Heterogeneous Markups, Growth and Endogenous Misallocation

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Motivation

- Growing empirical literature shows that markups vary systematically across firms and respond to changes in the environment.
- Firms' market power:
  - determinant of static allocative efficiency,
  - important for welfare consequences of policies like trade liberalization or changes in costs of entry.
- Standard firm dynamics models routinely abstract from such considerations.
- This paper:
  - Propose theory where the distribution of markups emerges as an equilibrium outcome and is jointly determined with the aggregate productivity growth rate.
  - Application to Indonesian manufacturing firms.

Summary of the model

- Schumpeterian growth in the spirit of Klette and Kortum (2004).
- Imperfect product markets: firms compete a la Bertrand, engage in non-competitive pricing and charge variable markups.
- Firms improving productivity to accumulate market power ...
- ... + Markup-reducing product churning induced by creative destruction shape distribution of markups.
  - After creative destruction $\implies$ Low markups as Bertrand competition forces given firm to limit price competitors.
  - Over time, firm spends resources to increase productivity, pulls away from competitors and raises optimal markup.
  - $\implies$ Within products markups increase if produced by a given firm.
  - Once the firm gets replaced by more productive producer, markups get "reset" as Bertrand competition intensifies.

The Environment

Measure one infinitely-lived HH. Supply inelastically unit time endowment. Preferences:

$$U = \int_{t=0}^{\infty} e^{-\rho t} \ln(c_t)\, \mathrm{d}t,$$

where c_t denotes consumption of the unique consumption good (numeraire) $\implies$ Composite of a continuum of differentiated products

$$\ln Y_t = \int_0^1 \ln \left(\sum_{f \in S_{it}} y_{fit} \right) \mathrm{d}i.$$

where y_{fit} is the quantity of product i bought from firm f and S_{it} denotes the number of firms competing in market i at time t.

Firms can produce multiple products. Firm f producing i with productivity q_{fi} (only source of heterogeneity) produces

$$y_{fi} = q_{fi} l,$$

where l is the amount of labor hired.

Static Allocations: Markups and Misallocation

Bertrand competition $\implies$ Most efficient firm resorts to limit pricing.

If q_i denotes productivity of current incumbent, equilibrium markup for product i

$$\mu_i \equiv \frac{p_i}{w/q_i} = \frac{w/q_i^F}{w/q_i} = \frac{q_i}{q_i^F},$$

where w denotes the equilibrium wage, and w/q_i^F is the marginal cost of the second most productive firm.

Cobb-Douglas preferences imply

$$p_{it} y_{fit} = Y_t,$$

so that

$$l_i = \frac{1}{q_i} y_i = \frac{1}{q_i} \frac{Y}{p_i} = \mu_i^{-1} \frac{Y}{w},$$

and

$$\pi_i = (1 - \mu_i^{-1}) Y.$$

Static Allocations: Markups and Misallocation

Let N_f be the set of products firm f produces, then

$$l_f = \sum_{i \in N_f} l_i = \sum_{i \in N_f} \mu^{-1} \frac{Y}{w} = \frac{Y}{w} n_f \mu_f^{-1}, \quad \text{where} \quad \mu_f = \left(\frac{1}{n_f} \sum_{i \in N_f} \mu_i^{-1} \right)^{-1},$$

$n_f = |N_f|$ is # of products produced by f and μ_f its average markup.

Letting L_{P_t} denote the total mass of production workers,

$$L_{P_t} = \int_f l_f \, \mathrm{d}f = \frac{Y}{w} \int_f \sum_{i \in N_f} \mu_i^{-1} \, \mathrm{d}f = \frac{Y}{w} \left(\int_0^1 \mu_i^{-1} \, \mathrm{d}i \right). \tag{1}$$

Similarly, as the final good is the numeraire, equilibrium wages are

$$w = \exp \left(\int_0^1 \ln q_i^F \, \mathrm{d}i \right) = \exp \left(\int_0^1 \ln \frac{q_i}{\mu_i} \, \mathrm{d}i \right) = Q \exp \left(\int_0^1 \ln \mu_i^{-1} \, \mathrm{d}i \right),$$

where $\ln Q = \int_0^1 \ln q_i \, \mathrm{d}i$.

