to orders. This decision paved the way for the SEC to approve the introduction of the speed bump on the IEX platform. See Securities and Exchange Commission release No. 34-78102; File No. S7-03-16.
[9] See LME (2020), "Technical change to LME select FIX message processing for the LME precious market to introduce a fixed minimum delay", 20/052.
[10] See the NYSE analysis on its website.
[11] See the position documents available on the SEC website, Comments on Cboe EDGA Rulemaking.
[12] See SEC Order Disapproving Proposed Rule Change to Introduce a Liquidity Provider Protection Delay Mechanism on EDGA, Release No. 34-88261.

ICE (Intercontinental Exchange Inc.)
Mechanism: An asymmetric speed bump imposing a 3-millisecond (= 0.003-second) delay on all orders that are not modifications or passive orders.
Scope: The measure concerns gold and silver futures and could be extended to other contracts in the future.
Objective: As ICE is not the preferred platform for gold and silver futures, the aim is to allow its investors to incorporate information when market movements, mainly from CME, affect prices.
Start of the mechanism: Accepted by the Commodity Futures Trading Commission (CFTC) in May 2019, the mechanism has not yet been implemented.[13]

Asymmetric speed bumps provide an advantage to market-makers, who play a particularly important role for less liquid instruments, such as options, where the probability of both buyers and sellers being present on the order book for all contracts on offer is low. On a market driven by prices rather than orders, the role of market-makers appears to be crucial; it will be analysed here by looking at how spreads evolve after the mechanism is introduced.

The implementation of an asymmetric speed bump assumes that the presence of high-frequency traders (HFTs) is perceived to have a negative impact on liquidity. The externalities of HFTs have also been widely documented, and some economists link higher speeds to more volatile prices, highlighting the role of HFTs in "flash crashes" (e.g. Kirilenko et al., 2017). Modelling the behaviour of HFTs highlights the possibility that they increase the instability of liquidity levels (Bongaerts et al., 2016) and discourage slower traders from submitting orders, thereby reducing trading (Hoffmann, 2014). More broadly, the increase in HFT speed appears to have reached a level where its benefit on improving the information available is diminishing. Baldauf and Mollner (2020) theoretically model the trade-off currently observed in markets with increasing HFT speed: faster speed allows HFTs to anticipate orders more effectively and reduce the price ranges offered (positive effect) but decreases the incentive to obtain and incorporate information into market prices, as informed traders cannot trade before HFTs, reducing the information contained in prices (negative effect).

Both conclusions of the academic literature can be understood in the differentiation practiced by Budish et al. (2015), who separate the activities of HFTs into two types of trading: high-frequency market making, which provides liquidity and is useful to investors; and high-frequency speculation, which is detrimental to investors because it increases the cost of liquidity in the market. As seen above, the possibility of being "overtaken" and outrun may prompt liquidity providers to increase their spreads in order to minimise their losses, or even to exit the order book and offer liquidity outside the order book (adverse selection).

In Budish et al.'s modelling, an environment with two or more HFTs is detrimental to market liquidity because this "high-frequency speculation" activity then increases, causing liquidity providers to build the cost of their adverse selection into the price of the liquidity they provide. An empirical analysis on Swedish data from 2009 to 2010 (Breckenfelder, 2019) confirmed this theoretical model. It found that competition between HFTs increases their high-frequency speculation activity by 11%, deteriorating liquidity and increasing short-term volatility.[14]

The competition between HFTs ultimately results in an "arms race", where participants invest heavily in technologies that allow them to gain speed and improve their chances of success in these speculative races. Aquilina, Budish and O'Neill (2020) suggest that these speculative races have a "cost" to the UK market. In a recent study, the UK's Financial Conduct Authority (FCA) found that these races[15] are very common, accounting for 22% of daily trading volume on the equity market. On average for FTSE 100 stocks, there were 537 latency arbitrage

[13] See the CFTC decision Submission No. 19-119.
[14] Among the indicators studied, the average bid-ask spread increased by 5%, while the price impact, which measures the execution cost incurred by a transaction, increased by 23%.
[15] The authors define a "race" as a situation where several traders send messages to the exchange at approximately the same time, and only one can "win". For example, if there is a passive sell order at €100.01 and two HFTs send buy orders at €100.01, one of these HFTs will win and the other will lose. An alternative scenario is where there is a passive sell order at €100.01, an HFT sends a buy order at €100.01 and the trader with the passive sell order sends a message to cancel that sell order (because, for example, the price rises and the trader no longer wants to sell at €100.01). Only one of these messages will win: either the HFT buyer will win (and the passive trader will lose), or the passive seller will win by managing to cancel their order (and the HFT buyer will not be able to complete their transaction).

races per day (one per minute) over the 44 trading days studied in 2015. The winner typically beats its competitor by just 5 to 10 microseconds. The cost of these races, defined as the ratio of daily race profits to daily trading volume, is 0.42 basis points (0.0042%), equivalent to £60 million for the UK market or $5 billion in total if extrapolated to other global markets. This cost is the additional cost of liquidity paid by those market participants who do not practice latency arbitrage. The winners and losers of these "races" are overwhelmingly the same HFTs.[16] The authors show that a market structure without these races would reduce the effective spread, i.e. the cost of liquidity for investors, by 17%.
The AMF had previously analysed the activity of the main HFT players on the Paris equity market from November 2015 to July 2016, also highlighting their dual role. It pointed out that while these HFTs are an important support for liquidity in ordinary times, they also account for a significant share of aggressive orders consuming liquidity, particularly during periods of higher volatility (AMF 2017).[17]

Where externalities appear to be too great – in the form of an estimated high cost of liquidity or the adverse selection of market makers who leave the order book as a result – one way of reducing high-frequency speculation, without limiting high-frequency market making, may be to give the liquidity provider a time advantage to prevent it from being "overtaken".[18] An asymmetric speed bump can be used to delay aggressive orders, giving the liquidity provider time to review its prices (even if it does not have high-speed technology) while being protected by the delay imposed on incoming orders. This may ultimately encourage the liquidity provider to post more competitive prices on the order book. On the other hand, it offers a free option to market makers who are then able to modify orders already in the book and can be compared, in a way, to that practice used on some foreign exchange markets, known as "last look", which allows market-makers to change their minds about whether to trade, by delaying or rejecting the transaction, when prices change.

Baldauf and Mollner (2020) theoretically model the impact of implementing an asymmetric speed bump similar to the one implemented by Eurex, slowing down only aggressive orders and not passive orders. They conclude that it improves market functioning. In their model, the asymmetric speed bump eliminates liquidity providers' expectations of the quote sniping mechanism, allowing them to maintain an incentive to change their passive orders as soon as new information arises. They therefore contribute to high-frequency market making, keeping the proposed price ranges tight and the information contained in the prices at the same level.

The implementation of a speed bump does not eliminate the interest in investing in faster systems, since the first agent crossing the speed bump will be able to execute their order. The speed advantage is therefore not eliminated (Budish et al., 2015). Nevertheless, it is reduced, as Khapko and Zoican (2019) show in their testing on simulated data of the Budish et al. (2015) modelling. They estimate the decrease in technological investment to be 20% after the implementation of an asymmetric speed bump; they observe no change in the case of a symmetric speed bump.

