Imprecise News, Gradual Information Processing and Mini Flash Crashes

Jérôme Dugast [1] Thierry Foucault[2]

[1]Banque de France

[2]HEC Paris

International Workshop on Algorithmic and High Frequency Trading

November 8, 2013 - Banque de France

Motivation

- Improvement in trading technologies enable speculators to trade very fast on news before it gets partially or fully reflected into prices.

- However, in reacting fast to information, speculators take the risk of trading on misleading information as information processing (e.g., checking news accuracy) takes time.

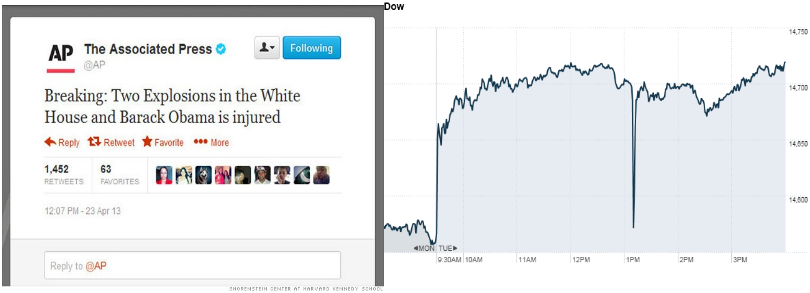


FIGURE : The "Twitter Crash" of April 2013

Motivation

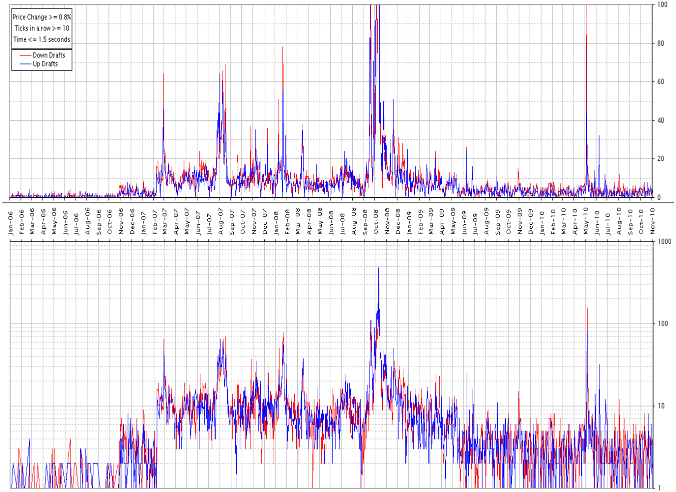


FIGURE : "Micro Flash Crashes 2006 - 2011", Nanex Research

Research Question

- Empirical studies suggest that high frequency trading has a positive effect on market efficiency (e.g Brogaard, Hendershott and Riordan (2013), Boehmer, Fong and Wu (2013)).
- **Can faster trading on information make financial markets more informationally efficient and yet more prone to mini-flash crashes ?**
- **Is faster trading sufficient to improve efficiency at medium term ?**

Gradual information processing

Yes... because information processing is gradual.

- What do we mean by information processing ?

→ turning a signal into sound information

→ figuring out if a signal is informative or not

- Processing information takes time

  Assumption : faster trading does not accelerate information processing. It remains **"gradual"**.

- But fast trading technologies allows for trading before information processing is terminated.

Findings

- **With faster trading, informational efficiency and mini flash crashes are not contradictory.**
- Faster trading allows informed traders for trading more times on the same signal (twice vs. once).
- However a low cost of fast trading technologies can reduce the demand for information.
- Overall, faster trading enhances efficiency because the market can better infer signals and their informative nature.
- Faster trading increases the likelihood of price reversals (mini flash crashes) because it involves a risk of trading on noise.

Literature Review

- **HFT and information :** Brogaard, Hendershott and Riordan (2013), Boehmer, Fong and Wu (2012), Biais, Foucault and Moinas (2011), Foucault, Hombert and Rosu (2012).
- **Early signal acquisition :** Froot, Scharfstein and Stein (1992), Hirshleifer, Subrahmanyam, and Titman (1994), and Brunnermeier (2005).
- **Market instability :** Golub, Keane and Poon (2012), Gao and Mizrach (2013).
- Carvalho, Klagge and Moench (2009), Engle, Hanse and Lunde (2011).

