Tradeworx, Inc. Public Commentary
on
SEC Market Structure Concept Release

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This presentation was created to serve two basic purposes:
- To serve as a primer and resource for regulators, policy-makers, the press, and the investing public on the topic of High-Frequency Trading (HFT) and its role in the US equity market, based on factual information, empirical data, and the insights of an experienced practitioner in both HFT and buy-side equity investing
- To respond to various requests for information and/or commentary made by the Securities and Exchange Commission in its Concept Release on Market Structure

Despite their complexity, we strongly believe that US equity markets are extraordinarily well-functioning. Given the centrality of HFT to the smooth functioning of equity markets, we strongly encourage policy-makers and regulators to observe the following guidelines as they consider changes to the market's structure:

- Don't make HFT a higher-risk activity
  - HFT is a very low-margin (low-risk, low-reward) activity
  - Regulations which increase the risk of running HFT strategies will, as a result, cause HF traders to seek higher reward
  - This would directly result in higher transaction costs and lower liquidity for long-term investors
- Avoid overreacting
  - Trading costs for long-term investors are extremely low, and liquidity extremely deep
  - US Equity markets performed well over a variety of stressful market conditions in the past 15 years
  - Wholesale change is unwarranted and irresponsible
- Avoid overreaching
  - We advocate modesty and incrementalism over large, ambitious, and complex regulations
  - Large regulations often have far-reaching, unintended, and unpredictable consequences
  - Complex regulations often impose artificial inefficiencies on trading behavior of buy-side investors
  - Inefficiencies created by regulation often serve as bountiful sources of arbitrage opportunities for HFTs
- Regulations should foster competition, not discourage it
  - Instead of imposing a market structure, let many coexist and compete; trust investors to decide which models work best
  - Be wary of the ability of regulations to entrench strong players by immunizing them from competition
- Embrace technology, don't vilify it!
  - Financial markets have a long history as early adopters of technology
  - As in other industries, traders use technology to gain a *competitive* advantage, not an *unfair* advantage
  - HFTs use technology to compete *with each other,* not with long-term investors
  - As in other industries, adoption of technology leads to compression of profit margins and reduced costs for consumers

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DEFINITION OF HFT:
- a strategy which trades for investment horizons of less than one day
- a strategy which seeks to unwind all positions before the end of each trading day

CONSEQUENCES OF DEFINITION
- because they must finish the day flat, HFTs must exhibit balanced bi-directional (i.e. "two-way") flow
- thus, HFTs can't accumulate large positions...
- thus, HFTs can't deploy large amounts of capital...
- thus, HFTs have little need for outside capital or leverage, and tend to be proprietary traders...
- HFTs can't "blow up" (they don't use much leverage, and don't *have* much capital, so they can't *lose* much capital!)

Q & A
- Q: Does HFT compete with long-term investors?
  - no - Long-term investors have neither the ability to identify HF opportunities, nor the interest
  - no - Long-term have commissions and trading costs that far exceed the expected return of a typical HFT trade
- Q: Where do opportunities for HFT come from?
  - HFTs take the *opposite side* of trades of long-term investors
  - Long term investors impact many securities besides the ones they are directly trade, because stocks are correlated
  - This creates opportunities for *Statistical Arbitrageurs*, whose activity keeps correlated stocks "fairly priced" with respect to one another
- Q: Is HFT a "bubble" that can "burst?"
  - no - HFTs can not deploy a lot of capital, and don't use significant leverage, so they can't experience significant losses, either
  - no - HFT is a low-risk, low-reward business, unlike derivatives trading, which is high-risk, high-reward
  - no - Bubbles are caused by herd-like behavior among LONG-TERM investors
- Q: Does HFT benefit from high volatility?
  - yes – when volatility is high, it is easier to overcome your transaction costs, which are fixed
  - yes – when volatility is high, liquidity is in short supply, and it becomes very profitable to provide it
- Q: Does HFT cause volatility?
  - no - HFTs *benefit* from volatility, so they can not *cause* it (otherwise they could make infinite amounts of money!)
  - no - volatility is caused by liquidity crises; i.e. excess demand for liquidity by *long-term* investors
  - no - HFTs can not significantly impact prices because they control very little capital, and take very small positions

BASIC ECONOMICS OF HFT IN US EQUITY MARKET

- net profit margin: approx 10 mils per share (i.e. 0.1 cents per share)
  - source: Tradeworx high-frequency proprietary trading, year 2009
  - source: Traders Magazine Oct 2005 *Q&A With Dave Cummings*
  - source: Knight Trading (Nasdaq: NITE) 2009 10K filing
- brokerage fees: 0.25 – 5 mils per share
  - source: Tradeworx, various brokerage firms
- sec fees: 5.4 mils / share
  - assumes rate of $16.90 per million
  - assumes average stock price: 63.8 (stock prices weighted by quarterly dollar volume, as of 3/19/2010)
- average trading market share: 40%
  - source: Tradeworx estimate; industry estimates range from 30% - 60%
- total annual profits: $2Bn / yr
  - assumes: 8 Bn shares / day of HF volume: 40% market share * 10 Bn shares/day * 2
  - assumes 10 mils/share of net profit
  - (8B shares) X (10 mils per share) equals $8M/day of profit
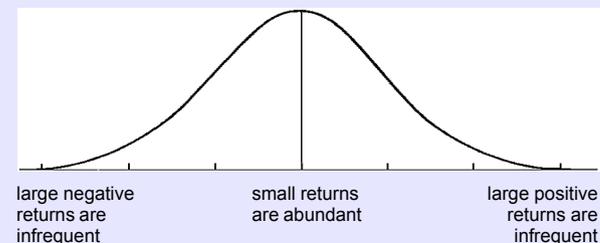 - ($8M per day) X (250 trading days) equals $2Bn per year

HIGH FREQUENCY TRADING VS LONG-TERM INVESTING
Economic Comparison and Tradeoffs

	HFT	Long-term Investing
profit margins	small	large
transaction costs	small	large
capital requirements	small	large
consistency of profits	high	low
total profit potential	small	large