As the speed bumps implemented so far have been mainly either symmetrical or random, the empirical literature does not yet, to the best of our knowledge, offer any conclusions on this type of asymmetrical speed bump. Analysis of the implementation of a symmetrical speed bump on the American IEX platform carried out by the SEC showed that it improved market liquidity by reducing adverse selection and tightening price ranges (Hu, 2019). By analysing two months of transactions and orders following the introduction of the speed bump on the US equity market, the

[16] The fact is that the winners and losers in these races are mostly the same firms; the gains and losses are therefore highly concentrated. By separating the first winning message (winning order) and the losing message (losing order) for each race, they found that the top three firms make up 55% of the winning orders and 66% of the losing orders. For the top six companies, the figures were 82% and 87% respectively.
[17] Over the period studied, HFTs were present more than 90% of the time at the best limit (best price offered for buying or selling) and represented on average 80% of the quantity present at the three best limits on the order book. On average, HFTs consume more liquidity than they provide, with a ratio of effective liquidity contributed (passive trades) to liquidity consumed (aggressive trades) equal to 53% on average over the period.
[18] Note that latency arbitrage can also be prevented by other means. For example, the Aquis platform has not allowed HFTs to take liquidity through "market" orders since 2016. As a result, only the part of the order flow arising from buyer exposure can be used to withdraw liquidity from the platform. Other options are also discussed in the academic literature, such as changing the structure of transaction fees to incentivise certain classes of traders or certain transactions, applying fees to order cancellations, or introducing regular auctions to replace continuous trading. See, for example, Derchu et al. (2020) "AHEAD: Ad Hoc Electronic Auction Design".

author observed a decrease in proposed and effective spreads of 1 to 2 basis points (-3%). Using a difference-in-difference analysis, he also finds that the impact of the speed bump decreases the spreads by 1.8 to 2.9 basis points. More broadly, the increase in IEX market share suggests that markets with this type of mechanism remain attractive to participants. Finally, the random speed bump proposed by the Canadian TSX Alpha platform seems too specific[19] to be able to extend the conclusions of the empirical analysis of Chen et al. (2017) to other speed bumps. They observe, however, that random protection of liquidity providers leads to continued high-frequency market making and to an increase in proposed and effective spreads of 0.5 basis points.

2. IMPACT OF THE IMPLEMENTATION OF THE EUREX SPEED BUMP ON FRENCH OPTIONS

2.1. DATA USED AND MAIN INDICATORS

The data used comes from the Refinitiv database,[20] which covers a very extensive range of transactions in French options, regardless of the transaction location (see Table 1). This database is made up of all trades in equity options under French jurisdiction[21] carried out on Eurex and Euronext that were recorded in Refinitiv in 2019. To conduct the analysis, this data was cross-referenced with data from the Financial Instruments Reference Data System (FIRDS) to obtain all the characteristics of these options. It was also supplemented by equity market transactions from Euronext received directly by the AMF.

A more complete presentation of the database and its level of coverage of the volumes traded on the two platforms is available in Annex 1. This database is also useful for observing the characteristics of the options market on the two platforms.[22] Table 1 presents the coverage and characteristics of the database created, which covers a significant period before and after the introduction of the speed bump on Eurex (five months before and seven months after), for all contracts for underlying equities under French jurisdiction.
The options contracts traded in 2019 cover 105 French underlying equities, including:

- 63 offered on both Eurex and Euronext
- 25 offered only on Euronext (a total of 88 on Euronext)
- 17 offered only on Eurex (a total of 80 on Eurex).

[19] The speed bump introduced in 2015 consists of a random delay of 1 to 3 milliseconds for all market participants, except for certain traders who can pay an additional fee to be immune to the speed bump. At the same time as the speed bump, TSX Alpha introduced a minimum order size above which limit orders are exempt from it, along with changes to its order execution fee structure.
[20] While the Financial Instruments Reference Data System (FIRDS)and the regulatory reporting of trades on Euronext sent to the AMF were used, the reporting of trades on regulated markets from MiFIR was not used here due to the quality of the data available on the market and the period considered.
[21] "French equity options" in this study refers to equity options under French jurisdiction (as defined by Article 16 of Delegated Regulation of 28/07/2016 supplementing MiFIR and concerning transaction reporting), i.e. whose most liquid market (as defined by the same Article) is located in France. The most liquid market for equities determines the authority to which transactions in associated options are reported, thereby enabling the AMF to receive details on trades in equity options whose most liquid market is in France, regardless of whether the options are traded on Eurex or Euronext.
[22] This analysis is available in the companion study entitled "Characteristics of the French Equity Options Market".

Table 1: Overview of the database used

Source	Indicators		Euronext	Eurex
Eurex, Euronext	Volumes 2019		24 839 147	25 325 704
Database	Volumes 2019		24 749 541	21 362 304
Database	% volumes studied		99,5%	84,4%
Database	Total nb transactions 2019		351 218	401 085
Database	Avergae nb transactions /day		1 379	1 586
Database	Nb instruments traded 2019		23 130	25 967
Database	Average nb instruments /day		569	653
Database	Total nb underlying proposed		87	80
Database	Nb underlyings offered only on the platform		25	17
Database	Average traded volume per trade		70	53
Database		Bloc	1 794	1 455
Database		Trade	24	23
Database	Average daily volumes (in nb)		97 110	84 436
Database	Median daily volumes (in nb)		92 033	83 265

Note: Traded volumes[23] represent the number of French equity options contracts traded and are not multiplied by 100.
Source: Refinitiv, AMF calculations

Table 1 confirms that the options market is characterised by a very large number of different instruments (over 23,000 on Euronext and 25,000 on Eurex), few of which are actually traded every day, and a low average number of daily transactions (1,379 on Euronext and 1,586 on Eurex). For comparison, in 2019 on Euronext, underlying French equities were traded on average more than 323,000 times daily.
The database created provides the price and quantities traded for each transaction. It also contains the prices and quantities available at the best limit for each transaction, for the entire scope of the analysis. It therefore provides an insight into changes in liquidity. However, as it provides no order data,[24] it is more difficult to assess changes in the quality of the price formation process. Furthermore, the database does not provide details on who is trading to be able to analyse whether HFTs are present.

The indicators studied in this section only include on-book transactions. The options market is characterised by a large number of contracts traded outside (or "off") the order book, mainly in the form of "blocks" of traded lots.[25] On Euronext, 67% of option volumes traded were off book in 2019, mainly in the form of "blocks" of an average of 1,794 option contracts. On Eurex, 55% of volumes were traded off book, with blocks of an average of 1,454 contracts. These transactions are not included in the following analysis, as they are not affected by the speed bump. Nevertheless, in order to observe changes in volumes between the two platforms, a variable calculating the proportion of block trades has been created and tested. Furthermore, the few trades for which the best buy/sell spread is not fully reported, trades with abnormal volumes (greater than twice the proposed buy and sell depth), and options with a strike price of one cent are excluded from the analysis.

Among the various indicators calculated, four liquidity indicators are considered: quoted spread, effective spread, market depth available at the best limit and volumes traded. Each of these is described in more detail below:

- The **quoted spread** is the bid-ask spread displayed and the best price available at the time of the trade. It is calculated by dividing the difference between the ask and the bid price by the mid-price. This quoted spread is normalised by the mid-price to obtain a comparable view between instruments. This is the relative spread, and its average over all securities gives a relevant measure of the overall spread of the market studied. This

[23] A trade consists of the purchase or sale of one or more option lots: in most cases, one lot gives the right to buy or sell the equivalent of 100 equities. Thus, "volumes" are the number of lots traded and are not multiplied by 100 unless otherwise stated.
[24] The AMF has order data for options listed on Euronext but not on Eurex. As a result, obtaining this data requires European cooperation if misconduct is suspected.
[25] Blocks are large transactions (above a threshold set by the platform), usually comprising a large number of contract lots, from 50 to several thousand.

indicator is strongly influenced by liquidity providers trying to be present in the order book at competitive prices.

- The **effective spread** at each trade is a more accurate approximation of the cost of liquidity actually paid by investors at the time of a trade. It is equal to twice the absolute value of the difference between the transaction price and the mid-price. Note that this effective spread is also normalised by the mid-price to obtain a comparable view between instruments and multiplied by two to be comparable to the quoted spread. It is also weighted by the volume of the trade when calculating its daily average value (M being the number of transactions observed for contract *i* on day *t*).

$$Effective\ spread_{it} = \frac{1}{\sum_{d=1}^{M} Volume_d} \sum_{d=1}^{M} \left| 2 * \left(\frac{(Price_d - mid\ price_d)}{mid\ price_d} \right) \right| * Volume_d$$

  The effective spread at each trade should not really be different from the quoted spread most of the time. The effective spread is only larger than the quoted spread when the trade size exceeds the quantity available at the best limit. On the options market, larger volume trades, which would exceed the best limit offered, can be expected to take place outside the order book.

- The **market depth** at each trade is the quantity available at the best limit at the time of the trade. It is expressed in euros and is equal to the sum of the quantity available at the bid price multiplied by the best bid price and the quantity available at the ask price multiplied by the best ask price, divided by two. This indicator is a way of quantifying the effective passive presence of market participants in the order book.
  An improvement in the liquidity offered following the introduction of speed bumps will be marked by an increase in the quantity offered at the best limits with a constant (or decreasing) spread or by a decrease in the spread with a constant (or increasing) market depth. However, if the presence of adverse selection persists, market depth should decrease as market-makers may choose to offer less liquidity by increasing spreads or even withdrawing from the order book to avoid being "overtaken" during the speculative runs described in section 1.

