Equilibrium High Frequency Trading

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What's High–Frequency Trading (HFT)

Fast connection (fiber–optic lines, colocation, high throughput)

Computerized strategies

Clever terse codes

Computer reads Bloomberg faster than eye blinks

$\rightarrow$ Minimize delay: information event – trade execution (latency)

HFT $\rightarrow$ Investment to observe info before others

Project Express: Fastest fiber-optic cable across Atlantic

Reduces data round-trip time between New York and London

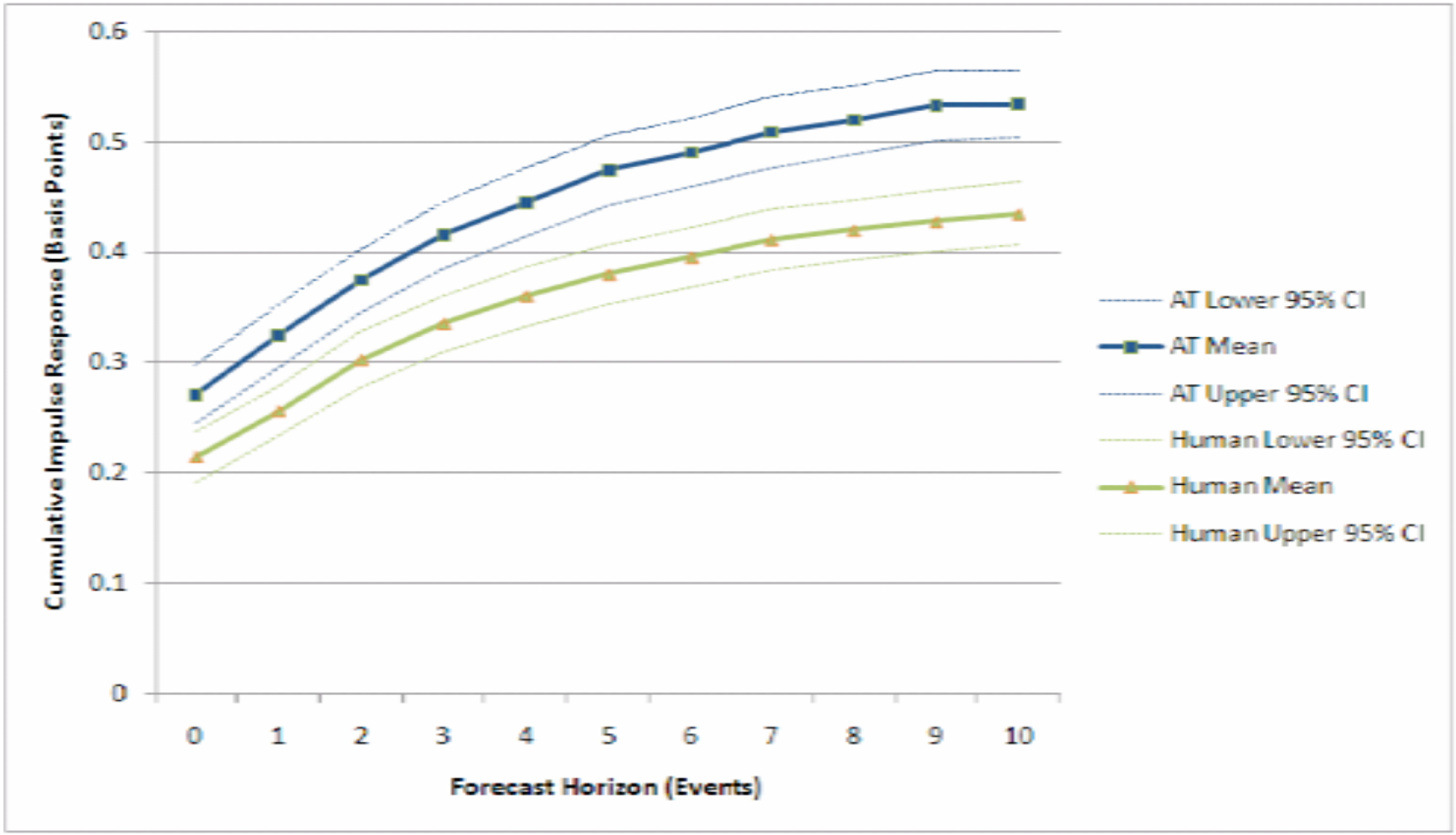
From current 64.8 milliseconds to 59.6 milliseconds

Handful of trading firms will have access to cable

Cost: $300 million.

