Productivity and Credibility in Industry Equilibrium

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Organization in Equilibrium

Organization of firms is affected by competitive environment

Competitive environment determined by firms

Equilibrium approach: efficiency of market equilibrium, role of institutions and environment on productivity distribution

Credibility is Important in Production

For a large firm to operate efficiently, it must decentralize

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Decentralization requires trust

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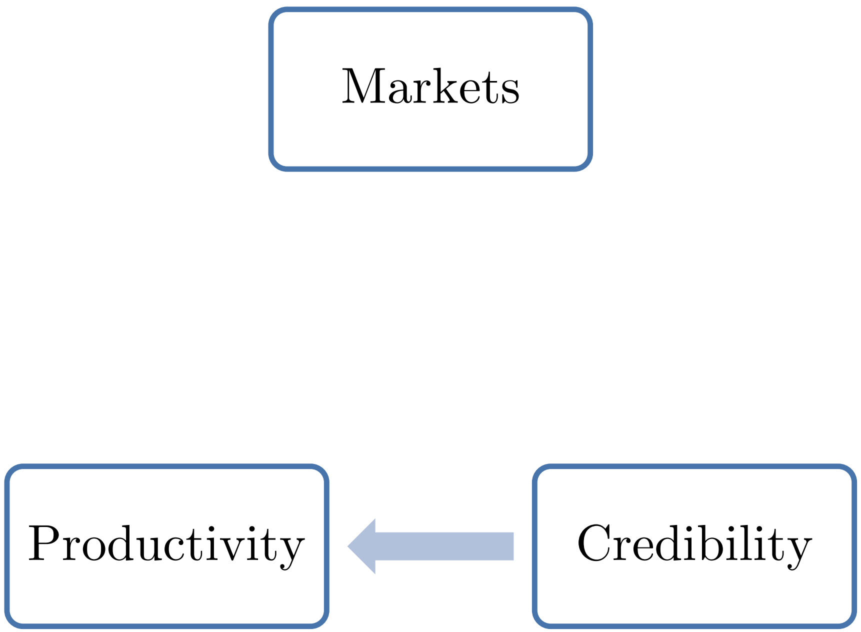
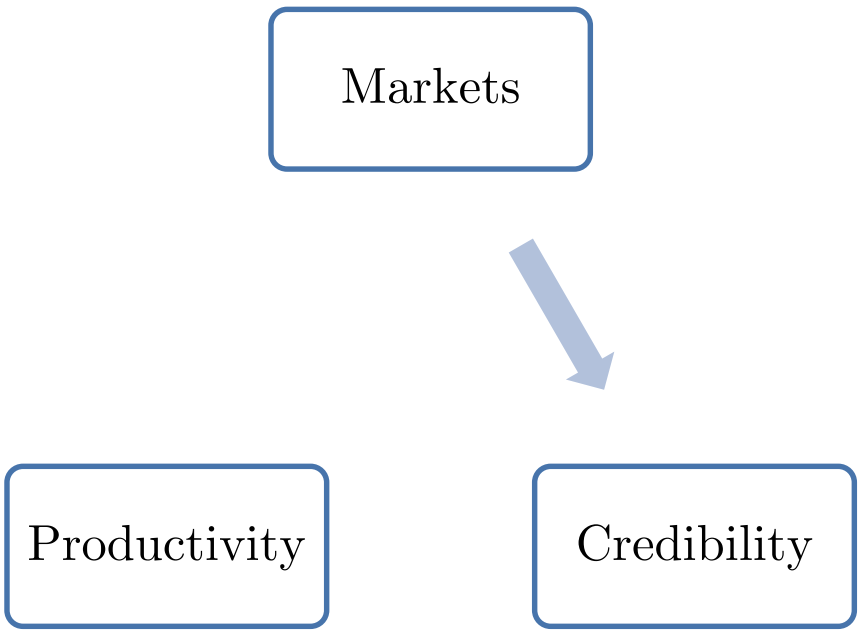


