Information Percolation in Centralized Markets

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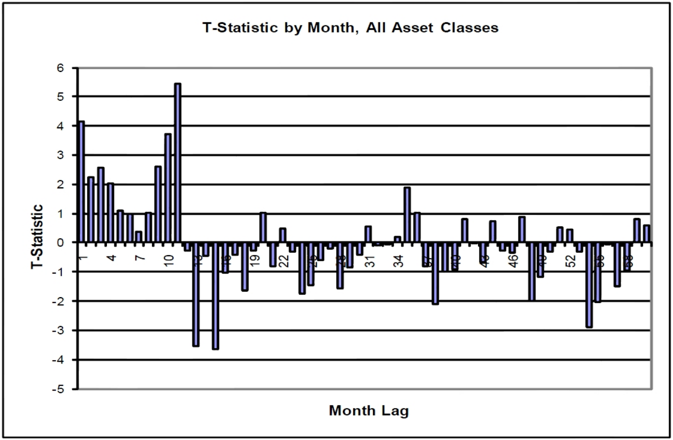
In a centralized market with *rational agents*, word-of-mouth effects will generate momentum and reversal.

Motivation I

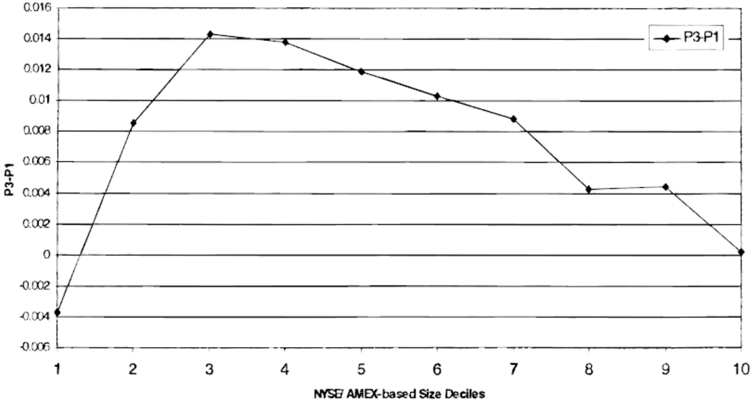
Panel A: $r_t^s / \sigma_{t-1}^s = \alpha + \beta_h r_{t-h}^s / \sigma_{t-h-1}^s + \varepsilon_t^s$



Momentum and reversal in 58 liquid instruments.

Source: Moskowitz, Ooi, and Pedersen (2010)

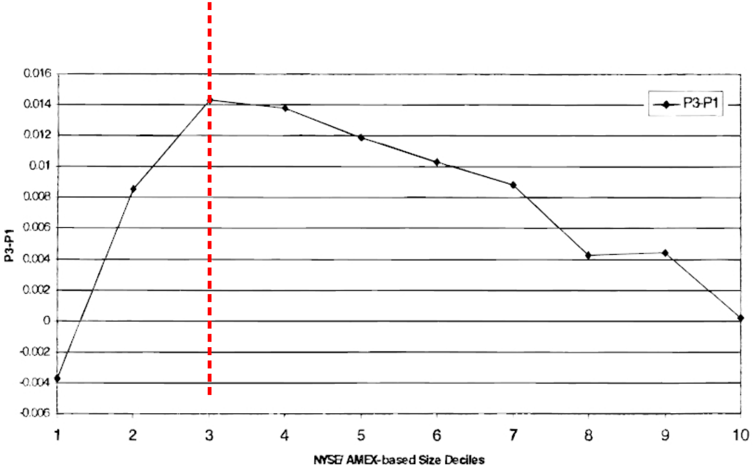
Motivation II



Relationship between size and the magnitude of the momentum

Source: Hong, Lim, and Stein (2000)

Motivation II



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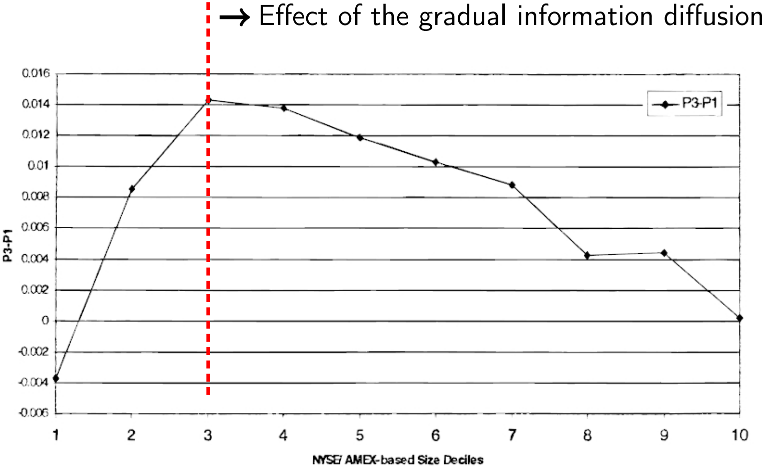
→ Effect of the gradual information diffusion



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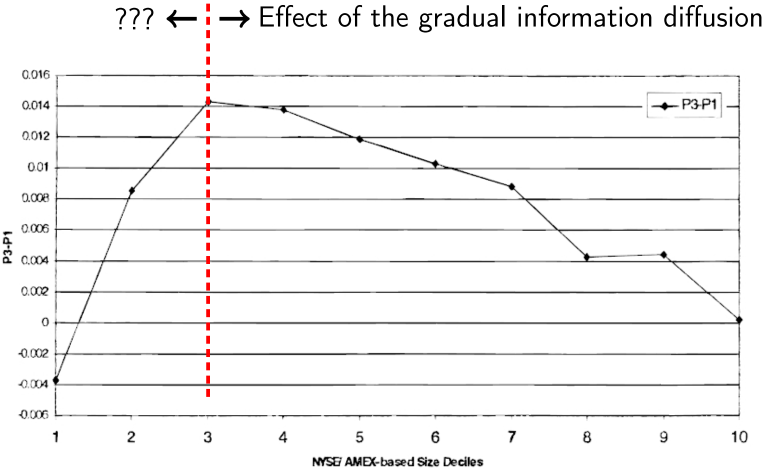
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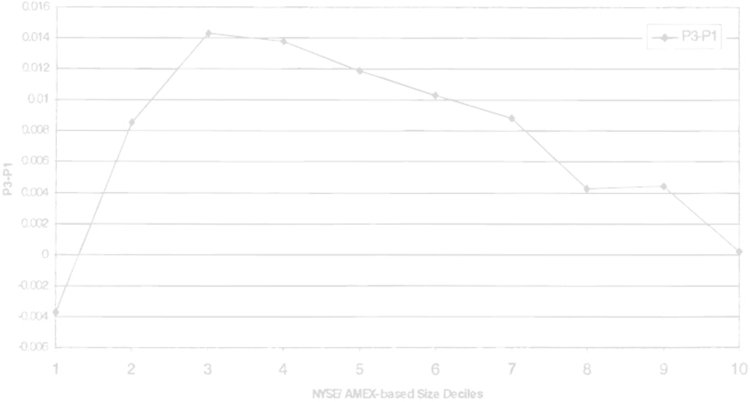
What We Do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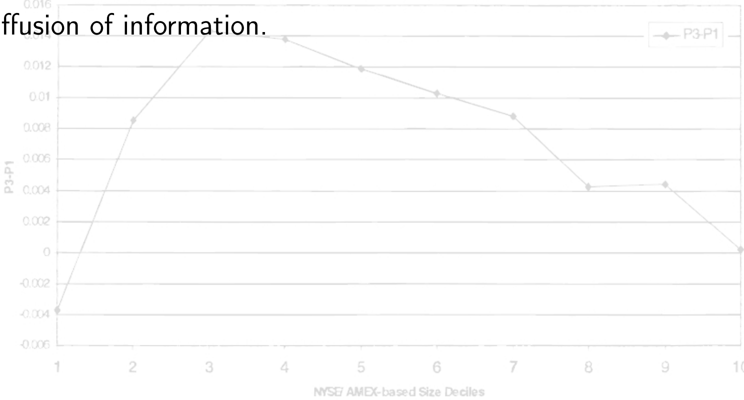
NYSE/ AMEX-based Size Deciles

What We Do

We obtain the inverted U-shape by correctly specifying the gradual diffusion of information.