Static Allocations: Markups and Misallocation

Aggregate output is therefore given by

$$Y = Q\mathcal{M}L_P, \quad \text{where} \quad \mathcal{M} \equiv \frac{\exp\left(\int_0^1 \ln \mu_i^{-1}\, \mathrm{d}i\right)}{\int_0^1 \mu_i^{-1}\, \mathrm{d}i} = \frac{\exp\left(\mathbb{E}\left[\ln \mu_i^{-1}\right]\right)}{\mathbb{E}\left[\mu_i^{-1}\right]}. \tag{2}$$

Aggregate TFP:

- Physical productivity Q $\times$ Markup misallocation $\mathcal{M} \leqslant 1$.
- Proportional increase in markups leaves misallocation unchanged, but higher markup dispersion reduces allocative efficiency and hence aggregate TFP.

Monopoly power also affects factor prices through a reduction in labor demand

$$\Lambda \equiv \frac{wL_P}{Y} = \left(\int_0^1 \mu_i^{-1}\, \mathrm{d}i\right) = \mathbb{E}\left[\mu_i^{-1}\right]. \tag{3}$$

Static macroeconomic implications of market power fully summarized by $\mathcal{M}$ and $\Lambda \implies$ Both depend on the distribution of markups.

Dynamics: Innovation and Creative Destruction

Firm efficiency modelled in a ladder with proportional productivity improvements $\lambda > 1$, i.e. letting r be the rung of the ladder, $q_{r+1} = \lambda q_r$. Eq. markups:

$$\mu_{it} = \frac{q_{it}}{q_{it}^F} = \frac{\lambda^{r_{it}}}{\lambda^{r_{it}^F}} = \lambda^{r_{it} - r_{it}^F} = \lambda^{\Delta_{it}}.$$

Current level of productivity of product i, q_{it}, can increase in three ways:

1. New firm enters in product i with a superior technology $\implies$ Quality gap declines from Δ to 1.
2. Existing firm, not currently active in market i, expands into i $\implies$ Quality gap declines from Δ to 1.
3. Current producer of product i increases productivity to gain monopoly power $\implies$ Quality gap increases from Δ to $\Delta + 1$.

Dynamics: Innovation and Creative Destruction

- State of a firm: productivity ($\sim$ quality) of its products $[q_j]_{j=1}^n$ and quality-gaps in each product line $[\Delta_j]_{j=1}^n$.
- Eq. profits only depend on quality gap $\implies$ Restrict attention to equilibria where firm behaviour depends on the payoff-relevant state variables $\left(n, [\Delta_j]_{j=1}^n\right)$.
- Firms choose own-innovation rates on existing products $[I_{it}]_{i=1}^n$ and rates of expansion $[x_{it}]_{i=1}^n$.
- The associated cost function (denoted in units of labor) is given by $\Gamma\left([x_i, I_i]_{i=1}^n; n, [\Delta_j]_{j=1}^n\right)$.

Dynamics: Innovation and Creative Destruction

Optimal behaviour is described by the value function $V_t(n, [\Delta_i]) \equiv \mathbf{V}_t$, given by

$$r_t \mathbf{V}_t - \dot{\mathbf{V}}_t = \sum_{i=1}^{n} \pi_t(\Delta_i) - \sum_{i=1}^{n} \tau_t \left[\mathbf{V}_t - V_t(n-1, [\Delta_i]_{i \neq j})\right] + \max_{[x_i, I_i]_{i=1}^{n}} \left\{ \sum_{i=1}^{n} I_i \left[V_t\left(n, [[\Delta_i]_{j \neq i}, \Delta_i + 1]\right) - \mathbf{V}_t\right] + \sum_{i=1}^{n} x_i \left[V_t(n+1, [[\Delta_i], 1]) - \mathbf{V}_t\right] - \Gamma([x_i], [I_i]; n, [\Delta_i]) w_t \right\}$$

where

$$\Gamma([x_i], [I_i]; n, [\Delta_i]) = \sum_{i=1}^{n} c(I_i, x_i : \Delta_i),$$

$$c(I, x, \Delta) = \lambda^{-\Delta} \frac{1}{\gamma_I} I^{\zeta} + \frac{1}{\gamma_x} x^{\zeta}.$$

