# **Sian**. ACTIVITY GROUP Financial Mathematics and Engineering

NEWSLETTER | Autumn 2018

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# CHAIR'S WELCOME

Dear Colleagues, Students, and Friends,

The fall semester at many Universities is on its way and to mark the occasion, the SIAG executive is sending out its latest newsletter.

Firstly, if it is not already in your calendar, you should block off **4-7 June, 2019** for the biennial **SIAM FME 19** meeting in **Toronto, Canada** in collaboration with the Fields Institute for Mathematical Sciences. Please see the conference webpage for further information: SIAM FM 19 Webpage.

This will be 7<sup>th</sup> meeting, the first time it will be held on a University campus, and, as the community voted for, it is the first time the conference will land in an odd year. This meeting is also different in that we will have an **industrial afternoon**, which aims to feature **industry focused minisymposia**, **panel discussions**, and a **recruitment** session. Finally, there will be new **student poster prizes** given to the best undergraduate and postgraduate student poster.

This newsletter also has another first: the op-ed piece on the effect of **latency on trading strategies** by **Álvaro Cartea**. We are **continuing to solicit op-ed pieces** that are of **wide interest to community** that showcase innovative, state-of-the-art, and thought-provoking aspects of research in Financial Mathematics and Engineering, both theoretical and applied.

The SIAG executives wishes everyone a productive and exciting fall term, and look forward to seeing everyone at FM 19!

Sincerely,

Sebastian Jaimungal, Chair SIAG FME



Sebastian Jaimungal University of Toronto, Canada *Chair* 



Tim Leung, University of Washington, USA *Vice Chair* 



Francesca Biagini, University of Munich, Germany Secretary



Agostino Capponi, Columbia University, USA Program Director

#### SIAM Activity Group on Financial Mathematics and Engineering Early Career Prize

The SIAM Activity Group on Financial Mathematics and Engineering Early Career Prize (SIAG/FME Early Career Prize) will be awarded at the SIAM Conference on Financial Mathematics and Engineering SIAM-FME 19 to one individual in their early career for distinguished contributions to mathematical modeling in finance in the eligibility period prior to the award year. The nomination for the SIAG/FME Early Career Prize is now closed. The winner will be announced at the SIAM Conference on Financial Mathematics and Engineering (FM19) in Toronto on June 4-7, 2019.

#### SIAM Activity Group on Financial Mathematics and Engineering Conference Paper Prize

The prize recognizes outstanding research presented by students or postdocs at the SIAM Conference on Financial Mathematics and Engineering. Finalists are selected before the con-

ference, and one or two winners are selected and awarded at the conference, based on the delivery of the paper.

The candidate must be a student or postdoc who received their PhD or equivalent degree no more than two calendar years earlier than the award year. Candidates will have submitted the title and abstract for their presentation either in a minisymposium or as a contributed talk by the conference submission deadline. In the case of co-authored work, candidates must be listed as the speaker. For all talks, prize eligibility is conditional on acceptance of the presentation to the conference program.

For the 2019 award, the candidate must have been accepted to present at the 2019 SIAM Conference on Financial Mathematics and Engineering and awarded their PhD no earlier than 2017.

# Nomination deadline: February 15, 2019.

Submissions are warmly encouraged!

### SIAM Conference on Financial Mathematics & Engineering (FM19)

The SIAM Conference on Financial Mathematics & Engineering (FM19) will be held on campus at the University of Toronto, Toronto, Canada on **June 4-7**, **2019**.

Plenary speakers are

- Alvaro Cartea, University of Oxford, United Kingdom
- Christa Cuchiero, University of Vienna, Austria
- Jean Pierre Fouque, University of California, Santa Barbara, U.S.
- Jim Gatheral, Baruch College, U.S.
- Albert S. Kyle, University of Maryland, U.S.
- Charles-Albert Lehalle, Capital Fund Management, France
- Fabio Mercurio, Bloomberg LP, U.S.
- Josef Teichmann, ETH Zurich, Switzerland

Minitutorial speakers:

- Emmanuel Gobet, Ecole Polytechnique, France
- Marcos Lopez de Prado, AQR Capital Management, U.S.