Spread Networks: similar, Chicago–New York

High–Frequency Traders better informed



Informational impact HFT vs human, Hendershott Riordan (2010)
Also: Brogaard (2010), Kirilenko, Kyle, Samadi and Tuzun (2011)

HFT privately profitable

Otherwise Project Express and Spread Networks would not have attracted investors

Renaissance Technologies (which locks up astrophysics PHDs in a Connecticut farm to program and conduct HFT) is one of the most profitable hedge funds ever

Annual aggregate profits of HFT estimated to 21 billion dollars (Saraiya Mittal, 2009)

Socially valuable?

The Private and Social Value of Information and the Reward to Inventive Activity, Hirshleifer, *AER*, 1971

"foreknowledge: whatever does actually occur will, in due time, be evident to all"

"the distributive aspect of access to superior information ... provides a motivation for the acquisition of private information that is quite apart from any social usefulness of that information"

"There is an incentive for individuals to expend resources in a socially wasteful way in the generation of such information"

The devil's advocate

"the (colocation) service terms are transparent, available to all market participants and the pricing is also transparent and non–discriminatory" (London Stock Exchange, 2010)

HFT improves the information efficiency of prices

It also reduces search costs (which is important in nowadays fragmented markets) and thus enhances the ability to seize valuable trading opportunities

We offer a theoretical framework to analyze these tradeoffs

Theories of HFT

Biais, Hombert, Weill (2012), Foucault, Hombert, Rosu (2012), Martinez, Rosu (2011), Hoffman (2011), Pagnotta, Philippon (2012) study **dynamic** trading strategies

In our **one–trade** model, high–frequency traders

1. observe and react to information before slow traders (minimal latency)
2. contact counterparty with greater probability than slow traders (same spirit Philippon and Pagnotta (2012) where speed is contact rate with market)

Main contribution relative to literature: analysis of equilibrium investment in HFT and its welfare consequences

Model

Market for risky asset

Traders with different private valuations $\rightarrow$ gains from trade (all agents rational, welfare well defined, no noise trading)

Traders can become fast at cost C

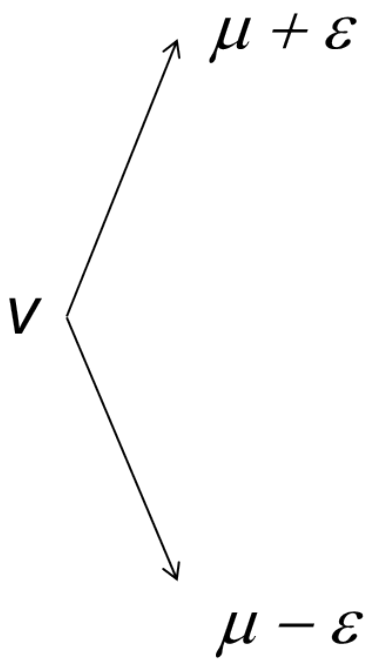
Fast traders privately observe advanced information on asset value: informational motivation for trade $\rightarrow$ purely redistributive, no welfare gain, in fact welfare cost of adverse–selection

Fast traders contact counterparties with greater probability $\rightarrow$ helps reap gains from trade

