Efficiency with Endogenous Information Choice

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Information and efficiency

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  - Hellwig (2005), Angeletos and Pavan (2007), Angeletos and La'O (2009).
  - Social versus private incentives to coordinate

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  - Social versus private incentives to coordinate
- This paper: Endogenous information.
  - Social versus private incentives to learn

Environment

1. Microfounded, general equilibrium business cycle model
2. Imperfectly competitive firms making price/quantity decisions
3. Uncertainty about aggregate shocks (real or nominal)
4. Costly private information

Preview of Results

Two sources of inefficiency

- Suboptimality of information use
  - Excess sensitivity to private signals $\longrightarrow$ Over-acquisition.

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- Suboptimality of information use
  - Excess sensitivity to private signals $\longrightarrow$ Over-acquisition.
- Market power
  - Private value of information $<$ social value $\longrightarrow$ Under-acquisition

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Implications

- Efficiency of business cycles
  - Suboptimal information choice $\longrightarrow$ suboptimal fluctuations

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- Efficiency of business cycles
  - Suboptimal information choice $\longrightarrow$ suboptimal fluctuations
- Policy
  - Correcting market power distortions
    - Also changes incentives to learn
    - Can lead to lower welfare.
  - Optimal policy

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Implications

- Efficiency of business cycles
    - Suboptimal information choice $\longrightarrow$ suboptimal fluctuations
- Policy
    - Correcting market power distortions
        - Also changes incentives to learn
        - Can lead to lower welfare.
    - Optimal policy
- Public information
    - Can crowd out private information and reduce welfare

Related Literature

Exogeneous information

- Morris and Shin(2002), Woodford (2003), Roca (2010), Hellwig (2005), Angeletos and Pavan (2007), Angeletos and La'O (2009)...

Endogeneous information

- Grossman and Stiglitz (1980), Hellwig and Veldkamp (2009), Mackowiak and Wiederholt (2009, 2011), Colombo et. al. (2012), Amador and Weill (2009) ....

Choice under uncertainty

- Weitzman (1972), Reis (2006)...

Efficiency under monopolistic competition

- Dixit and Stiglitz (1977), Grossman and Helpman (1991), Bilbiie, Ghironi and Melitz (2008)...

Outline

1. A business cycle model
2. Quantity (labor input) choice
3. Price choice
4. Policy

Preferences and technology

Final good producer : $Y_t = \left(\int_0^1 Y_{it}^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}} \qquad \theta > 1$

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Quantity equation : $$P_t Y_t = M.$$

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Shocks : $$a_t = \ln A_t \sim N\left(0, \sigma_a^2\right)$$

Information

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- Assumption : $\upsilon(\cdot)$ is such that the solution is in the interior

Timing

- Each period has three stages :

  Stage I : Each entrepreneur i chooses σ_i^2 taking as given σ_{-i}^2

  Stage II : Signals are realized and quantity/price decisions made

  Stage III : Production, consumption and market clearing

Quantity (labor input) choice

- Stage II : Entrepreneur i chooses N_i,

$$\Pi_{it} = \max_{N_{it}} \ \mathbb{E}_{it}\left(\frac{P_{it}}{P_t} A_t N_{it}^{\frac{1}{\delta}}\right) - N_{it}, \text{ where } \mathbb{E}_{it}(\cdot) \equiv \mathbb{E}(\cdot|s_{it}).$$

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- Stage I : Entrepreneur i chooses σ_i^2 to maximize ex-ante utility,

$$\max_{\sigma_i^2} \widehat{\Pi}_{it}\left(\sigma_i^2, \sigma_{-i}^2\right) - v\left(\sigma_i^2\right), \text{ where } \widehat{\Pi}_{it} \equiv \mathbb{E}\Pi_{it}.$$

$$\frac{\partial \widehat{\Pi}_{it}}{\partial \sigma_i^2} = v'(\sigma_i^2).$$

Equilibrium

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$$n_{it} = \kappa_n + \alpha_n s_{it},$$

$$\alpha_n = \left(\frac{\delta}{\delta - 1}\right) \left[\frac{\sigma_a^2}{\sigma_a^2 + \sigma^2 \left(\frac{1+\theta(\delta-1)}{\theta(\delta-1)}\right)}\right] > 0.$$

