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Are Speed Bumps Beneficial?

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Executive summary

This paper reviews the theoretical and empirical literature on speed bumps and market quality. Speed bumps are deliberate delays in processing order messages on an exchange. The academic evidence shows that implementing a speed bump benefits the exchange instituting it. It enhances competition at the top of the order book and reduces quoted and effective spreads on the delayed venue.

Should more exchanges implement speed bumps, given their benefits for delayed exchanges? Addressing this question is challenging, given that the literature on the market-wide impact of speed bumps is inconclusive. This is due to two factors. First, existing evidence is based on speed bumps implemented by small exchanges with minimal market share. Second, the existing studies fail to isolate the effect of speed bumps from other market structure changes made on the exchanges at the same time.

Despite the limitations in the existing research, it is possible to conceptually assess the potential impact of speed bumps on overall market dynamics. For instance, the widespread adoption of speed bumps across existing exchanges may add complexity to already complex and fragmented markets, potentially making it more challenging to deliver best execution. Speed bumps may also result in liquidity becoming more fragmented, particularly if new venues are created to offer speed bumps. Regulators should cautiously evaluate speed bump proposals to ensure that their introduction benefits the market as a whole and does not introduce further complexities or unintended consequences.

Liquidity protection programs and micro-burst fees (fees imposed on high-frequency trader liquidity takers during periods of intense message traffic) are alternatives to speed bumps to mitigate latency arbitrage. However, a comprehensive empirical assessment of these alternatives is also required.

Introduction

“Speed bumps” — a deliberate delay in processing order messages on an exchange — have been a topic of interest among practitioners and researchers in recent years. Speed bumps aim to promote a more equitable trading landscape by mitigating the adverse effects of latency arbitrage. Speed bumps come in two forms: asymmetric and symmetric. An asymmetric speed bump may slow down only liquidity-taking orders, therefore reducing latency arbitrage opportunities for high-frequency traders (HFTs) and providing a degree of protection to slower liquidity providers. Alternatively, it may slow certain order types but not others, such as delaying new order submissions but not cancellations. Again to protect slower liquidity providers. In contrast, a symmetric speed bump imposes delays on all orders. These aim to create a more equitable trading environment by reducing the advantage of ultra-low latency trading.

This paper reviews the existing academic evidence on speed bumps and evaluates their impact on market quality. It also considers alternative approaches to address latency concerns and provides policy recommendations based on academic evidence.

Table 1 provides a non-comprehensive list of market operators that have implemented speed bumps.

Table 1: Examples of exchanges offering speed bumps

Exchange	Country	Delay type	Duration	Implementation date
Aequitas NEO Exchange	Canada	asymmetric	3–9 milliseconds	March 2015
TSX Alpha Exchange	Canada	asymmetric*	1–3 milliseconds	September 2015
Investors Exchange	U.S.	asymmetric**	350 microseconds	June 2016
Eurex Exchange	Germany	asymmetric	1 or 3 milliseconds	June 2019

* Alpha implemented a randomised speed bump of 1 – 3 milliseconds to all incoming orders, except for passive limit orders that meet the minimum order size. The minimum order size to avoid the speed bump is stock-specific and determined based on a stock’s price and volume characteristics.

** Contrary to popular belief that Investors Exchange’s speed bump is symmetric, it is asymmetric in practice. Investors Exchange delays all orders except for pegged limit orders’ revisions. While all orders face a delay of 350 microseconds, the prices of resting pegged limit orders can be updated immediately.

Why do exchanges need speed bumps?

Liquidity and price discovery are crucial for high-quality markets, requiring robust protection, especially against potential disruptions, from low-latency trading. Investments in low-latency trading technologies have enabled HFTs to receive, process, and react to information at the highest speed possible. This gives them an edge over slower market makers, potentially making these liquidity providers set wider spreads if the risk of adverse selection from HFTs is high (e.g., **Foucault, Kozhan, and Tham** (**2017**)).