Timing

$t = 0$ $t=1$ $t=2$

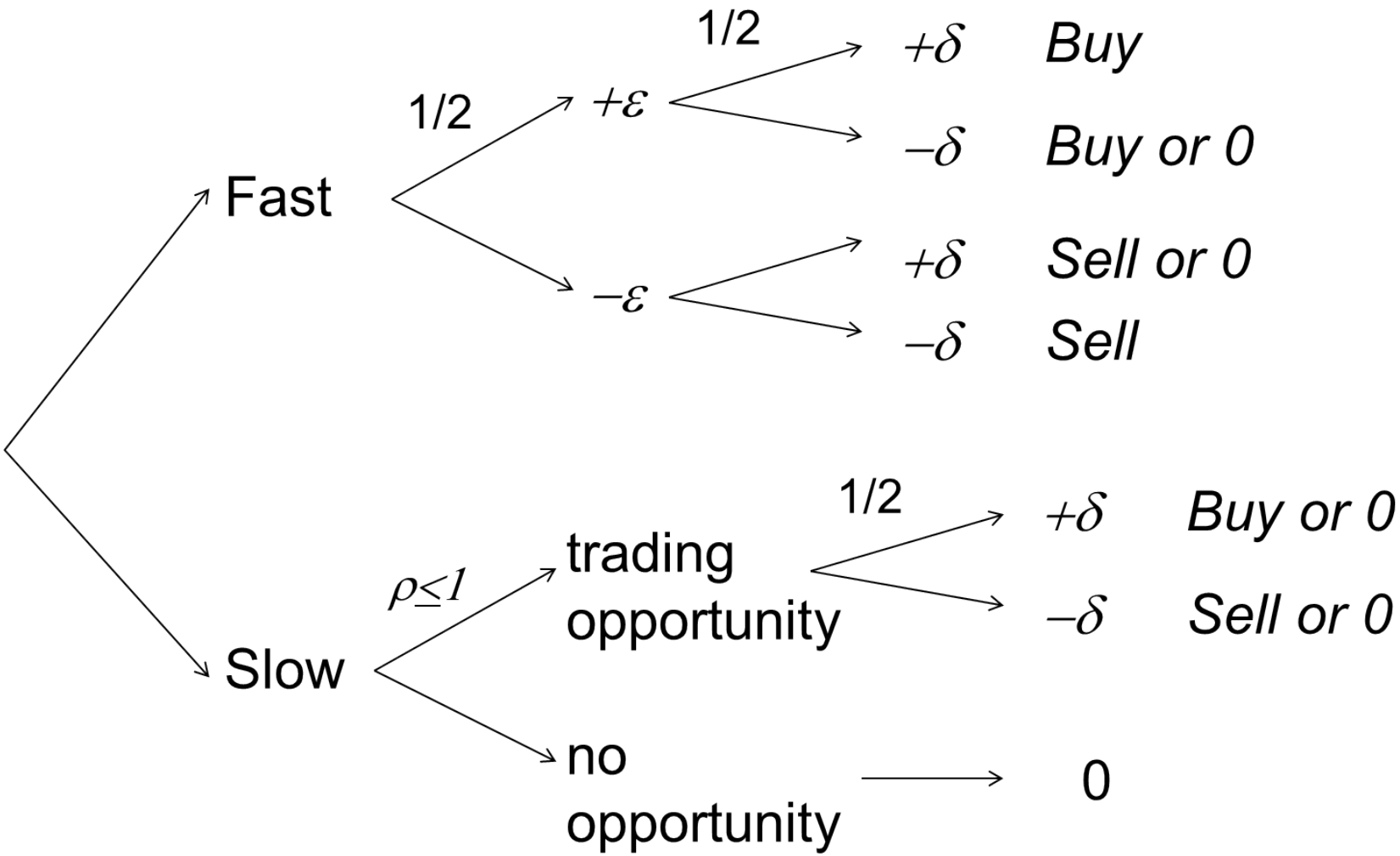
Investment	Information & trade	Value
Fast (cost C)	Observes if $+\delta$ or $-\delta$ if $+\varepsilon$ or $-\varepsilon$ Finds trading oppty	
Slow	Observes if $+\delta$ or $-\delta$ Finds trading oppty with proba ρ	