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- Information choice :

$$\left(\frac{\partial \widehat{\Pi}}{\partial \sigma_i^2}\right)_{\sigma_i^2 = \sigma^2} = -\frac{1}{2}\left(\frac{\theta - 1}{\theta\delta}\right) \widehat{\Pi} \ \alpha_n^2 = v'(\sigma^2).$$

Efficiency of information use

- Information-constrained planner

$$\max_{\alpha_n,\kappa_n} \mathbb{E}_{t-1} \int_0^1 \left(C_{it} - N_{it} \right) \, di,$$

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- Solution :

$$\begin{aligned} \alpha_n^* &= \alpha_n, \\ \kappa_n^* &= \kappa_n + \left(\frac{\delta}{\delta - 1} \right) \ln \left(\frac{\theta}{\theta - 1} \right) \end{aligned}$$

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- Implications (Angeletos and La'O, 2009) :
  - Constrained efficient fluctuations under exogenous information
  - Level distortion (disappears as $\theta \to \infty$)

Efficiency of information choice

- Utility maximizing level of precision :

$$\max_{\sigma^2} \underbrace{\mathbb{E}_{t-1} \int_0^1 \left(C_{it} - N_{it} \right) \, di}_{\mathbb{U}(\sigma^2)} - \upsilon \left(\sigma^2 \right) .$$

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- First order condition :

$$\frac{\partial \mathbb{U}}{\partial \sigma^2} = -\frac{1}{2\theta\delta} \left(\frac{1-\theta+\theta\delta}{\delta-1} \right) \mathbb{U} \, \alpha_n^2 = \upsilon'(\sigma^2).$$

Efficiency of information choice

The private value of information is less than its social value, i.e.

$$\frac{\partial \mathbb{U}}{\partial \sigma^2} = \left(1 + \frac{\delta}{(\theta - 1)(\delta - 1)}\right)\left(\frac{\partial \widehat{\Pi}}{\partial \sigma_i^2}\right)_{\sigma_i^2 = \sigma^2}.$$

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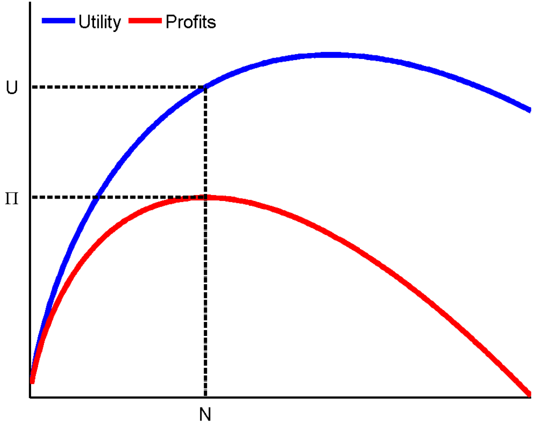
- Under-acquisition of information in equilibrium
- Inefficiency vanishes as $\theta \to \infty$.

Intuition



Details

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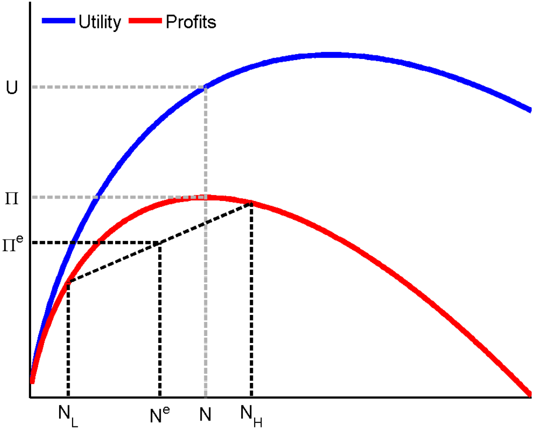

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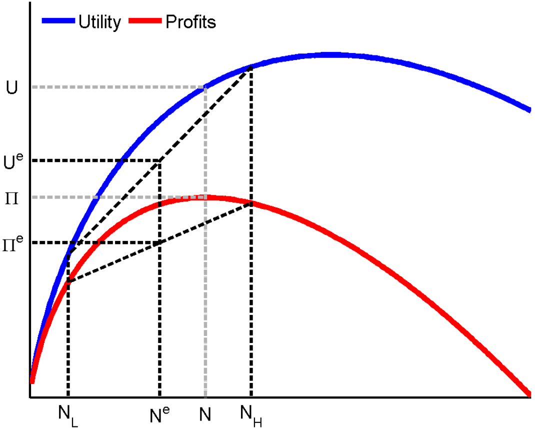