For a large firm to operate efficiently, it must decentralize

Decentralization requires trust

Trust = credibility in a repeated game

Future Profits as Collateral

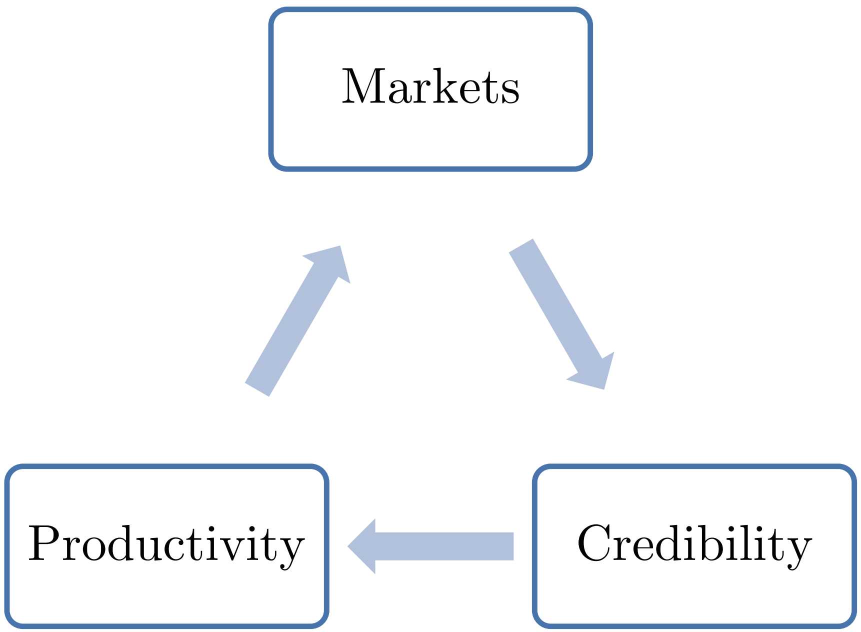


Failure to uphold promises may jeopardize firm's labor-market reputation

Future of the firm is at stake in its promises

Future profits serve as collateral

Industry Equilibrium



Future profits are endogenous

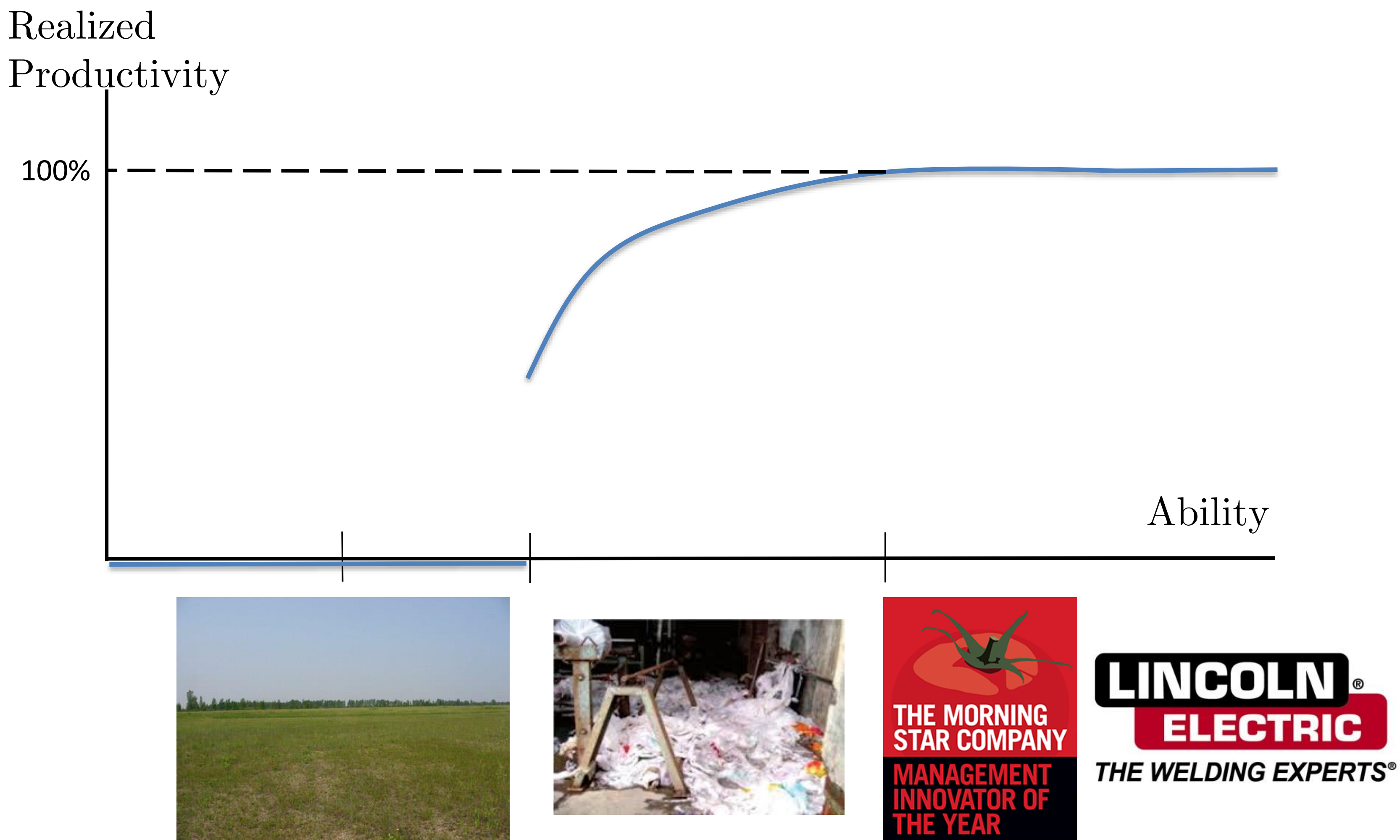
Profits, credibility, decentralization, and hence productivity jointly determined in equilibrium

