Wall Street and Silicon Valley: A Delicate Interaction

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• financial markets look at aggregate investment for clues about profitability
  (especially so during periods of intense technological change)
Motivation

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- firms’ incentives to invest depend on asset prices
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- two-way feedback between “Wall Street” and “Silicon Valley”
Motivation

- financial markets look at aggregate investment for clues about profitability (especially so during periods of intense technological change)
- firms’ incentives to invest depend on asset prices
- two-way feedback between “Wall Street” and “Silicon Valley”
- novel positive and normative implications under dispersed info
This paper

- a neoclassical environment:
This paper

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  - new technology with completely exogenous profitability
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  - 1st stage: real investment in the new technology ("Silicon Valley")
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  - fundamental shocks (underlying profitability)
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- only deviation: **dispersed information**

- two types of shocks
  - fundamental shocks (underlying profitability)
  - expectational shocks (correlated errors)
Key results

- endogenous complementarity in investment decisions
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- **endogenous complementarity** in investment decisions

- **source of non-fundamental volatility**
  - dampens fundamental shocks
  - amplifies expectational shocks
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- symptoms of **inefficiency**:
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- policies that restore efficiency without info advantage for government
Key results

- helps explain "bubbly" episodes around new technologies (Internet, China)
  - without any deviation from rationality and the like
  - no presumption that government more “intelligent” than market
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  - without any deviation from rationality and the like
  - no presumption that government more “intelligent” than market

- complete micro-foundation of Keyens’ "beauty contest"
  - investment driven by higher-order expectations
  - importantly: this effect is a source of inefficiency
Plan

- Baseline Model
Plan

1. Baseline Model
2. Equilibrium
Plan

1. Baseline Model
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3. Constrained efficiency
Plan

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4. Policy
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5. Extensions
## Model

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Timing and actions

- two types of agents, “entrepreneurs” and “traders”
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- $t = 0$: arrival of new technology of unknown productivity $\theta$
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- $t = 0$: arrival of new technology of unknown productivity $\theta$

- $t = 1$: entrepreneurs decide investment in new technology

- $t = 2$: entrepreneurs hit by “liquidity shock” sell to traders

- $t = 3$: $\theta$ is revealed and payoffs are realized
Payoffs

- risk neutral preferences:

\[ u_i = c_{i1} + c_{i2} + c_{i3} \]
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- investing \( k \) units at \( t = 1 \) costs \( \frac{1}{2}k^2 \)
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- entrepreneurs:
  \[
  u_i = \begin{cases} 
  pk_i - \frac{1}{2}k_i^2 & \text{if hit by liquidity shock (prob. } \lambda) \\
  \theta k_i - \frac{1}{2}k_i^2 & \text{if not (prob. } 1 - \lambda) 
  \end{cases}
  \]
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  \end{cases} \]

- traders:
  \[ u_i = (\theta - p)q_i \]
Information

- at $t = 0$ nature draws $\theta \sim \mathcal{N}(\mu_\theta, \pi_\theta^{-1})$
Information

- at $t = 0$ nature draws $\theta \sim \mathcal{N}(\mu_\theta, \pi^{-1}_\theta)$

- at $t = 1$ entrepreneurs observe
  - private signals $x_i = \theta + \xi_i$, $\xi_i \sim \mathcal{N}(0, \pi^{-1}_x)$
  - common signal $y = \theta + \varepsilon$, $\varepsilon \sim \mathcal{N}(0, \pi^{-1}_y)$

- at $t = 2$ everybody observes $K$

- at $t = 3$ everybody observes $\theta$ and payoffs are realized
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$$\mathbb{E}_i u = -\frac{1}{2}k_i^2 + \mathbb{E}_i [(1 - \lambda)\theta + \lambda p] k_i$$
A benchmark without informational frictions

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equil. investment driven only by first-order expectations

and independent of $\lambda$ (of how much entrepreneurs care about asset prices)
An equilibrium is an investment strategy $k : \mathbb{R}^2 \rightarrow \mathbb{R}$ and a price function $p : \mathbb{R}^2 \rightarrow \mathbb{R}$ such that:

- for all $(x, y)$,

$$k(x, y) \in \arg \max_k \mathbb{E} \left[ -\frac{1}{2} k^2 + (1 - \lambda) \theta k + \lambda p(\theta, y) k \mid x, y \right];$$
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- for all $(\theta, y)$,
  
  $$p(\theta, y) = \mathbb{E} [ \theta \mid K(\theta, y)],$$

where $K(\theta, y) \equiv \int k(x, y) d\Phi(x \mid \theta)$. 


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- for all $(\theta, y)$,
  $$p(\theta, y) = \mathbb{E} \left[ \theta \big| K(\theta, y) \right],$$

where $K(\theta, y) \equiv \int k(x,y) d\Phi(x|\theta)$.

