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The High Cost of High-Frequency Trading

I spent more than 7 years deeply involved in high-frequency trading (HFT). During this time, I was a senior quantitative analyst and a portfolio manager at a leading option market-making hedge fund, which engaged in HFT. This position gave me a unique view of how current incentives in the electronic securities markets encourage an HFT arms-race, which hurts investors in the long-term.

The securities markets began so that two parties could meet and exchange an object of economic value at a price established by market participants. In all of these markets, parties with better information had a competitive advantage, because they could adjust their supply or their demand in response to the information they received.

The telegraph's invention ushered in a new, electronic era in which those with better technology also possessed better information. The speed of this electronic communication increased as we progressed from the telegraph, to the telephone, to stand-alone computers, to networked computers connected to electronic exchanges.

This last evolution - networked computers connected to electronic exchanges - gave birth to HFT. In simplest terms, HFT is an automated trading platform. It uses powerful computers to transact a very large number of orders at speeds faster than a human can process. By 2013, HFT accounted for about 50%, by volume, of all U.S. equities trades.

Today's state-of-the-art computing hardware is so good that we have approached the physical limits imposed by the speed of light. A good HFT system makes decisions in a few millionths of a second. During such a short time, light can travel only a few thousand feet. This physical limitation necessitates the use of exotic, special-purpose hardware which HFT companies co-locate at the exchanges.

HFT is a double-edged sword. On the positive side, electronic trading, and HFT in particular, has significantly narrowed the bid/ask spread that market participants pay to transact, and that reduces costs to investors. On the negative side, compressing the bid/ask spread has decreased the quantity available to trade at the bid/ask, and that makes it difficult to purchase more than a few hundred shares at the bid/ask. This small quoted size leads to very thin markets. In turn, these thin markets are extremely susceptible to supply/demand dislocations, as we observed during the May 2010 "flash crash" and during similar mini flash crashes which occur in a few securities each week.

HFT contributes to these flash crashes because of the computer hardware and software that it requires. Consider how this plays out: when an HFT system receives data from the exchange, it must react instantly, adjust its calculations, and send new trading instructions back to the exchange, all within a few millionths of a second. By contract, a human eye blink takes 300 milliseconds. That is over 1,000 times longer than the microsecond turn-around that HFT systems require.

To achieve this microsecond turn-around, state-of-the-art HFT systems minimize how many computations they perform. The exotic hardware that HFT firms employ to reduce latency further constrains the number of computations. The limited silicon available on FPGAs (field-programmable gate arrays) and ASICs (application-specific integrated circuits) limits how many computations this exotic hardware can perform.

Unfortunately, minimizing computations means throwing out a great deal of error-checking, and that makes our markets very brittle. HFT contributes to problems in the markets, because it represents a huge hidden liability for the companies that practice it, as well as for their counterparties in the markets.

Knight Capital is one well-known example of HFT's effects. In August 2012, Knight Capital's HFT trading platform went haywire, quoting absurd prices for 148 NYSE stocks. This incident cost Knight $440M, and ultimately, its business.

More recently, in August 2013, Goldman's HFT system quoted absurd prices to the U.S. equity options markets. Had the exchanges not nullified these trades, Goldman would have lost approximately $500M. In this instance, the ones who truly lost were Goldman's counterparties in these trades. These counterparties traded with Goldman based on the absurd, HFT-generated prices. After the counterparties received confirmation from the exchanges of these trades, they hedged their positions with stock. The exchanges nullified Goldman's trades, but they did not nullify these hedges. This left Goldman's counterparties with most of the loss.

In both the Goldman and the Knight cases, error-checking was sufficiently lax for the problems to persist for an eternity in trading terms: 17 minutes for Goldman and 30 minutes for Knight. Such persistent, recurrent failures destroy trust in the robustness of the marketplace.

Our current electronic exchanges encourage HFT by design. HFT provides an enormous revenue stream for the exchanges, because the exchanges charge HFT firms fees for trading, fees for co-locating hardware, and fees for data feeds. Consider just the fees for data feeds. The exchanges sell multiple data feeds of varying speeds, and the price for the fastest feeds, which HFT firms demand, is several times the price of the slowest feed. The exchanges further encourage HFT by offering volume discounts; with these volume discounts, trading more leads

to a lower cost per trade.

Between exchange fees, exotic hardware, and specialized software developers, it is easy for HFT shops to spend well in excess of $20M/year just to keep their systems competitive. Indeed, some HFT firms spend well over $100M/year. Not only that, but the required overhead is growing rapidly. A technological arms-race exists between the HFT firms: all firms must invest in the latest-and-greatest technology, as soon as one competitor does.

For a $100M firm, this overhead of $20M/year amounts to an annualized expenditure of 20%. However, for a $1B firm, this overhead represents only 2% annually. Clearly, this puts better capitalized firms at an advantage.

If we allow this technological arms race to continue, it will significantly decrease competitiveness in the marketplace. Quite simply, smaller HFT firms will be unable to bear the overhead to stay in business. We are on an unfortunate trajectory to have just the four most capitalized HFT firms provide liquidity on the exchanges. This decreased competition is not good for investors.

The current paradigm is one of brittle, thin markets with little competition. Shouldn't we change this paradigm for the better? Change starts by recognizing that a difference exists between HFT and electronic trading. In the computer age, we should expect our markets to be electronic. Computers are much more efficient than a bunch of men yelling at each other on the exchange floor. On the other hand, these yelling men can pause to think before mindlessly executing a trade. If we choose to slow down the electronic speed game, then we could (1) give the machines more time to contemplate the consequences of their actions before submitting an order, and (2) increase the competition between firms providing liquidity in the market, since reducing the speed would likewise reduce the required overhead.

If the SEC enacted a few simple exchange requirements, it would have these results: (1) it would drastically slow down the pace of trading, (2) it would provide electronic trading systems with sufficient time to check for errors, and (3) it would not put careful firms at a disadvantage to their competitors.

What might these exchange requirements be? First, the exchanges should add a random delay to all submitted orders before it activates them. Second, the exchanges should enforce a minimum lifetime for all orders before they can be canceled. Third, the exchanges should remove volume discounts for trading. This would reduce the back-and-forth churn in the market.

A delay of 0.1 seconds is unnoticeable to a human, but it is an eternity for a computer. To us, this delay is microscopic, but it would provide sufficient time for error-checking for an HFT system running on even low-cost hardware.

The exchanges are now publicly traded companies, so they must answer ultimately to their shareholders. If we slow down HFT trading, it will kill the exchanges' HFT revenue stream, and that will be bad for their businesses. As a result, we should not expect the exchanges to initiate or to go along with reduced-speed trading. Instead, it is most likely that change will have to be forced upon them.

Before the rise of HFT, each communication improvement came with error-checking by humans. However, the current generation of HFT technology has less and less error-checking, both by humans and by computers. We can have markets which are robust, electronic, and competitive, but to achieve this goal, we have to end the HFT arms race. Slowing down the speed of trading will not be easy, but ultimately, it will produce the best results for investors and for the markets.

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