Firm-Level Heterogeneity

"... virtually without exception, enormous and persistent measured productivity differences across producers, even within narrowly defined industries." (Syverson `11)

Firm fixed effect: scarce, inalienable resource

Stronger Firms Realize their Potential



Future Profits are Today's Inputs

1. **Normative**: are profits allocated efficiently?

Profits are inefficiently concentrated at the top: pecuniary externality that is not internalized

Declining firm-level wealth effects with efficiency consequences

Productivity is Endogenous

2. **Positive**: how do firms of different profitability respond to environment?

Changes in aggregate demand? Lower-ability firms' productivities are more sensitive to demand-driven business cycles

Institutional environment? Improved formal contracts reduce importance of credibility, primarily benefiting low-ability firms

Agenda

- The Model
- Policies
- Empirical Implications

The Model

Continuum of firms of mass 1, indexed by $i \in [0,1]$, each consisting of risk-neutral owner of ability $\varphi \sim \Phi(\varphi)$

Large mass risk-neutral mgrs with outside opportunity W > 0

Common discount factor $\frac{1}{1+r}$

Owner-manager problem produces homogeneous output that is sold into perfectly competitive market at price p_t

Stationary quasilinear preferences. Demand $D_t(\cdot) = D(\cdot)$

Timing

Each period $t = 1,2,3,\ldots$ has several stages:

1. Owner i has can pay fixed cost F or exit

2. Owner i rents capital K_{it} (at rental rate R) and hires mass of managers M_{it}

3. Owner i offers each manager m a triple $(s_{itm}, b_{itm}, \delta_{itm})$

   s_{itm} - contractible (non-contingent) payment

   δ_{itm} - resources allocated to manager

   b_{itm} - promised bonus iff manager m utilizes δ_{itm}

Timing

4. Manager m accepts/rejects in favor of W

5. If manager m accepted, he chooses resources $\hat{\delta}_{itm} \leq \delta_{itm}$ to utilize and keeps remainder

6. Owner i observes $\hat{\delta}_{itm}$ and decides whether or not to pay m a bonus of b_{itm}

7. Output for firm i is realized and sold for p_t

Production

Production function for firm i: assume $\theta < 1 - \alpha - \theta$

$$y_i\left(\hat{\delta}_{it}, K_{it}, M_{it}\right) = \varphi_i K_{it}^{\alpha} \left(\int_0^{M_{it}} \left(\hat{\delta}_{itm}\right)^{\frac{\theta}{1-\alpha-\theta}} dm \right)^{1-\alpha-\theta}$$

Profit if pay all bonuses

$$\pi_{it} = p_t y_i\left(\hat{\delta}_{it}, K_{it}, M_{it}\right) - RK_{it} - \int_0^{M_{it}} \delta_{itm} dm - \int_0^{M_{it}} (s_{itm} + b_{itm}) dm - F$$

Perfect Public Monitoring

Assumption 1: Future potential managers commonly observe allocated resources, utilization choices, and bonus payments

- Future competitive rents can be used as collateral

Assumption 2: Managers outside options independent of employment history; capital is not firm-specific

- No quasi-rents from market frictions

Dynamic Enforcement

When can firm ensure that $\{\delta_{itm}\}$ will be utilized in equilibrium?

