Bibliography of Evidence-Based Research on High Frequency Trading

"High frequency trading is a tool that can be used for any strategy," James Overdahl recently told the *Financial Times.* Overdahl is a former Chief Economist of the Securities and Exchange Commission, and before that of the Commodity Futures Trading Commission. Now an adviser for a high frequency trading (HFT) lobbying group, he also rightly said "We need to move towards an evidence-based discussion, so people can see the benefits."

So let's look at some evidence.

High frequency strategies

According to the International Organization of Securities Commissions (IOSCO), there are several common high frequency strategies or business models, including market making, arbitrage and short-term trend trading. Of these three categories, the most pervasive is the market making business. One HFT market maker firm alone is estimated to participate in 10% to 20% of U.S. stock market trades.

Market making today is very different from what it was even just a few years ago. As U.S. stock markets enthusiastically deregulated in the last decade, market makers shed most of their responsibilities - among them, to not trade ahead of the public, to not shock prices by trading aggressively, and to maintain competitive quotes - but kept or expanded many of their advantages. Short selling rules are relaxed or waived for market makers, margin requirements are a fraction of those for ordinary investors, exchanges pay market makers to trade, and exchanges offer proprietary data feeds catering to their requirements. Where market makers once had to maintain smooth and orderly markets, now they don't. Where market makers once carried positions for weeks to meet their obligations, now they keep as little inventory as possible, and almost never overnight.

After deregulation, market making in the stock market became largely unregulated and unconstrained, and quickly evolved into a business model more familiar to the loosely regulated futures pits than to the stock market - "scalping." Over 85 years ago the U.S. Federal Trade Commission defined a "scalper" on the futures markets as a firm that "typically buys and sells in large quantities, expecting to hold the trade open only a very short time" and that "intends to be even as to quantities bought and sold at the close of the business day..." In other words, a scalper quotes and trades very rapidly, doesn't hold a position for very long - rarely more than seconds - and is flat or out of the market altogether at the end of day.

Though there is a long and detailed research literature on market maker scalpers in futures and over-the-counter markets around the world, they are a new phenomenon in U.S. stock markets. Some of the largest HFT market makers in U.S. stock markets today were founded just in the last 10 or 15 years by "locals" (scalpers) from U.S. commodity markets.

When they talk about their business model, these firms tell us that "In the old days, short-term liquidity was provided by specialists [market makers] or floor-traders. In the past 10 years, their role has largely been replaced by sophisticated high-speed computer models." Unsaid is that in the old days specialists and floor-traders operated under an extensive regulatory framework, and today's high-speed computer models do not.

They also tell us that "In the 'good old days' the specialist margins were much, much fatter (and the public footed the bill). With these ultra-slim margins, the only way to stay in business is to make it up on volume - huge volume." Unsaid is that today's high-speed computer models trade much more frequently with the public than specialists were ever allowed to - about three times more often - so though today's margins are slimmer they really do make it all up, and more, on volume.

These firms don't carry any inventory and trade aggressively to unload it. One of the largest HFT market makers in the world recently described its business by writing "Market makers typically attempt to end each trading day with as little risk or position as possible in a given security, i.e. flat...[and] often employ market making strategies that sometimes include removing liquidity [trading aggressively]..." Unsaid is that when they trade aggressively they can have a dramatic effect on prices.

Technology made this business model faster and cheaper. Deregulation made it more widespread than ever imagined. In just a few years, market maker scalpers gripped the stock market. Investors now find a market dominated by sophisticated HFT firms and have few of the safeguards that once protected them.

Margins and informed traders

First, let's look at how market maker margins have changed. In 2004 a large market maker on the New York Stock Exchange (NYSE) reported that it earned a little less than seven tenths of a cent per share traded.[1] 2004 is an important year because it is one of the last years of "the good old days" in many respects. The NYSE had a commanding 80% market share in its stocks, NYSE market makers held monopolies in the stocks they traded, and several deregulatory initiatives were still a few years away. Even with all of these advantages, because it was closely regulated the firm only inserted itself in about 23% of shares traded.

