The Decline of Labor Share and New Technology Diffusion: Implications for Markups and Monopsony Power

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July 7, 2023
Japan Fair Trade Commission

The Decline of Labor Share

- The Decline of Labor Share
  - Factor-biased technological changes and automation
  - Increased market power by large firms in product and labor markets
- Evolution of market power has attracted huge attention recently.
  - Findings are mixed in the literature.
    - Production Approach
      De Loecker, Eeckhout, and Unger (2020)
    - IO-type Demand Approach
      Grieco, Murry and Yurukoglu (2022)
  - Labor market power
    Azar, Berry, Marinescu (2022), Yeh, Macaluso, and Hershbein (2022)
- “Technology” plays a key role, but not directly observed!

Our Approach

- Looking at an industry where plant-level technology is observed
  - The Japanese cement industry and its new production technology from 1970-2010
- Examining the effects of technological change on labor share
- Examining the other explanations for the decline of the labor share

Main Findings

- New production technology is the main driver for the decline of the labor share
- Information on technology at plant is important to reject other explanations
  - increasing markups
  - declining worker power
- Without technology information, we would obtain the increasing trend of aggregate markups and labor market power.

Literature and our contribution

1. **The decline of the Labor share**
   - Grossman and Oberfield(2022), Karabarbounis and Neiman(2014), Kehrig and Vincent(2021)
   - Acemoglu and Restrepo(2020), Autor et al.(2020), Humlum(2021)

   Industry-level study, beyond the robot/automation/ICT era

2. **The evolution of market power**
   - Production approach: De Loecker et al. (2020), Syverson(2019), Jaumandreu(2022), Yeh et al. (2022)
   - Demand approach: Grieco et al. (2021), Dopper et al. (2022), Miller et al. (2022), Azar et al. (2021)

   Focus on a specific industry and technological change with "production approach"

3. **Factor-biased technological change in production function estimation**
   - Doraszelski and Jaumandreu (2018), Raval (2022), Zhang (2019), Demirer (2022)
   - van Biesebroeck (2003), Collard-Wexler and De Loecker (2015) Rubens (2022)

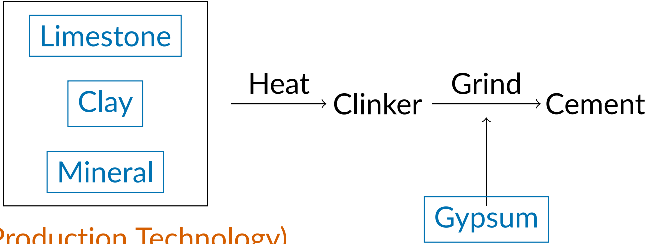
   Directly observe the differences in production technology at plants

Roadmap

1. Industry details and data
2. Descriptive and reduced-form analysis
3. Production function estimation
4. Implications for markups and monopsony power

Background (1/2): Features of Cement

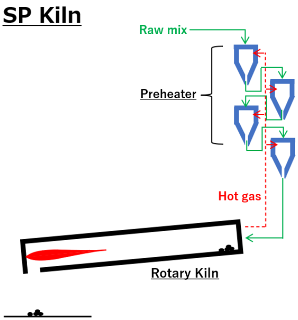
- Cement is a homogeneous product
- Cement requires only four inputs and production process is simple

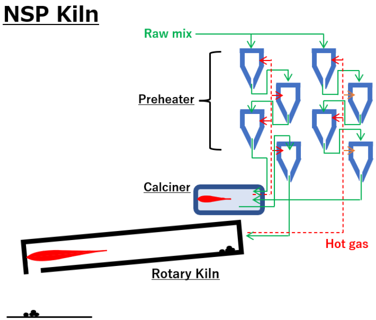


Kiln (Production Technology)

Background (2/2): Evolution of Kilns

- Historical evolution of kilns:
  - Very old technologies: Wet kilns and Dry kilns
  - Old technologies: SP (Suspension Preheater) kilns, 1960s-
  - New technology: NSP (New SP) kilns with a precalciner, 1973-
- Differences between SP Kilns and NSP Kilns