How HFT WORKS

- Opportunities for short-term returns follow a Gaussian (Normal) distribution
  - large expected returns are rare; tiny expected returns are abundant
- HF Traders target opportunities that are tiny (expected returns ~ 0.2 cps before costs)
- Long-term investors don't have the cost-structure to target such trades!
  - Retail investors pay brokerage fees of approx 5 cps
  - Long-term institutional investors pay brokerage fees of 1cps or more !
- The risk/reward of such trades is not meaningful to long-term investors
  - typical HF trade: expected return = 0.1 cps after costs, standard deviation = +/- 5 cents
  - such a trade is useless on its own – can not risk a lot of capital on this!
- Small returns are appealing to HFT because they are very plentiful:
  - typical HF trade: expected return = 0.1 cps after costs, standard deviation = +/- 5 cents
  - after 100 such trades: expected return = 0.1 cps; standard deviation = +/- 0.5 cps
  - if you do 100 such trades per day, for full year: sharpe ratio of 3.2
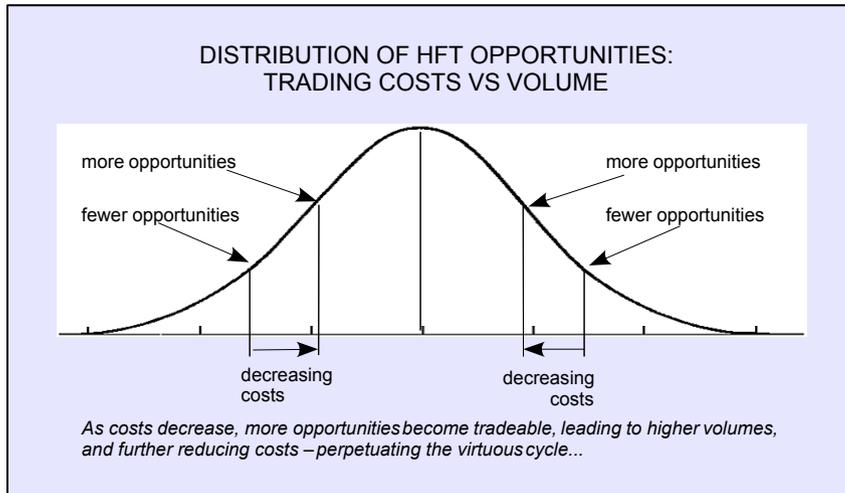 - if you do 10,000 such trades per day, for full year: sharpe ratio of 32

DISTRIBUTION OF SHORT-TERM RETURN OPPORTUNITIES

large negative returns are infrequent — small returns are abundant — large positive returns are infrequent
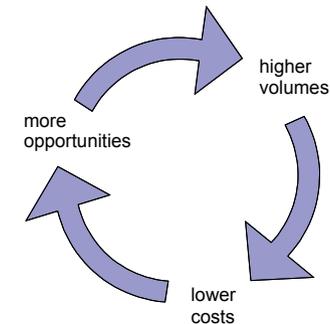
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HFTs and Technology

- Capturing HFT opportunities requires use of advanced technology
  - HFT opportunities are short-lived because they are very small
  - HFT opportunities are short-lived because they are heavily competed for
  - Economics of HFT requires identification of large quantities of trading signals, which is highly technology-intensive
  - HFT requires speed to capture opportunities before they are accessed by competitors

- Speed of market access is UNRELATED to average holding period !
  - low-latency market access ensures orders and cancellations arrive at the exchange in a timely fashion
  - low-latency market access does not imply high turnover !
  - example: a long-term investor may wish to use a VWAP algorithm to trade
    in such a case, the investor will likely desire the VWAP algorithm to have minimum latency for accessing the market
  - conversely, some HFT strategies have no special speed requirements and do not even require colocation!

- Trading costs are the primary driver of growth in HF volumes, not technology !
  - Trading costs include bid/ask spreads, commissions, market access fees, and SEC fees
  - As trading costs diminish, smaller and smaller opportunities become profitable to trade, leading to higher volumes
  - Higher volumes exert further downward pressure on trading costs, creating a virtuous cycle
  - This virtuous cycle has been the primary driver of HFT volumes since it was catalyzed by the advent of decimalized pricing
  - Costs are already near-zero for the largest HFTs
  - Corollary: The peak in HFT activity is already behind us!   (barring sub-penny pricing!)

**DISTRIBUTION OF HFT OPPORTUNITIES:
TRADING COSTS VS VOLUME**

more opportunities   more opportunities

fewer opportunities   fewer opportunities

decreasing costs   decreasing costs

As costs decrease, more opportunities become tradeable, leading to higher volumes, and further reducing costs – perpetuating the virtuous cycle...

THE VIRTUOUS CYCLE OF HFT VOLUMES

higher volumes

more opportunities

lower costs

*Higher volumes lead to gains in efficiency through the use of technology, leading to lower transaction costs. Technology is the enabler of the virtuous cycle, but cost is the driver. As costs approach zero, **volumes will peak as a result**.*

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- Liquidity is the *immediate availability* of transactable shares at a *fair price*

- HFTs are the liquidity backbone of the market
  - immediacy: Market-makers provide immediately transactable shares at prevailing prices
  - fair pricing: Statistical Arbitrageurs ensure that information is efficiently propagated from securities being impacted by long-term investors to other securities that are correlated, resulting in cross-sectionally fair prices

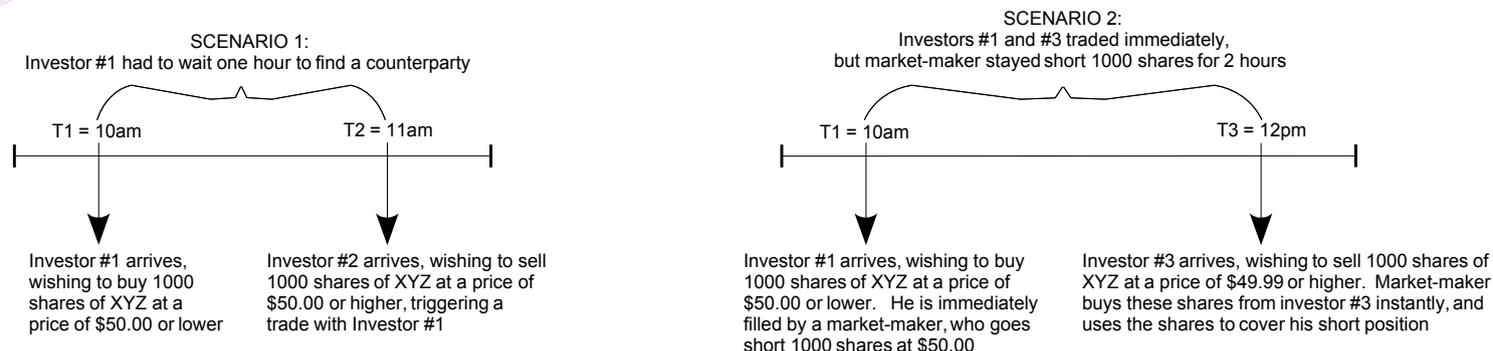- HFTs are an important part of the market's ecosystem for serving long-term investors:

