Production Technology, Information Acquisition and Disclosure, and Asset Prices

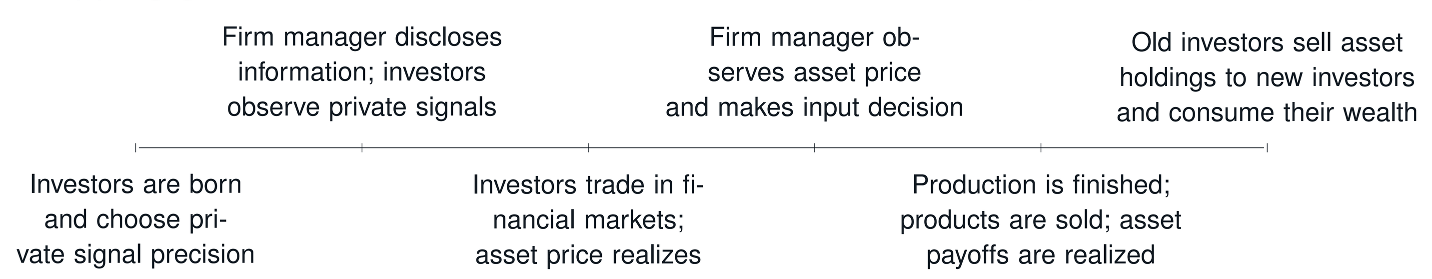
Minxing Zhu (minxing.zhu@connect.um.edu.mo)
University of Macau

Backgrounds and Research Question

Financial market efficiency measures the extent to which asset prices reflect information. Real production efficiency characterizes how efficiently inputs are transformed into outputs. A more efficient financial market provides more information to firm managers in the real economy, which enables them to make more efficient production decisions, increasing the real production efficiency and firm profits. However, **the impact of real production efficiency on financial market efficiency** is less explored. In this paper, I develop a model building on Benhabib, Liu, and Wang (2019, JF) and Farboodi and Veldkamp (2020, AER) to investigate this question.

Model

- Production technology: $Y_{t+1} = \bar{Z}A_{t+1}K_t^{\eta_t}$, product demand: $Y_{t+1} = (P_{t+1})^{-\theta}\epsilon_{t+1}\bar{Y}$
- Output elasticity: $\eta_t \equiv \frac{dY_{t+1}/Y_{t+1}}{dK_t/K_t} \in (0,1)$
  - **Exogenously affects production efficiency**: Given the same $K_t > 1$, $\eta_t \uparrow \Rightarrow Y_{t+1} \uparrow$
- Firm's income: $V_{t+1} = P_{t+1}Y_{t+1}$, $v_{t+1} = \ln V_{t+1}$
- Dividend process: $d_{t+1} - d_t = (1-G)(\mu - d_t) + \alpha v_{t+1}$
- Noise trading: $n_{t+1} \sim N(0, \tau_n^{-1})$
- An investor $i \in [0,1]$ born at the beginning of period t invests in period t and consumes in period $t+1$
- The firm discloses a signal about its productivity $s_t = a_{t+1} + e_t$, $e_t \sim N(0, \tau_{s,t}^{-1})$
- Investor i observes private signals $x_t^i = \varepsilon_{t+1} + \mathcal{Q}_t^i$, $\mathcal{Q}_t^i \sim N(0, \tau_{xit}^{-1})$; $g_t^i = n_{t+1} + \mathcal{Q}_{n,t}^i$, $\mathcal{Q}_{n,t}^i \sim N(0, \tau_{git}^{-1})$
- Overlapping generation structure. Timeline for investors born in period t:



- Firm's input decision: $\max_{K_t} E\left[P_{t+1}Y_{t+1} - R_f K_t | s_t, q_t\right]$
- Investor's portfolio choice: $\max_{m_{i,t}} E\left[U(c_{i,t+1})|F_{i,t}\right]$, s.t. $c_{i,t+1} = (W_{it} - m_{it}q_t)R_f + m_{it}(d_{t+1} + q_{t+1})$
- Investor's information choice: $\max_{\tau_{xit},\tau_{git}} E\left[U(c_{i,t+1})|I_t^-\right]$, s.t. $\tau_{xit}^2 + \chi\tau_{git}^2 \le H$
- Competitive noisy rational expectations equilibrium: learning from price, individual optimization, market clearing (i.e., $\int_0^1 m_{i,t}di + n_{t+1} = 1$)
- Solving the model: "conjecture and verify" and "backward induction"
- Equilibrium asset price: $q_t = \beta_{0,t} + \beta_{1,t}(\varepsilon_{t+1} + \beta_{2,t}s_t + \beta_{3,t}n_{t+1}) + \beta_{4,t}(d_t - \mu)$

* Asset payoff risk: $Var\left[d_{t+1} + q_{t+1}|F_{it}\right] = (R_f - G)^{-1}(R_f + G)Var\left[d_{t+1}|F_{it}\right] + Var\left[q_{t+1}|F_{it}\right]$

Benchmark Equilibrium with Exogenous Information

- For simplicity: $\tau_{xt} = \tau_x$, $\tau_{gt} = 0, \forall t$
- How much can the firm learn about product demand from the asset price in period t?

$$Var[\varepsilon_{t+1}|s_t, q_t, d_t] = [\tau_\varepsilon + (\tfrac{1}{\beta_{3,t}})^2\tau_n]^{-1}$$

- Price informativeness (revelatory price efficiency) in period t: $\frac{1}{\beta_{3,t}}$

$$\frac{1}{\beta_{3t}} = \frac{\alpha(1+\beta_{4,t+1})\tau_x}{\gamma\theta(\tau_\varepsilon + \tau_x + \tau_{qt})}\int_0^1 \left(Var[d_{t+1} + q_{t+1}|F_{it}]\right)^{-1} di$$

- Resale price for period-t investors ($\tau_a \to \infty$):

$$q_{t+1} = \zeta_{t+1} + \underbrace{\omega_{t+1}\int_0^1 x_{i,t+1}di}_{\text{Speculation}} + \underbrace{\varrho_{t+1}n_{t+2}}_{\text{Liquidity demand}} + \underbrace{\frac{\eta_{t+1}\alpha}{R_f - G}\left(1 - \frac{1}{\theta}\right)k_{t+1}}_{\text{Firm investment}}$$

