

## How fragile is competition in high-frequency trading?

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The last few years have seen much consolidation of the HFT business. Is that simply the result of the sector's maturity, along with generally low volatility and often stagnant overall volumes of trading? Or is something more profound happening? 'Jitter' (random fluctuation in processing time) in exchanges' systems has been falling, making small advantages in speed in HFT much more salient, while the costs of setting up and running an HFT firm – especially one trading US equities – are now very daunting.

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If you speak to high-frequency traders, as I often do, you get a sense of a fiercely competitive business. Some of the competition is the endless search for exploitable structure in the apparently random fluctuations of prices. Finding such structure is now much harder than when the HFT business was in its infancy twenty years ago, but nobody thinks that the search for it is over – that the lake has been fished dry, so to speak.

The more pressing side of the competition, though, is the speed race, with its requirements for the fastest datafeeds, the fastest microwave or millimetre wave links, the lowest processing times, the fastest field-programmable gate arrays (FPGAs), and so on. The trouble with a speed race is not simply that it's expensive, but that it can have a winner: that, at least in a particular market, or in trading on a particular exchange, one HFT firm – or a small number of firms – may achieve an advantage in speed that's very hard and very costly for their rivals to overcome.

The economic importance of an advantage in speed depends on, among other things, the extent of “jitter” – quasi-random fluctuation in processing times – in the computer systems of the exchange or exchanges in question. (I write “quasi-random” because it would be too narrow to think about this fluctuation as being caused only by stochastic aspects of the physical world, such as the heat-induced agitation of electrons. More broadly, jitter is speed fluctuation that a system’s architects neither desire nor can fully control, and may not even fully understand.) “Jitter is an equalizer,” pointed out Stéphane Tyč of communications supplier McKay Brothers in a June 2016 talk. A speed advantage that’s small relative to the jitter in an exchange’s system is limited in its effects. If there’s enough jitter, the second-fastest firm – and perhaps the sixth-fastest, or even the tenth-fastest – should “get the trade” often enough to stay in business and maybe generate sufficient revenue to make the investments needed to catch up on speed.

Exchanges’ software developers and engineers have, however, made considerable efforts, often successfully, to reduce jitter. The most dramatic example is the Chicago Mercantile Exchange (CME). When I first started interviewing high-frequency traders on the CME, in 2012-13, they weren’t complimentary about its systems. Suppose, one of them said in March 2012, that another firm’s ‘round-trip time’ (the different between its receipt of market data and the dispatch in response of an order or cancellation) was a millisecond, and his firm’s was 0.9 milliseconds. If “the difference randomly [in processing time] that could occur on the CME side is 10 milliseconds ... what does it matter if I get down to 0.9?”

Since 2012, the CME’s systems have been redesigned completely. They now, for example, incorporate FPGAs (which are not just fast, but highly deterministic, i.e. have very low jitter). Since the redesign, the complaints about jitter I heard in 2012-3 seem to have ended. The case of the CME, furthermore, is exceptional only in the extent to which jitter

has been reduced. Jitter seems to have declined considerably throughout the markets in which HFT firms are active.

Sharply reduced jitter makes even tiny speed advantages important. Consider what has become the famous purchase in 2016, by an affiliate of the HFT firm Jump Trading, of a field on the other side of the road that runs along the north side of the CME's datacentre. The point of the purchase was to place a couple of small microwave antennae and a diesel generator in the field, so as to remove a few hundred metres of what's called "fibre tail": the distance over which a signal has to pass not through the atmosphere but more slowly through fibre-optic cable. The amount of time thus saved could only be of the order of a microsecond – a hundredth of the time difference that my interviewee in 2012 had pointed out was swamped back then by the CME's jitter – and the advantage could only be temporary, since Jump must have known that its two competitors in the microwave speed race (Vigilant, owned by trading firm DRW, and McKay Brothers, which sells bandwidth and fast data to trading firms) also had sufficient resources to place their antennae similarly close to the datacentre. Yet Jump clearly reckoned that a microsecond advantage, even if it lasted – as it did – only around a year, was worth at least the \$13.9 million paid for the field. (The advantage would most likely have been not primarily on the CME itself, but in New Jersey, on exchanges – by then also very low jitter – in which "signals" from the CME are crucial guides to algorithmic trading.)