Baseline Model

- **A 3 periods model.** At $t = 1$ and $t = 2$ the market is open. At $t = 3$, the asset pays off.
- **Asset value.** The asset pay-off is V. V is equal to 0 or 1 with equal probabilities.
- **Liquidity Trading.** Some liquidity traders send random orders at $t = 1$ and $t = 2$. At each date, their order flow follows a uniform distribution on the interval $[-Q, Q]$.
- **Market making.** At each date a risk neutral and competitive market maker receives the aggregate order flow of liquidity and **informed** traders and set a price.

Informed Trading

- **Two types of informed traders :**

→ Ex-ante, a mass β of risk neutral traders becomes **informed** after paying a cost C_p.

→ A fraction $\alpha < \beta$ pays an extra cost Δ to become **fast** : they acquire a signal S and can trade before and after its processing, resp. at $t = 1$ and $t = 2$,

→ The remaining fraction of traders, $\beta - \alpha$, can only trade after processing S, at $t = 2$.

- **Trading constraint :** At each period, the trade size of one informed traders is in the interval $[-1, 1]$.

- **Information acquisition and processing :**

→ At $t = 1$, informed traders observe a signal S :

$$S = U \times V + (1 - U) \times \varepsilon,$$

with $U \in \{0, 1\}$, $Pr[U = 1] = \theta$ and ε a white noise.

→ At $t = 2$, informed traders observe S **and** U.

→ Information processing is **gradual** : it takes 2 periods.

Equilibrium Trading Strategies

Ex-ante

β traders become informed

$\alpha < \beta$ informed become fast.

$t = 1$

- Fast traders observe S, buy if $S = 1$ and sell $S = 0$.
- Liquidity traders send orders.
- The market maker receives the order flow and set the price p_1

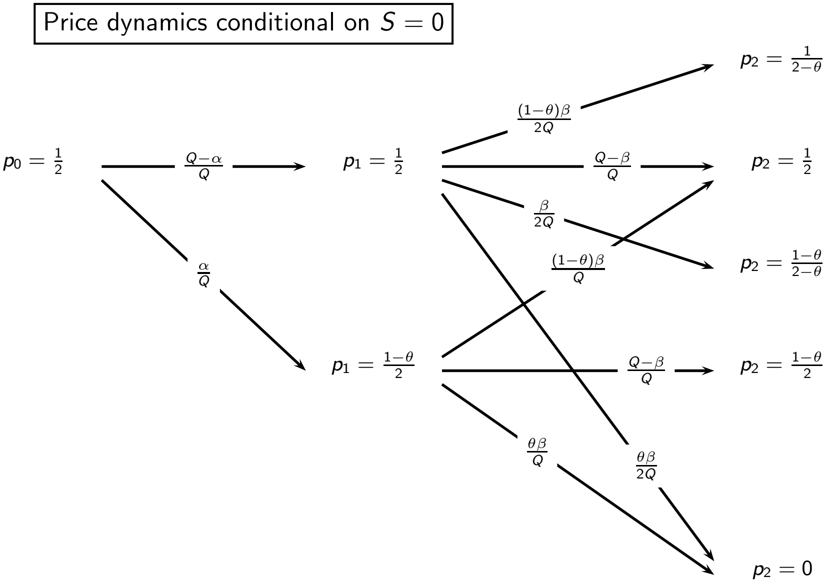
$t = 2$

- Informed traders observe S and U.

  If $U = 1$, they buy if $S = 1$ and sell $S = 0$

  If $U = 0$, they trade in the opposite direction of the $t = 1$ price change.
- Liquidity traders send orders.
- The market maker receives the order flow and set the price p_2.