Service Provider	Profit Margin	Services Provided
Broker	1-5 cps	market access, financing, order routing, clearing
Exchange	0.02-0.1 cps	matching of investors and traders
HFT	0.1 cps	liquidity & efficient pricing, orderly markets
Regulator	0.05 cps	ensure fairness and transparency

- Unlike other parts of the market ecosystem, HFTs risk their own capital to provide their services, yet earn razor-thin margins for doing so

- Liquidity is quite distinct from "posting orders" or "trading passively"
  - Accumulation of shares into inventory can be done actively or passively – either method removes shares from the market, creating price impact, and consuming liquidity
  - A VWAP algorithm used by a buy-side investor may seek to trade passively – it is still a consumer of liquidity because it is accumulating shares and creating a price impact
  - Active orders (i.e. those that interact with resting orders in the order book) can be used to push stock prices towards their fair value – this enhances liquidity by definition

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MARKET-MAKING

Market-making opportunities arise because long-term investors desire *immediacy* when making trades – see scenarios below:

SCENARIO 1:
Investor #1 had to wait one hour to find a counterparty

T1 = 10am   T2 = 11am

Investor #1 arrives, wishing to buy 1000 shares of XYZ at a price of $50.00 or lower

Investor #2 arrives, wishing to sell 1000 shares of XYZ at a price of $50.00 or higher, triggering a trade with Investor #1

SCENARIO 2:
Investors #1 and #3 traded immediately, but market-maker stayed short 1000 shares for 2 hours

T1 = 10am   T3 = 12pm

Investor #1 arrives, wishing to buy 1000 shares of XYZ at a price of $50.00 or lower. He is immediately filled by a market-maker, who goes short 1000 shares at $50.00

Investor #3 arrives, wishing to sell 1000 shares of XYZ at a price of $49.99 or higher. Market-maker buys these shares from investor #3 instantly, and uses the shares to cover his short position

MARKET-MAKING AND ADVERSE SELECTION
- In Scenario 2, the market-maker added value by providing Investor #1 with an immediate execution on his trade, and willingly carrying a short position to do so
- During that time, the market-maker was exposed to the possibility of adverse price movements of XYZ – for example, the price of XYZ could have increased while the market-maker was short, generating a loss for the market-maker
- In this example, the market-maker was able to earn the bid-ask spread of $0.01 on the trade as compensation for taking the risk of holding XYZ for 2 hours. However, this is not usually the case!
- In fact, the market-maker is *very likely* to be exposed to *adverse* price movements. For instance, if many investors are seeking to buy, the market will tend to go up, but market-makers will tend to be short, since they have taken the other side of the investors' trades. This is known as *adverse selection.*

THE BID-ASK SPREAD
- The bid-ask spread is used by market-makers to partly compensate for the risk of adverse selection.
- For thinly-traded stocks, a market-maker can expect to hold inventory for a significant period of time, resulting in greater risk. Volatile stocks also increase the market-maker's risk. To compensate for higher risk, the market-maker will demand higher reward, which results in higher bid-asked spreads.
- For actively-traded stocks, a market-maker does not need to hold inventory for a significant period of time, and therefore requires less compensation for taking less risk, resulting in narrow bid-ask spreads.

REBATES AND REBATE CAPTURE
- Most liquid stocks trade at 1-cent bid-ask spreads, but in most cases, 1 cent is not a large enough spread to defray the cost of adverse selection (see slide: **The Fairness of Market Structure** for empirical evidence). As a result, exchanges offer further inducement for traders to post orders in the form of "rebates."
- For stocks that are extremely liquid, some market-makers may be willing to buy and sell *at the same price;* assuming they are able to hold positions for extremely short periods, there is minimal risk of adverse price movements.
- Such market-makers are said to be operating *rebate-capture* strategies because their only compensation is the rebate offered by exchanges for posting orders.
- In cases where a rebate-capture strategy successfully buys and sells at the same price (thus earning 2 rebates), no real liquidity was added to the market. For instance, if T1 and T2 were very close in time in Scenario 1, then there is no need for both investors to have their trades intermediated as in Scenario 2.
- However, in the aggregate, rebate-capture strategies still add value to the market because they do not succeed in rapidly buying and selling at the same price 100% of the time...

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BACKGROUND

- Statistical Arbitrage opportunities arise because long-term investors create price impact in the securities they seek to accumulate or liquidate
- Because securities are correlated to each other, this price impact must propagate to other securities besides the ones directly impacted by the investor
- Statistical Arbitrageurs ensure that price impact is transferred systematically across the equity cross-section, based on the correlated structure of the market
- In so doing, Statistical Arbitrageurs enhance liquidity by ensuring that prices are cross-sectionally *fair* and *consistently* reflect publicly available information

ORIGINS OF CORRELATION

- Securities are correlated across markets and asset classes. Correlation can arise for structural or statistical reasons
- Structural correlations arise when one security is a *derivative* of another. Examples:
    - when MSFT changes in price, call and put options on MSFT also have to change in price, based on the *delta* of the options
    - when MSFT changes in price, stock which track indexes that contain MSFT, such as SPY and QQQQ, must also change in response
    - when SPY changes in price, other derivatives which track the same index, such as S&P futures contracts and a host of other ETF's, must also move
- Statistical correlations arise because securities are driven by *systematic factors* such as inflation, regulatory policies, currency prices, economic growth, and so on. Because there are far fewer systematic drivers than there are securities which depend on them, correlation between securities is guaranteed to exist!