A new addition to the conference this year is an industrial afternoon, with two parallel mini-symposia delivered by industry speakers, followed by two panel discussions, and then a recruitment session.

We warmly invite you to participate!

# CONFERENCE REPORT



July 9-13, 2018 Portland, Oregon, USA Oregon Convention Center (OCC)

2018 SIAM Annual Meeting (AN18), July 09-13, 2018, Oregon Convention Center (OCC), Portland, Oregon, USA.

The SIAM Activity group organized 7 mini-symposia as a part of the 2018 Annual Meeting in Portland. Stephan Sturm. Matthew Lorig, and Rebecca Conley organized a one-part mini-symposium. consisting of one session. Sebastian Jiaimungal and Agostino Capponi each organized a 2-part minisymposium consisting of two separate sessions. Each session consisted of four speakers. Speakers included senior professors at European and North-American schools, mid-career professors, junior professors, post-doctoral and Ph.D. students.

The topics covered ranged from partial differential equations in financial mathematics to post-crisis financial models including systemic risk and valuation adjustments, financial technology, algorithmic trading and mean field games.

Sessions were well attended not only by people in the financial mathematics community, but more broadly by people of other subcommunities within SIAM, working on PDEs, probability theory, and theoretical aspects of machine learning. The sessions were interactive and engaging for the audience.

– Reported by Agostino Capponi, Columbia University

# HOW ARE TRADING STRATEGIES IN ELECTRONIC MARKETS AFFECTED BY LATENCY?

Álvaro Cartea<sup>1,2</sup>

<sup>1</sup>Mathematical Institute, University of Oxford, Oxford, UK <sup>2</sup>Oxford-Man Institute of Quantitative Finance, Oxford, UK

#### Abstract

In this short piece I discuss how latency affects trading strategies. Latency is the time delay between an exchange streaming market data to a trader, the trader processing information and deciding to trade, the exchange receiving the order from the trader, and the trader being notified of the outcome of the operation.

Keywords: Latency, fill ratio, high-frequency trading, algorithmic trading, social welfare, Flash crashes.

Financial markets have undergone dramatic changes over the last couple of decades. Nowadays, most financial instruments are traded on electronic exchanges that match the orders of investors who demand and supply liquidity in the marketplace. Investors employ tailor-made computerised algorithms that buy and sell assets, choose when and where to trade, and handle inventories. The success of these algorithms depends on many factors, one of which is the speed to: process information, make a decision, and reach the exchange.

The speed of trading is continually improving with technological innovation. Everything else being equal, faster access to exchanges and faster algorithms are key ingredients in the profitability of many strategies. This has triggered an arms race amongst market participants who compete to be faster than their peers. Competition in the marketplace is desirable and healthy. However, investing resources with the sole objective of improving the speed of trading may be optimal for each individual trader, but, on aggregate, not necessarily optimal for society. Ultimately, stakeholders (e.g., pension funds, hedge funds, individual investors, companies that issue equity, and households) bear the costs of the speed arms race.

The fastest traders are known as high-frequency traders. They employ low-latency algorithms in electronic platforms to trade equity, bonds, commodities, foreign exchange, etc. The Flash crash of May 2010, when stock price indices (e.g., S&P 500 and Dow Jones Industrial Average) underwent a sudden sharp decline followed by a quick recovery within minutes, posed a number of questions about the effect of low-latency algorithms on the quality and integrity of markets. Since then, academics, regulators, and financial authorities have looked into the pros and cons of low-latency trading, see Securities et al. (2010). The findings are mixed. For example, in Sornette and Von der Becke (2011) the authors argue that highfrequency trading leads to market crashes. Cartea and

Penalva (2012) provide a theoretical model to show that in the presence of low-latency traders both the volatility of prices and the price impact of liquidity trades increase. On the other hand, Hasbrouck and Saar (2013) find that low-latency trading is beneficial to the quality of markets.<sup>1</sup>