- Dynamic Enforcement (DE) constraint

Trigger-strategy, full-utilization equilibrium:

- "Cooperate": δ_{itm} transferred, full utilization, promised bonus paid
- "Punish": owner doesn't pay F, all managers choose $\hat{\delta}_{itm} = 0$, bonuses never paid

Dynamic Enforcement

If manager m believes owner will pay b_{itm} if $\hat{\delta}_{itm} = \delta_{itm}$, then m will choose δ_{itm} iff

$$b_{itm} + \frac{1}{1+r}\left(U_{i,t+1,m} - \widetilde{U}_{i,t+1,m}\right) \geq \delta_{itm}$$

- $U_{i,t+1,m} = m$'s continuation payoff if not renege
- $\widetilde{U}_{i,t+1,m} = m$'s continuation payoff if renege

Dynamic Enforcement

Manager m's constraint:

$$b_{itm} + \frac{1}{1+r}\left(U_{i,t+1,m} - \widetilde{U}_{i,t+1,m}\right) \geq \delta_{itm}$$

Dynamic Enforcement

Manager m's constraint:

$$b_{itm} + \frac{1}{1+r}\left(U_{i,t+1,m} - \widetilde{U}_{i,t+1,m}\right) \geq \delta_{itm}$$

After δ_{itm} has been chosen, i pays b_{itm} iff

$$\frac{1}{1+r}\left(\Pi_{i,t+1,m} - \widetilde{\Pi}_{i,t+1,m}\right) \geq b_{itm}$$

- $\Pi_{i,t+1,m}$= i's continuation payoff if not renege on m
- $\widetilde{\Pi}_{i,t+1,m}$= i's continuation payoff if renege on m

Dynamic Enforcement

Manager $\boldsymbol{m}$'s constraint:

$$b_{itm} + \frac{1}{1+r}\left(U_{i,t+1,m} - \widetilde{U}_{i,t+1,m}\right) \geq \delta_{itm}$$

Owner's constraint:

$$\frac{1}{1+r}\left(\Pi_{i,t+1,m} - \widetilde{\Pi}_{i,t+1,m}\right) \geq b_{itm}$$

Can Pool within Dyad

Manager m's constraint:

$$b_{itm} + \frac{1}{1+r}\left(U_{i,t+1,m} - \widetilde{U}_{i,t+1,m}\right) \geq \delta_{itm}$$

Owner's constraint:

$$\frac{1}{1+r}\left(\Pi_{i,t+1,m} - \widetilde{\Pi}_{i,t+1,m}\right) \geq b_{itm}$$

Pool (DE) across m and i ($S = U + \Pi$)

$$\frac{1}{1+r}\left(S_{i,t+1,m} - \tilde{S}_{i,t+1,m}\right) \geq \delta_{itm}$$

Can Pool Across Dyads

$$\frac{1}{1+r}\left(S_{i,t+1} - \tilde{S}_{i,t+1}\right) \geq \int_0^{M_{it}} \delta_{itm} dm$$

Future Surplus Depends on Future Prices

$$\sum_{\tau=t+1}^{\infty}\left(\frac{1}{1+r}\right)^{\tau-t-1}\left[\begin{array}{l} p_{\tau}\varphi_i K_{i\tau}\left(\int_0^{M_{i\tau}}(\delta_{i\tau m})^{\frac{\theta}{1-\alpha-\theta}}dm\right)^{1-\alpha-\theta} \\ \quad -RK_{i\tau}-WM_{i\tau}-\int_0^{M_{i\tau}}\delta_{i\tau m}dm-F \end{array}\right]$$

Rational-Expectations Equilibrium

Definition: An **REE** is a sequence of prices $\{p_t\}_t$, capital and management $\{K_{it}, M_{it}\}_{it}$, offers $\{s_{itm}, b_{itm}, \delta_{itm}\}_{itm}$, and utilization choices $\{\hat{\delta}_{itm}\}_{itm}$ such that at each time t

1. Given promised bonus b_{itm}, manager m for firm i optimally chooses utilization level $\hat{\delta}_{itm} = \delta_{itm}$
2. Given price sequence $\{p_t\}_t$, owner i optimally makes offers $\{s_{itm}, b_{itm}, \delta_{itm}\}_{tm}$ and chooses capital and management levels $\{K_{it}, M_{it}\}_t$
3. Output, capital, and labor markets for all t

Stationary REE; Existence and Uniqueness

Definition: A **stationary REE** is a REE with constant prices, stationary relational contracts, and constant capital, labor, and utilization

Theorem: Suppose D is smooth, decreasing, and satisfies $\lim_{p\to 0} D(p) = \infty$ and $\lim_{p\to\infty} D(p) = 0$, and suppose Φ is absolutely continuous. There exists a unique stationary REE.