The impact of low-latency trading can vary depending on the strategies employed by HFTs. HFTs can assume two roles in the market: "liquidity providers" and "liquidity takers". As liquidity providers, they consistently post orders across various exchanges, frequently canceling and amending their orders as prices evolve.[1] In contrast, as liquidity takers, they remove liquidity from the order book when there are stale orders. They may also engage in back-running or order anticipation strategies when their order flow reveals a strong signal about a security's fundamental value (e.g., **Van Kervel and Menkveld** (**2019**); **Yang and Zhu** (**2020**)).

When acting as liquidity providers, HFTs typically enhance liquidity by narrowing the bid-ask spread (e.g., **Brogaard, Hagströmer, Nordén, and Riordan** (**2015**)). However, more recent evidence suggests that nanosecond-latency market-making may harm liquidity (**Menkveld and Zoican** (**2017**)). HFT liquidity providers also often engage in rapid order cancellations, a trend that intensifies with increasing speed (**Hasbrouck and Saar** (**2009**); **Hasbrouck and Saar** (**2013**)). The ability to revise/cancel orders helps HFT liquidity providers avoid being adversely selected (**Hoffmann** (**2014**)), hence being able to set tighter spreads.

As liquidity takers, HFTs can negatively affect liquidity by engaging in latency arbitrage opportunities, imposing adverse selection costs on passive limit order providers, leading to higher adverse selection, and trading costs for end-investors (e.g., **Budish, Cramton, and Shim** (**2015**); **Foucault et al.** (**2017**); **Shkilko and Sokolov** (**2020**)). **Shkilko and Sokolov** (**2020**) provide evidence that speed differential can harm liquidity. They show that the quoted and effective spreads decrease when disruption in the microwave network connection between Chicago and New York, which is only available to a small number of traders, blocks nanosecond trading, therefore reducing the speed advantage of a small set of traders.

When it comes to the impact of HFTs on price discovery, there is not yet a consensus. On the one hand, HFTs' ability to predict short-term future price movements may enhance price efficiency through both their role in liquidity provision (e.g., **Brogaard, Hendershott, and Riordan** (**2019**)) and liquidity demand (**Brogaard, Hendershott, and Riordan** (**2014**)). However, research also suggests that low latency trading reduces the pool of available information resulting in less informative prices (**Weller** (**2018**)). **Baldauf and Mollner** (**2020**) provide a theoretical framework showing that HFT liquidity-taking activity can result in diminished investment in research by fundamental investors. This is mainly due to the ability of HFTs to anticipate orders, enabling them to back-run fundamental investors, discouraging these investors from engaging in costly research.

Considering the potential adverse effects of low-latency trading on market quality, market operators must safeguard it by incentivising liquidity provision and providing a more equitable trading landscape. Slower liquidity providers should feel confident they are not at significant risk of high adverse selection costs from HFT activities. To evaluate the benefits of speed bumps, three crucial questions must be answered. First, does the introduction of a speed bump protect slower liquidity providers and improve market quality? And second, does the introduction of a speed bump reduce the HFTs' race toward investing in low-latency technologies? If the answer to the first two questions is yes, then a third question to answer is: what is the optimal design for a speed bump? These questions are central to developing regulations and identifying the most suitable market structure to ensure an equitable and high-quality market environment.

1 **Van Kervel** (**2015**) shows that a sizable cancellation of orders by HFT liquidity providers on competing venues follows a trade on one venue.

What are the implications of speed bumps?

The impact of speed bumps on market quality depends on the redistribution of order flow across exchanges following the implementation of the speed bump, as different investor/trader types adjust their strategies in response to the imposed delay. In this section, we review the evidence on the impact of speed bumps on liquidity, price discovery and the technology arms race. Table 2 summarises the theoretical and empirical research on speed bumps. It considers the impact on the delayed exchange, the traditional exchange (i.e., the exchange without a speed bump) and the market overall.