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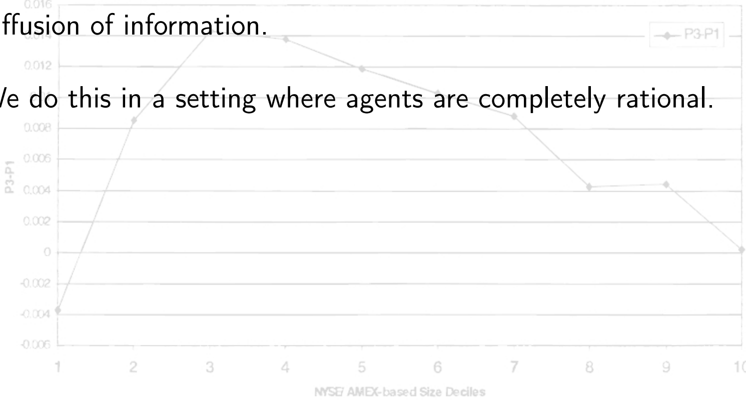

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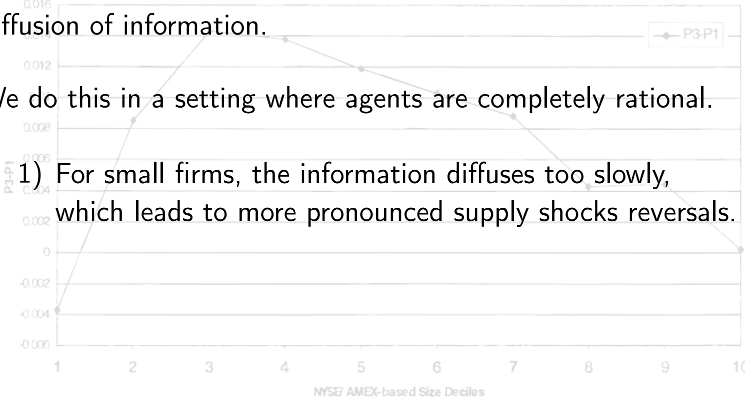

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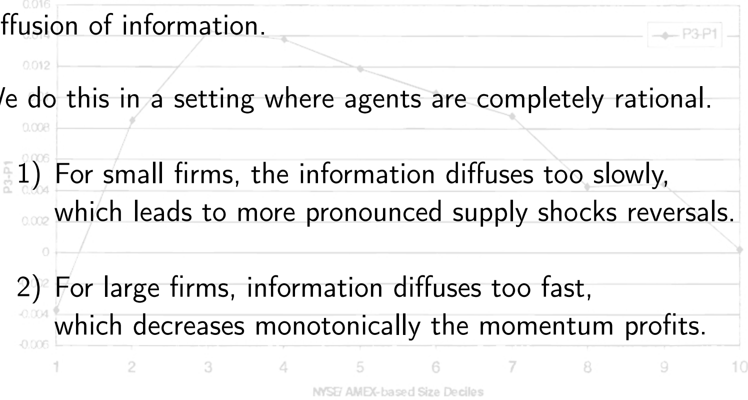

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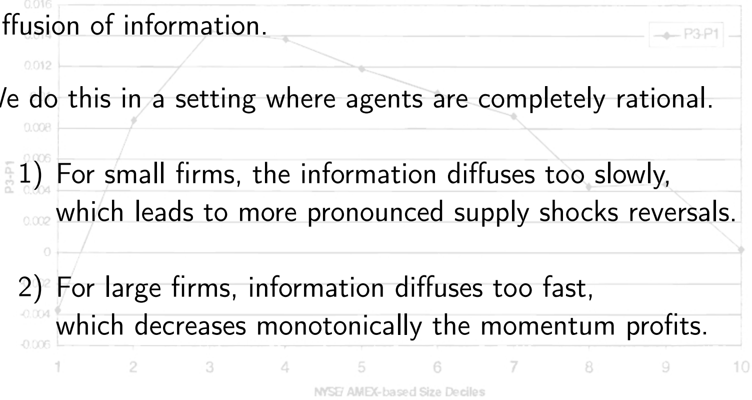

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2) For large firms, information diffuses too fast, which decreases monotonically the momentum profits.

We obtain this nonmonotonic effect with a single parameter, λ.

How We Do That

- We start from a Rational Expectations framework: *He and Wang (1995)*
- We let agents meet and share information, as in *Duffie, Malamud, and Manso (2009)*

Related Literature

Evidence on momentum and reversal

Cutler, Poterba, and Summers (1990), Jegadeesh and Titman (1993), Rouwenhorst (1998), Moskowitz, Ooi, and Pedersen (2010), Bernard (1992), Chan, Jegadeesh, and Lakonishok (1996), De Bondt and Thaler (1985), Lakonishok, Shleifer, and Vishny (1994), Poterba and Summers (1988), Hong, Lim, and Stein (2000).

Evidence on word-of-mouth communication and gradual diffusion of information

Shiller and Pound (1989), Hong, Kubik, and Stein (2004), Feng and Seasholes (2004), Brown, Ivkovic, Smith, and Weisbenner (2008), Grinblatt and Keloharju (2001), Ivkovic and Weisbenner (2005), Cohen, Frazzini, and Malloy (2008).

Theoretical Explanations

Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), Hong and Stein (1999), Holden and Subrahmanyam (2002), Hong, Hong, and Ungureanu (2010), Albuquerque and Miao (2010), Vayanos and Woolley (2010).

Outline

I. A Benchmark Model

- Setup
- Information Percolation
- Solution
- Results

II. Additional Uncertainty, or Rumors

- Setup and Solution
- Results

III. Conclusion

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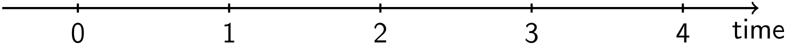

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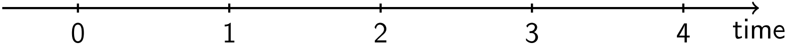

There is a risky asset with payoff $\tilde{U}$ realized at $t = 4$

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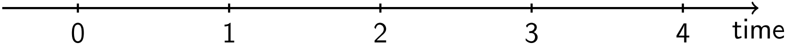

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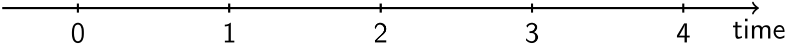

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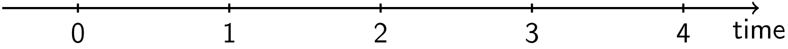

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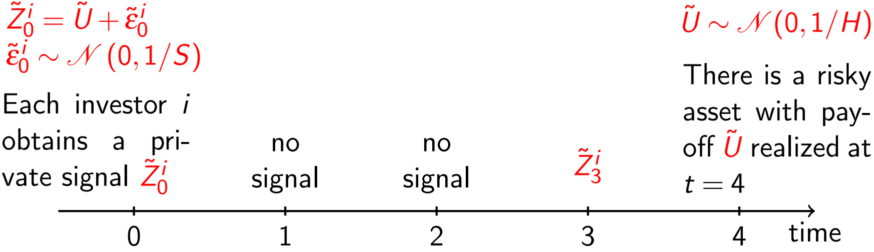

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no signal

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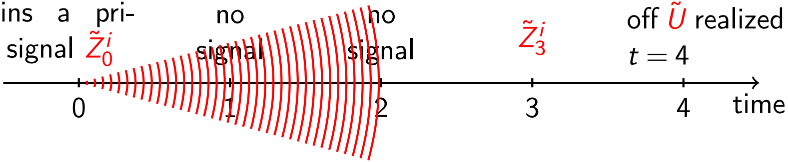

Agents meet with each other and share their private signals. The meeting intensity is λ.