Price Dynamics



Trading Profits

- The gross profit of an informed trader who trades before processing, at $t = 1$, is

$$\pi_1(\alpha) = \frac{\theta}{2} \times \left(1 - \frac{\alpha}{Q}\right).$$

- The gross profit of an informed trader who processes first and then trades, at $t = 2$, is

$$\pi_2(\alpha, \beta) = \frac{\theta}{2} \times \left[\left(1 - \frac{\alpha}{Q}\right) \times \left(1 - \frac{1}{2-\theta}\frac{\beta}{Q}\right) + (1-\theta)\frac{\alpha}{Q}\left(1 - \frac{\beta}{Q}\right)\right]$$

- An informed trader, who only trades after processing, obtains an expected profit of

$$\pi_2(\alpha, \beta) - C_p$$

while an informed trader, who trades before and after processing, obtains a total expected profit of

$$\pi_1(\alpha) + \pi_2(\alpha, \beta) - (\Delta + C_p).$$

Equilibrium Conditions

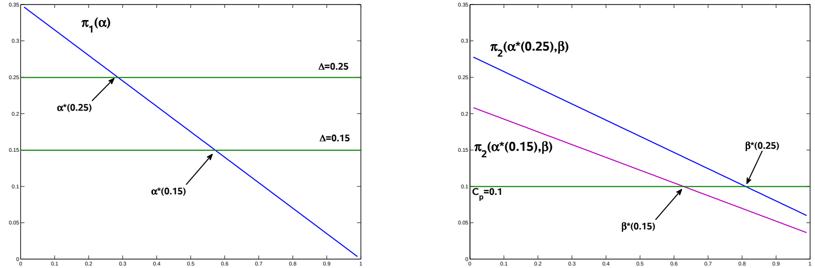


Figure : Equilibrium where $\alpha^* < \beta^*$

Equilibrium Conditions

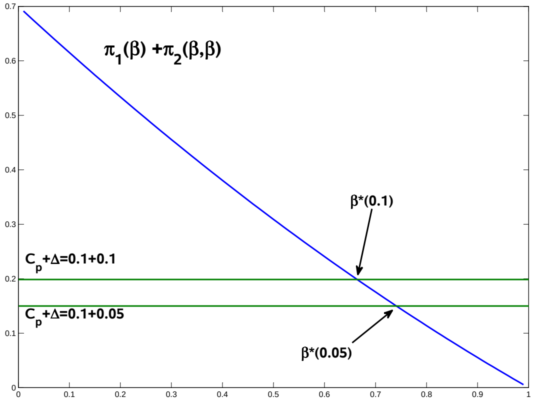


FIGURE : Equilibrium where $\alpha^* = \beta^*$

Demand for Information and The Growth of Fast Trading

Proposition

- *The demand for information in equilibrium, β^*, is a U-shape function of the cost of trading fast on information, Δ. It reaches a minimum for $\Delta = \bar{\Delta}$.*

- *For $\Delta > \bar{\Delta}$, some informed traders never trade on information without processing it before, $\beta^* > \alpha^*$, with $\alpha^* = \max\left[Q\left(1 - 2\frac{\Delta}{\theta}\right), 0\right]$.*

- *For $\Delta \leq \bar{\Delta}$, no informed traders choose to process information before trading on it, $\beta^* = \alpha^*$.*

- *There exists a value $C_p^* \in [\frac{\theta}{2}\frac{1-\theta}{2-\theta}, \frac{\theta}{2}]$ such that*

$\rightarrow$ *if $C_p > C_p^*$ then β^* is maximal for $\Delta = 0$*

$\rightarrow$ *while if $C_p < C_p^*$ then β^* is maximal when $\Delta \geq \frac{\theta}{2}$, and $\alpha^* = 0$.*