Dynamics: Innovation and Creative Destruction

Potential entrants have access to a linear entry technology, whereby each unit of labor generates a flow of φ_z marketable ideas. As firms enter in a single market with a unitary quality gap, the free entry condition is given by

$$V_t(1,1) \leqslant \frac{1}{\gamma_z} w_t, \quad \text{with} = \text{if } z > 0, \tag{4}$$

where z denotes the equilibrium flow rate of entry.

Finally, the aggregate rate of creative destruction τ_t is given by

$$\tau_z = z_t + \int_0^1 x_{it} \, \mathrm{d}i. \tag{5}$$

Stationary Equilibrium

Proposition 1

If $\rho > \frac{\xi-1}{\xi}\left(\frac{1}{\xi}\frac{\varphi_x}{\varphi_z}\right)^{1/(\xi-1)} \implies \exists$ *unique stationary equilibrium where*

1. *The value function is given by*

$$V_t(n, [\Delta_i]_{i=1}^n) = \sum_{i=1}^n V_t(\Delta_i) = V_t^P n + \sum_{i=1}^n V_t^M(\Delta_i)$$

where

$$V_t^P = \frac{\pi(1) + (\xi - 1)\frac{x^\xi}{\varphi_x} w_t}{\rho + \tau}; \quad V_t^M(\Delta) = \frac{\pi(\Delta_i) - \pi(1) + (\xi - 1)\lambda^{-\Delta_i}\frac{I^\xi}{\varphi_I} w_t}{\rho + \tau}$$

2. $([I_{it}, x_{it}], z_t, \tau_t) = (I, x, z, \tau)$, *for all* i, t,

$$x = \left(\frac{\varphi_x}{\varphi_z}\frac{1}{\zeta}\right)^{\frac{1}{\zeta-1}} \quad \text{and} \quad I = \left(\frac{\lambda-1}{\lambda}\frac{1}{\rho+\tau}\left(\frac{\varphi_I}{\zeta}\frac{Y_t}{w_t} - \frac{\zeta-1}{\zeta}I^\zeta\right)\right)^{\frac{1}{\zeta-1}}.$$

3. *Distribution of markups is stationary* $\implies \mathcal{M}$ *and* Λ *are constant.*
4. *Aggregate variables grow at* $g = \frac{\dot{Q}_t}{Q_t} = \ln\lambda \times (I + \tau)$.

Cross-Sectional distribution of markups

Cross-sectional distribution of markups characterized by $\{\nu(\Delta,t)\}_{\Delta=1}^{\infty}$ where $\nu(\Delta,t)$ denotes the measure of products with quality gap Δ at time t. This measure solves the set of differential equations

$$\dot{\nu}(\Delta,t) = \begin{cases} -(\tau+I)\nu(\Delta,t) + I\nu(\Delta-1,t) & \text{if } \Delta \geqslant 2 \\ \tau(1-\nu(1,t)) + I\nu(1,t) & \text{if } \Delta = 1 \end{cases}, \tag{6}$$

Note:

1. Distribution fully determined from (I,τ), thus jointly determined with g.
2. As I and x are constant across firms, firm size distribution does not show up.
3. Pro-competitive effects of creative destruction:
    - Productivity growth by existing producers are markup increasing...
    - ... but market churning through creative destruction shifts the distribution of markups downwards.
    - Creative destruction tends to reduce misallocation while firms' own-innovation efforts lowers allocative efficiency through higher and more dispersed markups.