Existence and Uniqueness

Sketch of Proof:

- Spse within each firm, there is a common conjecture $p_t = p$ for all t
- Fix an owner i and assume all other use a stationary relational contract $\left(s_{jtm}, b_{jtm}, \delta_{jtm}\right) = \left(s_{jm}, b_{jm}, \delta_{jm}\right)$ and choose constant capital and management levels $\left(K_{jt}, M_{jt}\right) = \left(K_j, M_j\right)$
- Suppose i chooses $(K_{it}, M_{it}) = (K_i, M_i)$ for all t
- Stationary environment $\Rightarrow$ i can replicate any optimal relational contract with a stationary relational contract
- For all i $(s_{itm}, b_{itm}, \delta_{itm}) = (s_{im}, b_{im}, \delta_{im})$ and$(K_{it}, M_{it}) = (K_i, M_i)$
- Hence constant aggregate supply $S(p)$
- $S(p)$ is increasing in p and smooth, since Φ is absolutely continuous
- Since aggregate demand has infinite choke price, is decreasing and smooth, there exists a unique price p

Non-Stationary Equilibria?

Multiplicity? (i.e., is this unique stationary REE the unique REE?)

Within firms, potentially suboptimal rel cons (folk theorem)

Even conditional on optimal rel cons, could have non-stationary REE

Optimal Relational Contracts

Suppose constant prices p

Manager symmetry and diminishing returns implies $\delta_{im} = \delta_i$ for all m

At steady state, per-period profits are

$$\pi_i = p\varphi_i \delta_i^{\theta} K_i^{\alpha} M_i^{1-\alpha-\theta} - RK_i - (W + \delta_i)M_i - F$$

Optimal relational contract chooses δ_i, K_i, and M_i to maximize π_i subject to (DE) constraint

$$\frac{\pi_i}{r} \geq M_i \delta_i$$

Unconstrained Problem

$$\max_{\delta_i, M_i, K_i} p\varphi_i \delta_i^{\theta} K_i^{\alpha} M_i^{1-\alpha-\theta} - RK_i - (W + \delta_i)M_i - F$$

Unconstrained Solution

Proposition: If $\varphi > \varphi_S$, optimal solution satisfies

$$\delta^{FB} = \frac{W}{1-\alpha-2\theta}\theta$$

$$M^{FB}(\varphi_i, p), K^{FB}(\varphi_i, p) \propto H(\varphi_i, p)$$

TFP is $A_i^{FB}(\varphi_i, p) = \frac{y}{K^{\alpha} M^{1-\alpha-\theta}} = \varphi_i (\delta^{FB})^{\theta}$

Constrained Problem

$$\max_{\delta_i, M_i, K_i} p\varphi_i \delta_i^{\theta} K_i^{\alpha} M_i^{1-\alpha-\theta} - RK_i - (W + \delta_i)M_i - F$$

subject to

$$p\varphi_i \delta_i^{\theta} K_i^{\alpha} M_i^{1-\alpha-\theta} - RK_i - (W + \delta_i)M_i - F \geq rM_i\delta_i$$

Solution Proportional to Unconstrained

Proposition: The optimal solution satisfies

$$\frac{\delta^*(\varphi_i, p)}{\delta^{FB}} = \frac{K^*(\varphi_i, p)}{K^{FB}(\varphi_i, p)} = \frac{M^*(\varphi_i, p)}{M^{FB}(\varphi_i, p)} = \mu^*(\varphi_i, p)$$