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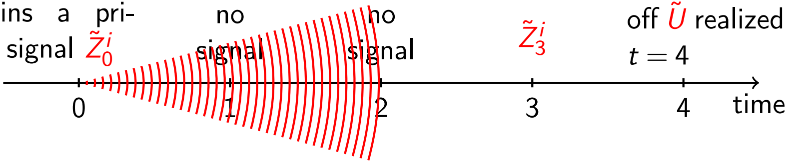

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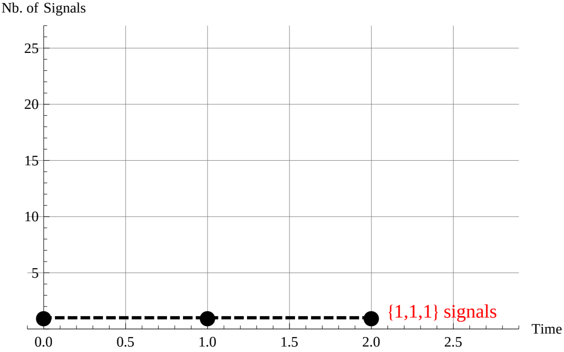
Noisy supply $\tilde{X}_t \sim \mathcal{N}(0, 1/\Phi)$ prevents prices to fully reveal the fundamental.

Simulation



Simulation Example: Different investor types

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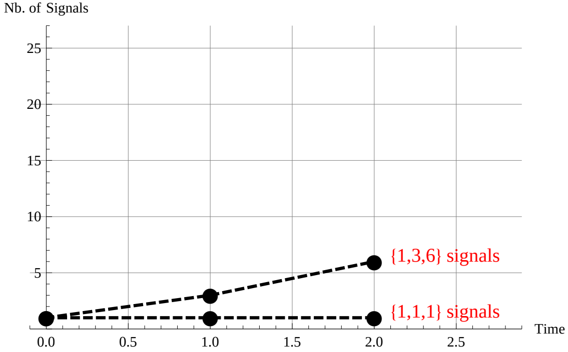

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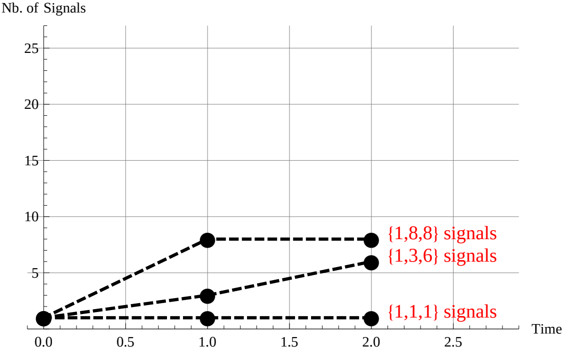

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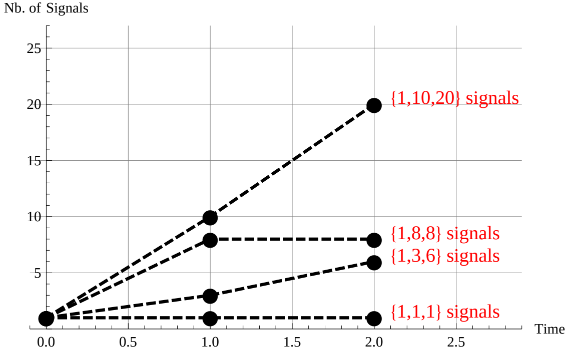

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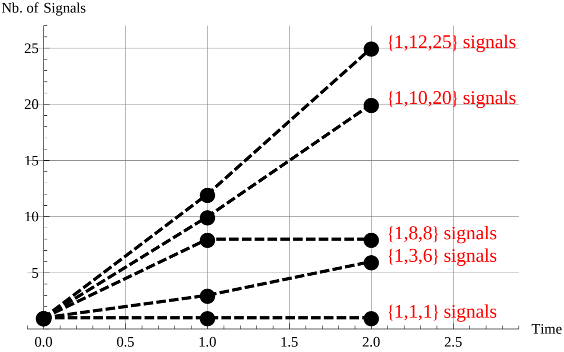

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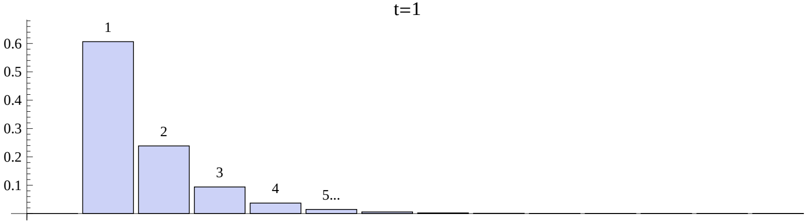
Probability Density Function of the Number of Signals



Distribution of signals: $\lambda = 0.5,\ t = 1$

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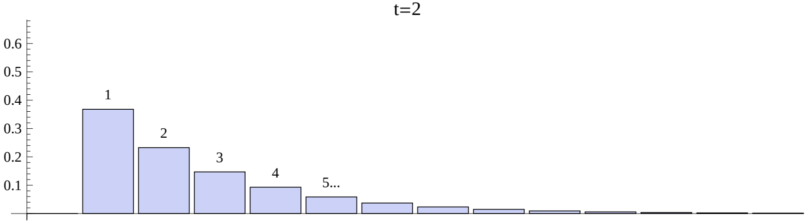

Distribution of signals: $\lambda = 0.5,\ t = 2$

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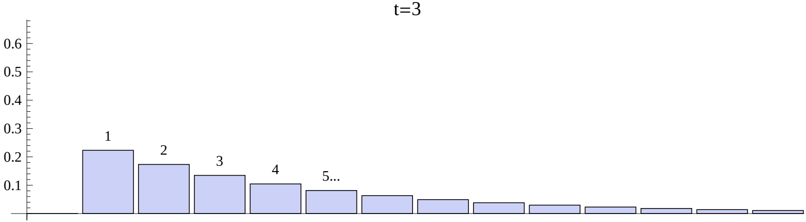