Demand for Information and The Growth of Fast Trading

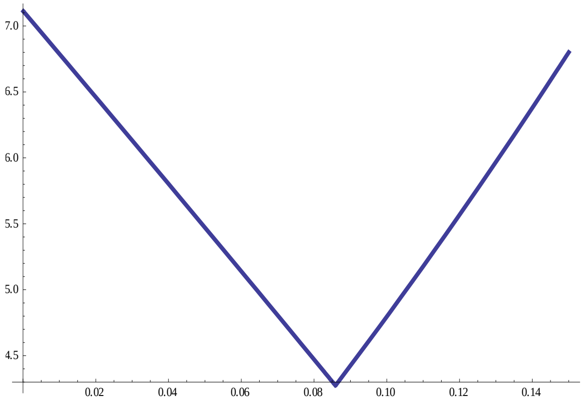


FIGURE : Total demand of information, β^*, as a function of Δ

Demand for Information and The Growth of Fast Trading

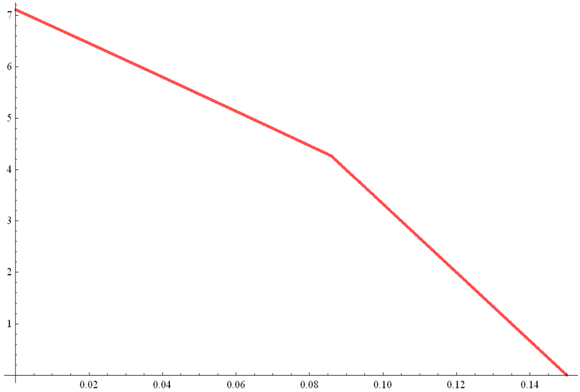


FIGURE : Mass of speculators who trade on information before processing it, α^*, as a function of Δ

Demand for Information and The Growth of Fast Trading

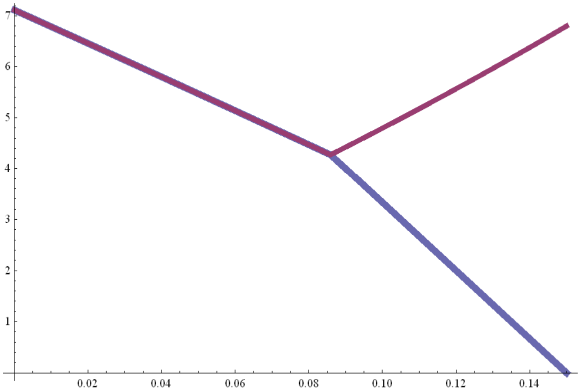


FIGURE : α^* and β^* as functions of Δ

Informational Efficiency

We measure informational efficiency at date t by the average pricing error at this date, $\mathcal{V}_t = \mathbb{E}[(\tilde{V} - P_t)^2]$

$$\mathcal{V}_1 = \frac{1}{4} - \frac{\theta}{2}(\frac{\theta}{2} - \pi_1(\alpha^*))$$
$$\mathcal{V}_2 = \frac{1}{4} - \frac{1}{2}(\frac{\theta}{2} - \pi_2(\alpha^*, \beta^*))$$

Proposition

A reduction in the cost of fast trading technologies $\Delta \in [0, \theta/2]$

- *always improve informational efficiency at* $t = 1$*,*
- *leaves informational efficiency at* $t = 2$ *when* $\Delta > \bar{\Delta}$*,*
- *improves informational efficiency at* $t = 2$ *if* $\Delta < \bar{\Delta}$

→ When Δ declines, the demand for information may decrease but the market is always more efficient **at medium term**.

→ Gradual trading help dealers to better disentangle these two sources of uncertainty : the signal and its informativeness.

Price Reversals

When the signal S proved to be noise, the model generates price reversal.

- The magnitude of a price reversal is

$$M_{Reversal} = \frac{\theta}{2}.$$

- The likelihood of a price reversal, between $t = 1$ and $t = 3$, is

$$p_{\text{Reversal}} = (1 - \theta)\frac{\alpha^*}{Q},$$

- The likelihood of a quick price reversal, between $t = 1$ and $t = 2$, is

$$p_{\text{Quick Reversal}} = (1 - \theta)\frac{\alpha^* \beta^*}{Q^2}.$$

Proposition

- *Holding θ fixed, $p_{Reversal}$ and $p_{Quick\ Reversal}$ increase when Δ decreases.*
- *$p_{Reversal}$ and $p_{Quick\ Reversal}$ are inverse U-shape functions of the precision of the signal received by event traders.*

Quick Reversals and Mini Flash Crashes

- Empirically, it is natural to define a **mini flash crash** as

→ a **quick reversal**

→ **large** relative to some measure of normal return volatility.

- We say that a mini-flash crash happens if :

→ there is a quick price reversal between $t = 1$ and $t = 2$,

→ the size of the reversal, equal to $\frac{\theta}{2}$, is larger than $\frac{R}{2}$ where $0 << R \leq 1$ is a positive constant less than one.