THE SPEED VS ANALYSIS SKILL SPECTRUM

- Structural correlations tend to be strong, steady, and robust.
    - As such, profitable opportunities based on structural correlations tend to be very easy to identify, and are thus heavily competed for.
    - Competition prevents structural price divergences from growing large – thus, such opportunities disappear very quickly, and do NOT allow for large bets
    - The transient nature of these opportunities means that tremendous speed is required in order to access them before competitors
    - Such opportunities tend to be the mainstay of HFTs, who specialize in fast trading
- Statistical correlations tend to be weak, time-varying, and non-stationary
    - As such, profitable opportunities based on statistical correlations tend to be harder to model, and more persistent in terms of their duration
    - Because they are harder to quantify, statistical price divergences can grow quite large before they are noticed
    - The size and duration of these opportunities facilitates large bet-sizes and overnight positioning, which in turn requires access to large sums of capital
    - Such opportunities tend to be favored by large quantitative hedge funds specializing in statistical analysis rather than speed

HFT AND STATISTICAL ARBITRAGE

- Statistical Arbitrage is characterized by the use of *alphas,* or forecasts of expected return
- Alphas are usually created by mixing a variety of underlying predictive signals based on time-series analysis of microstructure data
- Statistical Arbitrage strategies deploy a variety of execution styles, depending largely on the nature of the alphas being utilized
    - Passive: this style seeks to post orders to exchanges' order books. It is ideal for small, slow-moving alphas such as those based on *mean-reversion*. Rebates and bid-ask spreads are often explicitly modelled in order to augment the alphas. Such trading directly provides high-quality liquidity to the markets.
    - Active: this style seeks to trade against resting orders in the exchange's order book. It is applicable to fast-moving alphas, because of the immediate execution, and for large alphas, because of the large transaction costs associated with paying access fees and bid/ask spreads. Such strategies enhance liquidity by pushing stocks towards their "fair prices", which encourages market-makers to provide deeper two-sided markets at tight spreads.
    - Active/Passive: this style seeks to passively post orders, and then use active trading to hedge when its orders are filled. It is suitable for a variety of situations, such as strategies which seek to be "market-neutral" (i.e maintain no market-directional exposure). Such strategies enhance liquidity by *transferring* it from stocks where there is abundance of liquidity, to stocks where there is a shortfall of liquidity.
- It is increasingly difficult to differentiate market-making from statistical arbitrage. Statistical Arbitrage techniques are often used by market-makers, and *vice-versa*!

In general, we feel that the issue of systemic risk related to HFT is highly misunderstood and overstated, for the following very simple reasons:
- HFTs usually make money – thus, it is very simple for an operator of an HFT to identify an "anomalous" period based on P&L alone
- In such an instance, it is simple and nearly instantaneous for an HFT to simply "turn off" its strategy and unwind its positions, thereby eliminating any possibility of further losses
- By contrast, simply "turning off" is not an option for long-term investment strategies, because liquidating a large portfolio is an expensive and time-consuming proposition, and greater aggressiveness in liquidating magnifies and accelerates losses.

While it is tempting and facile to utilize familiar mental constructs such as bubbles, contagions, and liquidity crises when contemplating risks associated with investment strategies, regulators and policy-makers should keep in mind that such concepts arise due to herd-like behavior among LONGER-TERM investors. Such concepts ARE NOT RELEVANT TO HFTs, who can not accumulate large positions, do not use significant leverage, and *already* liquidate their entire portfolios on a daily basis. In fact, far from initiating or exacerbating market crises, HFTs fundamentally and empirically show a strong tendency to be exceptionally *profitable* during stressful market conditions, and are therefore invaluable for helping to restore order and liquidity to the markets during volatility spikes and liquidity crises.

Several specific issues raised by the Commission with regard to systemic risk are addressed below:

- Do HFTs pose systemic risks due to the possibility of "contagion effects"?
  - No! HFTs are not susceptible to the same sort of "contagion effect" that afflicted quant traders in August 2007
  - The well-chronicled quant meltdown of 2007 was caused by a chain-reaction of liquidations by major quant firms
  - No such thing is possible with HFT, because HFTs already liquidate 100% of their positions on a daily basis!
- Do HFTs pose systemic risks due to the possibility of "overcrowding" or widespread use of similar strategies or signals?
  - No! In general, when HFTs use similar "strategies" or "signals", only the fastest among them will gain exposure to the trade
  - Because of their razor-thin margins, HFT signals tend to be extraordinarily conditional on price.
  - Thus, for example, a buy signal at the current NBBO will, perforce, be conditional on the current NBBO still being in effect
  - Thus, if a dozen HFTs all using the same alpha signal suddenly decide to buy at the current offer on a particular stock, the first HFT to access the offer will win the trade, and all the others will "miss"
- Can high message volumes pose a systemic risk by threatening the integrity of trading operations at the exchanges?
  - No! Exchanges allow excess message traffic to queue up at their servers' ports, where it is processed sequentially at a fixed rate
  - Equity options markets produce far more message volume than equity markets, and have demonstrated no such risks
- How real is the risk of "runaway algorithms" in terms of *likelihood*?
  - Not very likely: empirically, this has been a non-issue thus far, and HFT is a mature business that has withstood many turbulent periods
  - Exchange-based risk checks, such as port-level limits on order size, along with post-trade risk checks by b/d's, eliminate most of the risk
  - Reg NMS prevents people from trading so quickly that their broker wouldn't notice excess risk on a post-trade basis
  - Orders to buy or sell shares at far-from-market prices are likely to get rejected because of Reg NMS
- How real is the risk of "runaway algorithms" in terms of *magnitude?*
  - Huge pnl losses can not occur "instantaneously" -- they take minutes or hours to materialize even in extremely volatile markets
    - thus, HFTs or brokers using post-trade checks can cut their systems off with ample notice when losses mount
  - Exchanges already have policies to break trades that are at obviously wrong prices, and halt trading in the event of "extraordinary activity"

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- Should colocation be banned?
  - No: A ban would create an arms race for proximity in place of colocation
  - Colocation can be regulated and made fair (it already is), whereas proximity can't be regulated at all!