Distribution of signals: $\lambda = 0.5,\ t = 3$

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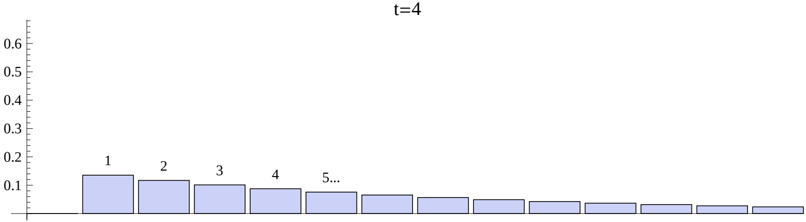
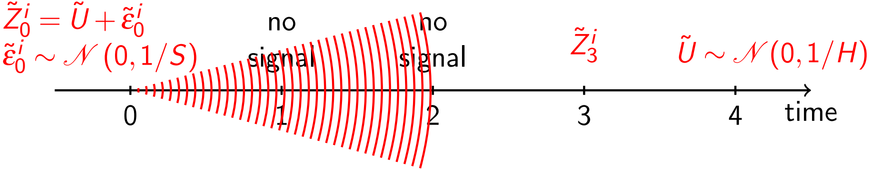


Distribution of signals: $\lambda = 0.5,\ t = 4$



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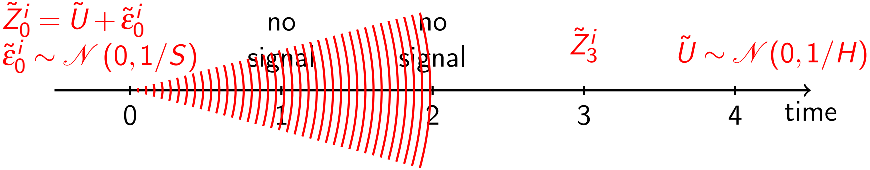
The solution method follows the usual steps (Grossman and Stiglitz (1980), He and Wang (1995), Brennan and Cao (1996))

First, conjecture that prices are linear functions of the random variables $\tilde{U}$ and $\tilde{X}_t$.

Second, find optimal demands for each agent, then impose market clearing.

Finally, solve for the undetermined coefficients conjectured above.



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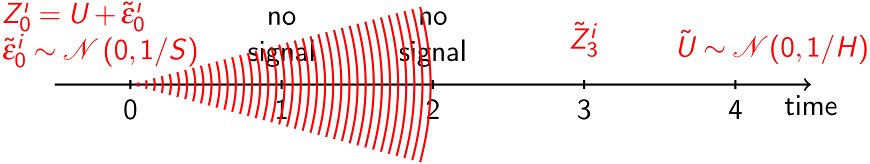

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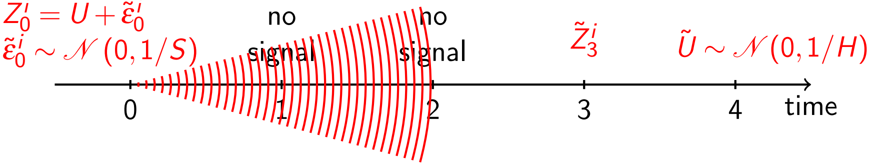

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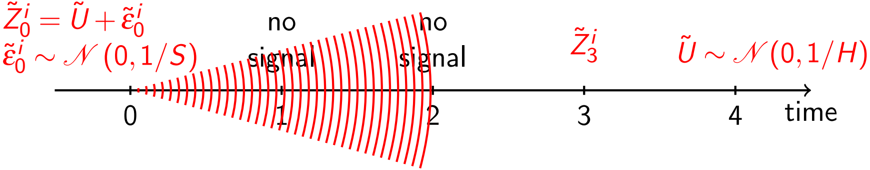

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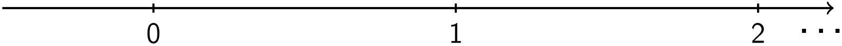
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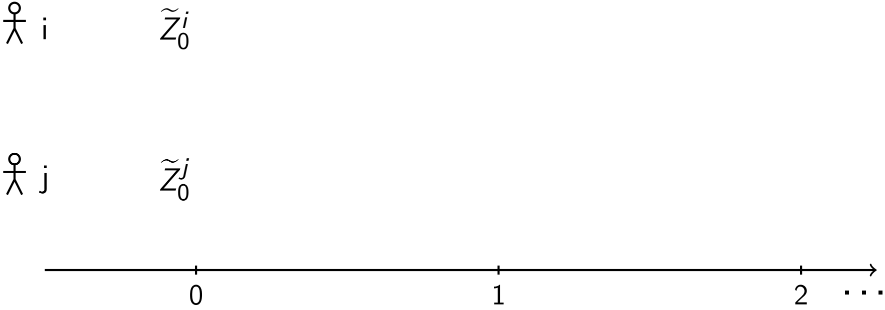

LEARNING $\widetilde{\mu}_0^i = E\left[\widetilde{U}\middle|\widetilde{Z}_0^i, \widetilde{P}_0\right]$

AGGREG. $\widetilde{X}_0 = \int_0^1 \widetilde{D}_0^i \mathrm{d}i$

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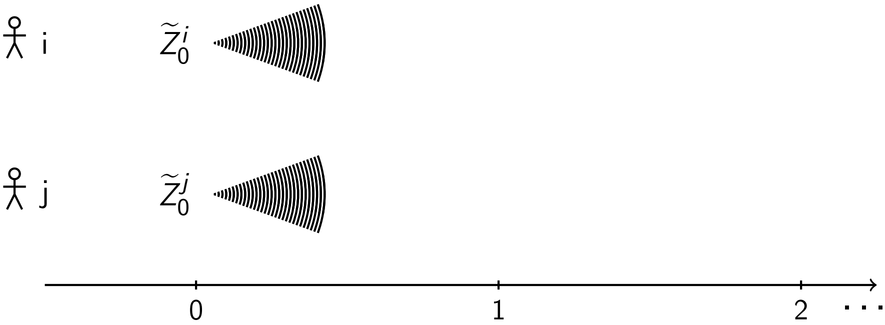

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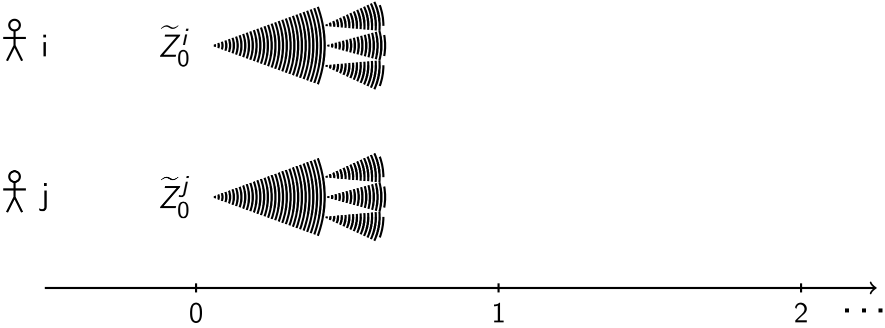

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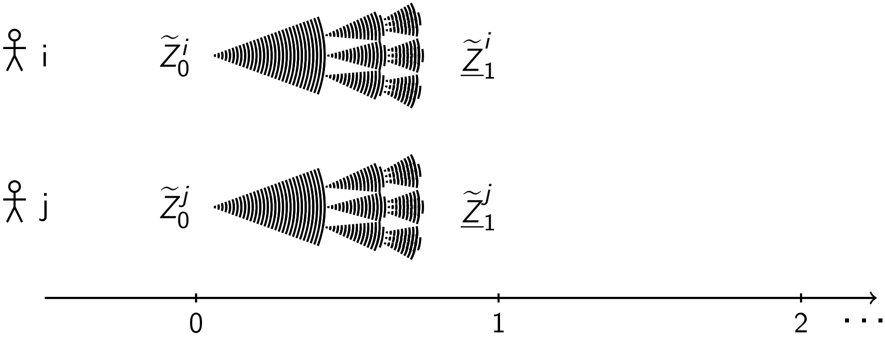