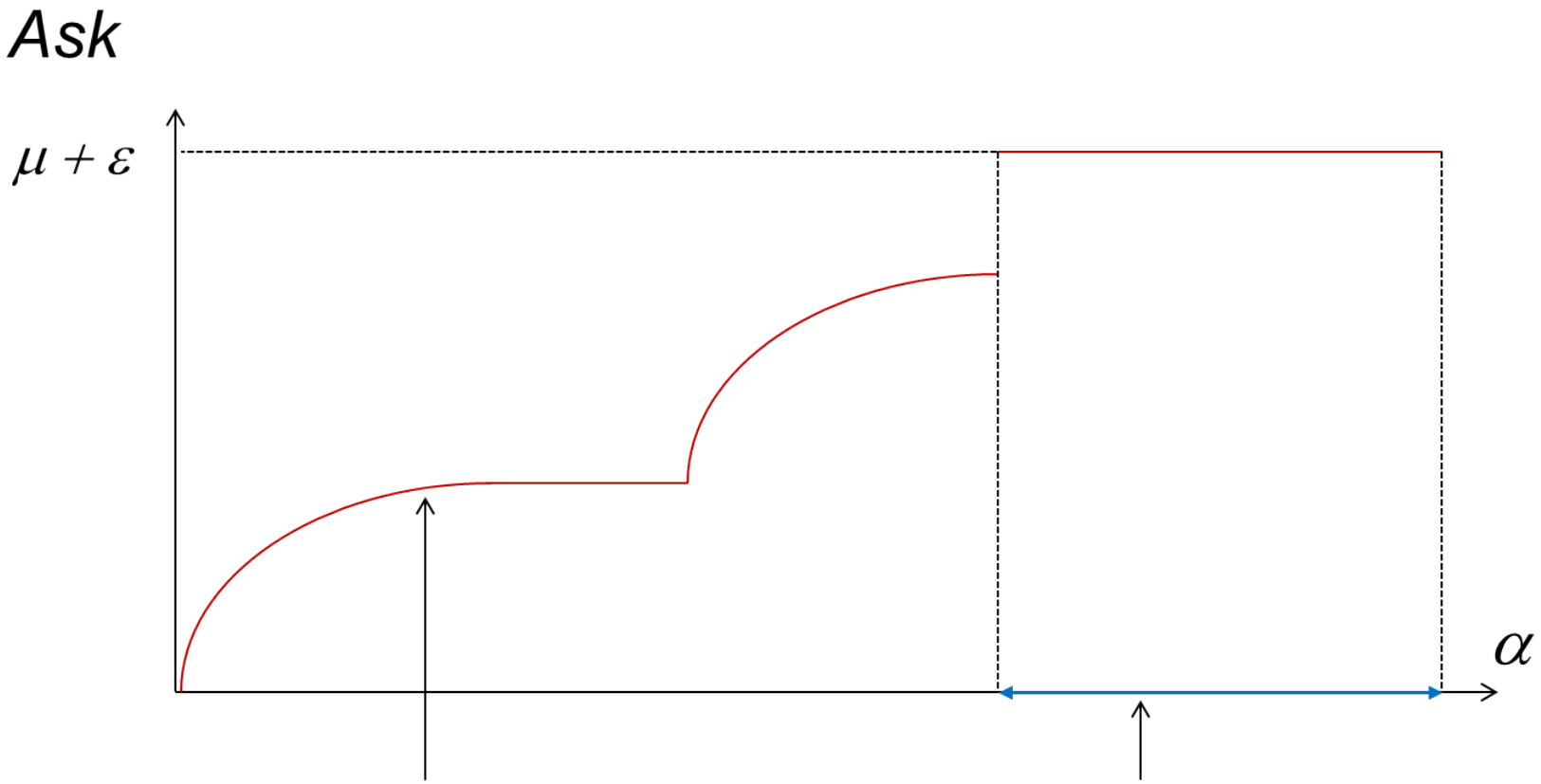
3 stages in analysis

1. Equilibrium prices, trades and gains for given α
2. Equilibrium α
3. Compare utilitarian optimum with equilibrium

Trades


Fast
Slow
1/2
1/2
$+\varepsilon$
$-\varepsilon$
$+\delta$
$-\delta$
$+\delta$
$-\delta$
Buy
Buy or 0
Sell or 0
Sell
$\rho \leq 1$
trading opportunity
no opportunity
1/2
$+\delta$
$-\delta$
Buy or 0
Sell or 0
0