- Should users of colocation be subject to liquidity obligations?
  - No: colocation is not a scarce resource, and is widely available at reasonable costs to any investor
  - No: it is highly capricious to single out colocation – the same argument could be made for *any* tool used by HFTs
  - No: this is nonsensical – colocation matters just as much to statistical arbitrageurs, who serve the vital liquidity-enhancing function of ensuring fair prices, as it does to market-makers
  - No: longer-term investors themselves increasingly use colocation directly, or make use of tools or services that benefit from colocation. Would the Commission also subject long-term investors to liquidity obligations?
  - No: if the Commission is interested in imagining a world with liquidity obligations, they can look to the niche of OTC market-making (wholesaling), a rarefied club with only four players of any significance, which nonetheless executes virtually 100% of all retail equity order flow. Is this the level of competition that regulators wish to see on the public markets?

- Should latency be deliberately introduced into direct feeds?
  - No: Such a ban would be harmful
    - direct feeds are the only way to know where the market really is because the SIP's are slow and useless for this purpose
    - Introducing latency would deter price formation
  - No: Such a ban is unnecessary
    - direct feeds are available to everybody
    - there is nothing preventing buy-side investors from using these, either directly or through vendors
    - if some choose to stay in the dark, that should not mean that everybody should be forced to be in the dark
  - No: Such a ban is unworkable
    - You still have to build a unified book from the delayed feeds, which is where most of the algorithmic complexity lies. People who can do this more efficiently will still have a competitive advantage in latency
    - You would also have to slow down direct feeds from futures and equity options markets – otherwise their users would still have a speed advantage
  - Instead, regulators should ensure that direct feeds are universally available and not overly expensive

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- Are tools and technologies used by HFTs also readily available to other investors who want them?
  YES:
  - Colocation – yes: supply is plentiful and costs are reasonable.
  - Direct Feeds – yes: anybody who colocates their servers can access the exchange's direct feeds
  - Aggregated Feeds – yes: many third-parties and certain brokers offer high-performance aggregated feeds commercially
  - Order Routing – yes: a plethora of third-party solutions, including exchange-based routing, are available to investors who do not want to directly cope with the market's fragmentation on their own
  - Execution Algorithms – yes: virtually every major prime broker offers investors access to sophisticated algorithms for executing block orders and basket orders, usually free of charge. Such algorithms are effectively HFTs themselves, utilizing the same data, tools, and signals -- the only distinction being that they the algorithms target non-zero end-of-day positions...

  NO:
  - ISO Orders – NO. Unfortunately, ISO orders, which are among the MOST USEFUL tools available to many HFTs, are largely off-limits to investors that are not broker/dealers. The reason is that brokers can not easily verify compliance with Reg NMS on a pre-trade basis, and are thus generally unwilling to assume regulatory risk by allowing their non-B/D clients to have access to them.
    - This asymmetric access to ISO orders puts buy-side investors at a SIGNIFICANT disadvantage to HFTs by effectively allowing the latter to easily anticipate the former's orders – this topic is discussed at length in subsequent slides
    - We highly recommend that the SEC modify Reg NMS to minimize the importance of having access to ISO orders!
  - Rebates – NO. Buy-side investors increasingly use algorithmic execution tools, which often make heavy use of passive trading techniques such as "pegging". However, many buy-side investors do not receive the maximum rebate from certain exchanges, who tier their rebates based on volume. As we show in the next slide, rebates are essential to overcoming adverse selection associated with posting orders; as such, tiered rebates are an extremely unfair and anti-competitive practice, and should be strongly discouraged or banned by regulators.

- Do investors NEED to invest in high-performance trading infrastructure to be competitive?
  - NO. High-performance infrastructure would allow a long-term investor to focus on opportunities that come and go in a fraction of a second, but such investors should instead be focused on opportunities that unfold over weeks, months, or years
  - NO. Spending bundles of money on high-performance execution creates benefits or efficiencies that can be measured in basis-points (100ths of a percent), or, more typically, in *fractions* of a basis point
    - it is worthwhile for HFTs to invest in such an infrastructure, because the resulting improvement in execution quality, though minute, is of the same order of magnitude as the profit margin of HFT itself
    - by contrast, an investment in such technology would allow a long-term investor to improve his returns from 10% (hypothetically) to 10.005%, which is a pointless and stupid exercise given that third-party solutions are available which provide most of the benefit for little or no cost!

- Should cancellation of posted orders be prohibited before a certain fixed length of time?
  - NO. This seems frivolous and superfluous. What is the purpose of this proposal?
  - Many orders get cancelled because the orders people wind up with are not the ones which they send.
    - This happens frequently because of of Reg NMS -- e.g. re-priced orders

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- Are prices posted by market-makers fair?
    - Theoretical Answer: YES
    Liquid stocks trade at penny spreads the vast majority of the time. Thus, for example, if an offer is unfairly high, then that implies that the bid is also likely high (i.e. attractively priced). In general, the tighter the spread, the fairer the price must be!
    - Empirical Answer: YES (see table below)
        - on liquid and super-liquid stocks, the average posted order moves against the maker (and in favor of the taker) one minute after execution
            - after accounting for take-fees and rebates, the market maker (passive party) comes out roughly even or slightly ahead (based on liquidity tiers), and the price taker (active party) comes out slightly behind
            - the exception is that on exchanges with inverted maker-taker pricing (e.g. Edge-A)
        - on illiquid stocks, the market-maker clearly has the advantage, but that is because market-making is extremely risky in these stocks!