Fast forward to 2009, after deregulation, and one researcher determined that HFT firms made a little more than two-and-a-half tenths of a cent per share traded.[2] At first glance, that's nearly two thirds less per share than before, an "ultra-slim" margin by comparison, and looks like a triumph for deregulation. But the same researcher reported that HFT firms inserted themselves into approximately 75% of all shares traded.[3]

We can do the math by imagining someone buying 1000 shares. In 2004, a market maker would trade with 230 shares (23%) of that - other investors would trade with the rest - and earn about $1.54. In 2009, HFT firms would trade with 750 shares (75%) of that and earn $1.99. Remarkably, investors today pay HFT firms *30% more* than they used to pay NYSE old-style market makers. Investor portfolio implementation costs have gone down in the last decade, most especially because of stock price decimalization and industry-wide automation, but HFT firms now capture a bigger piece of those costs and more than make up on share volume what they lost in per share margins.

They make it up in other ways too. Regulations once prohibited market makers from trading aggressively with a price trend on the theory that market makers should not exacerbate price swings or remove liquidity from the marketplace. Those regulations were dismantled by 2008. Now free to trade with the trend, and do it aggressively, HFT firms of all stripes, including market maker scalpers, incorporate very short-term trend strategies into their models.

Trend traders are said to be "informed." An informed trader believes he has an edge. Informed traders trade aggressively because they think they know where prices are going and they want to take a position as quickly as possible. In the stock market, regulators used to prevent market makers from acting like informed traders because market makers had privileges, access and information most investors didn't. Though they still have privileges, access and information most investors don't have, today the regulations are gone and HFT scalpers can trade as aggressively as they like whenever they have an edge, however short-lived. That edge also explains why HFT firms dominate the market.

Evidence

The bibliography attached to this note includes nearly a century's worth of evidence-based research discussing the effects of market maker scalper business models on markets around the world. Several papers describe how scalpers are not just simple passive market makers, as sometimes imagined, but trade aggressively on information they glean from their many privileges.

Several papers also describe how unregulated or unconstrained market maker firms manage inventory, and how, in volatile markets, these firms can exacerbate price volatility by trading as quickly and aggressively as they can, just as happened in the Flash Crash. The bibliography also includes evidence-based research papers that explore the benefits of market maker regulations and obligations in stock markets that have tried them, including, somewhat ironically, the U.S. itself before deregulation.

Finally, several papers discuss the effects of high frequency trading of all types on today's markets.

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[1] LaBranche & Co., Inc. form 10-K for 2004. LaBranche reported that its NYSE specialist unit traded 22.3 billion shares as principal in 2004 for trading revenue of approximately $149.5 million, or .67 cents per share traded.

[2] Extrapolated from Brogaard, "The Activity of High Frequency Traders" (2011). Brogaard reports that the HFT firms in his study earned approximately .75 cents per $100 value traded. With an average stock price of $35.42 in the study, we calculate revenue per share as .265 cents.

[3] Brogaard, "High Frequency Trading and its Impact on Market Quality" (2010).