Prices: $P = E(v|\text{Trade})$

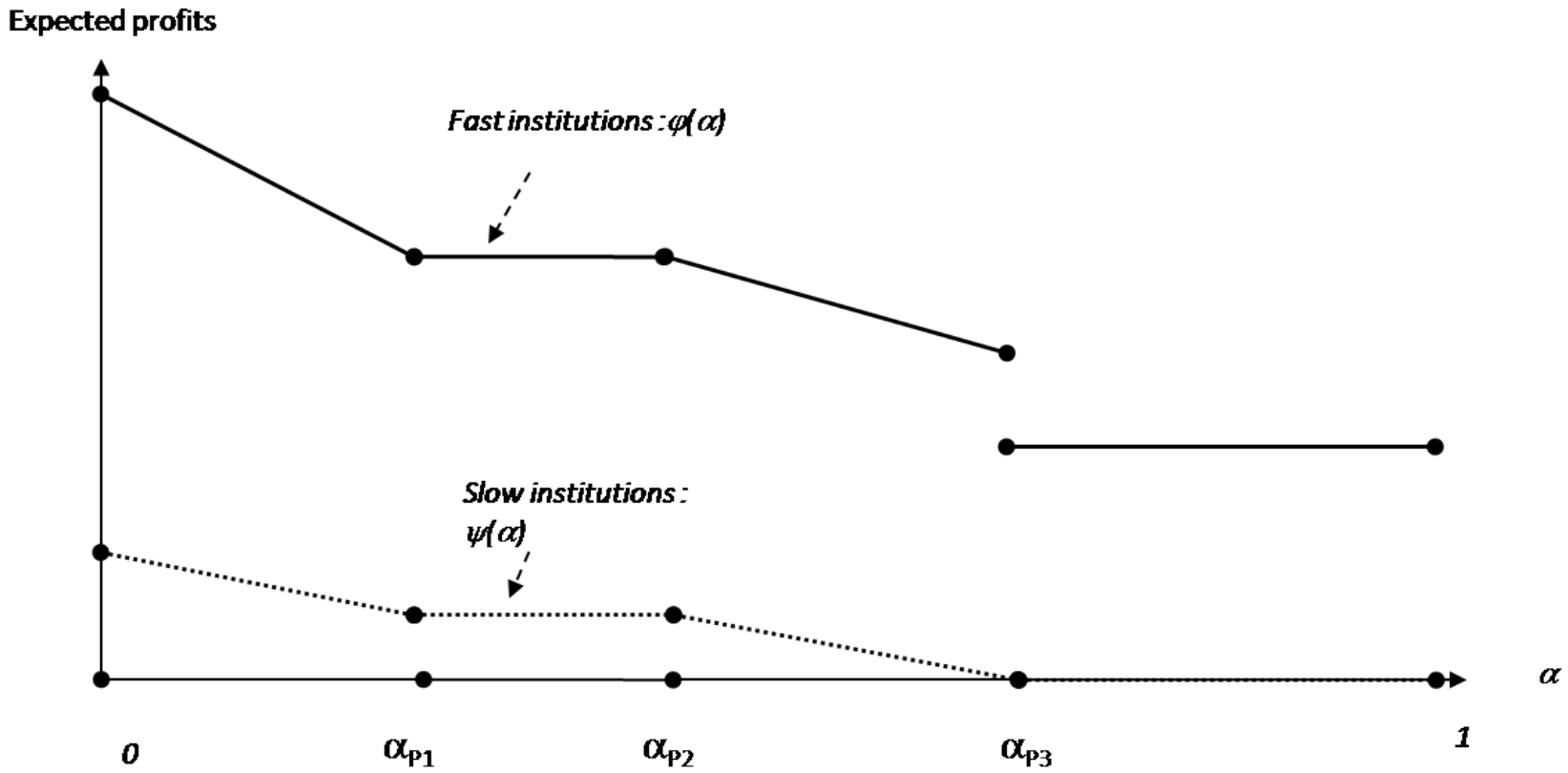


α increases, so does price impact and informational efficiency

α large, slow crowded out

Expected gains of slow and fast traders

As α increases, price impact rises for all: both ϕ and ψ decreasing



Equilibrium investment in HFT

Interior equilibrium: α s.t traders indifferent between fast and slow

$$\phi(\alpha) - \psi(\alpha) = C$$

Relative advantage of fast $=$ cost of investment in HFT technology