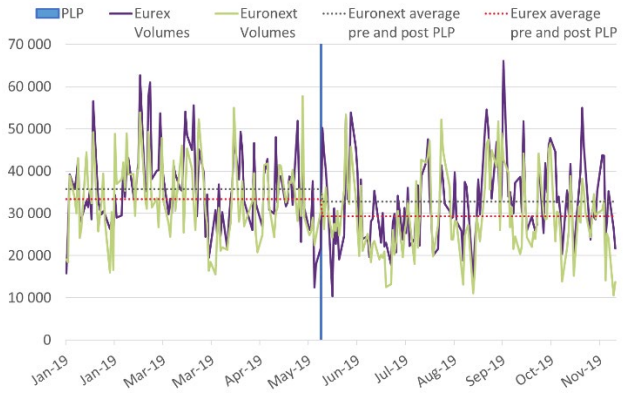
- The **volumes traded** indicator reflects the amount traded during the transaction. It is a simple indicator for measuring market activity.

It should be noted that the two indicators *quoted spread* and *market depth* can only be calculated here for each transaction and not by factoring in their changes throughout the session. Nevertheless, the small number of trades observed on the options markets suggests that the indicators available to us are still representative of how they change throughout the session. Analysis of the changes in transaction prices per contract during the day shows that 67% of price changes are zero on Eurex (71% on Euronext). This is mainly due to the fact that certain contracts are only traded once on the same day[26] or do not display a price change when they are traded more than once. The spreads displayed at each trade therefore seem to be a good proxy for the spreads displayed continuously during the day.

The main indicators on both markets during 2019 do not show any major change after the implementation of the speed bump on Eurex in June 2019. Daily trading volumes on both platforms decreased slightly during the second part of the year on both platforms (-7% daily volumes on Eurex and -11% on Euronext, see Figure 1). The spreads show that Eurex has a liquidity advantage, with lower average spreads (see Figure 2), which tend to decrease after the implementation of PLP, unlike Euronext. While there is no significant change in the distribution of the number of open positions in the second half of the year, depth increases sharply on both platforms from September 2019 onwards (see Figures in Annex 2). This underscores the importance of an econometric analysis that does not take into account this change, which is probably linked to other factors, so that the effect of the speed bump can be isolated.

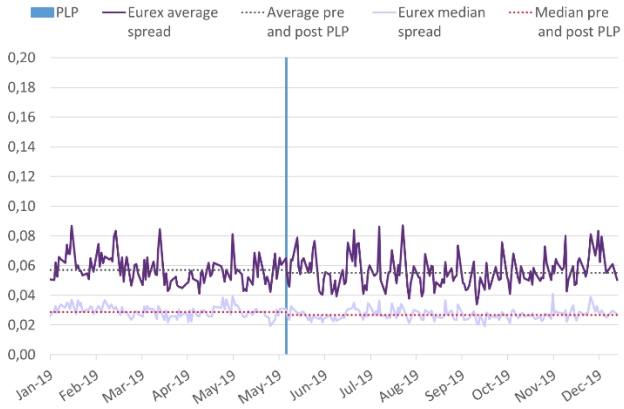
[26] Some of these contracts are traded several days a year, but with only one daily trade.

Figure 1: Daily volumes from the order book on Eurex and Euronext



Source: Refinitiv, AMF calculations

Figure 2: Average and median daily spreads on Eurex



Source: Refinitiv, AMF calculations

To measure the impact of Eurex's implementation of the speed bump on changes in liquidity in the French equity options market, we propose (i) an initial analysis of changes in liquidity on each of the platforms after implementation of the mechanism (section 2.2) and (ii) an estimate of the impact of the speed bump on French equity options traded on Eurex and Euronext, using several difference-in-difference analyses (section 2.3).

2.2. ANALYSIS OF CHANGES IN LIQUIDITY ON EUREX AND EURONEXT AFTER IMPLEMENTATION OF THE MECHANISM

An initial series of regression analyses is proposed to compare the significance of the changes observed on Eurex and Euronext before and after the implementation of PLP on Eurex, since French equity options are traded almost equally on these two platforms but only one introduced the mechanism. The objective is therefore to measure the change in average liquidity on each of the markets before and after Eurex implemented PLP.

On Eurex, the expected effect of implementing the PLP is a reduction in the presence of HFTs and an increase in the liquidity offered by market-makers on the platform, resulting in a reduction in spreads and/or an increase in available depth and/or volumes trades. On Euronext, the expected effects on the liquidity offered and on volumes traded are more difficult to predict. If implementing PLP on Eurex causes HFT activity to shift to the Paris-based platform, the effects could be not only an increase in volumes traded, but also an increase in related adverse selection, which would then increase spreads and/or decrease the average depth available.

This liquidity is assessed by analysing changes in quoted spreads, effective spreads, market depth and volumes traded (the last two on a logarithmic scale). The characteristics of a contract can nevertheless affect the level of liquidity. As the literature shows, the price level of the contract, its maturity and its "moneyness" (the absolute value of the difference between the option's strike price and the price of its underlying equity at the end of the day) can have a significant impact on the level of trading. The volumes of options traded have been shown to be concentrated in options with short maturities and whose strike price is closest to the price of the underlying equity (Cho and Engle, 1999).[27] Furthermore, contracts with the highest volumes traded tend to have narrower spreads (Mayhew, 2002). Similarly, the level of liquidity of an option can also be influenced by the characteristics of its underlying asset, notably the market capitalisation and trading volumes of the underlying equity and its degree of

[27] This is because the closer the expiration date, the easier it is to understand the price and volatility of the underlying equity and decide whether or not it is worth exercising the option. See the companion study entitled "Characteristics of the French Equity Options Market". Moneyness is calculated daily as the closing price of the underlying equity divided by the strike price of the option, as a percentage.

volatility. All these variables that may affect the degree of liquidity of the market under study are therefore included in the regression as control variables.[28]

The simple-difference model can be written as follows:

$$Indicator_{it} = \propto_i + \beta_1 PostPLP_{it} + \beta_2 X_{it} + \varepsilon_{it}$$

where $Indicator_{it}$ is the average liquidity indicator observed at date t for contract i, i.e. quoted spread, effective spread, market depth or volumes traded; $\propto_i$ is a fixed effect per contract, which captures the systematic effects that affect each of the options; $PostPLP_{it}$ is a binary variable equal to 1 after implementation of the speed bump; and X_{it} is a matrix gathering all the control variables described above, calculated on a daily basis for each contract and its underlying equity.

A statistically significant coefficient β_1 implies an effect on the average liquidity of the market concerned after implementation of the speed bump on Eurex. This model is estimated successively for contracts traded on Eurex and then for contracts traded on Euronext for 2019. The results of these regressions are presented in Table 2.

