Dispersed Information, Monetary Policy
and Central Bank Communication

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MOTIVATION

“The peculiar character of the problem of a rational economic order is determined precisely by the fact that the knowledge of the circumstances of which we must make use never exists in concentrated or integrated form but solely as the dispersed bits of incomplete and frequently contradictory knowledge which all the separate individuals possess. The economic problem of society is ... a problem of the utilization of knowledge which is not given to anyone in its totality.”

(Friedrich A. Hayek, 1945)
MOTIVATION

equilibrium and welfare in economies with

✓ complementarity in actions

✓ dispersed info on common fundamentals
MOTIVATION

- equilibrium and welfare in economies with
  - complementarity in actions
  - dispersed info on common fundamentals

- applications:
  - business cycles
  - investment in new technologies/markets
  - financial markets
QUESTIONS

Q1: equilibrium use of information?

response to fundamentals (inertia) and noise (volatility)?
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   response to fundamentals (inertia) and noise (volatility)?

Q2: inefficiency in the use of information?
   excessive inertia and volatility?
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   response to fundamentals (inertia) and noise (volatility)?

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Q3: policies that correct this inefficiency?
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Q3: policies that correct this inefficiency?

Q4: policies that communicate additional info?  
   CB transparency vs “constructive ambiguity”?
QUESTIONS

Q1: equilibrium use of information?  
    response to fundamentals (inertia) and noise (volatility)?

Q2: inefficiency in the use of information?  
    excessive inertia and volatility?

Q3: policies that correct this inefficiency?

Q4: policies that communicate additional info?  
    CB transparency vs “constructive ambiguity”?

Q5: aggregation of info through prices and macro data?  
    implications for monetary policy?
MODELING APPROACH (Angeletos & Pavan)

- a broad class of linear-quadratic games that nest various applications
  - flexible payoff interdependences
  - strategic complementarity/substitutability
  - dispersed info on common values
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- a broad class of linear-quadratic games that nest various applications
  - flexible payoff interdependences
  - strategic complementarity/substitutability
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- equilibrium vs. appropriate efficiency benchmark
  - optimal corrective taxation
  - comparative statics of equil welfare wrt information structure
KEY LESSONS

Q1: complementarity heightens inertia and volatility

Q2: inefficiency depends on social preferences over volatility and dispersion

Q3: contingency of policy on aggregate activity can correct inefficiency

Q4: transparency undesirable only if inefficiency

Q5: aforementioned contingency can improve info in prices/macro data
ROADMAP

✓ Environment
✓ Equilibrium (Question 1)
✓ Efficient benchmark (Question 2)
✓ Corrective policies (Question 3)
✓ Social value of information (Question 4)
✓ Information aggregation (Question 5)
✓ Applications: business cycles & financial markets
ROADMAP

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THE ENVIRONMENT

✓ large, symmetric, simultaneous-move game
✓ linear-quadratic payoffs
✓ unique and bounded equilibrium and efficient allocations
✓ dispersed information on a commonly relevant fundamental
\[ u_i = U( k_i, \{ k_j \}_{j \neq i}, \theta ) \]
ACTIONS & PAYOFFS

\[ u = U ( k, K, \sigma_k^2, \theta ) \]

\[ K = \int k' d\Psi (k') \quad \sigma_k^2 = \int (k' - K)^2 d\Psi (k') \]

Assumptions:

✓ \( U \) quadratic in \((k, K, \theta)\) and linear in \(\sigma_k^2\) (→best responses linear in \(K, \theta\))

✓ \( U \) such that equilibrium and first-best allocations are unique and bounded
EXAMPLES

1. investment complementarities (Angeletos & Pavan, 2004)

\[ u_i = A k_i - c(k_i), \quad A = \theta + aK, \quad c(k) = k^2 / 2 \]

\[ \implies k_i = \mathbb{E}_i[\theta + aK] \]

2. new-Keynesian models (Woodford, 2002; Hellwig, 2006; Lorenzoni, 2007; Angeletos & Lao, 2007)

\[ \pi_i = \pi^* - (p_i - p^*)^2, \quad p^* = (1 - \phi)\theta + \phi P \]

\[ \implies p_i = \mathbb{E}_i[(1 - \phi)\theta + \phi P] \]

3. beauty contests (Morris & Shin, 2002; Svensson, 2005; Angeletos, Lorenzoni & Pavan, 2007)
✓ common prior:
\[ \theta \sim \mathcal{N}(\mu_\theta, \sigma_\theta^2) \]