A linear equilibrium is an equilibrium in which $p(\theta, y)$ is linear in $(\theta, y)$. 
optimal investment of entrepreneurs:

\[ k(x,y) = \mathbb{E}[ (1 - \lambda) \theta + \lambda p | x, y ] \]
Equilibrium

- optimal investment of entrepreneurs:
  \[ k(x,y) = \mathbb{E}\left[ (1 - \lambda) \theta + \lambda p \mid x, y \right] \]

- linearity of \( p(\theta,y) \) implies linearity of \( k(x,y) \):
  \[ k(x,y) = \beta_0 + \beta_1 x + \beta_2 y \]
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- it follows \( \exists \gamma_0, \gamma_1 \) s.t.
  
  \[
  \mathbb{E} [\theta \mid K] = \gamma_0 + \gamma_1 K
  \]
Equilibrium

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  \[ \mathbb{E}[\theta|K] = \gamma_0 + \gamma_1 K \]

- equilibrium price satisfies
  \[ p = \gamma_0 + \gamma_1 K \]
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... endogenous complementarity!
Lemma

In any equilibrium, investment satisfies

\[ k_i = \mathbb{E}_i [ (1 - \alpha) \tilde{\theta} + \alpha K ], \]

where \( \alpha \equiv \lambda \gamma_1 > 0 \) and \( \tilde{\theta} \equiv \frac{(1 - \lambda) \theta + \lambda \gamma_0}{1 - \lambda \gamma_1} \).
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where \( \alpha \equiv \lambda \gamma_1 > 0 \) and \( \tilde{\theta} \equiv \frac{(1 - \lambda)\theta + \lambda \gamma_0}{1 - \lambda \gamma_1}. \)

In any equilibrium, the relative sensitivity of investment to the common signal increases with \( \alpha \) (equiv., with \( \gamma_1 \)):

\[ \frac{\beta_2}{\beta_1} = \frac{\pi_y}{\pi_x (1 - \alpha)}. \]
Endogenous complementarity

- best response structure similar to
  Morris-Shin (*AER* 2002), Angeletos-Pavan (*Ecma* 2007), etc.
Endogenous complementarity

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- but complementarity is **endogenous**
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- $\alpha > 0$ because, and only because, high $K$ is “good news” about $\theta$
Endogenous complementarity


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- $\alpha > 0$ because, and only because, high $K$ is “good news” about $\theta$

- when dispersion of info vanishes, complementarity also vanishes
Equilibrium characterization

- fixed point between equil strategy and equil price
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\[ \beta_2 / \beta_1 \rightarrow \]
Equilibrium characterization

- fixed point between equil strategy and equil price

\[ \frac{\beta_2}{\beta_1} \rightarrow \text{signal-to-noise ratio in } K \]
fixed point between equil strategy and equil price

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Equilibrium characterization

**Proposition**

- *There always exists an equilibrium*
Equilibrium characterization

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- There always exists an equilibrium
- There robustly exist multiple equilibria
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- The equilibrium is unique if $\lambda$ is small enough
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Whenever the equilibrium is unique,

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Proposition

Whenever the equilibrium is unique,

- high investment is “good news” for profitability
- $\alpha$ is positive and increasing in $\lambda$
Sensitivity to shocks

- write equilibrium aggregate investment as

\[ K = \beta_0 + (\beta_1 + \beta_2) \theta + \beta_2 \epsilon \]
write equilibrium aggregate investment as

\[ K = \beta_0 + (\beta_1 + \beta_2) \theta + \beta_2 \varepsilon \]

**Corollary**

*In any equilibrium in which high investment is “good news”,
relative impact of expectational shocks is higher with info frictions.*
Proposition

There exists $\hat{\lambda} \in (0, \bar{\lambda})$ such that, for all $\lambda \in [0, \hat{\lambda}]$, the following are true:

- absolute impact of expectational shocks higher with info frictions, and the more so the higher $\lambda$
Proposition

There exists $\lambda \in (0, \bar{\lambda})$ such that, for all $\lambda \in [0, \hat{\lambda}]$, the following are true:

- absolute impact of expectational shocks higher with info frictions, and the more so the higher $\lambda$
- the converse is true for fundamental shocks
Constrained efficiency

Definition

The efficient allocation is a strategy $k : \mathbb{R}^2 \to \mathbb{R}$ that maximizes ex-ante utility.
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- financial trades are zero-sum transfers ⇒

$$E u = \frac{1}{2} \int_{x,y,\theta} \left\{ -\frac{1}{2} k(x,y)^2 + (1 - \lambda) \theta k(x,y) \right\} + \frac{1}{2} \int_{y,\theta} \theta \lambda K(\theta,y)$$
Constrained efficiency

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- financial trades are zero-sum transfers $\Rightarrow$

$$\mathbb{E}u = \frac{1}{2} \int_{x,y,\theta} \left\{ -\frac{1}{2} k(x,y)^2 + (1 - \lambda) \theta k(x,y) \right\} + \frac{1}{2} \int_{y,\theta} \theta \lambda K(\theta, y)$$