Equilibrium depends on how $\phi - \psi$ vary with α

Strategic substitutes

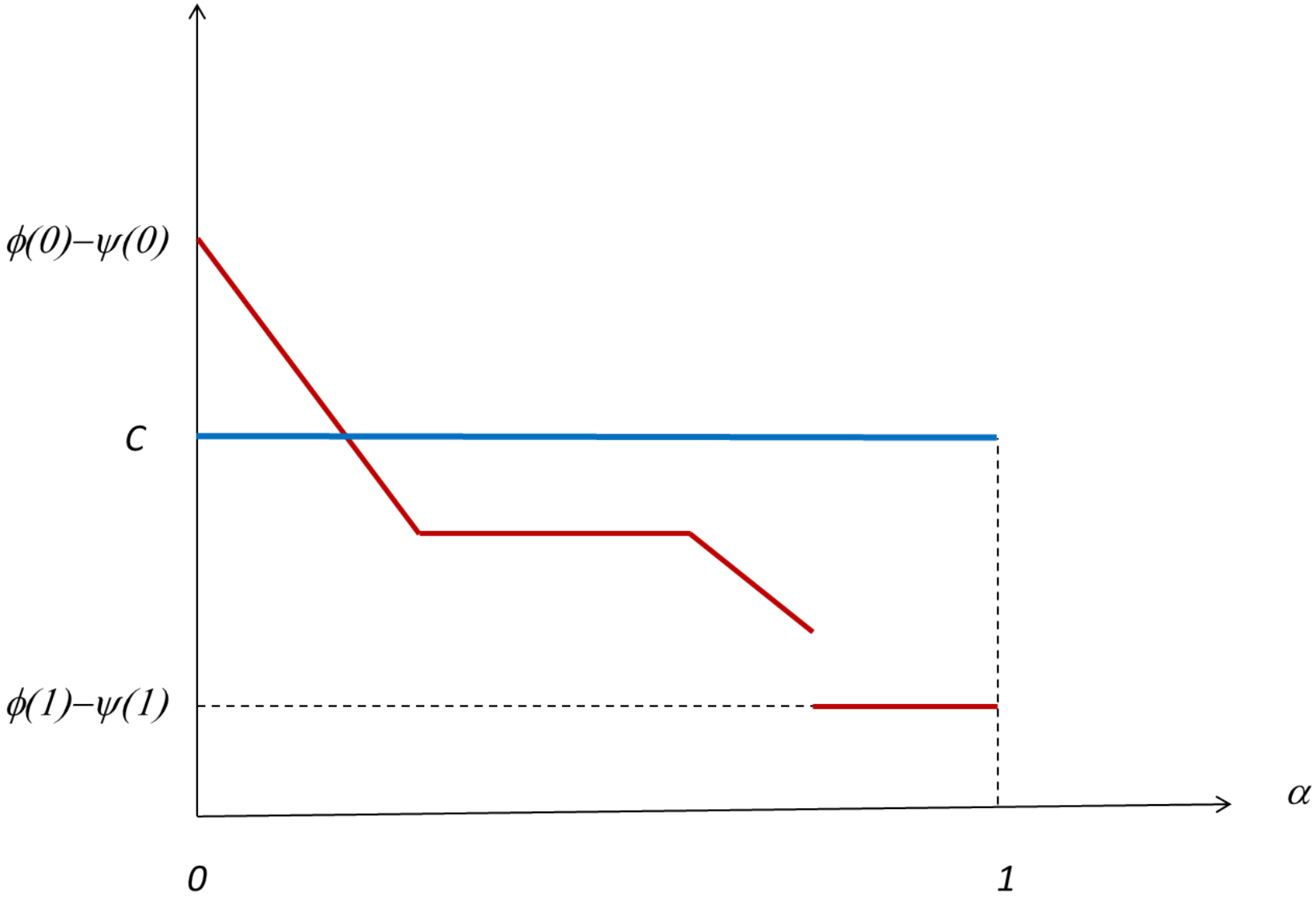
If $\rho \leq \frac{1}{2}$, the greater the fraction of fast traders, the lower their relative advantage over slow traders

$$\frac{\partial(\phi - \psi)}{\partial \alpha} < 0$$

Larger α raises price impact: hurts slow less than fast (who trade more)

Strategic substitutes: if the others do more of it, I do less

If $\rho < \frac{1}{2}$ generically unique equilibrium (if exists)