Table 2: Measure of the impact on liquidity on each platform

	EUREX					EURONEXT				
	Spread	Eff spread	Market depth	Volumes	Pct Bloc	Spread	Eff spread	Market depth	Volumes	Pct Bloc
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
PostPLP	**-0.0074*** **	**-0.0071*** **	**0.0430*** **	**0.0380*** **	**-0.0244**	**-0.0034***	**-0.0010**	**0.0151*** **	**0.0062**	**0.0191**
	(0.0011)	(0.0011)	(0.0045)	(0.0094)	(0.0269)	(0.0019)	(0.0012)	(0.0033)	(0.0097)	(0.0249)
Moneyness	0.0930***	0.0896***	-0.7936***	-0.9659***	0.2890*	0.1367***	0.0729***	-0.5582***	-0.7324***	-0.0536
	(0.0052)	(0.0053)	(0.0218)	(0.0452)	(0.1605)	(0.0084)	(0.0055)	(0.0147)	(0.0434)	(0.1534)
Price	-0.1691***	-0.1696***	0.8740***	-0.2119***	0.0342	-0.3293***	-0.1390***	0.9463***	-0.0666***	0.0289
	(0.0008)	(0.0008)	(0.0034)	(0.0070)	(0.0211)	(0.0014)	(0.0009)	(0.0025)	(0.0073)	(0.0201)
Maturity	0.00003***	0.00003***	-0.0008***	-0.0002***	0.0004**	0.0001***	0.00004***	-0.0014***	-0.0002***	0.00002
	(0.00001)	(0.00001)	(0.00003)	(0.0001)	(0.0002)	(0.00001)	(0.00001)	(0.00002)	(0.0001)	(0.0002)
Capi_under	-0.1308***	-0.1313***	0.2016***	0.8591***	-0.0135	0.0114	0.0117	-0.1883***	-0.0171	0.2284
	(0.0114)	(0.0116)	(0.0474)	(0.0982)	(0.3368)	(0.0179)	(0.0116)	(0.0313)	(0.0923)	(0.3129)
Volumes_under	0.0366***	0.0381***	-0.0829***	0.2928***	0.1081***	0.0662***	0.0288***	-0.0652***	0.1914***	-0.0334
	(0.0015)	(0.0015)	(0.0061)	(0.0126)	(0.0329)	(0.0025)	(0.0016)	(0.0044)	(0.0131)	(0.0339)
Volat_under	0.00002	0.0009	-0.0240***	0.0198	0.0141	-0.0041	-0.0025	0.0105**	0.0324**	0.0173
	(0.0016)	(0.0016)	(0.0065)	(0.0134)	(0.0357)	(0.0028)	(0.0018)	(0.0048)	(0.0143)	(0.0384)
Observations	151,217	151,217	151,217	151,217	3,174	132,697	132,697	132,697	132,697	3,248
Fixed effect	Contrat	Contrat	Contrat	Contrat	Contrat	Contrat	Contrat	Contrat	Contrat	Contrat
Adjusted R^2	0.6043	0.5926	0.7061	0.2913	0.2765	0.6386	0.4578	0.8645	0.2222	0.2342

*Note: *, ** and *** represent statistical significance at the levels of 10%, 5% and 1% respectively.*
Eff spread = effective spread, Capi_under, Volumes_under, Volat_under = respectively capitalisation, volumes, volatility of underlying equities.
Source: Refinitiv, AMF calculations.

The change in liquidity appears statistically significant on Eurex after implementation of the speed bump, with a limited impact on most of the explained variables. The decrease in both spread and effective spread is -0.7 basis points (bps) on this platform after implementing PLP. Market depth increases slightly (+€1.10 compared with an average daily depth of €130 in the first half of the year on the platform, see Figure 5 in the Annex).

[28] Volatility is calculated over 10 rolling days, and most of the control variables are converted to logarithms to linearise the relationship (price level, volumes, capitalisation and volatility of the underlying equity).

On Euronext, only average market depth is affected after the mechanism is introduced (+€1.03, compared with an average daily depth of €70 in the first half of the year, see Figure 6 in the Annex). The impact on spreads, however, is not significant[29].
Lastly, while the volumes increased slightly on Eurex, the change is not significant on Euronext.

2.3. ANALYSIS OF THE IMPACT OF THE SPEED BUMP ON EUREX AND EURONEXT

Using the difference-in-difference method provides the means to isolate the sole effect of the practice in question from all those effects that may have influenced each of the variables of interest. In this case, it means that the effect of the speed bump itself can be isolated from the market trends observed during the period, as these may be linked to other unknown factors. It therefore provides a more accurate measure of the effect on market liquidity caused by implementing the speed bump.

This method consists of comparing, before and after implementation of the mechanism (the treatment), groups of comparable options that are either exposed (treatment group) or not (control group) to the mechanism.
It assumes that, in the absence of the speed bump, liquidity would have behaved identically for both groups (parallel trend hypothesis). The econometric analysis therefore captures the effect of the PLP mechanism by measuring the difference between what was observed (i.e. what happened to the option group exposed to the mechanism) and the counterfactual (what happened to the control group not exposed to the mechanism).[30]
As the speed bump is implemented on all French equity options traded on Eurex, an initial analysis aimed at evaluating the effect of the speed bump on all French equity options is proposed, comparing the observed liquidity variables of French equity options on Eurex (treatment group) with those on Euronext (control group). However, this approach assumes that implementing the mechanism on Eurex had no impact on options traded on Euronext (i.e. no carry-over effect). In fact, the results presented in section 2.2 show that, while volumes did not change significantly on Euronext, the depth of trading increased slightly after the mechanism was implemented, thus calling into question this assumption of no carry-over.[31]
Consequently, in order to confirm the robustness of the first estimate, two other difference-in-difference estimates are proposed on a more limited scope: the first considering only options offered for trading on Euronext[32] and comparing them with options traded on both Eurex and Euronext[33], and the second comparing contracts that are only offered for trading on Euronext with those offered exclusively for trading on Eurex.

The three estimates are based on the same variables of interest considered in the previous regressions: spreads, effective spreads, market depth and volumes traded (the last two on a logarithmic scale). Furthermore, to take into account possible differences in individual observable characteristics between the two groups, control variables on the options themselves (price level, maturity, moneyness) and on the characteristics of the underlying equities (capitalisation, traded volumes and volatility of the underlying equities' closing prices) are added in the same way.

The difference-in-difference model can be written as follows:

$$Indicator_{it} = \propto_t + \beta_{post}\text{PostPLP} + \beta_{speed}\text{Speedbump} + \beta_{did}\text{PostPLP} \times \text{Speedbump} + \beta_4 X_{it} + \varepsilon_{it}$$

[29] Throughout this document, the term "significant" refers to the concept of statistical significance, i.e. when the estimated coefficient is significant at an error level of 5% or less.
[30] See, for example, Carl and Krueger (1994) on the minimum wage increase in New Jersey in 1992. To work, the method requires that the two groups behave identically before the treatment is implemented. This does not mean that the levels of the variables on which the effect of the treatment is measured must be equal, but rather that they move in parallel during the pre-treatment period – see the parallel trend graphs in the Annex.
[31] The ideal configuration would be to compare French equity options traded on Eurex with equity options of another nationality comparable to French options and traded on Eurex but not subject to PLP. However, this would require access to transactions in these other options over which the AMF does not have jurisdiction.
[32] An option is considered to be available only on Euronext when no contract on that option's underlying equity is available on Eurex (and vice versa for options available only on Eurex).
[33] In this case, the options are on the same underlying and provide the same exposure, but in practice they are not fungible.

where $Indicator_{it}$ is the indicator observed at date t pour contract i, i.e. quoted spread, effective spread, market depth or volumes traded; $\propto_t$ is a fixed effect per date, which captures the systematic effects that affect all options on each day t; X_{it} is a binary variable equal to 1 after implementation of the speed bump; *Speedbump* is a binary variable equal to 1 if the contract is affected by the speed bump (i.e. traded on Eurex); and is the set of control variables, calculated on a daily basis for each contract and its underlying equity.

The coefficient of interest here is β_{did}, which captures the isolated effect of the mechanism. When the coefficient is statistically significant, it means that the two groups evolutions are no longer parallel after implementation of the mechanism and that exposure to the speed bump has had a significant effect on the explained variable of the treatment group compared with the control group.

Table 3 presents the results from the first estimate that considers all French options (covering the 105 underlying equities). It compares the options traded on Eurex (80 underlying equities) with those traded on Euronext (88 underlying equities).