✓ private signals:
\[ x_i = \theta + \sigma_x \xi_i \quad \xi_i \sim \mathcal{N}(0, 1) \]

✓ public signal:
\[ y = \theta + \sigma_y \varepsilon \quad \varepsilon \sim \mathcal{N}(0, 1) \]

(with \( \xi_i, \xi_j, \varepsilon \) orthogonal to one another, as well as to \( \theta \))
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✓ Applications
EQUILIBRIUM

**Proposition.** A strategy is an equilibrium if and only if

\[ k(x, y) = \mathbb{E} \left[ (1 - \alpha) \kappa(\theta) + \alpha K(\theta, y) \mid x, y \right] \]

where \( \kappa(\theta) = \) complete-info equilibrium, \( K(\theta, y) = \mathbb{E}[k(x, y) \mid \theta, y] \), and

\[ \alpha \equiv \frac{U_{kK}}{|U_{kk}|} = \text{equilibrium degree of coordination} \]
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\[ \checkmark \text{ higher } \alpha \Rightarrow \text{higher sensitivity to public info, and lower to private} \]
EQUILIBRIUM

✓ to simplify, let $\kappa(\theta) = \theta$

✓ CE guess: $k_i = E_i \theta = \lambda_\mu \mu + \lambda_y y + \lambda_x x_i$
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CE guess:

$$k_i = \mathbb{E}_i \theta = \lambda_\mu \mu + \lambda_y y + \lambda_x x_i$$

actual equilibrium:

$$k_i = \gamma_\mu \mu + \gamma_y y + \gamma_x x_i$$
EQUILIBRIUM

✓ to simplify, let $\kappa(\theta) = \theta$

✓ CE guess: $k_i = \mathbb{E}_i \theta = \lambda_\mu \mu + \lambda_y y + \lambda_x x_i$

✓ actual equilibrium: $k_i = \gamma_\mu \mu + \gamma_y y + \gamma_x x_i$

higher $\alpha \Rightarrow$ higher $\gamma_\mu$ and $\gamma_y$, lower $\gamma_x$

Corollary. Complementarity heightens inertia and volatility.
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EFFICIENT USE OF INFO

**Definition.** Efficient strategy \( k(x, y) \) maximizes ex-ante utility.

- ✓ team problem \( \rightarrow \) all agents maximize the same objective (welfare)
  but with different information sets

- ✓ planner’s problem \( \rightarrow \) control incentives but cannot communicate info
**EFFICIENT USE OF INFO**

**Proposition.** A strategy is efficient if and only if

\[
k(x, y) = \mathbb{E} \left[ (1 - \alpha^*) \kappa^*(\theta) + \alpha^* K(\theta, y) \mid x, y \right]
\]

where \( \kappa^*(\theta) = \) first-best allocation, \( K(\theta, y) = \mathbb{E}[k(x, y)\mid \theta, y] \), and

\[
\alpha^* \equiv 1 - \frac{|U_{kk} + 2U_{kK} + U_{KK}|}{|U_{kk} + 2U_{\sigma_k^2}|} = \text{optimal degree of coordination}
\]
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\[ \alpha^* \equiv 1 - \frac{|U_{kk} + 2U_{kK} + U_{KK}|}{|U_{kk} + 2U_{\sigma_k^2}|} = \text{optimal degree of coordination} \]

✓ higher \( \alpha^* \) ⇒ higher efficient sensitivity to public info
EFFICIENT USE OF INFO

Proposition. A strategy is efficient if and only if

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\[ \alpha^* \equiv 1 - \frac{|U_{kk} + 2U_{kK} + U_{KK}|}{|U_{kk} + 2U_{\sigma_k^2}|} = \text{optimal degree of coordination} \]

Corollary. Equil inertia and volatility are excessive iff \( \alpha > \alpha^* \).
OPTIMAL DEGREE OF COORDINATION

\[ \mathbb{E} u \mid \text{inco info} = \mathbb{E} u \mid \text{first best} - \mathcal{L}^* \]

\[ \mathcal{L}^* = \frac{|U_{kk} + 2U_{kK} + U_{KK}|}{2} \operatorname{Var}(K - \kappa^*) + \frac{|\hat{U}_{kk} + 2\hat{U}_{\sigma_k^2}|}{2} \operatorname{Var}(k - K) \]