Author(s), Title, Year	Data	Relevant findings
Ananda, Tanggaarda, Weaver, "Paying for Market Quality" (2009)	Swedish equities, 2002-2004	Designated market makers with affirmative obligations improve market quality, increase market valuation.
Bank for International Settlements, "High frequency trading in the foreign exchange market" (2011)	Foreign exchange, 2010 and 2011	"HFT has had a marked impact on the functioning of the FX market in ways that could be seen as beneficial in normal times, but also in ways that may be harmful to market functioning, particularly in times of market stress."
Chae, Wang, "Determinants of Trading Profits: The Liquidity Provision Decision" (2009)	Taiwanese equities, 1997-2002	Absent mandatory obligations, market maker privileges don't induce market makers to provide liquidity; privileged but unconstrained market makers make profits when demanding liquidity in their own informed trades; unconstrained market makers are informed traders rather than liquidity providers in most scenarios.
Easley, Lopez del Prado, O'Hara, "The Microstructure of the Flash Crash" (2011)	U.S. futures, 2010	Unregulated or unconstrained HFT market makers can exacerbate price volatility when they dump inventory and withdraw, flash crashes will recur because of structural issues.
Ferguson, Mann, "Execution Costs and Their Intraday Variation in Futures Markets" (2001)	U.S. futures, 1992	Unregulated or unconstrained market makers in the futures market have much more rapid inventory cycles than (regulated) equity market makers, are active rather than passive traders, and "actively trade for their own accounts, profiting from their privileged access..."
Frino, Forrest, Duffy, "Life in the pits: competitive market making and inventory control-further Australian evidence" (1999)	Australian futures, 1997	Unregulated or unconstrained market makers are not passive liquidity providers, they behave aggressively like informed traders.
Frino, Jarnecic, "An empirical analysis of the supply of liquidity by locals in futures markets: Evidence from the Sydney Futures Exchange" (2000)	Australian futures, 1997	Unregulated or unconstrained market makers demand liquidity to profit from information advantages of privileged access, less likely to supply liquidity in volatile markets, almost as likely to demand as to supply liquidity.
Frino, Jarnecic, Feletto, "Local Trader Profitability in Futures Markets: Liquidity and Position Taking Profits" (2009)	Australian futures, 1997	Unregulated or unconstrained market makers are active and informed traders.
Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues, "Recommendations Regarding Regulatory Responses to the Market Events of May 6, 2010" (2011)	U.S. futures and equities, 2010	"In the present environment, where high frequency and algorithmic trading predominate and where exchange competition has essentially eliminated rule-based market maker obligations, liquidity problems are an inherent difficulty that must be addressed. Indeed, even

		in the absence of extraordinary market events, limit order books can quickly empty and prices can crash simply due to the speed and numbers of orders flowing into the market and due to the ability to instantly cancel orders."
Kirilenko, Samadi, Kyle, Tuzun, "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market" (2010)	U.S. futures, 2010	Unregulated or unconstrained HFT market makers exacerbated price volatility in the Flash Crash, hot potato trading, two minute market maker inventory half-life; "...High Frequency Traders exhibit trading patterns inconsistent with the traditional definition of market making. Specifically, High Frequency Traders aggressively trade in the direction of price changes...when rebalancing their positions, High Frequency Traders may compete for liquidity and amplify price volatility."
Kurov, Lasser, "Price Dynamics in the Regular and E-Mini Futures Markets" (2004)	U.S. futures, 2001	Unregulated or unconstrained market makers demand liquidity to profit from information advantages of privileged access.
Linton, O'Hara, "The impact of computer trading on liquidity, price efficiency/discovery and transaction costs" (2011)	Literature review and survey	"The nature of market making has changed, shifting from designated providers to opportunistic traders. High frequency traders now provide the bulk of liquidity, but their use of limited capital combined with ultra-fast speed creates the potential for periodic illiquidity"; in "regular market conditions," liquidity has improved and transaction costs are lower.
Locke, Sarajoti, "Interdealer Trading in Futures Markets" (2004)	U.S. futures, 1995	Unregulated or unconstrained market makers demand liquidity to manage inventories.
Lyons, "A Simultaneous Trade Model of the Foreign Exchange Hot Potato" (1997)	Model derived from empirical studies of 1992 U.S. foreign exchange market.	Demonstrates hot potato trading among unregulated or unconstrained market makers. "Hot potato trading" means cascading inventory imbalances from market maker to market maker in response to a large order. Hot potato trading explains most of the volume in foreign exchange markets. Hot potato trading is not innocuous - it makes prices less informative.
Lyons, "Foreign exchange volume: Sound and fury signifying nothing?" (1996)	U.S. foreign exchange, 1992	Unregulated or unconstrained market makers cascade inventory imbalances from one to another, as "...trading begets trading. The trading begotten is relatively uninformative, arising from repeated passage of inventory imbalances among dealers...this could not arise under a specialist microstructure."
Manaster, Mann, "Life in the pits:	U.S. futures, 1992	Unregulated or unconstrained market