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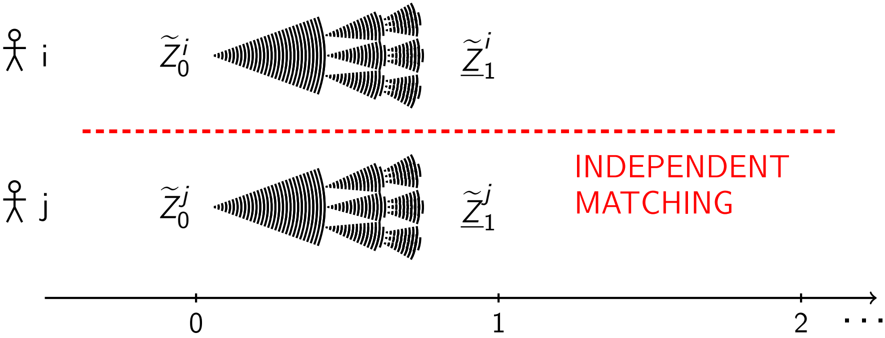

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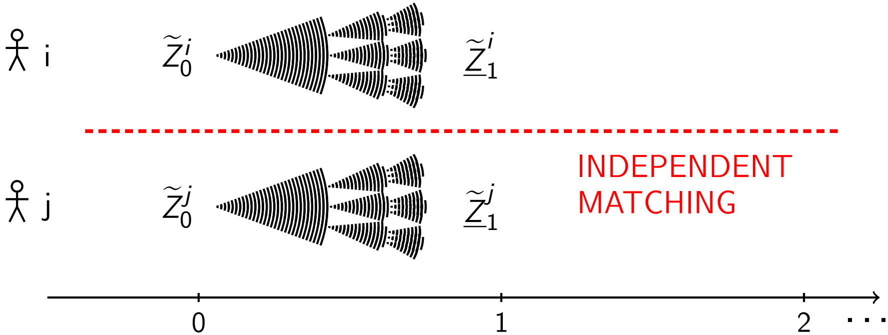


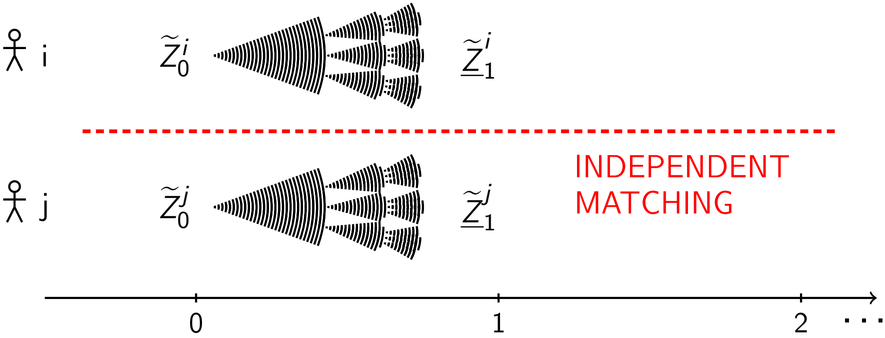
INDEPENDENT MATCHING

LEARNING $\widetilde{\mu}_0^i = E\left[\widetilde{U}\middle|\widetilde{Z}_0^i, \widetilde{P}_0\right]$ $\widetilde{\mu}_1^i = E\left[\widetilde{U}\middle|\underline{\widetilde{Z}}_1^i, \widetilde{P}_0, \widetilde{P}_1\right]$

AGGREG. $\widetilde{X}_0 = \int_0^1 \widetilde{D}_0^i \mathrm{d}i$ $\widetilde{X}_0 + \widetilde{X}_1 = \int_0^1 \widetilde{D}_1^i \mathrm{d}i$

$\longrightarrow$ $\boxed{\int_0^1 \widetilde{Z}_0^i \mathrm{d}i = \widetilde{U}}$

$\longrightarrow$ $\widetilde{P}_0 \perp \widetilde{\varepsilon}_0^i$



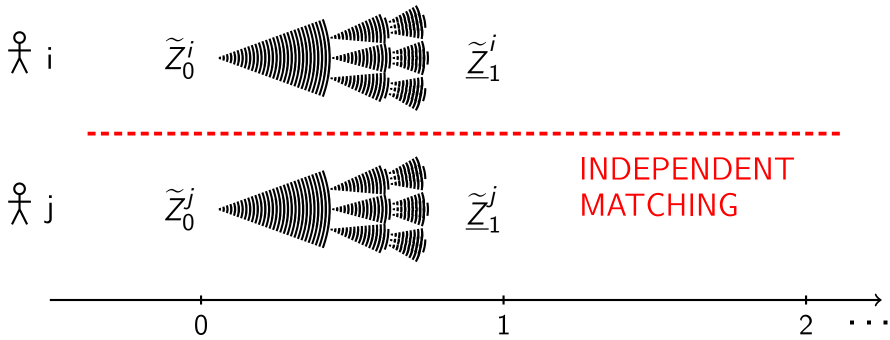
INDEPENDENT
MATCHING

LEARNING $\widetilde{\mu}_0^i = E\left[\widetilde{U} \middle| \widetilde{Z}_0^i, \widetilde{P}_0\right]$ $\widetilde{\mu}_1^i = E\left[\widetilde{U} \middle| \underline{\widetilde{Z}}_1^i, \widetilde{P}_0, \widetilde{P}_1\right]$

AGGREG. $\widetilde{X}_0 = \int_0^1 \widetilde{D}_0^i \mathrm{d}i$ $\widetilde{X}_0 + \widetilde{X}_1 = \int_0^1 \widetilde{D}_1^i \mathrm{d}i$

$\longrightarrow$ $\boxed{\int_0^1 \widetilde{Z}_0^i \mathrm{d}i = \widetilde{U}}$ $\boxed{\int_0^1 \underline{\widetilde{Z}}_1^i \mathrm{d}i = \widetilde{U}}$

$\longrightarrow$ $\widetilde{P}_0 \perp \widetilde{\varepsilon}_0^i$ $\widetilde{P}_1 \perp \widetilde{\varepsilon}_0^i, \underline{\widetilde{\varepsilon}}_1^i$



INDEPENDENT MATCHING

LEARNING $\widetilde{\mu}_0^i = E\left[\widetilde{U}\middle|\widetilde{Z}_0^i, \widetilde{P}_0\right]$ $\widetilde{\mu}_1^i = E\left[\widetilde{U}\middle|\underline{\widetilde{Z}}_1^i, \widetilde{P}_0, \widetilde{P}_1\right]$

AGGREG. $\widetilde{X}_0 = \int_0^1 \widetilde{D}_0^i \mathrm{d}i$ $\widetilde{X}_0 + \widetilde{X}_1 = \int_0^1 \widetilde{D}_1^i \mathrm{d}i$ …

$\longrightarrow$ $\boxed{\int_0^1 \widetilde{Z}_0^i \mathrm{d}i = \widetilde{U}}$ $\boxed{\int_0^1 \underline{\widetilde{Z}}_1^i \mathrm{d}i = \widetilde{U}}$