TFP is $A_i^*(\varphi_i, p) = \mu^*(\varphi_i, p)^\theta A_i^{FB}(\varphi_i, p)$

Solution Proportional to Unconstrained

Proposition: The optimal solution satisfies

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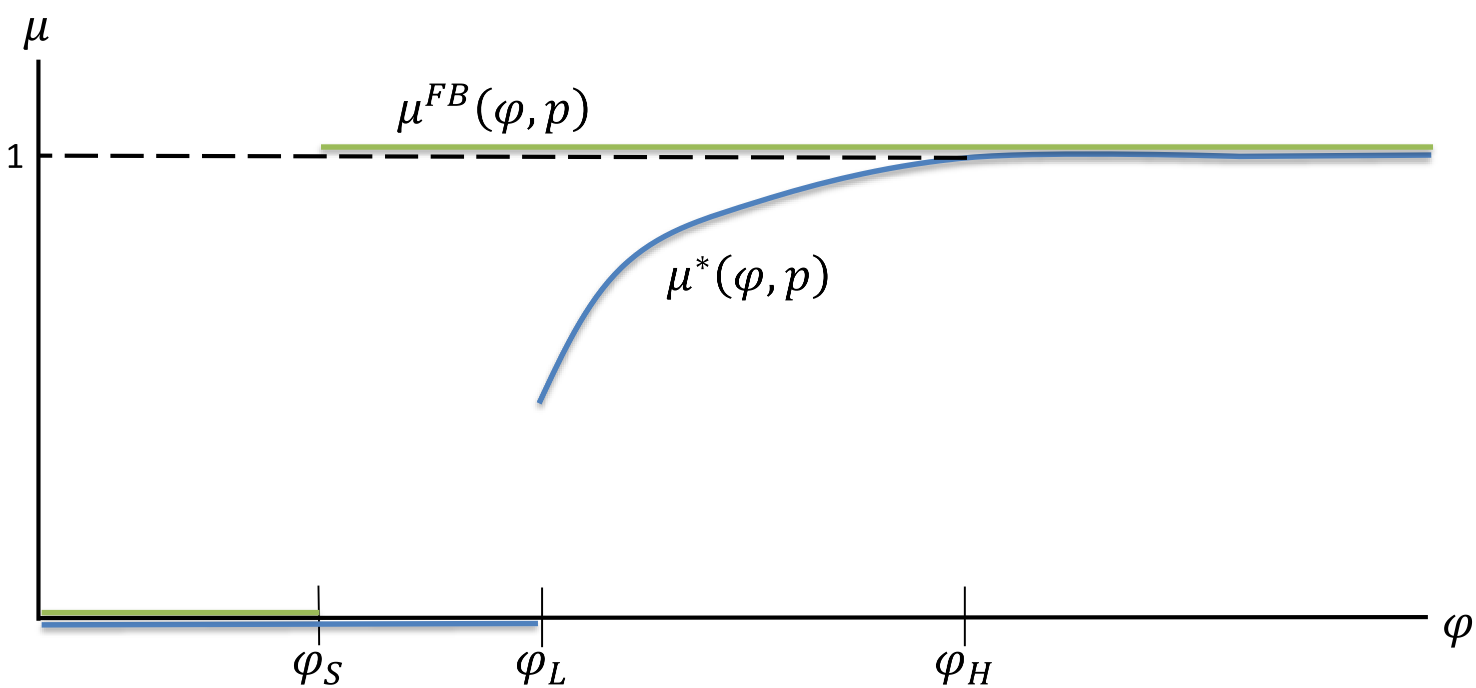
TFP is $A_i^*(\varphi_i, p) = \mu^*(\varphi_i, p)^\theta A_i^{FB}(\varphi_i, p)$

↑

Management as technology

Higher Ability -> Less Constrained



Prices Clear Output Markets

For given p, firm of ability φ produces $y^*(\varphi, p)$

Aggregate supply at price p

$$S(p) = \int_{\varphi_L(p)}^{\infty} y^*(\varphi, p) d\Phi(\varphi)$$

$y^*(\varphi, p)$ is increasing and $\varphi_L(p)$ (the cutoff level) is decreasing, so $S(p)$ is increasing

Equilibrium prices p^* solve

$$D(p^*) = S(p^*)$$

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Profits Inefficiently Concentrated at Top

$$\mathcal{L} = \pi(\varphi) + \lambda(\varphi)(\pi(\varphi) - rM\delta)$$

Are competitive rents allocated efficiently?