Details

Implications

- Constrained efficiency of fluctuations
  - Exogenous $\sigma^2 \longrightarrow$ Efficient α_n
  - Endogenous $\sigma^2 \longrightarrow$ Suboptimally low α_n
- Public information exacerbates this inefficiency $\longrightarrow$ can even reduce welfare
- Optimal policy : revenue subsidy $\frac{\theta}{\theta-1}$

Nominal price setting

- Stage II : Entrepreneur i chooses P_i

$$\Pi_{it} = \max_{P_{it}} \; E_{it}\left(\frac{Y_t}{P_t^{1-\theta}}\right) P_{it}^{1-\theta} - E_{it}\left(P_t^{\theta\delta}\frac{Y_t^{\delta}}{A_t^{\delta}}\right) P_{it}^{-\theta\delta}.$$

- Stage I : Entrepreneur i chooses σ_i^2 to maximize ante-utility,

$$\max_{\sigma_i^2} \; \widehat{\Pi}_{it}\left(\sigma_i^2, \sigma_{-i}^2\right) - v\left(\sigma_i^2\right), \text{ where } \widehat{\Pi}_{it} \equiv E_{t-1}\Pi_{it}.$$

$$\frac{\partial \widehat{\Pi}_{it}}{\partial \sigma_i^2} = v'(\sigma_i^2).$$

Equilibrium

- Symmetric equilibrium $\sigma_i^2 = \sigma^2 \ \forall \ i$.
- Nominal prices (in logs) :

$$p_{it} = \kappa_p + \alpha_p s_{it},$$

$$\alpha_p = -\left(\frac{\delta}{\delta - 1}\right)\left[\frac{\sigma_a^2}{\sigma_a^2 + \sigma^2\left(\frac{1+\theta(\delta-1)}{\delta-1}\right)}\right] < 0$$

- Information choice :

$$\left(\frac{\partial \widehat{\Pi}}{\partial \sigma_i^2}\right)_{\sigma_i^2=\sigma^2} = -\delta\theta\left(\frac{\theta - 1}{2}\right)\widehat{\Pi}\ \alpha_p^2 = v'(\sigma^2).$$

Efficiency of information use

$$\max_{\alpha_p, \kappa_p} \ \mathbb{E}_{t-1} \int_0^1 \left(C_{it} - N_{it} \right) \, di,$$

- Solution :

$$\alpha_p^* = -\left(\frac{\delta}{\delta - 1}\right) \left[\frac{\sigma_a^2}{\sigma_a^2 + \theta \left(\frac{1-\theta+\theta\delta}{\delta-1}\right) \sigma^2}\right] > \alpha_p,$$

$$\kappa_p^* = \kappa_p(\alpha_p^*) - \left(\frac{1}{\delta - 1}\right) \ln \left(\frac{\theta}{\theta - 1}\right).$$

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- Uncertainty about others' actions $\longrightarrow$ Marginal cost uncertainty
  - This effect not internalized in equilibrium $\longrightarrow$ excess sensitivity
- Higher θ worsens this inefficiency

Efficiency of information choice

$$\max_{\sigma^2} \underbrace{\mathbb{E}_{t-1} \int_0^1 \left(C_{it} - N_{it} \right) \, di}_{\mathbb{U}(\sigma^2)} - v\left(\sigma^2\right).$$

- First order condition :

$$\frac{\partial \mathbb{U}}{\partial \sigma^2} = v'(\sigma^2).$$

Efficiency of information choice

The private value of information can be higher or lower than the social value, i.e.

$$\frac{\partial \mathbb{U}}{\partial \sigma^2} \begin{matrix} > \\ < \end{matrix} \left(\frac{\partial \widehat{\Pi}}{\partial \sigma_i^2} \right)_{\sigma_i^2 = \sigma^2}$$

- $\Longrightarrow$ Over- or under-acquisition of information

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- $\implies$ Over- or under-acquisition of information
- Two opposing effects :
  - Monopoly power $\rightarrow$ lowers private value $\rightarrow$ under-acquisition
  - Inefficient use $\rightarrow$ lowers social value $\rightarrow$ over-acquisition
- Larger values of θ $\rightarrow$ second effect dominates $\rightarrow$ over-acquisition