Speed bumps delaying only liquidity-taking orders

In a theoretical model, **Brolley and Cimon** (**2020**) show that introducing an asymmetric latency delay exposes liquidity takers to execution risks on the delayed exchange. This risk prompts latency-sensitive traders, including speculators, to shift their activities to the traditional exchange. This shift narrows the spread on the delayed exchange. Slower liquidity providers offer tighter spreads because there is a lower risk of being picked off by an HFT. However, the speed bump simultaneously widens the spread and increases the price impact on the traditional exchange due to the concentration of speculators. The concentration of speculators on the traditional exchange intensifies competition to exploit latency arbitrage opportunities, leading to increased adverse selection costs.

The authors argue that introducing a speed bump gives the delayed exchange a competitive advantage. This advantage comes not just from improving liquidity but also from potentially increasing the exchange's overall trading volume. Specifically, the lower adverse selection costs on the delayed exchange draws latency-insensitive liquidity investors (i.e., non-fundamental investors) away from the traditional exchange.

Autorité des Marchés Financiers (**2021**) empirically analyses the impact of introducing a speed bump on Eurex on liquidity. In 2019, Eurex implemented its asymmetric speed bump called "Passive Liquidity Protection" to equity options to improve liquidity and price discovery (**Eurex** (**2021a**)).[2] Focusing on French equity options, **Autorité des Marchés Financiers** (**2021**) shows that when Eurex faces competition from the traditional exchange, namely Euronext (i.e., for equity options traded on both Eurex and Euronext), the speed bump decreases bid-ask spreads, effective spreads and increases depth on Eurex significantly.

In contrast to **Brolley and Cimon (2020**)'s model, the traditional exchange also experiences a significant improvement in liquidity following the introduction of the speed bump on Eurex. However, neither exchange records any significant change in trading volume.[3,4] **Autorité des Marchés Financiers (2021**) also shows that when the delayed exchange, Eurex, does not face any competition from other venues (for options traded only on Eurex), the positive impact of the speed bump is limited to the quoted spread. While the quoted spread decreases, the effective spread, depth, and trading volume do not experience any significant changes.[5] **Eurex** (**2021b**) documents similar liquidity effects and a significant increase in the competition at the top of Eurex order book for DAX index options traded on Eurex.

Despite the significant positive effect of speed bumps on the delayed exchange, it is essential to consider how they influence the market as a whole: How do speed bumps affect market-wide liquidity? This is not studied in either **Brolley and Cimon** (**2020**) or **Autorité des Marchés Financiers** (**2021**).

In September 2015, TSX Alpha underwent a strategic redesign, incorporating three crucial changes: the introduction of a speed bump, the establishment of a minimum order size for passive limit orders to exempt them from the speed bump and the adoption of an inverted fee structure.[6] **Anderson, Andrews, Devani, Mueller, and Walton** (**2022**) empirically show that Alpha's redesign has a neutral to slightly positive impact on market-wide liquidity (a reduction in the effective spread and an increase in the depth). The authors attribute this modest improvement in liquidity to the market-wide increase in the share of retail trading on Alpha following the redesign.

The authors show that although Alpha's redesign attracted more retail volume, it did not lead to complete order flow segmentation across venues. They argue that the redesign reorganises order flow in line with investors' liquidity and latency sensitivity preferences. Specifically, lower latency-sensitive liquidity investors prefer the delayed exchange, while higher latency-sensitive liquidity investors are more likely to trade at the traditional exchange. However, it is crucial to acknowledge that the outcomes of this study cannot be exclusively attributed to the implementation of the speed bump. Alpha concurrently introduced the speed bump and altered its fee structure, potentially attracting aggressive retail volume. The authors do not explicitly state any linkage between the surge in retail participation and the reorganisation of order flow to the fee structure. Instead, they discuss the outcomes under the broader umbrella of "Alpha's redesign" rather than explicitly addressing the impact of the speed bump.

2 Eurex implemented its speed bump in June 2019 to only French and German single stock options and extended it to all single stock and DAX index options in August 2020.

3 **Autorité des Marchés Financiers** (**2021**) posits two potential explanations for this liquidity effect: one possibility is the migration of HFT speculators to Euronext, intensifying competition among them and reducing the spread. Another potential factor may be a reduction in the pace of placing aggressive orders on Euronext by HFT speculators.