- Are rebates a fair and useful feature of market structure?
    - rebates encourage deeper markets; the table below clearly demonstrates that the higher the rebate an exchange offers, the more adverse selection a market-maker is willing to incur !
        - NYSE offers significantly lower rebates than Nasdaq, Arca, and BATS, and as a result, market-makers are willing to suffer very little adverse selection for posting orders
        - DirectEdge's EDGA exchange offers INVERTED pricing (market maker pays a fee to post orders!), so market-makers refuse to experience adverse selection at all on this exchange
    - Many exchanges have tiered pricing – they offer much lower rebates to low-volume customers, and large rebates to high-volume customers.
        - This is an UNFAIR and ANTI-COMPETITIVE practice and ought to be banned by regulators!
        - The table below clearly shows that low-tier customers can not profitably post orders; this discourages competition

	average daily dollar volume	AVERAGE PROFITABILITY OF POSTED ORDERS*				
		Nasdaq	NYSE Arca	BATS	NYSE	EdgeA
superliquid stocks	>50M	-0.28	-0.24	-0.26	-0.1	0.08
liquid stocks	10M-50M	-0.27	-0.23	-0.23	-0.08	0.1
semi-liquid stocks	1M-10M	-0.11	-0.06	-0.02	0.06	0.14
illiquid stocks	<1M	0.19	0.23	0.32	0.3	0.25

(*) Profitability of a posted order, in cents-per-share, marked to mid-market price, without access fees or rebates
SOURCE: TradeworxResearch; Market data, direct feeds, year 2010 only

TRADEWORX

- Should HFTs be discouraged from sending ACTIVE orders (i.e. orders that trade against existing orders)?
  - NO. Providing liquidity is not the same thing as posting orders or trading passively
  - VWAP and other buy-side algorithms often seek to trade passively, but they are nonetheless seeking a target position, thus taking shares out of the market.   That creates price impact, and removes liquidity from the market
  - Market-makers who trade passively must sometimes exit positions actively for risk management reasons
  - Mean-reversion strategies are liquidity providers of last-resort, and often trade actively
  - Statistical arbitrageurs often provide liquidity where it is in short supply, and hedge themselves by consuming liquidity where it is abundant.   This results in useful liquidity transfer and information propagation.

- What metrics can be used to judge how much liquidity an HFTs orders add to the market?
  - Generally, an HFTs orders are adding liquidity if, in the aggregate, they create no net price impact
    - this is equivalent to saying that the HFTs executed flow should be balanced: buy shares = sell shares
    - this is generally the case with all HFT strats
  - Generally, an HFTs orders are useful if they facilitate trades that would not have happened otherwise
    - the longer an HFTs holding period, the likelier this is to be true
    - strategies that hold positions for only seconds are likely to have intermediated between trades that would have occurred even without the HFTs intervention
  - NOTE: we do not think regulators can or should be in the business of judging the moral value of traders' orders
    - instead, they should focus on whether the playing field is level and the rules are fair and properly enforced

- Should HFTs be prevented from making trades that reinforce the prevailing trend?
  - This is impossible: there is no legitimate way to define the trend!
    - what if the stock is up sharply for one timeframe, but down sharply over another?
    - what if the stock is up a lot but has underperformed other stocks? is the "trend" up or down?
  - This is misguided: the stock's fair price may lie significantly farther in the direction of the "trend," and an HFT that pushes the stock in the direction of its fair price is doing the market a service!
    - an HFT is adding value if it's action moves the stock closer to its "fair value"
    - fair value can not be defined by regulation

TRADEWORX

- Should the anticipation of the behavior of other market participants by HFTs be prohibited?   NO!
  - successful investing and trading BOTH require anticipating other investors' behavior, and acting before they do!
    - there is no good reason to buy a stock unless you think other people will also buy it after you do...
  - predicting the *aggregate behavior* of all investors is exactly equivalent to predicting market direction!
  - predicting the behavior of a single investor may be more dubious, but how can a regulator differentiate?
    - should we also ban long-term investors from looking at institutional ownership stats?
  - is it morally wrong for a market-maker to try to anticipate whether they are about to get run over by a large block trade?

- We submit that any trading signal is perfectly fair so long as publicly available data is being used in its construction
  - if somebody is able to build a better signal using the same data, should that be discouraged?
  - no matter what restrictions regulators impose, some players will always be superior in terms of their ability to analyze data!
  - the same thing applies for long-term investors – should we ban people from looking at 10Q Filings (balance sheets and income statements), because some people can analyze them more effectively than others?
  - simple and commonly used signals for anticipating aggregate behavior of market participants:
    - opening-cross volume imbalances
    - buy volume vs sell volume
    - total volume of quotes or feed messages
  - HFTs and buy-side VWAP algo's BOTH use these kinds of signals!

- Are "predatory algorithms" a widespread phenomenon?
  - CLEARLY NOT! see slide on "Fairness of Market Structure" for empirical evidence!
  - Many things can give the illusion that people are anticipating your orders
    - For example: many people use very similar models to trade – this can easily create the perception of order anticipation
  - Many accounts of "predatory algos" are bogus, either reflecting a lack of knowledge of market microstructure, or simply cynical attempts to scare the public and policy makers
  - Example: the "predatory algorithm" of Sal Arnuk and Joseph Saluzzi is easily debunked (see next slide). No such thing exists.

TRADEWORX

The following verbiage is taken from the paper "Latency Arbitrage" by Arnuk and Saluzzi of Themis Trading, which has received widespread attention in internet forums related to trading.   Comments by Tradeworx are interspersed in red type.

Here's an example of how an HFT trading computer takes advantage of a typical institutional algo VWAP order to buy ABC stock:

1. The market for ABC is $25.53 bid / offered at $25.54.
2. Due to Latency Arbitrage, an HFT computer knows that there is an order that in a moment will move the NBBO quote higher, to $25.54 bid /offered at $25.56.

>   There is no conceivable way for an HFT or any other trader to "know" that an order of this sort will arrive in the future. The authors are clearly confused.   What they mean (as is evident from their premise about "Latency Arbitrage") is that the order in question HAS ALREADY ARRIVED, but has not yet been published on the SIP. Apparently, they are concerned that an HFT with direct feeds knows that order has already been placed, even though the SIP does not yet reflect it.

3. The HFT speeds ahead, scraping dark and visible pools, buying all available ABC shares at $25.54 and cheaper.

>   More confusion by the authors.   If the hypothetical order was successfully able to move the NBBO higher, then by definition, no "visible pools" have any size remaining at that price. The fact that the SIP's are showing the price is due solely to the latency of the feed.   It is true that a "dark pool" may have size available at an offer of $25.54, but if the VWAP algo was already an interested buyer at that price, it should have already tried to access the dark pool itself, rather than waiting for the competing order that spurred the HFT to action.   There is no semblance of "arbitrage" here!

4. The institutional algo gets nothing done at $25.54 (as there is no stock available at this price) and the market moves up to $25.54 bid / offered at $25.56 (as anticipated by the HFT).