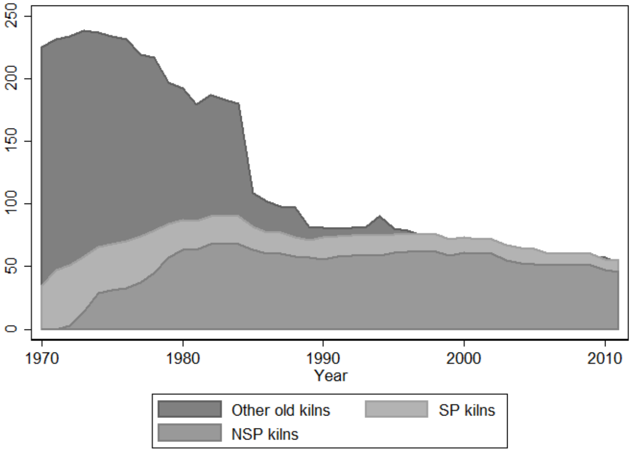
Data Sources

	Cement Yearbook	Census of Manufacture
Freq.	Annual	Annual
Unit	Plant	Plant
Period	1970–2010	1980–2010*
Price (in JPY)	Local market price ($\bar{p}_{mt}$)	–
Production (in ton)	Clinker (q_{it})	–
Revenue (in JPY)	–	Total revenue ($(pq)_{it}$)
Wage (in JPY)	Pref-ind. avg. wage ($\bar{w}_{mt}$)	Total wages ($(wL)_{it}$)
Labor (in Person)	Num of workers (l_{it})	Num of workers**
Assets (in JPY)	–	Tangible Assets
Capacity (in ton/month)	Monthly capacity	–
Material Input (in JPY)	–	Material input (m_{it})
Kilns	Num of kilns & technology	–

The Decline of Labor Share and New Technology

Adoption Process of New Technology

Figure: # of kilns in the industry



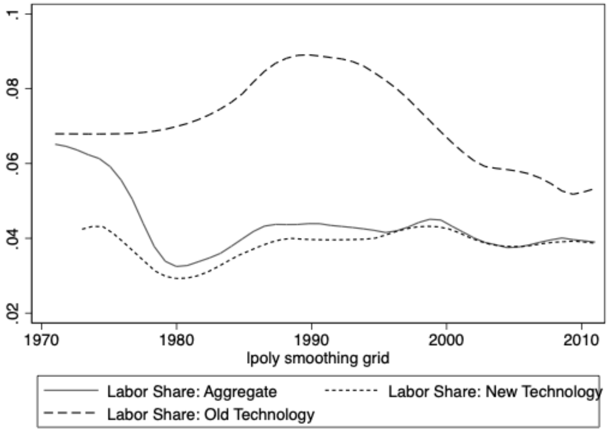
Industry Trend

- The industry-level labor share declined, especially in the 1970s.

Figure: Aggregate Labor Share

Industry Trend by Technology

- Labor shares are constant within the same technology plants



Evidence from Event Study: Motivation

- What happens at the plant level?
  - Labor share
  - wage, # of workers, output, capital-labor ratio
- An event study design to investigate what happens when plants adopt NSP kilns.
- The method proposed by Callaway and Sant'Anna (2021) to deal with
  - multiple adoption timings
  - heterogeneous effects

Evidence from Event Study: Our Approach

- We adopt the method proposed in Callaway and Sant'Anna (2021).
- ATT for cohort t in τ years from the "treatment":

$$\text{ATT}(t,\tau) = E\left[\left(\frac{G_{it}}{E[G_{it}]} - \frac{\frac{p_t(X_{i,t-1})C_{it}}{1-p_t(X_{i,t-1})}}{E\left[\frac{p_t(X_{i,t-1})C_{it}}{1-p_t(X_{i,t-1})}\right]}\right)(y_{i,t+\tau} - y_{i,t-1})\right], \quad (1)$$

  - $\tau_{min} = -3$, $\tau_{max} = 10$
  - G_{it} : an indicator variable for treatment cohort t
  - C_{it} : an indicator variable for control group
  - control group is never treated individuals and not yet treated individuals
  - $p_t(X_{i,t-1})$: propensity of treatment.