Table 3: Difference-in-difference model, all French equity options

	Spread	Eff spread	Market depth	Volumes
	(1)	(2)	(3)	(4)
Did	**-0.1032*** **	**-0.0329*** **	**0.1899*** **	**-0.0342**
	(0.0055)	(0.0039)	(0.0136)	(0.0290)
Speedbump	-0.1432***	-0.0567***	0.1139***	0.0505**
	(0.0041)	(0.0029)	(0.0101)	(0.0214)
Post	0.7495***	0.3512***	-0.5270***	-
	(0.0069)	(0.0049)	(0.0171)	(0.0365)
Maturity	0.0001***	0.0001***	-0.0003***	-
	(0.000004)	(0.000002)	(0.00001)	(0.00002)
Moneyness	0.1605***	0.0984***	-0.3910***	-
	(0.0026)	(0.0019)	(0.0065)	(0.0138)
Price	-0.1969***	-0.1205***	0.8866***	-
	(0.0006)	(0.0004)	(0.0014)	(0.0031)
Capi_under	-0.0313***	-0.0083***	0.1258***	0.1290***
	(0.0008)	(0.0005)	(0.0019)	(0.0040)
Volumes_under	-0.0732***	-0.0445***	0.4901***	0.2737***
	(0.0010)	(0.0007)	(0.0024)	(0.0051)
Volat_under	0.0728***	0.0434***	-0.2705***	-0.0034
	(0.0011)	(0.0008)	(0.0027)	(0.0057)
Observations	283,072	283,072	283,072	283,072
Adjusted R^2	0.37	0.28	0.66	0.07
Fixed effects	Day	Day	Day	Day

*Note: *, ** and *** represent statistical significance at the levels of 10%, 5% and 1% respectively.*
Eff spread = effective spread, Capi_under, Volumes_under, Volat_under = respectively capitalisation, volumes, volatility of underlying equities.
Source: Refinitiv, AMF calculations.

Implementing the speed bump had an effect on the liquidity of the securities concerned, with a significant impact on spreads, effective spreads and the average depth available. The mechanism caused a decrease in spreads (-10 bps), effective spreads (-3 bps) and an increase in market depth (+€1.55 compared with an average daily depth of €130 in the first half of the year on the Eurex platform – see Table 5 in the Annex). On the other hand, we do not observe any effect of speedbumps on the volumes traded on Eurex[34].

[34] However, this effect is not highlighted by Eurex, which anticipated an improvement in spreads as well as depth at the best limit.

To verify this first estimate, and to measure a potential carry-over effect, two other difference-in-difference analyses are proposed, in which the treatment and control groups are smaller. The first estimate uses the same model to observe the impact of the mechanism on French equity options offered on Euronext by comparing options that are offered on both Euronext and Eurex (and therefore exposed to the speed bump, which constitutes the new treatment group) with those that are only offered on Euronext (control group). Accordingly, there are now 63 underlying equities in the treatment group and 25 in the control group.
This modelling allows any carry-over effect to be taken into account. If volumes were divided equally between Euronext and Eurex before implementing the speed bump, targeting HFTs, the mechanism could lead to HFTs moving from Eurex to Euronext. This increase in the number of market participants competing for arbitrage opportunities could have a beneficial effect, by causing spreads to decrease and/or market depth to increase on Euronext for options exposed to the speed bump, compared with those that are not exposed to it. The effect could, however, be negative, by causing market-makers to wish to protect themselves against adverse selection, prompting them to widen their price ranges and provide less liquidity or even exit the market. The extent of either effect is difficult to predict.

On average, these two groups of options have different characteristics, as shown in Table 4. Options traded on both platforms have higher spreads and volumes than those in the control group (traded on Euronext only). This compositional bias is controlled by introducing the control variables.
The trend graphs (Annex 3) confirm that both groups have comparable levels of spread, effective spread, market depth and volume traded over the period studied.

Table 4: Main characteristics of the two groups observed

Group	Treatment	Control
Contrats (in nb)	14 599	972
Underlyings (in nb)	62	23
Average spread (in %)	0,14	0,37
Average eff spread (in %)	0,06	0,17
Average market depth (in €)	242	45
Traded volumes	5 876 033	47 472
Average maturity (day)	145	114
Average moneyness (ratio)	0,104	0,115
Average price (in €)	3,3	2,4
Underlying average market capitalization (in M	28 631	5 261
Underlying average traded volumes	1 690,6	611,8
Underlying average volatility	1,0	0,7

Source: Refinitiv, AMF calculations.

Table 5: Difference-in-difference model, options traded on Euronext

	Spread	Eff spread	Market depth	Volumes
	(1)	(2)	(3)	(4)
Did	**-0.1389*** **	**-0.0475*** **	**0.2680*** **	**0.0137**
	(0.0077)	(0.0046)	(0.0149)	(0.0355)
Speedbump	-0.0557***	-0.0517***	0.0374***	0.0226
	(0.0065)	(0.0039)	(0.0127)	(0.0301)
Post	0.1307***	0.0445***	0.1575***	-0.1399*
	(0.0167)	(0.0101)	(0.0324)	(0.0771)
Maturity	0.0001***	0.00003***	-0.0002***	-0.0005***
	(0.000004)	(0.000002)	(0.00001)	(0.00002)
Moneyness	0.1696***	0.0869***	-0.3962***	-0.2373***
	(0.0041)	(0.0025)	(0.0080)	(0.0191)
Price	-0.2313***	-0.0989***	0.8918***	-0.0959***
	(0.0010)	(0.0006)	(0.0020)	(0.0047)
Capi_under	-0.0372***	-0.0082***	0.2056***	0.0792***
	(0.0014)	(0.0008)	(0.0026)	(0.0062)
Volumes_under	-0.0879***	-0.0378***	0.5225***	0.3430***
	(0.0017)	(0.0010)	(0.0034)	(0.0080)
Volat_under	0.0860***	0.0370***	-0.2572***	-0.0812***
	(0.0019)	(0.0012)	(0.0038)	(0.0090)
Observations	107,084	107,084	107,084	107,084
Adjusted R^2	0.42	0.26	0.75	0.09
Fixed effects	Day	Day	Day	Day

*Note: *, ** and *** represent statistical significance at the levels of 10%, 5% and 1% respectively.*
Eff spread = effective spread, Capi_under, Volumes_under, Volat_under = respectively capitalisation, volumes, volatility of underlying equities. Source: Refinitiv, AMF calculations.

The analysis shows a significant impact of the speed bump mechanism on several liquidity indicators. The coefficients in the *Did* line show that the effect of the speed bump decreased the spreads and effective spreads of the options exposed to it on Euronext (by -14 and -5 basis points respectively). Exposure to the speed bump also increases the depth for these Euronext options (+€1.85). However, the speed bump has no significant impact on the volumes traded in these options. These results therefore confirm those obtained previously, and show that a positive effect can also be observed on Euronext. This improvement in spreads and depth on Euronext may be the result of a shift of HFT participants to the Euronext options market, which would initially increase competition in the order book between these players, or of a possible virtuous effect of the implementation of the mechanism on Eurex, encouraging these same players to slow down the speed at which they place aggressive orders on Euronext[35]. This beneficial effect of the mechanism on the liquidity of options on Euronext needs to be confirmed over time.

[35] Only an analysis of the Euronext and Eurex order book data would make it possible to favor one or other of the hypotheses

This last estimate shows the impact of the speed bump on the liquidity of contracts offered for trading only on Eurex. The hypothesis analysed in this estimate is the one that Eurex was seeking when the mechanism was set up, i.e. a reduction in adverse selection. This would have the effect of increasing the presence of market-makers and therefore reducing spreads and/or increasing depth for the treatment group exposed to the speed bump, compared with those in the control group.
We compare changes in the liquidity of French equity options that are only offered for trading on the Eurex platform and therefore impacted by the speed bump, covering 17 underlying equities (treatment group), with options that are only offered for trading on Euronext, covering 25 underlying equities (control group). The analysis is therefore limited to those options for which no carry-over of trading from one platform to another is possible.
More consistent with the prerequisites of difference-in-difference model, the analysis is nevertheless restricted, de facto, to options with low average liquidity, and therefore to those for which the expected effect of attracting market-makers could be weaker.

Table 6 presents the averages of the variables studied by the group to which they belong for the estimate. Furthermore, their trends over the first part of the year are parallel (see Annex 4). The following table confirms that the options considered for the estimate are on average less liquid and less traded than the options offered on the two platforms. The average displayed and effective spreads are also on average higher for both groups. The regression results are presented in Tableau 7.

Table 6: Main characteristics of the two groups observed

Group	Treatment	Control
Contrats (in nb)	1 262	1 315
Underlyings (in nb)	17	25
Average spread (in %)	0,17	0,37
Average eff spread (in %)	0,17	0,17
Average market depth (in €)	48,6	40,4
Traded volumes	51 992	60 247
Average maturity (day)	76,6	94,1
Average moneyness (ratio)	0,11	0,09
Average price (in €)	2,7	2,2
Underlying average market capitalization (in M€)	560,4	4 960,2
Underlying average traded volumes	740,6	560,4
Underlying average volatility	1,5	0,6

Source: Refinitiv, AMF calculations.