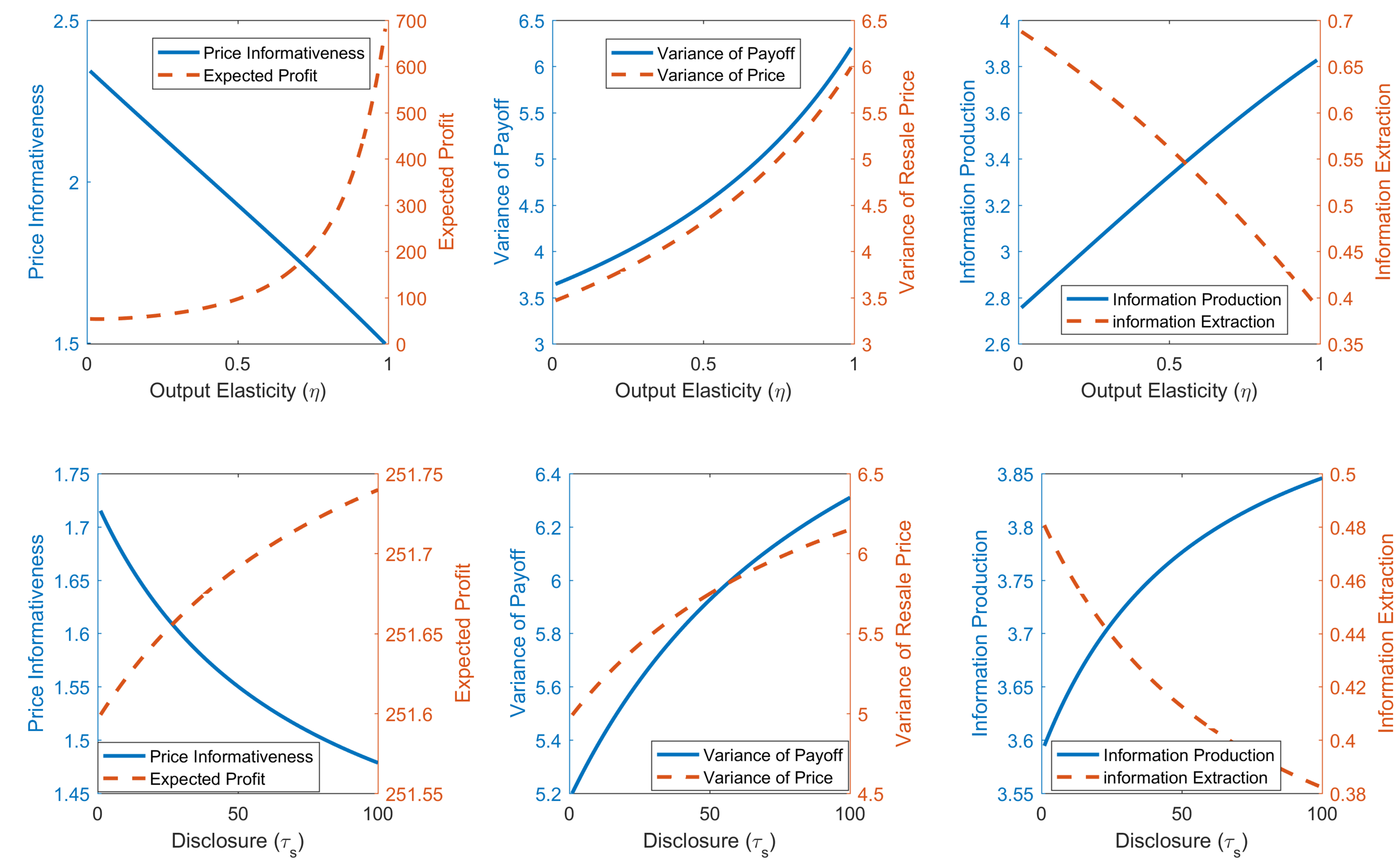
- Investors in period t are uncertain about the firm's next period's input k_{t+1}
- Benchmark result: $\eta_{t+1} \uparrow \Rightarrow Var[q_{t+1}|F_{i,t}] \uparrow \Rightarrow \frac{1}{\beta_{3t}} \downarrow$
- Intuition: **A more efficient production technology can lead to a less efficient financial market**

More Discussion on Real Efficiency

Goldstein and Yang (2019, JFE) define the real efficiency as the profit from a real investment. Now we show in a simple case how the output elasticity connects to profit. Consider a firm operating in a competitive product market. The production function is $Y = CK^\eta$, where $C > 0$ is a constant and $\eta \in (0,1)$. So the firm chooses investment level K to maximize $CK^\eta - K$. Solving the problem, we know that the firm's profit is $\Pi(\eta) = (\eta C)^{1/(1-\eta)}(\eta^{-1} - 1)$. If $C > 1$, then we can calculate that $\lim_{\eta\to1}\Pi(\eta) = +\infty$, and $\lim_{\eta\to0}\Pi(\eta) = C$. Intuitively, when C is sufficiently high, and when the production technology has constant returns to scale, a firm can earn an infinite profit, which is the most efficient case. In this sense, as a production technology gets closer to constant returns to scale, we say that it becomes more efficient.

Full Equilibrium with Endogenous Information

- Stationary equilibrium: $\eta_t = \eta$, $\tau_{st} = \tau_s$, and thus $\beta_{l,t} = \beta_l$, $l = 0,1,2,3,4$, and $\tau_{xt} = \tau_x$, $\tau_{gt} = \tau_g$, $\forall t$