>   The HFT also got nothing done at $25.54. The price was on the tape was stale. There were no visible shares to take (as guaranteed by rule 611 of Reg NMS), and the VWAP algo had an edge over the HFT at the dark pools, because he was an interested buyer BEFORE the HFT detected the change in price.

5. The HFT turns around and offers ABC at $25.55 or $25.56.

>   No, it didn't, because it never bought at $25.54.   By the way, where did the $25.56 come from? These sorts of tape anomalies only occur on penny-spread stocks. Why didn't the author use $29, just to make the numbers look even more impressive?

6. Because it is following a volume driven formula, the institutional algo is forced to buy available shares from the HFT at $25.55 or $25.56.

>   Nobody is forcing the algo to follow a volume-driven formula, and nobody is forcing it to buy shares at a bad price, either. If the algorithm behaves this way, it is clearly poorly constructed, and its clients should cease using it at once.

7. The HFT makes $0.01-$0.02 per share at the expense of the institution.

>   Another hyperbolic and misleading statement.   Even if the author's scenario were plausible (which it isn't), 1-2 cents of profit is the margin on a WINNING trade.   There would also obviously be losing trades – unless the author is claiming that the HFT has a 100% winning percentage.   In reality, HFTs losemoney on close to 50% of their trades, so the average profit of this apocryphal algorithm would still be only a fraction of a penny.

- Regulators need to recognize the difference between FAIR and UNFAIR practices related to order anticipation
- Using *publicly-available* data more intelligently than your competitors is a FAIR practice, even if the goal is to predict their behavior!
- Jumping ahead of an order that was placed *earlier* at the same price by another trader is an UNFAIR practice, because it undermines the principle of PRICE-TIME priority on which our equity markets are premised
- Unfortunately, this UNFAIR practice is widespread, due to a deficiency in Rule 611 of Regulation NMS
- HFTs should not be blamed for exploiting it – in fact, many HFTs who exploit this deficiency do so unwittingly
- Instead, the regulators should work to correct this deficiency in the market structure ASAP !

- Here is how it works:
    - Suppose the NBBO of stock WXYZ is 19.99 (bid) – 20.00 (ask)
    - Assume 1000 shares of WXYZ are offered on INET at $20.00 and 1000 shares are also offered on ARCA at $20.00
    - I am an investment advisor who wishes to buy 3000 shares of WXYZ
    - I decide to send a bid for 1500 shares at $20.00 to ARCA, and 1500 shares to INET
    - My orders cross against the posted offers at INET and ARCA, resulting in trades of 1000 shares at each exchange
    - The balance of my orders – 500 shares at each exchange -- should be posted as the new bid of $20.00 at each exchange.
    - Because my order was the first bid of $20.00 to arrive at both exchanges, it should be the first order to post – i.e. it should have "time priority" over all other orders at the same price.
    - Unfortunately, this will typically not happen. Here is the reason:
        - UQDF, the SIP used for Reg-NMS compliance by both exchanges, is slow, and will still show the obsolete $20.00 offer that my order removed from both exchanges
        - Because UQDF is still showing a $20.00 offer at ARCA, INET will not allow my order to post, because it would "lock the market"
        - Because UQDF is still showing a $20.00 offer at INET, ARCA will not allow my order to post either, for the same reason
    - In the mean time, any HFT with direct feeds to both exchanges will notice that the offer is gone, but is still displayed on UQDF. Many such HFTs will rush to form the new $20.00 bid, and will circumvent the Order Protection Rule by sending ISO orders.
    - I can not use an ISO order because I am not a broker/dealer. Most executing brokers do not allow their non-broker/dealer customers to utilize ISO orders, because compliance with Reg-NMS can not easily be verified on a pre-trade basis.
    - INET's policy will be to post my order immediately, but to make it a "hidden order" so that it does not lock the market.
    - ARCA's policy will be to do the same thing, but make my order visible after the SIP has updated to show the real price.
    - In both cases, I will be BEHIND the HFTs who sent ISO orders in priority, even though my order arrived at both exchanges first !

- Here is why it matters:
    - In a price-time priority market, orders that are at the front of the queue experience the LEAST adverse selection, and orders that are the back of the queue receive the MOST adverse selection.
    - This is obvious, because if you are the last one to buy on the bid, that means the bid is about to become the new offer -- Conversely, if many people are behind you on the bid, that means the bid is likely to hold after you trade
    - Empirically there is a 1.7 cps difference in profitability for a posted share that is first in line vs one which is last in line
    - This results in tens of millions of dollars (conservatively) of extra trading costs for investors (and profits for HFTs)

TRADEWORX

The following are recent real-world examples (from Tradeworx's trading activity)
of violations in price/time priority caused by Rule 611 of Reg NMS.

Such violations occur with tremendous regularity throughout the trading day,
as an unintended but direct consequence of the ban against "locked markets."

EXAMPLE 1: NASDAQ: date = 02/17/2010   ticker = SPY
-We sent a sell order for 1643 shares, trying to hit the bid at 110.18 and post an offer there.

```
<timestamp>    <event>
44740149566    we actively fill quote id #151913900 100 @ 110.18
44740149566    we actively fill quote id #151914097 200 @ 110.18
44740149566    we actively fill quote id #151915176 300 @ 110.18
44740149566    we actively fill quote id #151915775 1000 @ 110.18
44740149566    post remaining 43 shares as offer at 110.19 (order was
                   repriced to comply with REG-NMS), our quote id is #151918883
44740152636    quote ID #151919503 posts offer at 110.18
44740159434    quote ID #151919503 is filled by an incoming
                   buy order at 110.18 (match id #4112719)
44740188406    we cancel our order, which was not filled
```

here an order clearly arrived later than ours with the same limit price,
yet it was filled and we were not.