- We introduce some variation in return volatility by allowing θ to be stochastic with distribution $f(\theta)$

$$p_{crash} = \int_{R}^{1} p_{\text{Quick Reversal}}(\theta) f(\theta) d\theta$$

Quick Reversals and Mini Flash Crashes

Example : $\theta = X^{\lambda}$ with X uniformly distributed on $[0,1]$

$$Pr[\theta > R] = 1 - R^{\frac{1}{\lambda}}, \quad \mathbb{E}[\theta] = \bar{\theta} = \frac{1}{\lambda + 1}$$

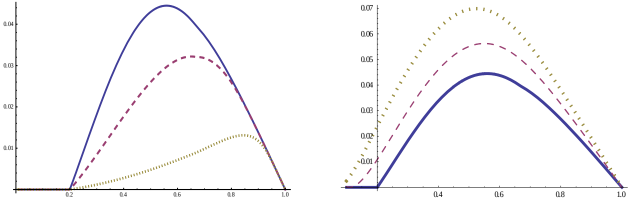
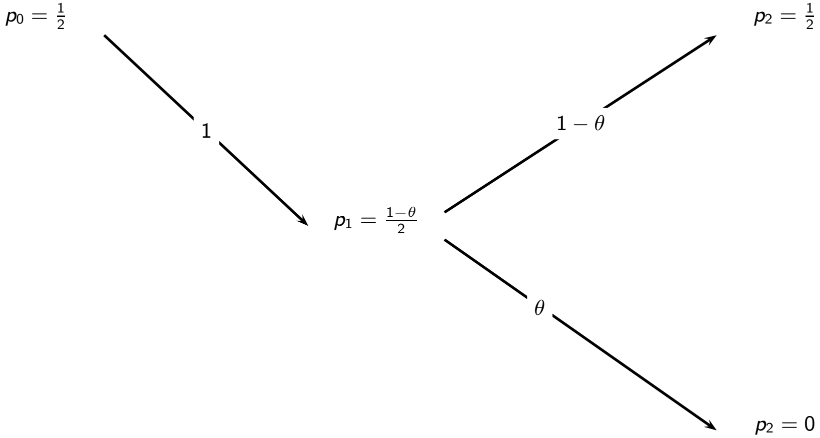


FIGURE : Likelihood of a flash crash as a function of the mean signal precision $\bar{\theta}$
(i) for different values of R : $R = 10\%$ (plain line), $R = 30\%$ (dashed line), and $R = 70\%$ (dotted line),
(ii) for different values of Δ : $\Delta = 0.1$ (plain line), $\Delta = 0.05$ (dashed line), and $\Delta = 0.01$ (dotted line)

Benchmark Case : Informed Dealer

Price dynamics conditional on $S = 0$



Trade Patterns

Proposition

In equilibrium, the covariance between the trades of a trader who trades before and after processing information, at $t = 1$ and $t = 2$ is :

$$Cov(x_1, x_2) = \theta - (1 - \theta)\frac{\alpha^*}{Q},$$

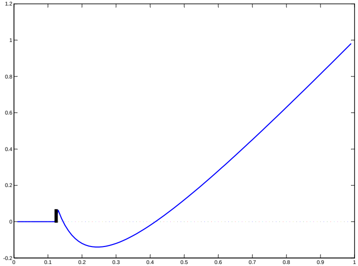


FIGURE : $Cov(x_1, x_2)$ as a function of θ

Trade Patterns

Proposition

In equilibrium, the covariance between the first period return ($p_1 - p_0$) and the trade of an informed trader at $t = 2$ is :

$$Cov(p_1, x_2) = \theta(2\theta - 1)\frac{\alpha^*}{Q}.$$

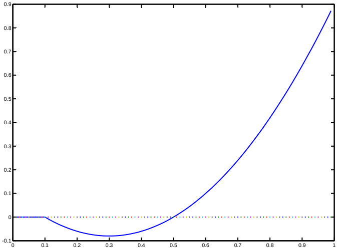


FIGURE : $Cov(p_1, x_2)$ as a function of θ

Conclusion

- When information processing is gradual and news are imprecise, a lower cost for fast trading technologies ameliorates efficiency but generates mini flash crashes.
- A lower cost for fast trading technologies has also a non-monotonic effect on the demand for information.
- The precision level of news has a positive effect on efficiency and a non-monotonic effect on mini flash crashes.
- Depending on the precision level of the news, the trades of fast traders across periods can be positively or negatively correlated on average.
- Similarly, the correlation between the trades of fast traders and past price returns can be positive or negative.