Profits Inefficiently Concentrated at Top

$$\mathcal{L} = \pi(\varphi) + \lambda(\varphi)(\pi(\varphi) - rM\delta)$$

Are competitive rents allocated efficiently? They serve two roles:

$$\frac{d\pi^*(\varphi)}{d(-F)} = \underbrace{1}_{Consumption} + \underbrace{\lambda(\varphi)}_{Collateral}$$

Goal of production – reallocation is a transfer

Collateral for promises – reallocation could improve productivity

Shadow cost of (DE) constraint is decreasing in $\varphi \Rightarrow$ profits are inefficiently concentrated at the top

Welfare-Improving Tax Scheme

Suppose Φ is unbounded from above

Impose an excise tax τ on $\varphi_i \geq \varphi_H(p) + \zeta$ firms, $\zeta > 0$

Total welfare:

$$W(\tau) = CS + PS(Untaxed) + PS(Taxed) + Taxes$$

Theorem: W'(0) > 0

Proof: Step 1 – Price effect

At $\tau = 0$ and p^0, $\tau \uparrow$ implies $S \downarrow$, so prices must increase

Therefore

$$\frac{dp^\tau}{d\tau}|_{\tau=0} > 0$$

Theorem: W'(0) > 0

Proof: Step 2 – Simplify

$$W(\tau) = CS + PS(Untaxed) + PS(Taxed) + Taxes$$

THEOREM: W'(0) > 0

Proof: Step 2 – Simplify

$$W(\tau) = \int_{p^\tau}^{\infty} D(p)dp + \int_{\varphi_L(p^\tau)}^{\varphi_H(p^\tau)+\zeta} \pi^*(p^\tau, \varphi; 0) d\Phi(\varphi) + \int_{\varphi_H(p^\tau)+\zeta}^{\infty} \pi^*(p^\tau, \varphi; \tau)\, d\Phi(\varphi) + T(\tau)$$

THEOREM: W'(0) > 0

Proof: Step 2 – Simplify

$$W(\tau) = \int_{p^\tau}^{\infty} D(p)dp + \int_{\varphi_L(p^\tau)}^{\varphi_H(p^\tau)+\zeta} \pi^*(p^\tau, \varphi; 0)d\Phi(\varphi)$$
$$+ \int_{\varphi_H(p^\tau)+\zeta}^{\infty} \pi^*(p^\tau, \varphi; \tau)\, d\Phi(\varphi) + T(\tau)$$

Let $T(\varphi;\tau) = \pi^*(p^\tau, \varphi; 0) - \pi^*(p^\tau, \varphi; \tau) - O(\tau^2)$

Then, $T(\tau) = \int_{\varphi_H(p^\tau)+\zeta}^{\infty} T(\varphi;\tau)d\Phi(\varphi)$

Theorem: W'(0) > 0

Proof: Step 2 – Simplify

$$W(\tau) = \int_{p^\tau}^{\infty} D(p)dp + \int_{\varphi_L(p^\tau)}^{\varphi_H(p^\tau)+\zeta} \pi^*(p^\tau, \varphi; 0) d\Phi(\varphi)$$
$$+ \int_{\varphi_H(p^\tau)+\zeta}^{\infty} \pi^*(p^\tau, \varphi; 0)\, d\Phi(\varphi) - O(\tau^2)$$

Marginal tax + lump-sum subsidy makes unconstrained firms as well off to first-order

Theorem: W'(0) > 0

Proof: Step 2 – Simplify

$$W(\tau) = \int_{p^\tau}^{\infty} D(p)dp + \int_{\varphi_L(p^\tau)}^{\infty} \pi^*(p^\tau, \varphi; 0)d\Phi(\varphi) - O(\tau^2)$$

THEOREM: W'(0) > 0

Proof: Step 3 – Differentiate

$$W'(0) = \frac{d}{d\tau}\int_{p^{\tau}}^{\infty} D(p)dp\,|_{\tau=0} + \frac{d}{d\tau}\int_{\varphi_L(p^{\tau})}^{\infty} \pi^*(p^{\tau},\varphi;0)d\Phi(\varphi)\,|_{\tau=0}$$

Theorem: W'(0) > 0

Proof: Step 3 – Consumers

$$W'(0) = \frac{d}{d\tau}\int_{p^\tau}^{\infty} D(p)dp\,|_{\tau=0} + \frac{d}{d\tau}\int_{\varphi_L(p^\tau)}^{\infty} \pi^*(p^\tau,\varphi;0)d\Phi(\varphi)\,|_{\tau=0}$$

Quasi-linear preferences:

$$\frac{d}{d\tau}\int_{p^\tau}^{\infty} D(p)dp\,|_{\tau=0} = -D(p^0)\frac{dp^\tau}{d\tau}\,|_{\tau=0}$$