How real is the threat to competition in HFT posed by the combination of an expensive speed race and the decline of jitter? The list of HFT firms that have disappeared through merger in recent years is headed by Getco (the firm that, more than any other, gave shape to the HFT business), and also includes Chopper, Infinium, Teza, RGM Advisors and Sun Trading, as well as a number of less well-known names. True, new entrants have

emerged, but as far as I can tell only two of them, Headlands Technologies and XTX Markets, approach the scale of the firms that have disappeared.

Consolidation in HFT in US equities is particularly striking. In January, the *Financial Times* reported that just two firms, Virtu and Citadel, “account for around 40 per cent of daily US trading flow.” The *FT* didn’t cite its sources, so the figure could be an exaggeration, but it would certainly be noteworthy if just two firms are now responsible for two-fifths, not just of HFT in US shares, but of *all* US share trading.

What the case of US equities also demonstrates is the potential for costs to mount up in aggregate to a substantial barrier to entry. Recruiting and retaining a sufficient number of sufficiently skilled and experienced members of staff is always likely to be the dominant category of cost, but a 2018 paper by Columbia University’s Charles Jones suggests that a medium-sized proprietary firm trading US equities would also have to pay around \$1.8 million a year for datafeeds from the equities exchanges owned by the three main operators, NYSE/ICE, Nasdaq and CBOE.

In addition, the firm would need colocation of its servers in each of those operators’ datacentres, cables connecting those servers to the exchanges’ systems, and trading “sessions”: there’s a useful guide to expenses of this sort in a recent report from IEX, and a deeply thought-provoking analysis of the background to them in a paper by the economists Eric Budish, Robin Lee and John Shim. The speed race, Budish and his colleagues point out, lies in the background of these additional costs. If a market maker does not cancel its quotes quickly enough when they become stale, they will be “picked off” by HFT algorithms that specialize in liquidity-taking. Both sides in this speed race thus have an incentive to pay for extreme speed – there may be little alternative but to pay up. The fastest, highest-capacity fibre-optic connection to an exchange’s system, for example, can cost a lot more than a

basic connection. Nasdaq's prices, for instance, currently range from \$2,500 a month for a 1Gb connection to \$20,000 a month for 40Gb. If, e.g., two of the latter cables are needed for redundancy, that's a cost of \$480,000 a year in that datacentre alone.

The expenses faced by an HFT firm also include trading fees (which would tend to be proportionately higher for a new entrant that isn't as yet trading at scale), technology costs, the tick-by-tick data needed to back-test strategies, the far-from-trivial costs of regulatory compliance, and so on. Once you start to think about the list of costs and their likely magnitude, you can see why entry to the HFT business is hard, and why even experienced firms have quietly been drowning, with static or declining trading revenues submerging in a rising sea of costs. Competition in HFT lives on – Jump's year-long microsecond advantage, for example, didn't cause the sky to fall – but its health should certainly not be taken for granted.

## Links

**Stéphane Tyč talk:** <https://www.mckay-brothers.com/exchanges-vs-networks/>

**Jump's purchase of field:** <https://www.bloomberg.com/news/articles/2017-05-12/mysterious-antennas-outside-cme-reveal-traders-furious-land-war> (subscription may be needed)

**Financial Times report** with market share of Virtu and Citadel:

<https://www.ft.com/content/4908c8b0-1418-11e9-a581-4ff78404524e> (subscription needed)

**Charles Jones paper:**

<https://www0.gsb.columbia.edu/faculty/cjones/papers/2018.08.31%20US%20Equity%20Market%20Data%20Paper.pdf>

**IEX report** on cost of exchange services:

<https://iextrading.com/docs/The%20Cost%20of%20Exchange%20Services.pdf>

**Budish, Lee and Shim** paper: <http://faculty.chicagobooth.edu/eric.budish/research/Stock-Exchange-Competition.pdf>

**Nasdaq price list** for trading connectivity:

<http://nasdaqtrader.com/Trader.aspx?id=PriceListTrading2>