Tableau 7: Difference-in-difference model, options traded only on Eurex

	Spread	Eff spread	Market depth	Volumes
	(1)	(2)	(3)	(4)
Did	**-0.0922*** **	**-0.0033**	**0.0033**	**-0.0278**
	(0.0142)	(0.0112)	(0.0179)	(0.0368)
Speedbump	-0.1232***	0.0160*	-0.0010	0.0898***
	(0.0110)	(0.0086)	(0.0138)	(0.0283)
Post	0.1411	0.1086	-0.3129**	-0.2234
	(0.0991)	(0.0776)	(0.1248)	(0.2559)
Maturity	-0.00005	0.00004	-0.0001*	0.0001
	(0.00005)	(0.00004)	(0.0001)	(0.0001)
Moneyness	0.2362***	0.1959***	-0.0727	-0.1359
	(0.0352)	(0.0276)	(0.0443)	(0.0909)
Price	-0.3890***	-0.2763***	0.9847***	0.0424*
	(0.0084)	(0.0066)	(0.0106)	(0.0218)
Capi_under	-0.0346***	0.0259***	0.0610***	0.1979***
	(0.0101)	(0.0079)	(0.0127)	(0.0261)
Volumes_under	-0.0477***	-0.0515***	0.1551***	0.0288
	(0.0103)	(0.0081)	(0.0130)	(0.0267)
Volat_under	0.0614***	0.0652***	-0.1575***	-0.0949***
	(0.0121)	(0.0095)	(0.0153)	(0.0314)
Observations	5,228	5,228	5,228	5,228
Adjusted R^2	0.44	0.31	0.69	0.05
Fixed effects	Day	Day	Day	Day

*Note: *, ** and *** represent statistical significance at the levels of 10%, 5% and 1% respectively.*
Eff spread = effective spread, Capi_under, Volumes_under, Volat_under = respectively capitalisation, volumes, volatility of underlying equities.
Source: Refinitiv, AMF calculations.

The difference-in-difference analysis shows that the speed bump mechanism has a significant impact on the change in the quoted spreads for options that are only offered for trading on Eurex. The coefficients in the *Did* line show that implementing the speed bump did indeed significantly reduce the quoted spreads for these options, by 10 basis points on average. However, neither the change in the effective spread nor the change in trading volumes or market depth were significant. This seems to be consistent with the observation of their initial liquidity. It is likely that the characteristics of these illiquid options make them less attractive to high-frequency speculators. As a result, these options may have benefited from the increased presence of market-makers on the platform, encouraged by the speed bump, and have seen their spreads decrease. Nevertheless, the speed bump has not had any other effects.

3. CONCLUSION

Using a database containing all trades in French equity options on Eurex and Euronext in 2019, the changes in liquidity on the two platforms were assessed through several econometric analyses to determine the impact of implementing a speed bump on Eurex in June 2019. The estimate confirms that implementing the mechanism had a statistically significant effect on both Eurex and Euronext

By using the difference-in-difference method to isolate the effect of the speed bump, the expected impact of reducing adverse selection, by increasing the presence of market-makers and therefore reducing spreads and/or increasing market depth for the treatment group exposed to the speed bump, appears to be validated. The decrease in spreads and effective spreads (-10 and -3 basis points respectively) and the significant increase in depth (+€1.55) for the options benefiting from the mechanism on Eurex confirm this trend. However, the effect of the speedbump is not statistically significant on the volumes traded on Eurex, a sign that this mechanism is primarily intended to impact the quality of liquidity and not necessarily to increase volumes.

Moreover, options traded on both Euronext and Eurex benefited from a significant improvement in their spreads on both platforms, when compared with those traded only on EuronextThis is a sign of a possible shift of high-frequency speculators to the Paris platform, leading to an increase in competition between these players, or of a possible virtuous effect of the implementation of the mechanism on Eurex, encouraging these same players to slow down the speed at which they place aggressive orders on Euronext. This beneficial effect of the mechanism on the liquidity of options on Euronext needs to be confirmed over time.
A comparison of contracts that are only offered for trading on Eurex with those only offered on Euronext shows that these options, which are by nature less liquid, benefited only marginally from the improvement in liquidity.

Although these results cannot be compared with existing literature on market slowdowns, because the Eurex mechanism is an asymmetric speed bump, they do confirm a slight narrowing of spreads and effective spreads on the platform, indicating an improvement in the liquidity offered and paid for by investors. This decrease in spreads is comparable to those values found in the empirical literature analysing the effect of symmetric speed bumps. It is also consistent with some of the current theoretical literature, which emphasises the cost of high-frequency speculators' speed bumps for slower investors. As the first example of an asymmetric speed bump implemented in Europe, it would be relevant in the future to study this Eurex speed bump by comparing it to changes in the liquidity of options markets of other nationalities or underlying equities and to the liquidity of market participants present in the order book.

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Annex 1: Presentation of the data and coverage

The transaction data was taken from Refinitiv using its Datascope select tool. The database was created by listing, for each underlying equity with options on the Eurex or Euronext platform, all options with a single underlying equity under French jurisdiction that were available for trading as recorded in Refinitiv during 2019. Refinitiv was then used to provide a list of each of these instruments' transactions for trades executed on Eurex and Euronext over the year.

The instruments identified in Refinitiv were then cross-referenced with the European Financial Instruments Reference Data System (FIRDS) to obtain the characteristics of the instruments observed. This stage required switching from Reuters codes to ISIN codes and identifying the instruments in FIRDS. At each of these two steps, some instruments were not identified and their transactions were discarded. Consequently, the transaction database only contains instruments that could be identified in FIRDS in 2019.

Information on the equities underlying the options was taken from the Euronext TRDSUM database received by the AMF, which provides, for each day, the amounts traded, the number of transactions and the closing price of the equities traded on Euronext. Data on equities that have options on Eurex and/or Euronext was extracted from this database for each trading day in 2019. Note that some underlying equities traded on Euronext but which are not under French jurisdiction (Unibail Rodamco, ST Microelectronics, Solvay, Nokia) were excluded.

Lastly, to assess the representativeness of the resulting database of transactions, a comparison of monthly volumes was performed for each underlying equity. The aggregated results per month are shown in the table below. Overall, the data collected and cleaned in this way was close to Eurex volumes and similar to Euronext trades, providing an excellent degree of coverage of the transactions studied.

Table 8: Comparison of volumes by product

	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	2019
Total volumes Eurex	2,47	2,31	2,12	2,17	2,16	1,86	1,49	1,67	2,00	2,14	3,09	1,84	**25,33**
Total volumes on final database	2,14	1,91	1,83	1,81	1,86	1,63	1,40	1,49	1,95	1,96	1,88	1,51	**21,36**
	87%	*82%*	*86%*	*83%*	*86%*	*88%*	*94%*	*89%*	*98%*	*92%*	*61%*	*82%*	***84%***
Total volumes Euronext	2,08	2,50	2,26	1,92	1,98	1,96	1,59	1,85	2,66	2,21	2,12	1,70	**24,84**
Total volumes on final database	2,02	2,43	2,18	1,94	1,98	1,96	1,59	1,85	2,66	2,23	2,14	1,70	**24,75**
	97%	*97%*	*96%*	*101%*	*100%*	*100%*	*100%*	*100%*	*100%*	*101%*	*101%*	*100%*	***100%***

Source: Refinitiv, Euronext, Eurex, AMF calculations
Note: In the resulting database, some instruments have a slightly higher trading volume than that observed on Euronext, although it is not possible to identify duplicate transactions. These instruments increase the coverage on Euronext. Nevertheless, this additional volume is marginal, being less than 3% of total volumes for 2019.