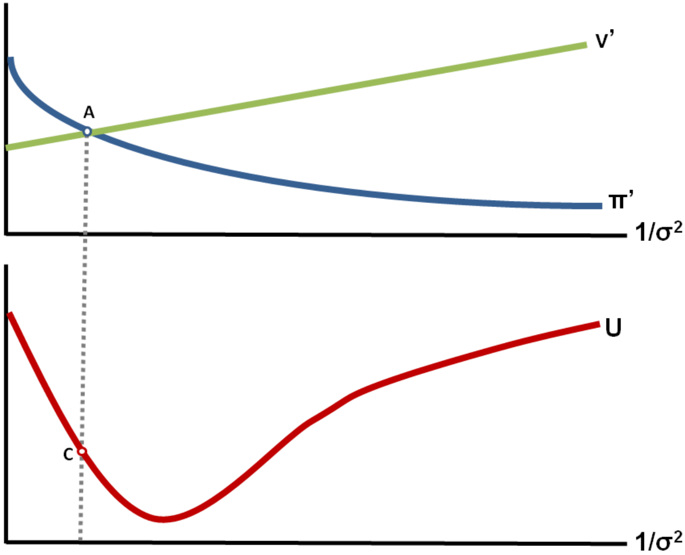
Fiscal Policy

- Constant revenue subsidy :

$$\Lambda = \frac{\theta}{\theta - 1}$$

- <u>Quantity choice</u> $\rightarrow$ constrained efficiency
- <u>Price setting</u> $\rightarrow$ can reduce welfare

Effect of subsidy under price setting



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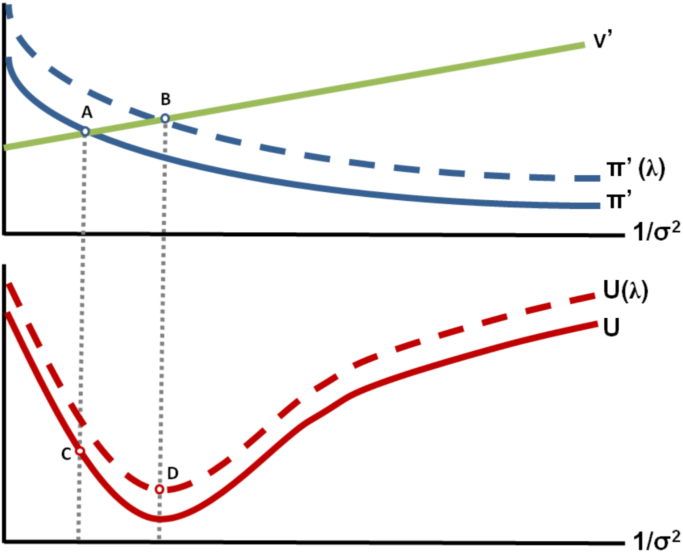

Optimal policy under price setting

- State-contingent revenue subsidy :

$$
\begin{aligned}
& \Lambda A_t^{\delta\tau} && \text{where} \\
\tau &= \frac{\alpha_p^*}{\alpha_p} - 1 < 0, \\
\Lambda &= \left(\frac{\theta}{\theta - 1}\right) \exp\left\{\frac{\sigma_a^2 \delta\tau \left(2\alpha_p^* - \delta\tau\right)}{2}\right\}
\end{aligned}
$$

- τ corrects inefficiency in information use.
- Market power correction as before, adjusted for level effects of τ.

Other results

- Robustness
  - Labor markets, risk aversion
- Nominal shocks
  - Qualitatively the same ▸ Details
- Beauty contest-model
  - Efficiency in information use $\not\Longrightarrow$ efficiency in information choice ▸ Details

Final remarks

- A novel source of inefficiency
- Feedback of ex-post inefficiencies into information choice
- Policies also affect extent of learning
- Next steps: other shocks and signals, quantitative evaluation

Monopolist

Consumer : $CS = \frac{\theta}{\theta-1} Q^{\frac{\theta-1}{\theta}} - PQ \qquad \theta > 1$

Monopolist : $\Pi = PQ - N$,

$Q = AN^{\frac{1}{\delta}}$

Social surplus : $U \equiv CS + \Pi = \frac{\theta}{\theta-1} PQ - N$

Shocks : $a_t = \ln A_t \sim N\left(0, \sigma_a^2\right)$

Information : $s = a + e \qquad e \sim N(0, \sigma^2)$

Inefficiency of information choice

$$\frac{dEU}{d\sigma^2} = \left[\frac{\frac{\theta}{\theta-1}\frac{\theta\delta}{\theta-1} - 1}{\frac{\theta\delta}{\theta-1} - 1} \right] \frac{dE\Pi}{d\sigma^2} < \frac{dE\Pi}{d\sigma^2}$$

- Market power reduces the incentives to learn ($\Longrightarrow$too high σ^2).
- Monopolist is not compensated enough $\rightarrow$ under-acquisition.