However fast a trading algorithm is, the time it takes to make a decision and instruct the exchange is not zero. Algorithms require time to process information and devise strategies, instructions take time to arrive and to be processed by the exchange, and finally, it takes time for the trader to learn about the outcome of the operation. This time delay, known as latency, hinders the efficacy of trading strategies because, in the meantime, the exchange processes other trading instructions that update the limit order book (LOB) with information not known by the investor's algorithm when the strategy was devised. The LOB is a collection of limit orders that provide liquidity to buy or sell a quantity of the asset at a given price. These limit orders rest in the LOB until they are cancelled or amended by the trader who posted them, or until they are executed against an incoming liquidity taking market order.



Figure 1. The effect of latency: a liquidity taking order 'arrives late' and cannot be filled because the market has moved.

<sup>&</sup>lt;sup>1</sup>The literature on high-frequency trading and market quality is vast, see for example Hagströmer and Norden (2013), Hoffmann (2014), Cartea et al. (2018), Scholtus et al. (2014), Budish et al. (2015), Conrad et al. (2015).

Figure 1 illustrates the effect of la- at the 'right' time and compete for a tency on a liquidity taking order sent by a client to purchase a currency pair on a foreign exchange (FX) platform. The *y* axis shows the exchange rate for the currency pair and the x axis shows time in milliseconds (ms). The dashed lines show the price-grid of the exchange – changes in prices are in multiples of  $10^{-3}$  units of the exchange rate. The solid line shows the best ask in the LOB of the FX exchange and the markers (triangles) denote the times when a client receives, processes, makes a trading decision, and is notified the outcome of the trade.

In the figure, at t = 0, the FX exchange streams quotes to the client. This information reaches the client at t = 8 ms. Immediately after, the client's computerised algorithm processes other data, explores trading opportunities, and decides to send a buy order to the exchange at t = 14 ms. The client's order specifies the quantity of currency pairs and the maximum price the client is willing to pay, which in this case is 115.400 per lot of currency pair. This instruction is processed by the exchange at t = 21ms. The order sent by the client is rejected by the exchange because by the time the order is processed, the best ask price for the currency pair has increased to 115.404, which is higher than the price cap specified in the buy order of the client. Finally, the client receives the rejection message sent by the exchange at t = 27 ms. Thus, latency in this trade is 27 ms.

Latency affects the trading strategies of liquidity takers (i.e., those who send market buy and sell orders) and of liquidity makers (i.e., those who send limit orders that rest in the LOB). As illustrated in the figure, liquidity takers face a moving target problem as a consequence of their latency. On the other hand, liquidity makers bear the risk of not being able to withdraw or amend a quote they made to the market as a result of latency, so they face the risk that their quotes are adversely selected. Similarly, latency may preclude a liquidity maker from sending quotes to the market

favourable position in the queue of the LOB.

The effect of latency on algorithmic trading strategies is a ubiquitous problem for traders. Latency affects the profitability of strategies in many ways. The cost of not completing the trade in the example depicted in Figure 1 is difficult to quantify. One can proxy the cost for this particular trade as the difference between the ask price at the time the order arrived in the exchange and the ask price seen by the client – this difference is four ticks, i.e.,  $4 \times 10^{-3}$ . However, this proxy may not take into account other knock-on costs stemming from missing a trade. For example, the missed trade could be one leg of a trading strategy consisting of multiple orders that are executed in more than one exchange.

The mathematical finance literature has cast many of the problems faced by investors in the framework of stochastic optimisation, see the monographs by Cartea et al. (2015) and Guéant (2016). A great deal of progress has been made in this direction. There is a large number of excellent papers that investigate the mathematical and financial nuts and bolts of the main trading strategies employed in financial markets, e.g., execution of large orders, statistical arbitrage, pairs trading, market making.

However, the vast majority of papers assume that trading algorithms operate with zero latency in the marketplace. This assumption is useful. but unrealistic. From a mathematical viewpoint, including the effect of latency in models of trading is a challenging and interesting question. On the other hand, for a trader, the costs borne by strategies as a result of latency are comparable to other costs that traders endeavour to minimise.