4 **Autorité des Marchés Financiers** (**2021**) emphasises that the liquidity effect on Euronext should be confirmed over time.

5 Using the same event and analysing French equity options, **Le Moign** (**2022**) also shows that the Eurex speed bump improves market quality on Eurex and Euronext in terms of quoted spread, effective spread, and depth. Different from **Autorité des Marchés Financiers** (**2021**), **Le Moign** (**2022**) documents an increase in the traded volume on both venues.

6 Alpha implemented a randomised speed bump of 1 – 3 milliseconds to all incoming orders, except for passive limit orders that meet the minimum order size. The minimum order size to avoid the speed bump is stock-specific and determined based on a stock's price and volume characteristics.

The impact of latency delays on price discovery can vary depending on the ratio of speculators to liquidity investors (**Brolley and Cimon** (**2020**)). The concentration of speculators on the traditional exchange intensifies competition among parties trading on order flow information. This increases price impact but reduces the overall information acquisition. The authors show that when there are many speculators relative to liquidity investors, the reduction in information outweighs the increased price impact, harming price discovery. However, when there are fewer speculators it may improve price discovery.

Table 2: Research on the impact of speed bumps

	Speed bump type	Study type	Market quality: delayed exchange	Market quality: traditional exchange	Market quality: market-wide impact	Low-latency arms race
Brolley and Cimon (2020)	asymmetric	theoretical	↓quoted spread ↓adverse selection costs ↓latency-sensitive traders ↑latency-insensitive traders ↑total volume	↑quoted spread ↑adverse selection costs ↑latency-sensitive traders ↓latency-insensitive traders	—	—
Baldauf and Mollner (2020)	asymmetric*	theoretical	improvement in liquidity & price discovery	—	—	—
Chakrabarty, Huang, and Jain (2020)	asymmetric**	empirical	—	—	↓quoted spread ↓effective spread	—
Autorité des Marchés Financiers (2021)	asymmetric	empirical	↓quoted spread ↓effective spread ↑depth no change in volume	↓quoted spread ↓effective spread ↑depth no change in volume	—	—
Anderson et al. (2022)	asymmetric***	empirical	—	—	slight improvement in effective spread & depth	—
Aldrich and Friedman (2023)	asymmetric****	theoretical	↓trading costs*****	—	—	—
Khapko and Zoican (2021)	asymmetric & symmetric	experimental	—	—	—	↓with asymmetric speed bumps, no change with symmetric speed bumps, no difference between fixed and random speed bumps

* The authors propose a trading mechanism with a speed bump known as Non-Cancellation Delay, which introduces a brief delay to all types of orders except cancellations.

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*** Alpha implemented a randomised speed bump of 1 – 3 milliseconds to all incoming orders, except for passive limit orders that meet the minimum order size. The minimum order size is applied only to passive limit orders.

**** They theoretically study a market design that protects pegged orders by imposing a delay on all new orders, but resting pegged orders are immediately repriced.

***** They measure trading cost as the deviation of transaction prices from the fundamental value.

Speed bumps selectively delaying specific order types

Baldauf and Mollner (**2020**) propose a trading mechanism featuring a speed bump, known as Non-Cancellation Delay (NDs) mechanisms, to counteract the detrimental impact of HFTs' order anticipation activities on limit order books, which tend to discourage in-depth fundamental research. NDs introduce a brief delay to all order types except cancellations. This structure eliminates the negative consequences of diminished fundamental research, as it prevents HFT liquidity takers from capitalising on their ability to anticipate orders. This change incentivises fundamental investors to engage in costly fundamental research, potentially enhancing the price discovery process. NDs also offer slower liquidity providers an additional layer of protection against HFT liquidity takers. By allowing them to retract their stale quotes before HFTs can exploit them, NDs help maintain a more equitable trading environment.