Back

Nominal shocks

$$\begin{aligned} \underline{\text{Shocks}}: \quad & A_t = \bar{A} \\ & m_t \equiv \ln M_t \sim N\left(0, \sigma_m^2\right) \\ \underline{\text{Information}}: \quad & s_{it} = m_t + e_{it} \qquad e_{it} \sim N\left(0, \sigma_m^2\right) \end{aligned}$$

- Intermediate goods producer solves

$$\Pi_{it} = \max_{P_{it}} \; E_{it} \left(\frac{P_{it}}{P_t}\right)^{1-\theta} Y_t - \left[\left(\frac{P_{it}}{P_t}\right)^{-\theta} \frac{Y_t}{A}\right]^{\delta}$$

- The same as before:

1. Monopoly power and inefficient use.
2. Over- or under-acquisition, depending on parameters

Back

A Beauty-Contest Model

- Private and social payoffs

$$\Pi_i = -\phi (x_i - Z)^2 - \psi (x_i - \bar{x})^2$$
$$U = -\phi^* \int (x_i - Z)^2 di - \psi^* \int (x_i - \bar{x})^2 di$$

where

$$Z \sim N(0, \sigma_z^2) \qquad \bar{x} = \int x_i \; di$$

$$\phi, \phi^*, \psi, \psi^* > 0$$

- Private signal

$$s_i = Z + e_i \qquad e_i \sim N(0, \sigma_i^2)$$

- Utility cost of information

$$v(\sigma_i^2)$$

Equilibrium

- Best response

$$x_i = \alpha^{eq} \; s_i = \left[\frac{\phi \sigma_z^2}{\phi \sigma_z^2 + (\phi + \psi)\sigma^2} \right] \; s_i$$

- Information choice

$$\left[\frac{\partial \hat{\Pi}_i(\sigma_i^2, \sigma_{-i}^2)}{\partial \sigma_i^2} \right]_{\sigma_i^2 = \sigma_{-i}^2} = -(\phi + \psi) \left(\alpha^{eq}\right)^2 = \upsilon'(\sigma^2)$$

Efficient use

- Symmetric response rule

$$x_i^* = \alpha^* s_i = \left[\frac{\phi^* \sigma_z^2}{\phi^* \sigma_z^2 + (\phi^* + \psi^*)\sigma^2} \right] s_i$$

- Efficiency in information use

$$\alpha^{eq} = \alpha^* \qquad \Longleftrightarrow \qquad \frac{\phi}{\psi} = \frac{\phi^*}{\psi^*}$$

- Efficiency in information choice

$$\frac{d\hat{U}}{d\sigma^2} = \frac{d\hat{\Pi}}{d\sigma_i^2} \left[\left(\frac{\phi^* + \psi^*}{\phi + \psi} \right) - 2\frac{\phi^*}{\phi} \left(\frac{\alpha^{eq}}{\alpha^*} - 1 \right) \right]$$

Inefficiency of information choice

- Suppose $\phi^* + \psi^* = \phi + \psi$ but $\alpha^{eq} > \alpha^*$

$$\frac{d\hat{U}}{d\sigma^2} = \frac{d\hat{\Pi}}{d\sigma_i^2}\left[1 - 2\frac{\phi^*}{\phi}\left(\frac{\alpha^{eq}}{\alpha^*} - 1\right)\right] > \frac{d\hat{\Pi}}{d\sigma_i^2}$$

$\Rightarrow$ Over-acquisition .

- Suppose $\phi^* + \psi^* < \phi + \psi$ but $\alpha^{eq} = \alpha^*$

$$\frac{d\hat{U}}{d\sigma^2} = \frac{d\hat{\Pi}}{d\sigma_i^2}\left(\frac{\phi^* + \psi^*}{\phi + \psi}\right) > \frac{d\hat{\Pi}}{d\sigma_i^2}$$

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