Theorem: W'(0) > 0

Proof: Step 4 – Producers

$$W'(0) = -D(p^0)\frac{dp^\tau}{d\tau}|_{\tau=0} + \frac{d}{d\tau}\int_{\varphi_L(p^\tau)}^{\infty} \pi^*(p^\tau, \varphi; 0)d\Phi(\varphi)\,|_{\tau=0}$$

Only a price effect:

$$\frac{d}{d\tau}\int_{\varphi_L(p^\tau)}^{\infty} \pi^*(p^\tau, \varphi; 0)\,|_{\tau=0} = (S(p^0) + \Delta + E[\chi|\varphi \geq \varphi_L])\frac{dp^\tau}{d\tau}|_{\tau=0}$$

Δ – extensive-margin improvement

$E[\chi|\varphi \geq \varphi_L]$ - intensive-margin improvement

THEOREM: W'(0) > 0

Proof: Step 5 – Result

$$W'(0) = -D(p^0)\frac{dp^\tau}{d\tau}|_{\tau=0} + (S(p^0) + \Delta + E[\chi|\varphi \geq \varphi_L])\frac{dp^\tau}{d\tau}|_{\tau=0}$$

Equilibrium: $D(p^0) = S(p^0)$. Therefore

$$W'(0) = (\Delta + E[\chi|\varphi \geq \varphi_L])\frac{dp^\tau}{d\tau}|_{\tau=0} > 0$$

Summary of Proof

Small marginal tax on high-ability firms, returned lump-sum $\Rightarrow$ these firms indifferent

Reduced production, so increase in prices

- Transfer from consumers to constrained producers
- Improves efficiency of constrained producers

Increase in total welfare

What About Subsidizing Small Firms?

Taxing big firms ≠ subsidizing small firms

Subsidizing small firms (via tax credit funded by nondistortionary head tax) improves their profits by more than cost of tax

Such firms expand, driving down prices, reducing profits of all other firms, some of which are constrained

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- The Model
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- Empirical Implications
    - Within Countries
    - Across Countries

Productivity is Endogenous

Key: low-ability firms' TFP more sensitive

Two applications:

1. Within-country, over time: agg demand shifts
2. Across countries: institutional environment

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Productivity Dynamics Facts

1. Pro-cyclical aggregate productivity

   Hultgren (1960)

2. Pro-cyclical within-firm productivity

   Bartelsman and Doms (2060)

3. Counter-cyclical dispersion

   Baily, Bartelsman, and Haltiwanger (2001), Kehrig (2015)

Many stories for [1] and [2], but [3] is puzzling. All three are consistent with "credibility."

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Cross-Country Facts

1. Lots of productivity dispersion within country

   Syverson (2011) for a survey

2. More productivity dispersion in developing countries

   Hsieh and Klenow (2009), Bartelsman, Haltiwanger, and Scarpetta (2013)

3. Distribution has thick left tail in developing countries

   Hsieh and Klenow (2009)

Better formal contracts reduce importance of credibility, especially benefiting low-ability firms

What Else Could Firms Do?

Overinvest in specific capital

Leverage profits from other business lines (conglomerates)

Family-managed firms

(Over)invest in improving capabilities

But, these just shift the inefficiencies

Conclusion

Developed a model of optimal rel cons in a competitive environment

- Unique stationary rational-expectations equilibrium

Inefficient competitive equilibrium

- Profits are inefficiently concentrated at the top
- Distortionary tax induces transfers from consumers to low-φ firms, improving welfare

Low-φ firms more constrained and thus sensitive to changes in rents

- Two applications: productivity over the business cycle and misallocation

Conclusion

Productivity dynamics over the business cycle

- Pro-cyclical within-firm productivity
- Low-ability firms more sensitive to cycles than high-potential firms
- Consistent w/micro evidence from Baily, et. al. `01 and Kehrig `12

Misallocation

- Improved formal contracts disproportionately improve low-ability firms, reducing productivity dispersion
- Improved formal contracts also reduce size dispersion

Other Implications of this Approach

Industry Dynamics

- Productive firms overproduce, making small entrants relatively less profitable (in the short-run) and thus harder to get off the ground
- Improved formal contracts can lead to more firm mobility, preventing industry stagnation

Trade Liberalization

- Trade liberalization concentrates profits with already-successful firms (Melitz), which in turn can harm smaller competitors
- Trade can harm countries with poor formal contracts but is good for countries with stronger institutions