Investors Exchange (IEX) implemented a speed bump in 2016, delaying all orders except for pegged limit orders' revisions. While all orders face a delay of 350 microseconds, the prices of resting pegged limit orders can be updated immediately. Hence, contrary to popular belief, IEX's speed bump is asymmetric, not symmetric. **Chakrabarty et al.** (**2020**) provide evidence that IEX's speed bump positively impacts the overall market quality within the U.S. market. This is primarily observed through reductions in the quoted and effective spreads.

Along the same line, **Aldrich and Friedman** (**2023**), theoretically study a market design that protects pegged orders by imposing a delay on all new orders, but resting pegged orders are immediately repriced, similar to IEX speed bump. The authors show that the delay reduces trading costs, measured as the deviation of transaction price from the fundamental value.

Speed bumps and the low-latency arms race

Imposing a delay to the order execution of HFTs can also impact their decision to invest in low-latency technologies, as low-latency strategies may become less profitable. **Khapko and Zoican** (**2021**) examine speed bumps in the context of the arms race by conducting an experimental study. The authors show that the association between investing in high-speed technology and speed bumps is closely tied to how the speed bump is designed. Asymmetric speed bumps, where liquidity providers can cancel orders without delay, lead to a 20% drop in investments in low-latency technology. In contrast, symmetric speed bumps do not change investment decisions by participants. They also show no significant difference between fixed and random speed bumps.

Summary of evidence

Overall, research suggests that speed bumps significantly improve market quality on the delayed exchange. It enhances competition at the top of the order book and reduces quoted and effective spreads. However, only a minority of exchanges have chosen to implement speed bumps. Why have more exchanges not adopted speed bumps? One explanation is the risk of losing a substantial volume of trades generated by HFTs, who might prefer venues without such trade execution delays. HFTs contribute significantly to trading volumes and, consequently, to the exchanges' revenue streams. Therefore, the prospect of alienating these market participants can be a serious consideration for exchanges. Exchanges might also be wary of the operational changes, technological adjustments, and regulatory scrutiny that come with implementing speed bumps. They might be cautious about how these changes can affect their competitive standing in a highly dynamic market, where even minor shifts can have substantial implications.

Nevertheless, when it comes to the aggregate market impact, research has yet to reach a conclusive result. This primarily stems from either the findings being based on the speed bump implemented by a small exchange like IEX with a minimal market share (**2.1%**) or the research failing to isolate the effect of the speed bump from other market structure changes on the same exchange like Alpha's redesign, making it challenging to discern its specific impact.

Alternatives to speed bumps

Speed bumps are just one of several market designs proposed to counteract HFT latency arbitrage. Researchers and market operators have suggested multiple alternatives to address the negative impacts of latency arbitrage in financial markets. This section discusses the main alternatives.

In February 2016, Aquis introduced a ban on liquidity taking by proprietary trading firms, with the aim of protecting slower liquidity providers from HFT latency arbitrageurs. This ban resembles a speed bump by effectively introducing an infinite delay in proprietary liquidity-taking orders. **Qu** (**2023**) shows that Aquis' ban leads to an 11% reduction in spreads, a doubling of depth at the European Best Bid and Offer (EBBO), and a 16% decrease in adverse selection on Aquis. The author also confirms that the ban does not adversely impact other exchanges. However, Aquis recently lifted its ban. Aquis states that while the initial ban brought benefits, it eventually resulted in a decrease in liquidity and longer execution times due to the absence of aggressive HFT orders. **CEO Alasdair Haynes** explains that clients now prioritise liquidity and rapid execution more than concerns about market toxicity.

Budish et al. (**2015**) suggest replacing the current continuous-time trading system, which enables HFT latency arbitrage, with a discrete-time design like Frequent Batch Auctions (FBA). They argue that this design eliminates latency arbitrage and improves liquidity by batching orders and executing them at randomized intervals, reducing HFTs' speed advantage. **Aquilina, Budish, and O'Neill** (**2022**) estimate that modifying the continuous limit order book to a hypothetical market design without latency arbitrage, such as a frequent batch auction, would lead to a 17% reduction in the effective spread. Although some European exchanges have implemented FBAs to mitigate speed impacts, their design differs from that proposed in **Budish et al.** (**2015**). These periodic auctions have captured limited market share (**Comerton-Forde** (**2021**)).