Strategic complements

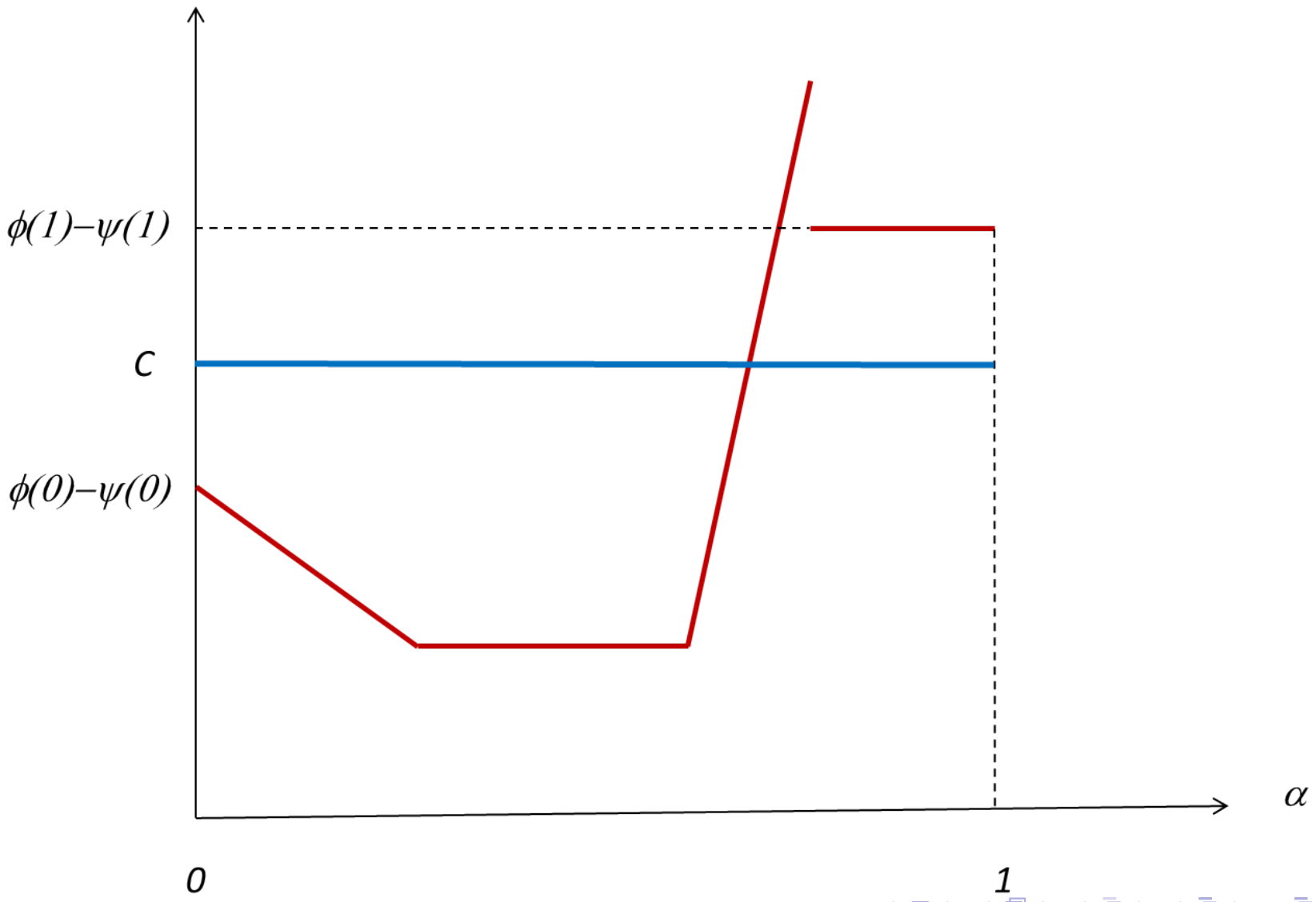
If $\rho \geq \frac{1}{2}$, and α large, the greater the fraction of fast traders, the greater their advantage relative to slow traders

$$\frac{\partial(\phi - \psi)}{\partial \alpha} > 0$$

Slow crowded out when α large: HFT hurts slow more than fast

Strategic complements: if the others do more of it, I also do more

If $\rho > \frac{1}{2}$ there can be multiple equilibria: $\alpha = 0, \alpha = 1$ (both stable) $\alpha \in (0, 1)$ (unstable)



Equilibrium overinvestment

Entry of a new fast trader increases price impact $\rightarrow$ negative externality on all others (whether slow or fast):

More adverse selection, less gains from trade, eviction of slow

When deciding whether to become fast, traders don't internalize this externality

Equilibrium investment in HFT $\geq$ Socially optimal investment

If $\rho > 1/2$, any equilibrium $\alpha > 0$ involves over–investment

Implications

As proportion of HFT (α) increases:
Adverse-selection component of spread increases

Hence as α increases

- Slow traders evicted from market
- Fast traders stop realizing all potential gains from trade

$\rightarrow$ Volume does not monotonically increase

Even if HFT increases volume, not necessarily good:
Welfare may decrease as volume increases

How can the problem be fixed?

Market response: Offer HFT–free platforms

Feasible only if fast orders can be identified: not easy (e.g., camouflage via broker)

Policy response: tax observable investment in speed (colocation, fiber–optic lines)

If done within one country only or for exchanges only: fast migrate to tax haven