EXAMPLE 2: BATS: date = 03/16/2010   ticker = PBR
-We sent a sell order for 379 shares, trying to hit the bid at 46.44 and post an offer there.

```
<timestamp>    <event>
37177806764    we actively fill quote id #8G279M00XQGF 100 @ 46.44
37177806764    we actively fill quote id #8G279M00XQGG 100 @ 46.44
37177806764    post remaining 179 shares as offer at 46.45 (order was repriced to
                   comply with REG-NMS), our quote id is #8G279M00XRD7
37177808721    quote ID #8G279M00XRE7 posts offer at 46.44
37177808721    BATS automatically moves our quote to be visible at 46.44 and
                   adds it to the queue after #8G279M00XRE7
37177922267    quote ID #8G279M00XRE7 is filled by an incoming
                   buy order at 46.44 for 100 shares (match id #8AP01DG2)
37177922267    our quote is filled by an incoming buy order
                   at 46.44 for 100 shares (match id #8AP01DG3)
37179806320    we cancel our order, the remaining 79 shares unfilled
```

here the 2nd order was clearly ahead of us in priority, even though ours arrived
first; there was an incoming buy order for 200 shares, and 100 of them went to
completely filling the 2nd order, so that we only got 100 shares filled instead
of the 179 that we posted.

SOURCE: Tradeworx, Inc. proprietary trading

This is a widespread and large-scale issue,
as can be inferred from the large market
share of ISO orders as a proportion of all
executions:

Average ISO Market Share
(as % of total trades
and % of shares traded)

dates: 3/4/2010 -- 3/17/2010
tickers: 20 most liquid stocks
by avg quarterly dollar volume

```
Sym trades volume
SPY  51.0% 48.0%
AAPL 51.4% 37.0%
IWM  47.8% 42.3%
QQQQ 49.4% 46.1%
C    18.4% 28.1%
BAC  34.6% 31.1%
FAS  66.8% 55.4%
EEM  48.1% 41.2%
GOOG 47.9% 36.7%
GS   52.3% 38.4%
GE   37.0% 34.6%
XOM  38.8% 27.8%
GLD  54.5% 48.7%
CSCO 38.9% 36.5%
JPM  41.7% 33.0%
INTC 42.7% 40.8%
BIDU 48.0% 43.1%
AIG  49.9% 35.6%
XLF  39.6% 44.8%
MSFT 39.4% 34.7%

source:  CTS/UTDF
```

TRADEWORX

- Rule 611 of Reg NMS bans "locked markets" -- this ban is ENTIRELY superfluous, serving no useful purpose whatsoever in the market
- A "locked market" is simply a market with a bid-ask spread of zero. Just as surely as a 1-cent spread is preferable to a 2-cent spread, a zero-cent spread is superior to a 1-cent spread, and reflects greater price visibility and greater market efficiency!
- Locked markets are a highly desirable feature of electronic markets. Locked markets do not "slow down" or otherwise impede trading – quite the contrary: tighter spreads are *logically* and *empirically* guaranteed to INCREASE the odds of a trade occurring!

- The ban does not withstand logical scrutiny, because "locked markets" are not really locked !
  - Buying by taking a $20.00 offer is very different from buying by being filled on a $20.00 bid
    - The odds of execution are dramatically different – the first alternative has MUCH higher odds of execution
    - Due to access fees and rebates, there is a greater than 0.5 cent per share difference between the two outcomes
  - Investors should be allowed to chose between these economically distinct alternatives

- Imposing a ban on locked markets has numerous unintended consequences which severely impede trade execution by buy-side investors, putting them at a distinct and UNFAIR disadvantage relative to HFTs

  - In a fast market, a SIP is likely to display stale (obsolete) prices
    - This makes it very difficult for investors to trade, even if they have direct feeds and know the "real price"
    - Exchanges will continually decline to execute investor orders because SIPs will tend to show "better" (but obsolete) quotes on other exchanges.
    - In the mean time, the price will continue to move away from the investor, increasing slippage costs
    - HFTs using ISO orders are not impacted by this problem, and can easily trade in fast markets without competition from buy-side investors, who are generally unable to use ISO orders themselves

  - In a slow market, buy-side investors are impeded from posting orders (see previous two slides)
    - This discourages price formation, and relegates investors to using IOC orders to trade
    - This allows HFTs to have a virtual monopoly on "well-placed" orders in the order book
    - This results in a direct wealth transfer from investors to HFTs for no value added

- Lifting the ban would not compromise the trade-through restriction, and would have many salutary side-effects:
  - Significantly tighten bid-ask spreads (locked markets have zero spreads), resulting in lower transaction costs for investors
  - Significantly mitigate the need for ultra-fast connectivity between exchanges, a major component of the technology "arms race"
  - Dramatically reduce the ability for HFTs to engage in UNFAIR order anticipation which violates price-time priority
  - Shifts more volume from dark pools to exchanges because of increased incidence of zero-spread quotes
  - Significantly reduce "pinging" and cancellation rates, which are both elevated partly due to efforts by investors to cope with deficiencies of Rule 611
- Significantly improve the fairness of the market structure without risk of unintended consequences

- We believe a 1-month pilot program in 1-3 highly liquid stocks (such as SPY) would yield ample empirical data to allow regulators to observe and measure the benefits of lifting the ban

TRADEWORX

If enacted, the SEC's recent Market Access Proposal would have several implications and unintended consequences for market structure:

- by seeking to prevent HFTs from using their own risk checks, the rule promises to exacerbate the technology arms race: a new cottage industry will arise to provide the fastest risk-checks. Already, a recent announcement from Lime Brokerage has intensified competition within the industry to acquire faster risk checks.

- the rule has several unintended consequences which are anti-competitive, and are likely to immunize large and established HFTs against competition from smaller or newer players
    - sponsored access is primarily for smaller players -- the rule will entrench players that built up their market shares using sponsored access and now no longer need it
    - smaller HFTs will be forced to chose between losing their speed advantage (by using third-party risk checks), or their top-tier rebates (by becoming a B/D and exchange member), either of which will severely disadvantage them relative to larger and more established HFTs
    - by eliminating sponsored access, the rule will also significantly reduce the accessibility of ISO orders by most HFTs, thereby entrenching the large firms that do have access

- we support the aims of the Market Access Proposal, so long as additional steps are taken to minimize these anti-competitive effects and unintended consequences:
    - provide a FAIR and CLEAR definition of "independent" third-parties
    - amend rule 611 of reg NMS so that importance of using ISO orders is not even further amplified -- eliminate the ban on locked markets
    - ban the use of tiered pricing by exchanges -- it is morally wrong and its ill-effects will become magnified when the sponsored-access ban goes into place

TRADEWORX