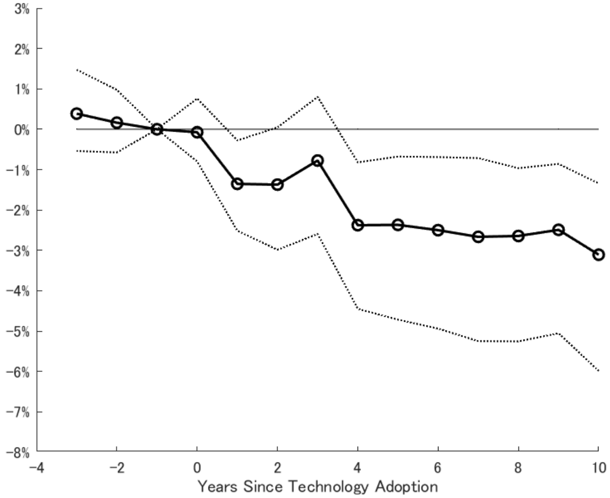
Evidence from Event Study: Our Approach

- We estimate $\text{ATT}(t, \tau)$ by its sample analog
- We define ATT τ years from the treatment as the weighted average of $\text{ATT}(t, \tau)$ as:

$$\text{ATT}(\tau) = \sum_t w_t \text{ATT}(t, \tau),$$

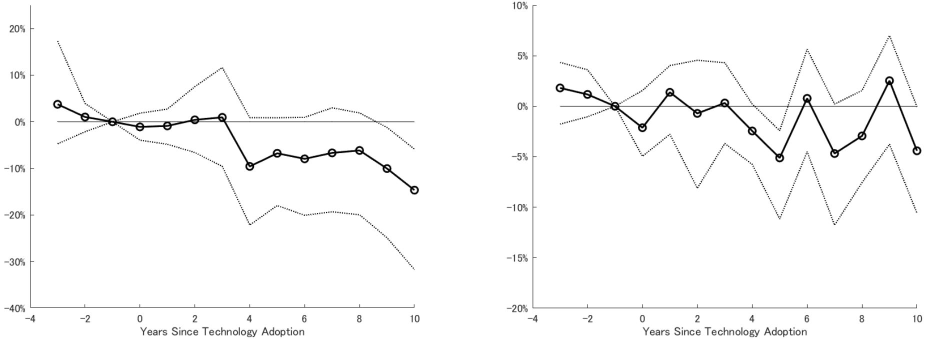
Results(1/3): Labor Share

- Evolution of the labor share (relative to the timing of new technology adoption)



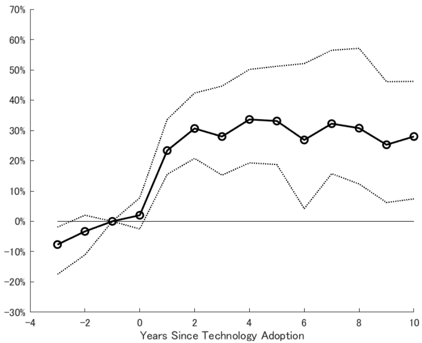
Results(2/3): # of Employees and wage growth

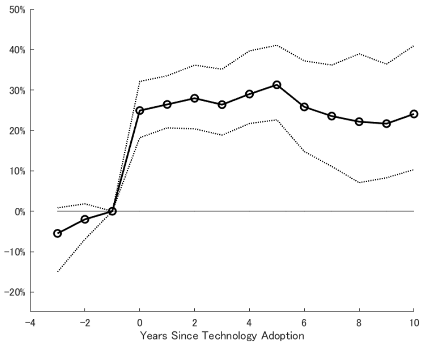
- Evolution of the employment (left) and wage growth (right)