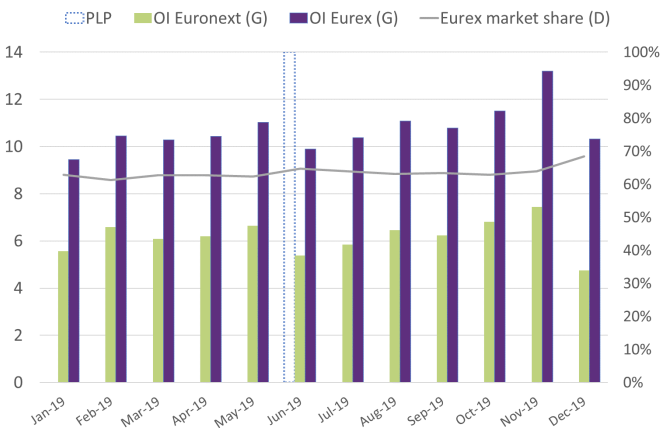
Lastly, to verify the number of instruments traded on the two platforms and improve understanding of the quality of the data obtained, a comparison was made between the list of instruments in the database created and the instruments in the reports received by the AMF (data from Direct Transaction Reporting system and the Transaction Report Exchange Mechanism, the computerised system for exchanging information between the various European regulators provided for under MiFID). The list of instruments traded at least once on one of the two platforms as reported to the regulator shows that the coverage of the database created is 96% of the number of instruments traded on Euronext and 97% of the number traded on Eurex.

Annex 2: Description of changes in market liquidity

The main indicators on both markets during 2019 did not show any major change after the implementation of the speed bump (PLP) on the Eurex platform on 3 June 2019. Overall, the number of open positions in French equity options, as published by both platforms, highlights that Eurex has a higher market share, which did not change during the second half of the year. Eurex accounted for an average of 64% of total open positions in French equity options in 2019, a proportion that remained broadly constant over the year (except in December 2019 when Eurex's market share rose to 68% – see Figure 3).

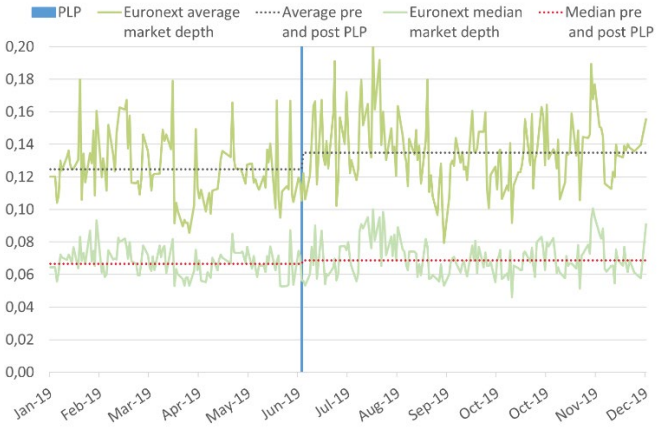
Figure 3: Open positions at the end of the month on Euronext and Eurex, and Eurex's share of the total

By number



Source: Euronext, Eurex, AMF calculations

Figure 4: Average and median daily spreads on Euronext



Source: Refinitiv, AMF calculations

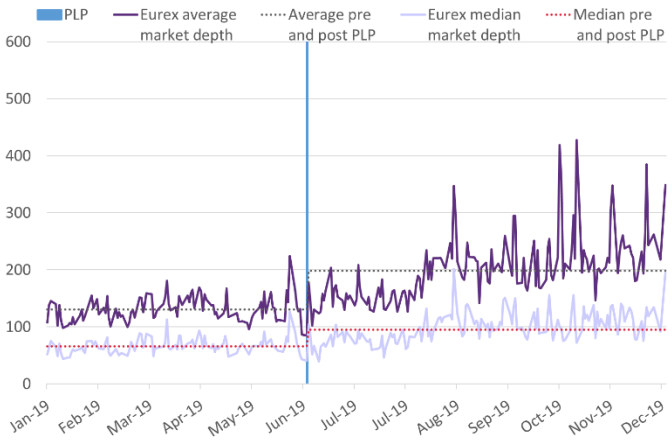
Looking only at the on-order-book trades made using the database created (excluding block trades), the daily trading volumes on both platforms decreased slightly after the introduction of the speed bump (Figure 1 in section 2.1 above). Daily trading volumes were higher on Eurex in 2019 (34,016 lots traded daily on average, compared with 30,960 on Euronext). During the second half of the year, trading volumes decreased on both platforms (-7% daily volumes on Eurex and -11% on Euronext).

The spreads show the liquidity advantage enjoyed by Eurex (Figure 2 and Figure 4). Average spreads on Euronext were 2.2 times higher than those on Eurex before the speed bump was introduced, and this gap widened after its introduction, with average spreads 2.4 times higher on Euronext. The median of the daily spreads, which avoids giving a biased view of non-representative instruments with atypical spreads, appears tighter on both markets after the speed bump (PLP) was introduced. While the Eurex platform is characterised by smaller average and median spreads[36] – a sign of higher liquidity – the effective spreads were similar on both platforms. Overall, this cost of liquidity for the aggressive investor, initially lower on Euronext, increased by 11% compared with Eurex.

[36] To confirm this difference in the range of prices offered between the two platforms on all the instruments traded, an analysis of the changes in the average and median spreads was carried out using only the most traded instruments, namely the "in-the-money" options (i.e. call options with an exercise price lower than the closing price of the underlying equity, and put options with an exercise price higher than the closing price of the equity, plus or minus 10% depending on whether the price is lower or higher). While the spreads are tight in both cases, the spread between the two platforms remains similar to the spread observed for all instruments.

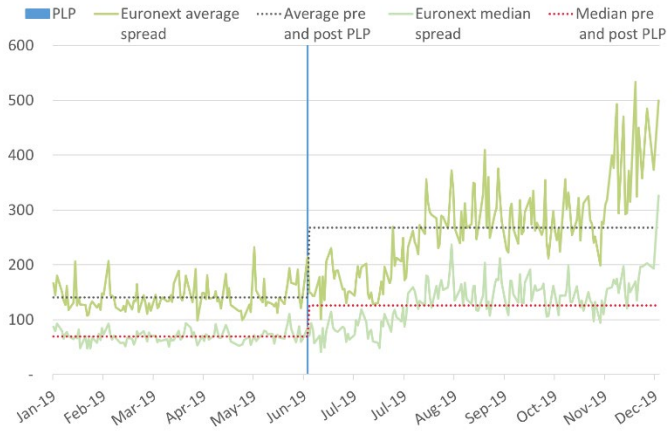
Market depth increased sharply on both platforms after the speed bump (PLP) was introduced – by +51% on Eurex and +91% on Euronext – with a more marked increase for both from September 2019. It is possible that this increase is linked to the widening of the spread and to the fact that the depth calculated here is best-limit depth. Other factors not observed here may also have contributed to this increase, such as the volatility of the underlying equity market or the arrival of new market participants. The econometric analysis removes the effect of the speed bump from this increase, which is probably linked to other factors.

Figure 5: Mean and median market depth on Eurex



Source: Refinitiv, AMF calculations

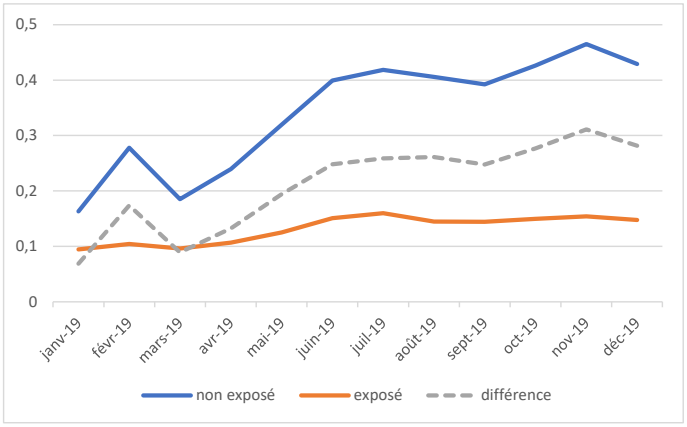
Figure 6: Mean and median market depth on Euronext



Source: Refinitiv, AMF calculations

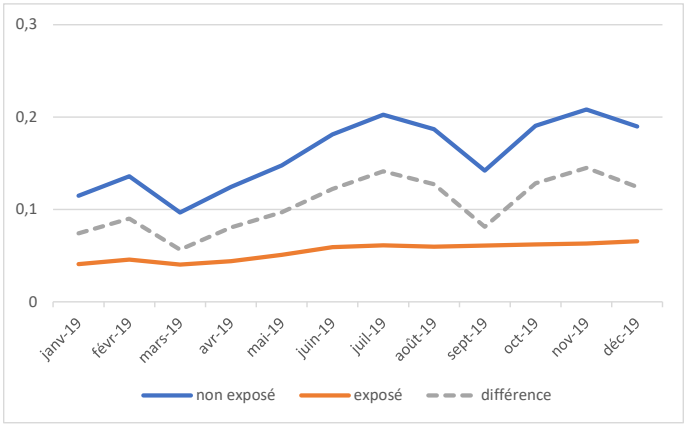
Annex 3: Parallel trends in the variables of interest for the difference-in-difference estimate, options traded on Euronext