$\longrightarrow$ $\widetilde{P}_0 \perp \widetilde{\varepsilon}_0^i$ $\widetilde{P}_1 \perp \widetilde{\varepsilon}_0^i, \underline{\widetilde{\varepsilon}}_1^i$

Theorem

There exists a partially revealing rational expectations equilibrium in the 4 trading session economy in which the risky asset price, $\tilde{P}_t$*, and individual asset demands,* $\tilde{D}^i_{t,k}$*, for* $t = 0, .., 3$*, are given by:*

$$\begin{aligned} \tilde{P}_t &= \frac{K_t - H}{K_t} \tilde{U} - \sum_{j=0}^{t} \frac{1 + r^2 S \Phi \Omega_j}{r K_t} \tilde{X}_j, \\ \tilde{D}^i_{t,k} &= r \left[\sum_{j=0}^{t} \left(k_j S \bar{Z}^i_{j,k_j} - S \Omega_j \tilde{U} + \frac{\tilde{X}_j}{r} \right) - \Delta K^i_{t,k} \tilde{P}_t \right] \end{aligned} \tag{1}$$

where $K^i_{t,k} \equiv Var^{-1} \left[\tilde{U} \mid \tilde{F}^i_{t,k} \right]$, $K_t \equiv Var^{-1} \left[\tilde{U} \mid \tilde{F}_t \right] = \sum_{k \in \mathbb{N}} \pi_t (k) K^i_{t,k}$ *and* Ω_t *represents the cross-sectional average of signals at time* t*,* $\sum_{k \in \mathbb{N}} \pi_t (n) n$*.The difference* $\Delta K^i_{t,k} \equiv K^i_{t,k} - K_j$ *represents the precision (dis)advantage of agent* i *with respect to the average precision of all investors.*

- The optimal trading strategy of the individual investor i at time $t = 1, 2, 3$ is given by

$$\nabla \tilde{D}^i_{t,k} = r \left[k_t S \left(\bar{Z}^i_{t,k_t} - \tilde{P}_t \right) - S \Omega_t \left(\tilde{U} - \tilde{P}_t \right) + \frac{\tilde{X}_t}{r} - \Delta K^i_{t-1,k} \nabla \widetilde{P}_t \right]$$

- We focus on the correlations between consecutive price differences:

$$\mathrm{corr}\left(\widetilde{P}_1 - \widetilde{P}_0, \widetilde{P}_2 - \widetilde{P}_1 \right)$$
$$\mathrm{corr}\left(\widetilde{P}_2 - \widetilde{P}_1, \widetilde{P}_3 - \widetilde{P}_2 \right)$$

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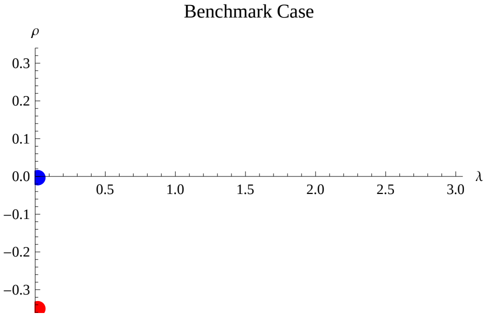
- We focus on the correlations between consecutive price differences:

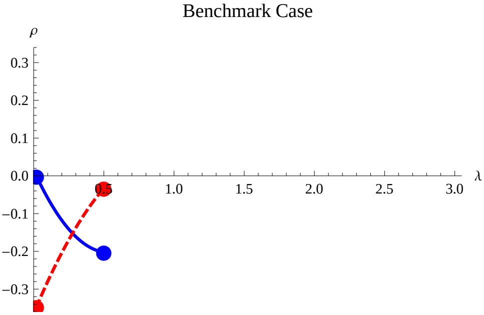
$$\operatorname{corr}\left(\widetilde{P}_1 - \widetilde{P}_0, \widetilde{P}_2 - \widetilde{P}_1 \right)$$
$$\operatorname{corr}\left(\widetilde{P}_2 - \widetilde{P}_1, \widetilde{P}_3 - \widetilde{P}_2 \right)$$

Price Drift in the Benchmark Case



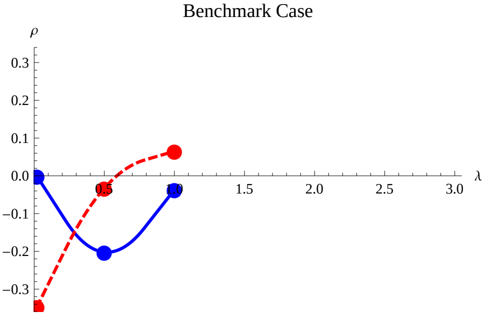
Autocorrelation of stock returns: No information percolation

Price Drift in the Benchmark Case



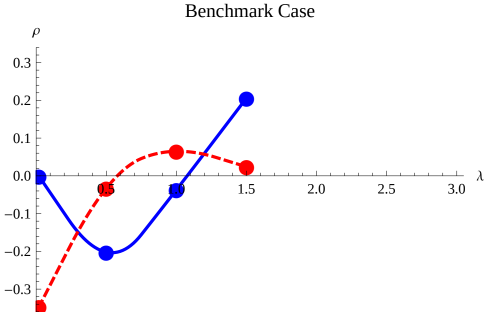
Autocorrelation of stock returns: $\lambda \in [0, 0.5]$

Price Drift in the Benchmark Case



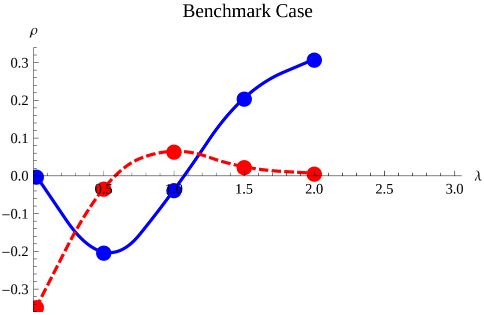
Autocorrelation of stock returns: $\lambda \in [0, 1]$

Price Drift in the Benchmark Case



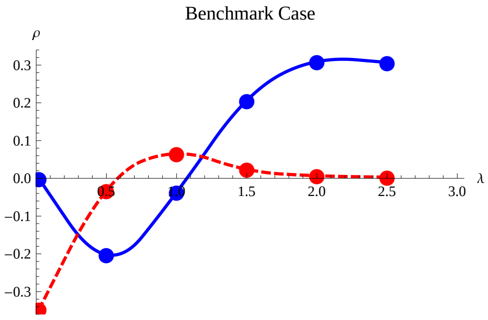
Autocorrelation of stock returns: $\lambda \in [0, 1.5]$

Price Drift in the Benchmark Case



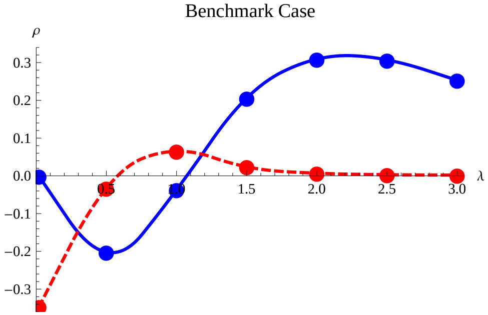
Autocorrelation of stock returns: $\lambda \in [0, 2]$