Results(3/3): Output value and production capacity

- Evolution of the output value (left) and production capacity (right)





From reduced-form to production function

- Reduced-form analysis finds that after the adoption of NSP kilns
  - Labor share gradually decreased
  - The number of workers gradually decreased
  - Wage growth did not change
  - Output value increased and a jump in production capacity (capital)
- Difficult to rationalize the patterns if the new technology is just an increase in TFP

$$Y_{it} = A_{it} K_{it}^{\beta_k} L_{it}^{\beta_l}$$

- Different shape of production functions for different technology

Production Technology: Estimation Results

- Production Function (Cobb-Douglas) Estimates via ACF (2015):

$$
\begin{aligned}
\text{(i)} &: \quad y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \dots \\
\text{(ii)} &: \quad y_{it} = \beta_0 + \beta_l^{old} l_{it} + \beta_k^{old} k_{it} + \mathbf{1}_{\{\text{NSP Kilns}_{it}\}} (\beta_0^{new} + \beta_k^{new} k_{it} + \beta_l^{new} l_{it}) + \dots \\
\text{(iii)} &: \quad y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_0^{new} \mathbf{1}_{\{\text{NSP Kilns}_{it}\}} + \dots
\end{aligned}
$$

	(i)	(ii)		(iii)
	Pooling	Separately		Pooling
	Both Tech.	Old Tech	New Tech	Both Tech.
β_k	0.971	0.778	0.907	0.872
	(0.110)	(0.110)	(0.085)	(0.071)
β_l	0.184	0.259	0.099	0.237
	(0.140)	(0.103)	(0.096)	(0.094)
β_0^{new}	-	-	0.106	0.060
(TFP Gain)	-	-	(0.710)	(0.103)
N	1,408	1,408		1,408

Why Do We Care about Technology Information?

Implications for markups and monopsony power

Implications for markups and monopsony power

- Other explanations for the decline of labor share
  - Increasing market powers among firms
- Economy-wide markups are rising (De Loecker et al., 2020)
- The remaining section: an industry study of market power with production approach
  - Do markups increase over time?
  - Is worker power declining?
- The absence of technology information leads to qualitatively different implications

Do markups increase over time? (1/3): One Technology

"Production Approach" (De Loecker and Warzynski, 2012)

- Consider the following environment
  - Firm i has production technology: $Y_i = A_i K_i^{\beta_k} L_i^{\beta_l}$

- Using cost minimization,

$$\text{Markup}_i \equiv \frac{P_{it}}{MC_{it}} = \beta_l \frac{P_i Y_i}{wL_i}, \qquad \widehat{\text{Markup}}_i = \hat{\beta}_l \frac{P_i Y_i}{wL_i}$$

- Industry-level markup is a weighted average:

$$\widehat{\text{Markup}} = \sum \omega_i \widehat{\text{Markup}}_i$$

Do markups increase over time? (2/3): Two Technologies

- Two types of production technology $\beta_l^N < \beta_l^O$:
  - Labor-intensive (old) technology: $Y_i = A_i K_i^{\beta_k^O} L_i^{\beta_l^O}$
  - Capital-intensive (new) technology: $Y_i = A_i K_i^{\beta_k^N} L_i^{\beta_l^N}$