Cross-Sectional distribution of markups

Proposition 2

Let

$$\theta = \frac{\ln(1+\vartheta_I)}{\ln \lambda} \quad \textit{where} \quad \vartheta_I = \frac{\tau}{I}.$$

Then:

- *The distribution of markups is given by*

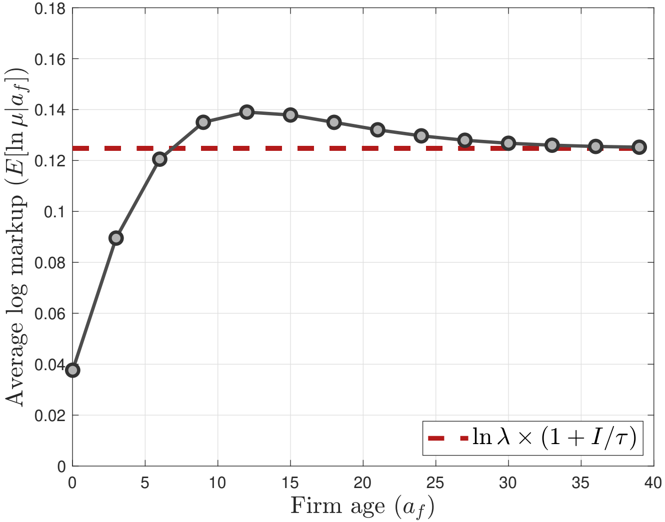
$$G(\mu) = 1 - \mu^{-\theta},$$

- *The aggregate misallocation measures* $\mathcal{M}$ *and* Λ *are given by*

$$\mathcal{M} = e^{-1/\theta}\frac{1+\theta}{\theta} \quad \textit{and} \quad \Lambda = \frac{\theta}{1+\theta}.$$

Churning intensity ϑ_I (speed with which firms are being replaced by new producers relative to firms' own-innovation efforts) fully determines endogenous distribution of markups.

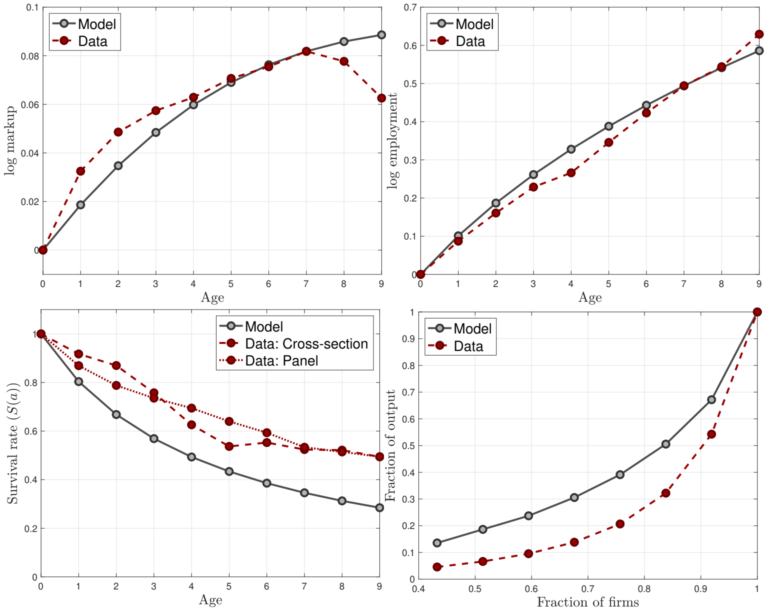
Markup Dynamics at the Firm-Level



Quantitative Application

- Apply theory to Indonesian manufacturing plant-level data.
- Calibrate the model by targeting the life cycle growth of Indonesian manufacturing firms (7 year old firms).
- Objective: Quantify the importance of heterogenous markups as a source of misallocation.

Results


Model
Data
log markup
Age
Model
Data
log employment
Age
Model
Data: Cross-section
Data: Panel
Survival rate ($S(a)$)
Age
Model
Data
Fraction of output
Fraction of firms

Results

- Markups lower TFP by 0.5% and depress wages by 10% relative to their social marginal product.
- Implied reduction in TFP is relatively small, especially compared to the much bigger numbers reported Hsieh and Klenow (2009) or De Loecker and Eeckhout (2017).
  - Model implies that markups only account for a small fraction of the observed dispersion in revenue products.
  - Remainder could hence be explained by other frictions, e.g. adjustment costs, model misspecification or measurement error.
  - Model relies on unitary elasticity of substitution (much higher in related work, e.g. HK $\sigma = 3$).