competitive market making and inventory control" (1996)		makers aggressively manage inventory, are "active profit-seeking," have much shorter inventory cycles than equities market makers.
Manaster, Mann, "Sources of Market Making Profits: Man Does Not Live by Spread Alone" (1999)	U.S. futures, 1992	Unregulated or unconstrained market makers demand liquidity to profit from information advantages of privileged access, are "predominant" informed traders.
Panayides, "Affirmative obligations and market making with inventory" (2007)	U.S. equities, 1991 and 2001	Mandatory market maker obligations reduce volatility.
Silber, "Marketmaker Behavior in an Auction Market: An Analysis of Scalpers in Futures Markets", (1984)	U.S. futures, 1982-1983	Unregulated or unconstrained market makers profit from the information advantages of privileged access, two minute inventory cycles.
Smidt, "Trading Floor Practices on Futures and Securities Exchanges: Economics, Regulation, and Policy Issues" (1985)	Literature review and survey	On futures exchanges, inventory imbalances among unregulated or unconstrained market makers create "potentially unstable" markets and price overreactions during "scalper inventory liquidation."
United States Commodity Futures Trading Commission and Securities and Exchange Commission, "Findings Regarding the Market Events of May 6, 2010" (2010)	U.S. futures and equities, 2010	Unregulated or unconstrained HFT market makers exacerbated price volatility in the Flash Crash, hot potato trading.
United States Federal Trade Commission, "Report of the Federal Trade Commission on the Grain Trade," Volume 7 (1926)	U.S. futures, 1915-1922	Unregulated or unconstrained market makers both cause and exacerbate price volatility; “The scalpers who operate with reference to fractional changes within the day may have a stabilizing effect on prices so far as such changes with the day are concerned, but when the market turns they run with it, and they may accentuate an upward or downward movement that is already considerable.”
Van der Wel, Menkveld, Sarkar, "Are Market Makers Uninformed and Passive? Signing Trades in the Absence of Quotes" (2009)	U.S. futures, 1994-1997	Unregulated or unconstrained market makers demand liquidity for a substantial part of the day and are active and informed speculators.
Venkataraman, Waisburd, "The Value of the Designated Market Maker" (2006)	French equities, 1995-1998	Designated market makers with affirmative obligations improve market quality, increase market valuation.
Wang, Chae, "Who Makes Markets? Do Dealers Provide or Take Liquidity? " (2003)	Taiwanese equities, 1997-2002	Absent mandatory obligations, market maker privileges don’t induce market makers to provide liquidity; they derive profits from their own informed trades; “While dealers may be meant to perform the socially beneficial function

		of liquidity provision, the institutional advantages granted to them also give the ability to act as super-efficient proprietary traders if they choose to.”
Working, "Tests of a Theory Concerning Floor Trading on Commodity Exchanges" (1967)	U.S. futures, 1952	Unregulated or unconstrained market makers are also trend traders, profiting from the information advantages of privileged access; they can trade aggressively, especially when the market goes against the firm; inventory cycles of "minutes"; trend trading accelerates price changes (but may moderate extremes).
Zigrand, Cliff, Hendershott, "Financial stability and computer based trading" (2011)	Literature review and survey	Self-reinforcing feedback loops in computer-based trading can lead to significant instability in financial markets; market participants become inured to excessive volatility in a cultural "normalization of deviance" until a large-scale failure occurs; research to date has not shown a persistent increase in market volatility, but HFT research is nascent.