Price Drift in the Benchmark Case



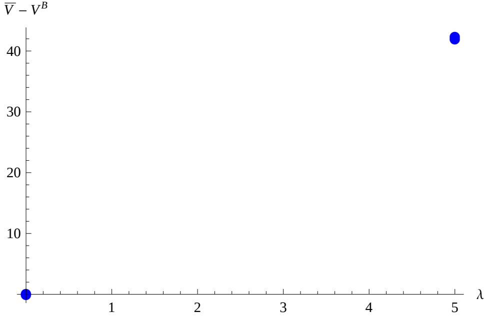
Autocorrelation of stock returns: $\lambda \in [0, 2.5]$

Price Drift in the Benchmark Case



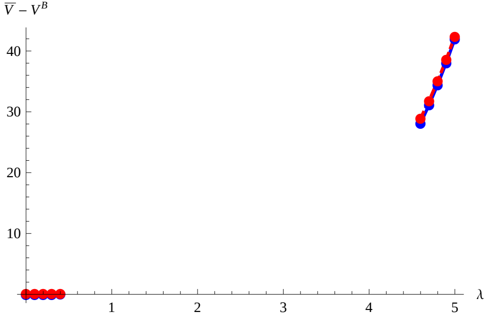
Autocorrelation of stock returns: $\lambda \in [0,3]$

Trading Volume in the Benchmark Case



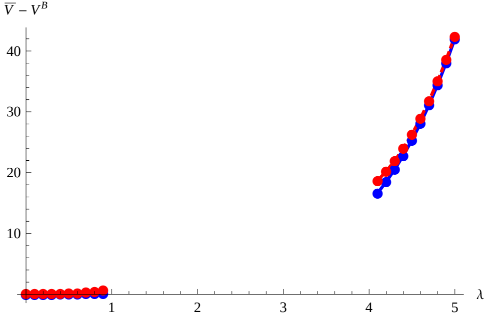
Expected Trading Volume: $\lambda = 0$ and $\lambda = 5$

Trading Volume in the Benchmark Case



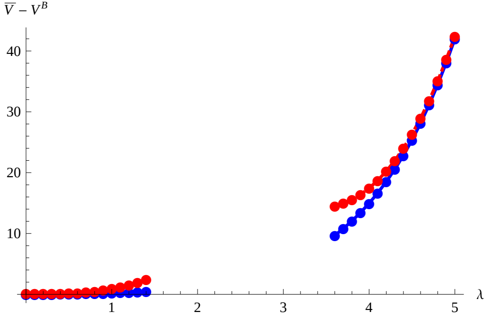
Expected Trading Volume: Low and Large λ's

Trading Volume in the Benchmark Case



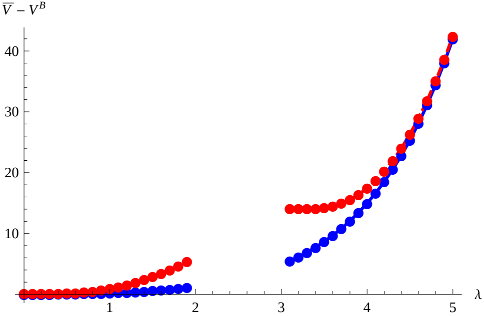
Expected Trading Volume: Low and Large λ's

Trading Volume in the Benchmark Case



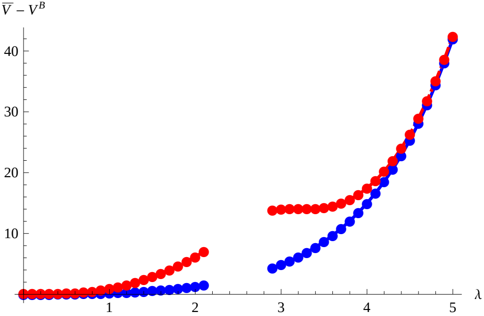
Expected Trading Volume: Intermediate λ's

Trading Volume in the Benchmark Case



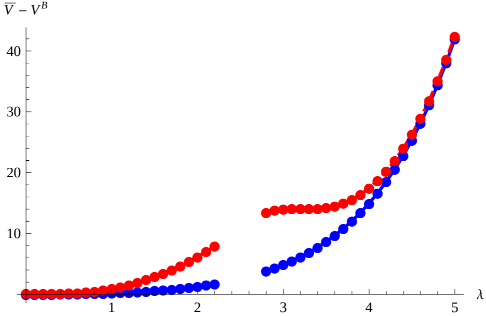
Expected Trading Volume: Intermediate λ's

Trading Volume in the Benchmark Case



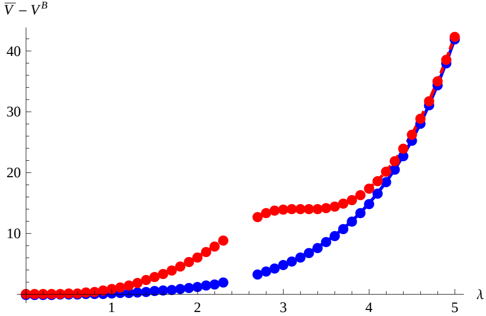
Expected Trading Volume: Intermediate λ's

Trading Volume in the Benchmark Case



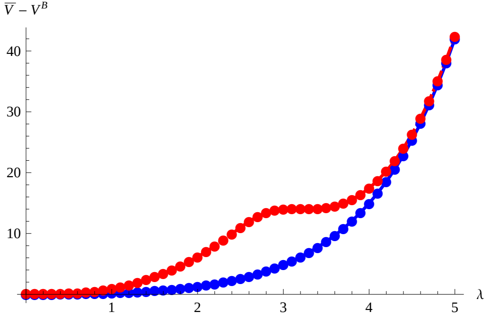
Expected Trading Volume: Intermediate λ's

Trading Volume in the Benchmark Case



Expected Trading Volume: Intermediate λ's

Trading Volume in the Benchmark Case



Expected Trading Volume: Intermediate λ's

Outline

I. A Benchmark Model

- Setup
- Information Percolation
- Solution
- Results

II. Additional Uncertainty, or Rumors

- Setup and Solution
- Results

III. Conclusion

- Everything is exactly as in the benchmark model, except that

$$\tilde{Z}_0^i = \tilde{U} + \tilde{V} + \tilde{\varepsilon}_0^i$$
$$\tilde{Z}_3^i = \tilde{U} + \tilde{\varepsilon}_3^i$$

- The private signals at time 0 are not centered on the fundamental $\tilde{U}$. There is a additional (common) noise $\tilde{V} \sim \mathcal{N}(0, 1/\nu)$, *unobserved* by the individual investors.
- The parameter ν represents the precision of the rumor. If $\nu \to \infty$, then we obtain the Benchmark Model.