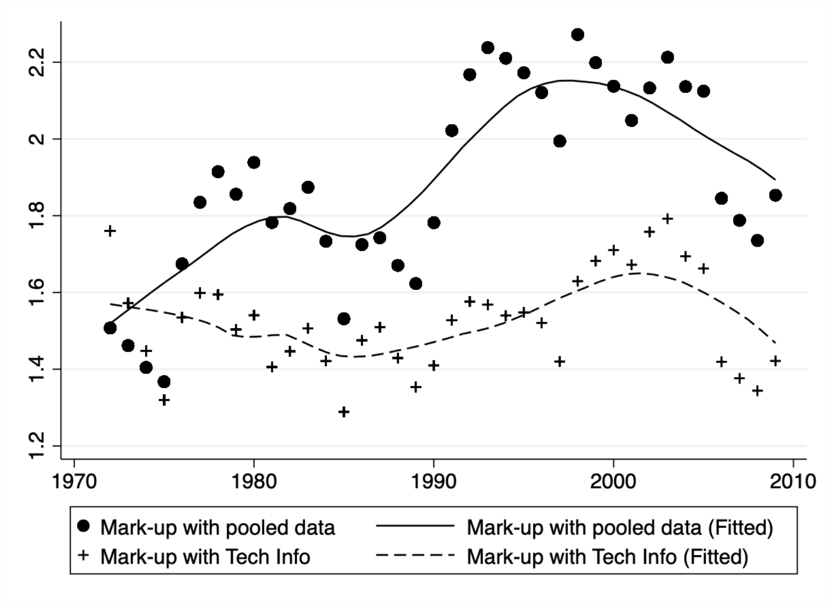
- Assuming one technology, we would get one number for $\hat{\beta}_l$.

- The estimated markups for type τ technology would be biased:

$$\widehat{\text{Markup}}_i^{\tau} = \hat{\beta}_l \frac{P_i Y_i}{wL_i} = \frac{\hat{\beta}_l}{\beta_l^{\tau}} \text{Markup}_i^{\tau} \lesseqgtr \text{Markup}_i^{\tau}$$

- If production technology shifts from labor-intensive to capital-intensive, markups would seemingly increase. $(\beta_l^N < \beta_l^O)$

Do markups increase? (3/3): With and w/o Tech. Info.



Labor market power: MRPL and Wage

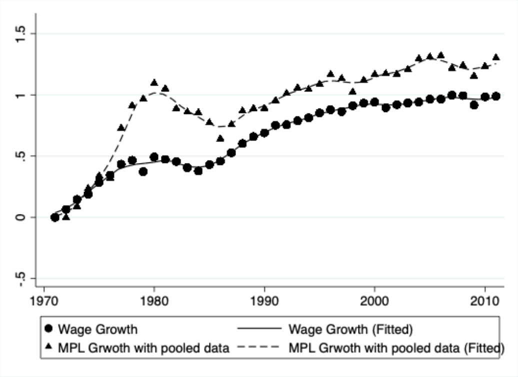
- Do firms suppress wages below MRPL?
- MRPL under Cobb-Douglas: $\beta_l \frac{PY}{L}$ (= wage)
- The estimated MRPL for τ type technology are then biased:

$$\widehat{\text{MRPL}}_i^\tau = \hat{\beta}_l \frac{P_i Y_i}{L_i} = \frac{\hat{\beta}_l}{\beta_l^\tau} \text{MRPL}_i^\tau \lesseqgtr \text{MRPL}_i^\tau$$

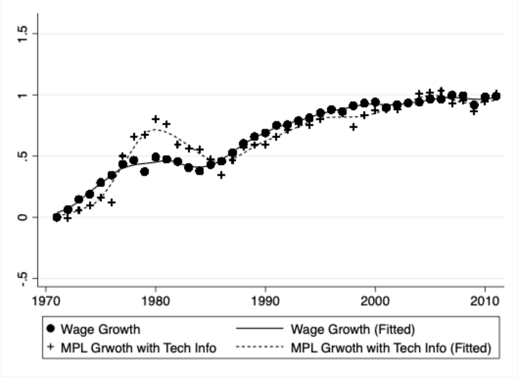
- If production shifts from labor-intensive firms to capital-intensive firms, industry-level MRPL would seemingly increase.

Gap between MRPL and Wage Growth (log change since 1970)

(a) without technology information



(b) with technology information



Conclusion

- New technology adoption/diffusion explains the decline of the labor share
- Information on plant-level technology is a key to rejecting other explanations
- Indirectly observe technological change

  $\rightarrow$ Literature on PF estimation with factor-augmenting productivity (e.g., Doraszelski and Jaumandreu(2018), Raval(2022), Demirer(2022))