Figure 7: Changes in quoted spreads by exposure to speed bump, Euronext restricted analysis group
Monthly average and difference



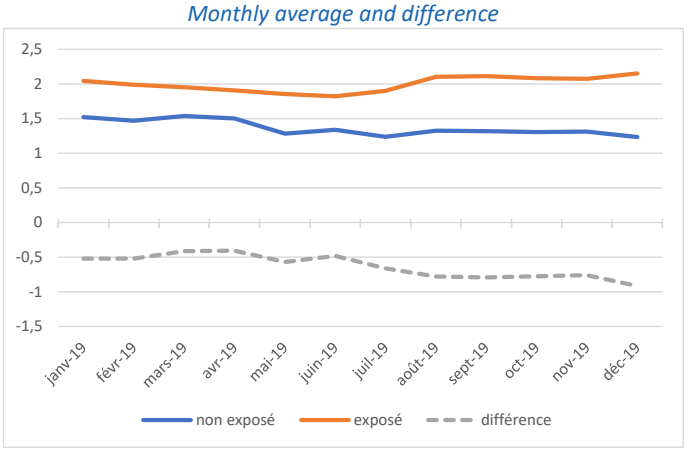
Source: Refinitiv, AMF calculations

Figure 8: Changes in effective spreads by exposure to speed bump, Euronext restricted analysis group
Monthly average and difference



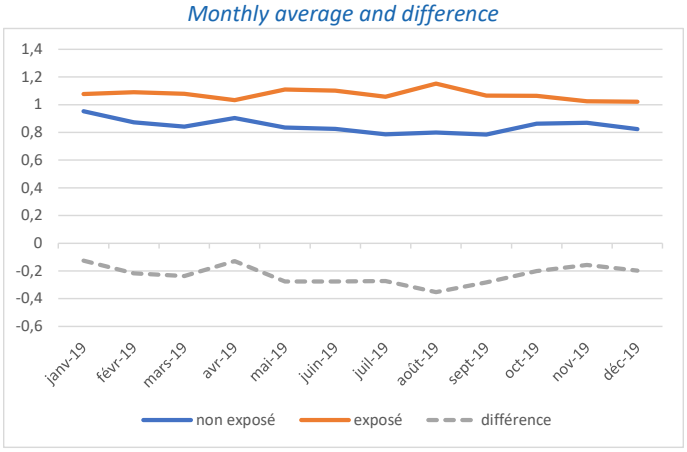
Source: Refinitiv, AMF calculations

Figure 9: Changes in market depth (logarithmic scale) by exposure to speed bump, Euronext restricted analysis group
Monthly average and difference



Source: Refinitiv, AMF calculations

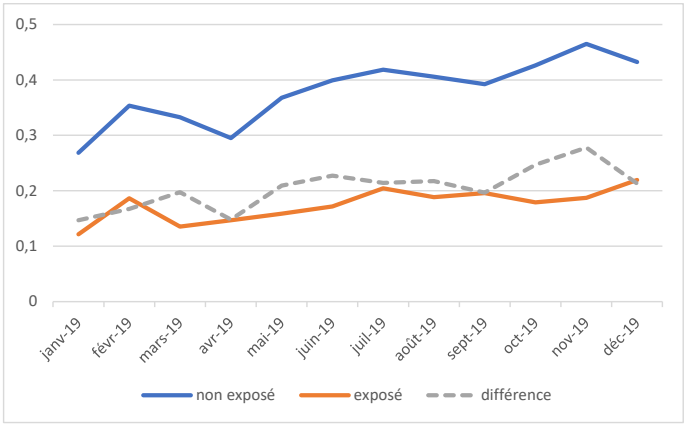
Figure 10: Changes in volumes traded (logarithmic scale) by exposure to speed bump, Euronext restricted analysis group
Monthly average and difference



Source: Refinitiv, AMF calculations

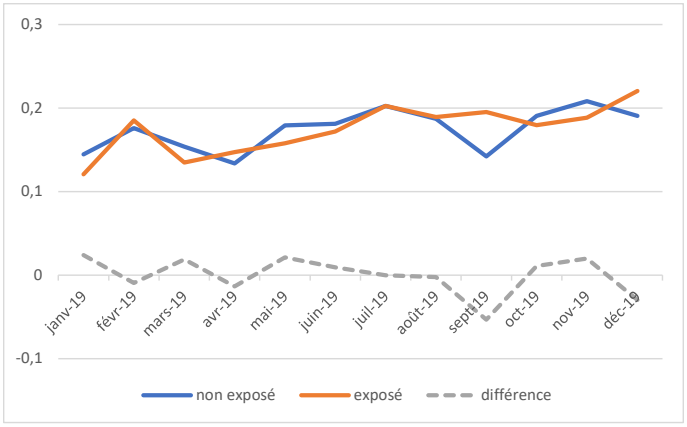
Annex 4: Parallel trends in the variables of interest for the difference-in-difference estimate, options traded on Eurex

Figure 11: Changes in quoted spreads by exposure to speed bump, Eurex restricted analysis group
Monthly average and difference



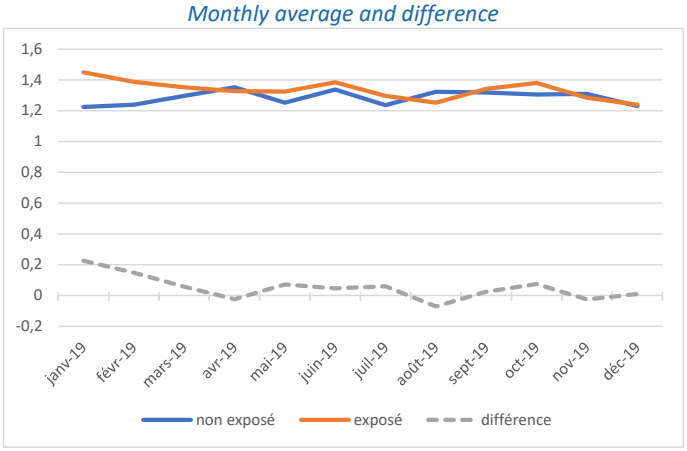
Source: Refinitiv, AMF calculations

Figure 12: Changes in effective spreads by exposure to speed bump, Eurex restricted analysis group
Monthly average and difference



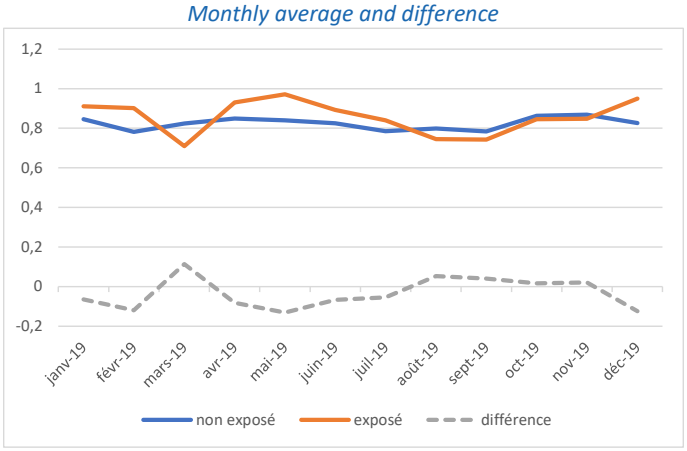
Source: Refinitiv, AMF calculations

Figure 13: Changes in market depth (logarithmic scale) by exposure to speed bump, Eurex restricted analysis group
Monthly average and difference



Source: Refinitiv, AMF calculations

Figure 14: Changes in volumes traded (logarithmic scale) by exposure to speed bump, Eurex restricted analysis group
Monthly average and difference



Source: Refinitiv, AMF calculations