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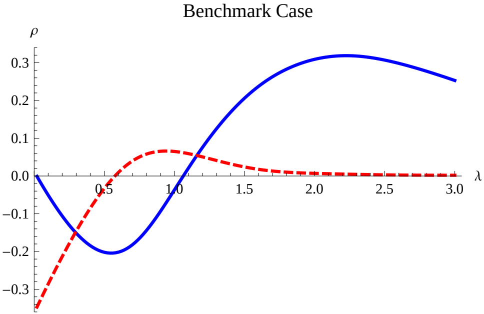
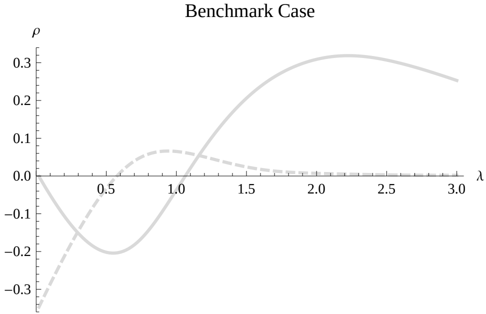
Price Drift in the Benchmark Case



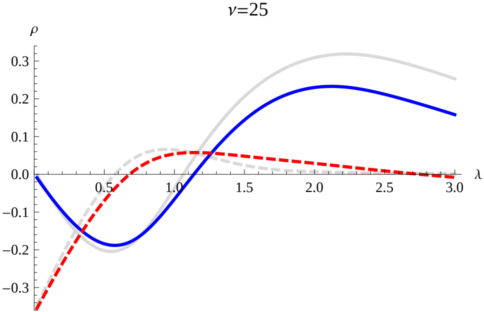
Autocorrelation of stock returns: No Rumor

Price Drift in the Benchmark Case



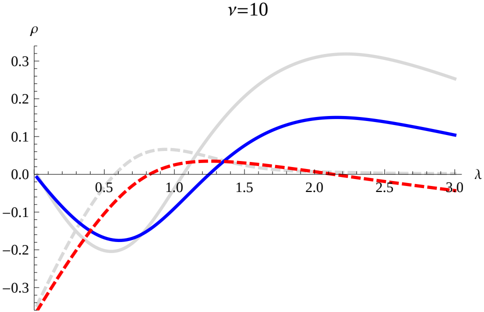
Autocorrelation of stock returns: No Rumor

Price Drift When there is a Rumor



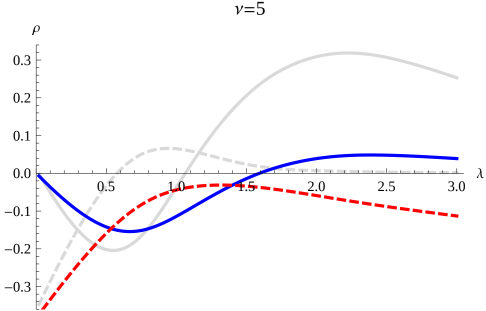
Autocorrelation of stock returns: $\nu = 25$

Price Drift When there is a Rumor



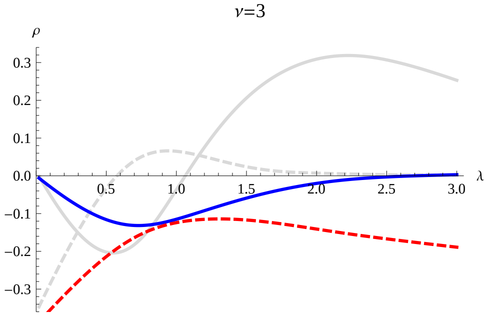
Autocorrelation of stock returns: $\nu = 10$

Price Drift When there is a Rumor



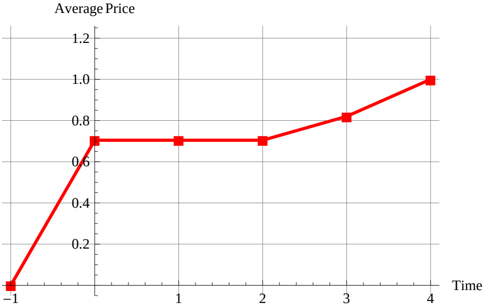
Autocorrelation of stock returns: $\nu = 5$

Price Drift When there is a Rumor



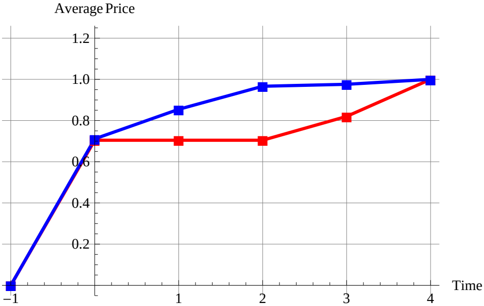
Autocorrelation of stock returns: $\nu = 3$

Hump-Shaped Patterns in Stock Prices



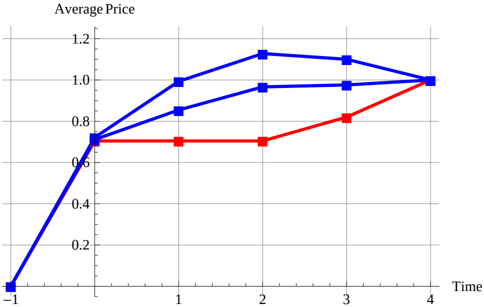
Stock Prices: $\tilde{U} = 1, \tilde{V} = 0.5, \lambda = 0$

Hump-Shaped Patterns in Stock Prices



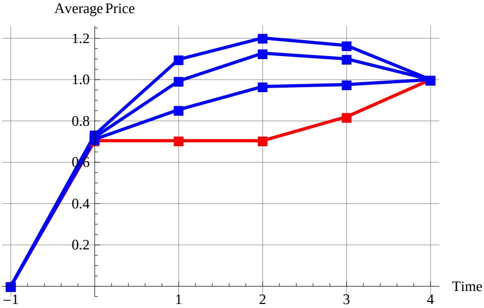
Stock Prices: $\tilde{U} = 1, \tilde{V} = 0.5, \lambda = 0.5$

Hump-Shaped Patterns in Stock Prices



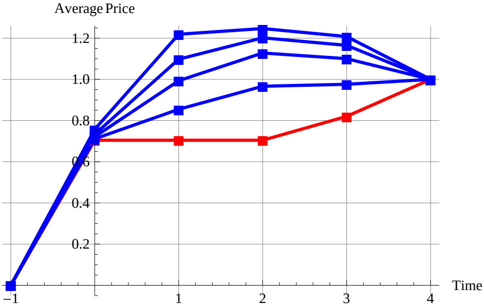
Stock Prices: $\tilde{U} = 1, \tilde{V} = 0.5, \lambda = 1$

Hump-Shaped Patterns in Stock Prices



Stock Prices: $\tilde{U} = 1, \tilde{V} = 0.5, \lambda = 1.5$

Hump-Shaped Patterns in Stock Prices



Stock Prices: $\tilde{U} = 1, \tilde{V} = 0.5, \lambda = 3$

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Conclusion

- The diffusion of information through financial markets has a significant impact on the dynamics of asset prices.
- The information percolation produces price drift.
- Rumors might propagate and produce reversals.
- Many interesting extensions are work in progress.

Related Literature

Evidence on momentum and reversal

Cutler, Poterba, and Summers (1990), Jegadeesh and Titman (1993), Rouwenhorst (1998), Moskowitz, Ooi, and Pedersen (2010), Bernard (1992), Chan, Jegadeesh, and Lakonishok (1996), De Bondt and Thaler (1985), Lakonishok, Shleifer, and Vishny (1994), Poterba and Summers (1988), Hong, Lim, and Stein (2000).

Evidence on word-of-mouth communication and gradual diffusion of information

Shiller and Pound (1989), Hong, Kubik, and Stein (2004), Feng and Seasholes (2004), Brown, Ivkovic, Smith, and Weisbenner (2008), Grinblatt and Keloharju (2001), Ivkovic and Weisbenner (2005), Cohen, Frazzini, and Malloy (2008).

Theoretical Explanations

Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), Hong and Stein (1999), Holden and Subrahmanyam (2002), Hong, Hong, and Ungureanu (2010), Albuquerque and Miao (2010), Vayanos and Woolley (2010).

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Vayanos, D., and P. Woolley (2010): "An Institutional Theory of Momentum and Reversal," *Working Paper*.