Brolley and Zoican (**2023**) suggest a market design that limits latency arbitrage by imposing a fee on HFT liquidity-takers during periods of intense message traffic, a concept they refer to as a "micro-burst fee". Their research indicates that this strategy reduces latency arbitrage and adverse selection and generates more exchange revenue than co-location fees. By making it costlier for HFTs to trade against stale quotes during these micro-bursts, the competition among HFT latency arbitragers decreases, thereby enhancing liquidity. This improvement benefits liquidity investors who typically do not trade during these high-traffic periods.

It is also essential to acknowledge that the need for liquidity protection can differ significantly across asset classes. This is particularly true in options markets, where electronic liquidity providers (ELPs) post orders for many contracts across a wide range of strike prices. When there is a market movement (for example, due to new information), ELPs may seek to adjust or withdraw their orders. However, ELPs can typically only cancel or alter one message at a time, a limitation that exposes them to considerable adverse selection costs.

One protective strategy can be mass cancellations combined with "purge ports" as discussed by **Optiver** (**2023**), a market-making firm. Purge ports offer a direct route to the matching engine exclusively for cancellation messages, ensuring cancellations bypass any delays during peak trading times. By lowering their risk of adverse selection, this method encourages liquidity providers to continue offering competitive, affordable liquidity. **MIAX Pearl Exchange** in the U.S. options market offers mass cancellation for orders through Priority Purge Ports (PPPs), allowing members to cancel all or a subset of their orders. This is particularly valuable in the fast-paced and complex environment of options trading.

Policy implications and further research

A well-functioning market provides high levels of liquidity and price efficiency. Encouraging liquidity provision in order books is vital in making this happen. However, slower liquidity providers often face adverse selection costs from interacting with high frequency liquidity takers who engage in latency arbitrage. If these liquidity providers cannot effectively manage adverse selection risks, they might respond by setting wider spreads or leaving the market altogether. This reaction harms the market's liquidity and, in turn, the quality of trade executions for end investors (i.e., retail and institutional investors). Therefore, protecting slower liquidity providers from disruptive activities is necessary to maintain a high-functioning and stable market.

Research shows that implementing a speed bump is associated with lower spreads and increased competition at the top of the book on the delayed exchange, potentially benefiting end investors trading on that exchange. Does this mean more exchanges should implement a speed bump? Should regulators encourage speed bumps? When addressing these questions, separating an exchange's incentives for adopting a speed bump and its market-wide implications is essential. Despite the improvements on the delayed exchange, there is not yet a consensus on the impact that speed bumps have on overall market quality. A detailed, comprehensive assessment of the market-wide effects of speed bumps is required for an informed conclusion on their broader implementation across exchanges.

Despite the absence of a uniform conclusion on the overall impact of speed bumps on market quality, regulators can still conceptually evaluate their potential impacts on the market. For example, if multiple existing exchanges were to implement various forms of speed bumps, this may add more complexity to the already complex, fragmented market. This may lead to poorer execution outcomes for end investors as their orders must navigate many different marketplaces, each with its unique structure. Additionally, the launch of new exchanges with the sole objective of implementing speed bumps can increase market liquidity dispersion. Hence, regulators must adopt a cautious approach. While there is no evidence of a need for intervention, any proposal for new speed bumps should undergo a thorough review, with the market-wide impact of the proposal taking precedence in consideration.

Regulators can also encourage exchanges to explore alternatives to speed bumps that safeguard the interests of slower liquidity providers and exchanges without introducing additional unintended consequences or complexities to the market. Liquidity protection programs can safeguard slower liquidity providers while also being considerate of the strategies employed by liquidity takers. Implementing micro-burst fees that reduce latency arbitrage while keeping the exchange's revenue may also be more beneficial than speed bumps in maintaining a high-quality market. However, a definitive assessment of these alternatives can only be confirmed through an empirical evaluation of their impact post-implementation.

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