Robustness: Alternative Assumptions about Firm and Asset

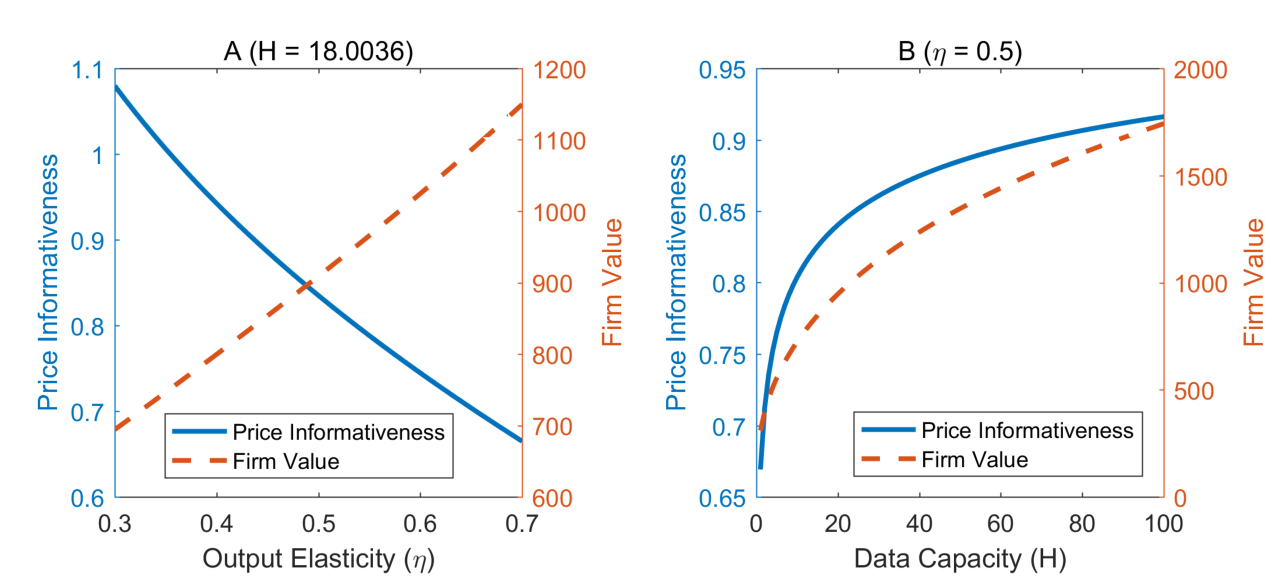
- The firm's problem:

$$\max_{\{I_t\}_{t=0}^{\infty}} E\left\{\sum_{t=0}^{\infty}\beta^t\left[(\bar{Z}A_t)^{(1-\frac{1}{\theta})}(\bar{Y}\epsilon_t)^{\frac{1}{\theta}}K_t^{\eta(1-\frac{1}{\theta})} - R_f I_t\right]|s_0, \hat{q}_0, A_0, \epsilon_0\right\}$$

s.t. $K_{t+1} = (1-\delta)K_t + I_t$, K_0 is given

- Dividend process (log-linearization is needed to make this alternative model tractable):

$$d_{t+1} = (\bar{Z}A_{t+1})^{(1-\frac{1}{\theta})}(\bar{Y}\epsilon_{t+1})^{\frac{1}{\theta}}K_{t+1}^{\eta(1-\frac{1}{\theta})} - R_f[K_{t+2} - (1-\delta)K_{t+1}]$$



Preliminary Suggestive Evidence

- Price informativeness ($INFO_j$): Using the methods proposed in Davila and Parlatore (2018, NBER)
- Production Efficiency (SEN_j): Sensitivity of income growth to new investment
- Corss-sectional regression: $INFO_j = \alpha_0 + \alpha_1 \times SEN_j + \delta \times X_j + \zeta_j$

	(1)	(2)	(3)	(4)
Production Efficiency	-0.03	-0.03	-0.03	-0.03
	(-6.46)	(-7.95)	(-6.26)	(-7.72)
Market Capitalization			0.01	0.01
			(12.57)	(10.77)
Constant	0.16	0.16	0.14	0.14
	(37.22)	(37.53)	(31.80)	(32.66)
R-squared	0.01	0.01	0.06	0.06
Heteroskedasticity-Robust Standard Error	No	Yes	No	Yes

Full Paper: WeChat: LinkedIn:

Presented at the 2025 AFA Annual Meeting (PhD Student Poster Session).