( welfare losses = volatility + dispersion )
OPTIMAL DEGREE OF COORDINATION

\[ \mathbb{E} u \mid _{\text{inco info}} = \mathbb{E} u \mid _{\text{first best}} - \mathcal{L}^* \]

\[ \mathcal{L}^* = \frac{|U_{kk} + 2U_{kK} + U_{KK}|}{2} \text{Var}(K - \kappa^*) + \frac{|U_{kk} + 2\sigma^2_k|}{2} \text{Var}(k - K) \]

\[ \alpha^* = 1 - \frac{\text{weight on volatility}}{\text{weight on dispersion}} \]
ROADMAP

✓ Environment
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✓ **Policy (Question 3)**
✓ Social value of information (Question 4)
✓ Information aggregation (Question 5)
✓ Applications
POLICY

✓ timing: 1) agents receive info and choose actions

2) government observes actions and implements policy
POLICY

✓ timing: 1) agents receive info and choose actions

          2) government observes actions and implements policy

✓ linear taxes:

\[ t_i = -\tau(K, \theta) \cdot k_i + T(K, \theta) \]

where, by budget balance, \( T(K, \theta) = \tau(K, \theta) \cdot K \)
POLICY

✓ timing: 1) agents receive info and choose actions

2) government observes actions and implements policy

✓ linear taxes:

\[ t_i = -\tau(K, \theta) \cdot k_i + T(K, \theta) \]

where, by budget balance, \( T(K, \theta) = \tau(K, \theta) \cdot K \)

**Proposition.** There exists a unique tax scheme that implements the efficient allocation as an equilibrium.
✓  policy goal: correct equilibrium use of information
POLICY

✓ **policy goal:** correct equilibrium use of information

✓ **instrument:** sensitivity $\tau_K$ of marginal tax $\tau$ wrt aggregate $K$
  controls complementarity perceived by the agents
POLICY

✓  *policy goal:* correct equilibrium use of information

✓  *instrument:* sensitivity $\tau_K$ of marginal tax $\tau$ wrt aggregate $K$

  controls complementarity perceived by the agents

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**Corollary.** Optimal $\tau$ increases with $K$ iff $\alpha > \alpha^*$. 
POLICY

✓ *policy goal:* correct equilibrium use of information

✓ *instrument:* sensitivity $\tau_K$ of marginal tax $\tau$ wrt aggregate $K$
  controls complementarity perceived by the agents

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**Corollary.** Optimal $\tau$ increases with $K$ iff $\alpha > \alpha^*$. 

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→ contingent of interest rates on realized inflation/aggregate activity
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SOCIAL VALUE OF INFO: a useful decomposition

**Definition.** The *accuracy* and the *commonality* of available information are

\[
\text{accuracy} \equiv \frac{1}{\text{Var}(\eta_i)} \quad \text{commonality} \equiv \text{Corr}(\eta_i, \eta_j)
\]

where \( \eta_i = \theta - \mathbb{E}[\theta|x_i, y] \) denotes \( i \)'s forecast error.
SVI 1: efficient economies

∇  $\kappa = \kappa^*$ and $\alpha = \alpha^*$
SVI 1: efficient economies

\[ \nabla \quad \kappa = \kappa^* \quad \text{and} \quad \alpha = \alpha^* \implies \]

✓ welfare necessarily increases with accuracy

✓ welfare increases with commonality if and only if \( \alpha > 0 \)

✓ no matter \( \alpha \), welfare increases with either private or public info,
  but higher \( \alpha \) increases relative value of public info
SVI 2: inefficiency only when info is incomplete

\[ \nabla \quad \kappa = \kappa^* \quad \text{but} \quad \alpha \neq \alpha^* \]
SVI 2: inefficiency only when info is incomplete

∇ $\kappa = \kappa^*$ but $\alpha \neq \alpha^*$ ⇒

✓ social value of accuracy remains positive

✓ $\alpha < \alpha^*$ → increases social value of commonality (favoring public info)

✓ $\alpha > \alpha^*$ → decreases " " (favoring private info)
SVI 2: inefficiency only when info is incomplete

\[ \nabla \kappa = \kappa^* \text{ but } \alpha \neq \alpha^* \Rightarrow \]

- \( \checkmark \) social value of accuracy remains positive
- \( \checkmark \) \( \alpha < \alpha^* \rightarrow \) increases social value of commonality (favoring public info)
- \( \checkmark \) \( \alpha > \alpha^* \rightarrow \) decreases “” ” (favoring private info)

- \( \checkmark \) more precise public info can decrease welfare only if private incentives to coordinate are excessively high \((\alpha > \alpha^*)\)
SVI 3: inefficiency even under complete info