One of the few papers that look into the costs of latency is that of Moallemi and Saglam (2013). The authors present a model of liquidity provision and employ market data to quantify the costs of latency in equity markets.

# PAST EVENTS

#### 9TH WESTERN CONFERENCE ON MATHEMATICAL FINANCE (WCMF-9)

November 16-18, 2018 University of Southern California. Los Angeles, CA, USA

#### 3RD EASTERN CONFERENCE ON MATHEMATICAL FINANCE

October 26-28, 2018 Illinois Institute of Technology, Chicago, IL, USA

#### CONFERENCE ON FINANCIAL **REGULATION AND SYSTEMIC RISK:** 10 YEARS AFTER LEHMAN

September 17, 2018 Paris, France

#### CONFERENCE ON ROBUST TECHNIQUES IN QUANTITATIVE **FINANCE**

September 3-7, 2018 University of Oxford, Oxford, United Kingdom

#### SUMMER SCHOOL ON TOPOLOGICAL DATA ANALYSIS FOR BANKING AND FINANCE

July 16-27, 2018 Western University, in cooperation with the Fields Institute for Research in the Mathematical Sciences, London, Ontario, Canada

#### **10TH WORLD CONGRESS OF THE BACHELIER FINANCE SOCIETY**

July 16-20, 2018 Trinity College, Dublin, Ireland

## PAST EVENTS

EURO 2018 - 29TH EUROPEAN CONFERENCE ON OPERATIONAL RESEARCH

> July 8-11, 2018 Valencia, Spain

COMMODITY AND ENERGY MARKETS ASSOCIATION ANNUAL MEETING

> June 20-21, 2018 Rome, Italy

#### NEW IDEAS & CUTTING-EDGE DEVELOPMENTS IN FINTECH

May 26, 2018 NYU Courant, New York, NY, USA

#### COMPLEX NETWORKS: THEORY, METHODS, AND APPLICATIONS

May 14-18, 2018 Lake Como School of Advanced Studies, Como, Italy

QUANTITATIVE RISK MANAGEMENT & FINANCIAL ANALYTICS WORKSHOP

May 10, 2018 University of Ottawa, Ottawa, Ontario, Canada

#### BYRNE WORKSHOP ON STOCHASTIC ANALYSIS IN FINANCE AND INSURANCE

May 9-11, 2018 University of Michigan, Ann Arbor, MI, USA

#### PRINCETON-RUTGERS MATH FINANCE DAY

April 7, 2018 Rutgers University, New Brunswick, NJ, USA

They show that latency costs in liquidity provision are of the same order of magnitude as other trading costs such as commissions and exchange fees (see also Gao and Wang (2018)). In a more recent paper, Cartea and Sánchez-Betancourt (2018) consider the problem of latency from the viewpoint of a liquidity taker and how latency affects the efficacy of their strategies. In their paper, the authors derive a latency-optimal strategy for a trader in FX markets and employ proprietary data to quantify the cost of latency for various market participants.

Market participants can reduce their latency by investing in hardware and co-location services. Alternatively, or in addition, traders can devise strategies that minimise the adverse effects of latency. As shown in Cartea and Sánchez-Betancourt (2018), latencyoptimal strategies are not costless, but they may be cheaper than investing in hardware and other services to shave off milliseconds in the latency of a trader. Financial mathematicians are in an ideal place to devise latencyoptimal strategies and to help the market, and society, to reach an efficient tradeoff between the cost of latencyoptimal strategies and the costs of computer power and other latency reduction expenses. Paying the costs of computer power and other infrastructure to reduce latency may be optimal for an individual trader, but not for society if too many traders join in the arms race to improve their speeds of trading.

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# **UPCOMING EVENTS**

# SIAM Conference on Financial Mathematics & Engineering

June 4-7, 2019 University of Toronto Toronto, Ontario, Canada

International Congress on Industrial and Applied Mathematics

JULY15-19 VALENCIA · SPAIN