- social return to investment $= \theta :$

$$\mathbb{E}u = \frac{1}{2} \int_{x,y,\theta} \left\{ -\frac{1}{2} k(x,y)^2 + \theta k(x,y) \right\}$$
Proposition

The efficient investment strategy is unique and is given by

\[ k(x, y) = \mathbb{E}[\theta|x, y] \]

for almost all \((x, y)\).
Constrained efficiency

Proposition

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Corollary

In any equilibrium in which high investment is “good news”,

relative impact of expectational shocks is inefficiently high.
To recap

- **positive result: amplification**

  info frictions $\rightarrow$ *higher* sensitivity to expectational shocks
To recap

- **positive result: amplification**
  
  info frictions $\rightarrow$ *higher* sensitivity to expectational shocks

- **normative result: inefficiency**
  
  info frictions $\rightarrow$ *excessive* sensitivity to expectational shocks
contingent transfers at $t = 3$

$$m_i = -\tau(K, \theta) s_i + T(K, \theta)$$
Policy

- contingent transfers at $t = 3$

$$m_i = -\tau(K, \theta)s_i + T(K, \theta)$$

**Proposition**

*There exists a unique linear tax scheme that implements the efficient allocation. The optimal marginal tax satisfies*

$$\tau(\theta, K) = \tau_0 + \tau_1 \theta + \tau_2 K$$

*with $\tau_0 > 0$, $\tau_1 < 0$, and $\tau_2 > 0$.*

- no need for the government to “know better” than the market
contingent transfers at $t = 3$

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- no need for the government to “know better” than the market
- no need to intervene during the fact
- the key is to make marginal taxes increasing in aggregate investment
Extensions

- trading costs, downward slopping demands at $t = 2$
  \[ \Rightarrow \text{source of strategic substitutability} \]
Extensions

- trading costs, downward slopping demands at $t = 2$
  $\Rightarrow$ source of strategic **substitutability**

- entrepreneurs not hit by liquidity shock can also trade
  $\Rightarrow$ **info aggregation** in the financial market
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- trading costs, downward slopping demands at $t = 2$
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- traders can also invest
Extensions

- trading costs, downward slopping demands at \( t = 2 \)
  - \( \Rightarrow \) source of strategic **substitutability**

- entrepreneurs not hit by liquidity shock can also trade
  - \( \Rightarrow \) **info aggregation** in the financial market

- traders can also invest

- drop \( y \), introduce other unobserved sources of variation for \( K \)
Extensions

- equilibrium with frictions:

\[ k_i = \mathbb{E}_i \left[ (1 - \alpha) \tilde{\theta} + \alpha K \right] \]
Extensions

- equilibrium with frictions:

  \[ k_i = \mathbb{E}_i \left[ (1 - \alpha) \tilde{\theta} + \alpha K \right] \]

- equilibrium without frictions and efficient allocation:

  \[ k_i = \mathbb{E}_i \left[ (1 - \alpha^*) \tilde{\theta} + \alpha^* K \right], \]
Extensions

- equilibrium with frictions:

  \[ k_i = E_i \left[ \left( 1 - \alpha \right) \tilde{\theta} + \alpha K \right] \]

- equilibrium without frictions and efficient allocation:

  \[ k_i = E_i \left[ \left( 1 - \alpha^* \right) \tilde{\theta} + \alpha^* K \right] \]

  both \( \alpha \) and \( \alpha^* \) can be negative, but

  "good news" effect \( \iff \alpha > \alpha^* \)
Extensions

- equilibrium with frictions:

\[ k_i = \mathbb{E}_i[ (1-\alpha) \tilde{\theta} + \alpha K ] \]

- equilibrium without frictions and efficient allocation:

\[ k_i = \mathbb{E}_i[ (1-\alpha^*) \tilde{\theta} + \alpha^* K ] \]

- both \( \alpha \) and \( \alpha^* \) can be negative, but

"good news" effect \( \iff \alpha > \alpha^* \)

- key positive and normative results unaffected
Conclusion

- high investment is good news $\Rightarrow$ endogenous complementarity
Conclusion

- high investment is good news $\Rightarrow$ **endogenous complementarity**

- micro-foundation of (normative aspect of) beauty contest
Conclusion

- high investment is good news ⇒ endogenous complementarity

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- source of both amplified non-fundamental volatility and inefficiency
Conclusion

- high investment is good news ⇒ \textit{endogenous complementarity}

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- particularly relevant for periods of intense technological change
Conclusion

- high investment is good news ⇒ endogenous complementarity

- micro-foundation of (normative aspect of) beauty contest

- source of both amplified non-fundamental volatility and inefficiency

- particularly relevant for periods of intense technological change

- but also for business cycles