∇ \kappa \neq \kappa^*
SVI 3: inefficiency even under complete info

$\nabla \ k \neq k^* \Rightarrow$

✓ now welfare can decrease with accuracy

✓ either private or public info can reduce welfare
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INFO AGGREGATION
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✓ dispersed info partially aggregated through **prices and macro indicators**

✓ **informational externality:**

   the more heavily agents rely on their private info

   ⇒ the better the quality of info in prices/macros indicators
INFO AGGREGATION

✓ implications for CB communication:

  more public info disseminated by the CB can
deteriorate info contained in prices/macro indicators
INFO AGGREGATION

✓ implications for **CB communication**:

   more public info disseminated by the CB can
deteriorate info contained in prices/macro indicators

✓ implications for **optimal monetary policy**:

   CB can use contingency of monetary policy on realized activity
to improve quality of info in prices/macro indicators
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APPLICATIONS
APPLICATION 1: beauty contest (Morris & Shin, 2002)

✓ beauty contest ≡ economy where $\alpha > 0 = \alpha^*$ and $\kappa = \kappa^*$
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✓ beauty contest ≡ economy where $\alpha > 0 = \alpha^*$ and $\kappa = \kappa^*$

Result. Welfare increases with accuracy but non-monotonic in commonality

← welfare can decrease with public info

← but only because private value of aligning choices not socially warranted
APPLICATION #2: new-Keynesian monetary economies

✓ α > 0, but what about α*?
APPLICATION #2: new-Keynesian monetary economies

✓ $\alpha > 0$, but what about $\alpha^*$?

✓ Negative welfare effect of price dispersion ($U_{\sigma_k^2} < 0$) ensuring $\alpha^* > \alpha$
APPLICATION #2: new-Keynesian monetary economies

✓ $\alpha > 0$, but what about $\alpha^*$?

✓ negative welfare effect of price dispersion ($U_{\alpha^2} < 0$) ensuring $\alpha^* > \alpha$

**Result.** Welfare increases with both accuracy and commonality

$\leftrightarrow$ welfare necessarily increases with public info

$\leftrightarrow$ central bank transparency is desirable

... see Hellwig (2006), Roca (2006)
APPLICATION #3: inefficient fluctuations

✓ suppose \( \text{Cov} (\kappa^* - \kappa, \kappa) \ll 0 \) (e.g., \( \kappa^* = \text{constant} \))

✓ e.g., business cycles driven by “mark-up” shocks
APPLICATION #3: inefficient fluctuations

✓ suppose $Cov(\kappa^* - \kappa, \kappa) \ll 0$ (e.g., $\kappa^*$ =constant)

✓ e.g., business cycles driven by “mark-up” shocks

Result. Welfare decreases with either private or public info.

$\Rightarrow$ ignorance can be a (social) bless!

$\Rightarrow$ transparency can be undesirable
APPLICATION #4: financial markets (Angeletos, Lorenzoni & Pavan, 2007)

✓ two-way feedback between real and financial activity:

1. positive news about aggregate activity raise financial prices
2. higher financial prices boost real investment

↩️ endogenous complementarity in real investment decisions
APPLICATION #4: financial markets (Angeletos, Lorenzoni & Pavan, 2007)

✓ two-way feedback between real and financial activity:
   1. positive news about aggregate activity raise financial prices
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      \[\implies\] endogenous complementarity in real investment decisions

Result. investment and prices react too much to noise, too little to fundamentals

✓ symptoms like irrational exuberance without irrationality
APPLICATION #4: financial markets (Angeletos, Lorenzoni & Pavan, 2007)

✓ two-way feedback between real and financial activity:
   1. positive news about aggregate activity raise financial prices
   2. higher financial prices boost real investment
      → endogenous complementarity in real investment decisions

Result. investment and prices react too much to noise, too little to fundamentals

✓ symptoms like irrational exuberance without irrationality

✓ CB can correct inefficiency by stabilizing prices/using key contingency
CONCLUSIONS
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1. lessons for CB communication

✓ transparency desirable if equil is efficient

✓ transparency more likely to be desirable with effective monetary policy

✓ caveat: mark-up shocks
CONCLUSIONS

1. lessons for CB communication

✓ transparency desirable if equil is efficient

✓ transparency more likely to be desirable with effective monetary policy

✓ caveat: mark-up shocks

2. lessons for monetary policy

✓ novel role for monetary policy:

   control degree of complementarity → equil use of information

✓ correct overreaction to noisy public news

✓ improve information contained in prices/macro indicators
RELATED LITERATURE


✓ **exchange rates:** Bacchetta & Wincoop (2006).


✓ **policy:** Angeletos & Pavan (2007c)