MICRO DATA AND MACRO TECHNOLOGY

GROUP 10

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Main Academic Positions

- Assistant Professor of Economics, Princeton University, 2013 - present
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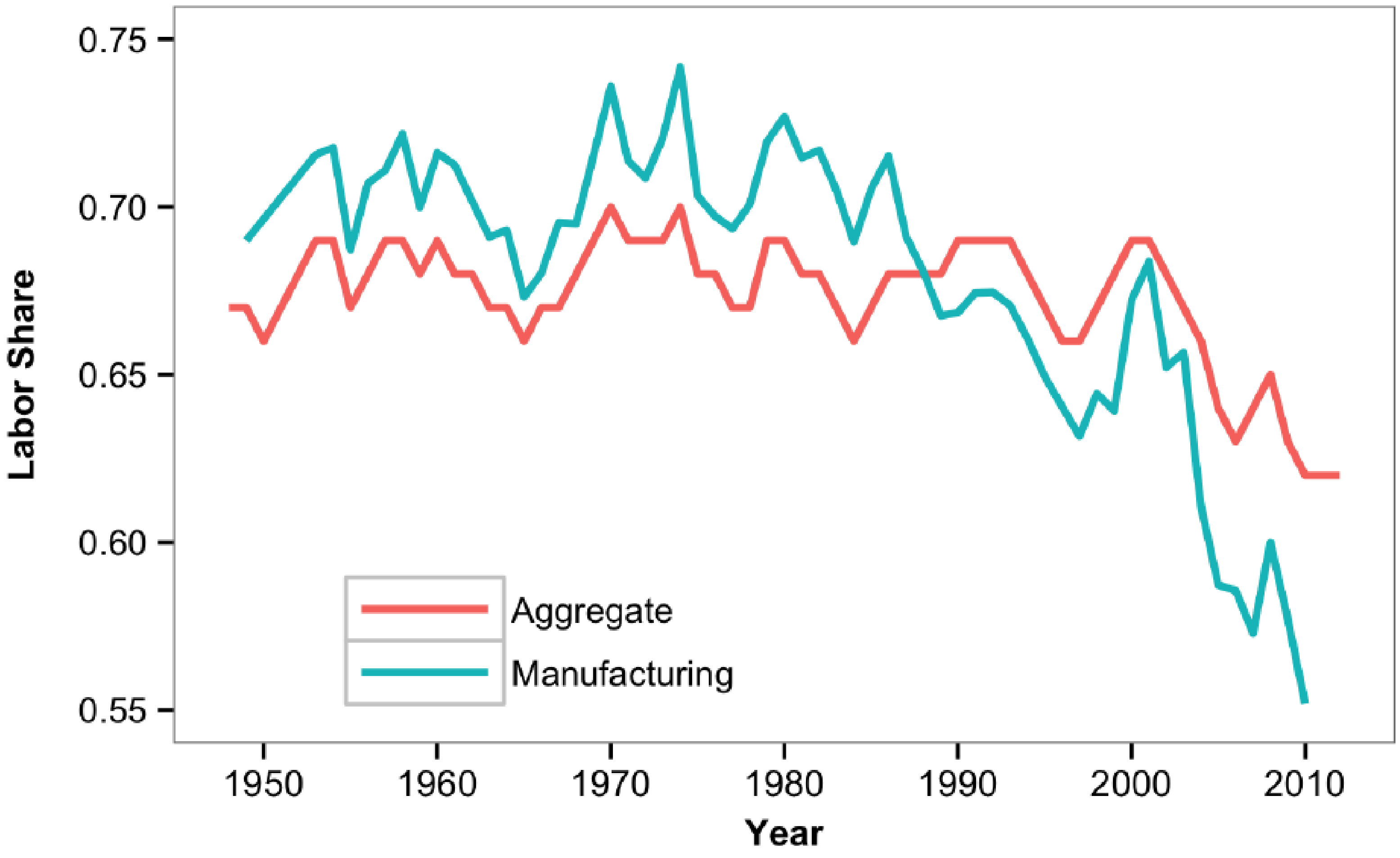
- Areas of specialization Industrial Organization; Productivity; Applied Econometrics.

LABOR'S SHARE HAS FALLEN



WHY HAS THE LABOR SHARE FALLEN?

Supply

- Piketty: Increased capital accumulation
- Karabarbounis & Neiman: Investment–specific technical change

Demand

- Automation / Offshoring

Key is the Aggregate Elasticity of Substitution:

$$\sigma^{\text{agg}} \equiv \frac{\mathrm{d}\ln K/L}{\mathrm{d}\ln w/r}$$

AGGREGATE CAPITAL-LABOR ELASTICITY OF SUBSTITUTION

<u>Impossibility Theorem of Diamond, McFadden, & Rodriguez (1978)</u>

Cannot identify σ or bias of tech. with time series of quantities and prices

Need variation in prices that is independent of technology

<u>Parametric assumptions on the bias of technical change</u>

No bias/constant bias

METHOD 2: USE MICRO DATA

More plausibly exogenous diferences in prices

Houthakker (1955) micro and macro elasticities can be very different

an economy of Leontief micro units can have a Cobb–Douglas aggregate production function.

Typical estimate: 0.4-0.5

Identies a micro elasticity of substitution

2.1 SIMPLE EXAMPLE

$$Y_i = \left[(A_i K_i)^{\frac{\sigma-1}{\sigma}} + (B_i L_i)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

$$\sigma^{\text{agg}} \equiv \frac{\mathrm{d} \ln K/L}{\mathrm{d} \ln w/r}$$

$$K \equiv \sum_{i \in I} K_i \quad L \equiv \sum_{i \in I} L_i$$

- a large set of plants I
- constant elasticity of substitution σ
- CES production function
- Capital K_i labor L_i
- Capital-augmenting productivity A_i
- Labor-augmenting productivity B_i

2.1 SIMPLE EXAMPLE

$$\alpha_i \equiv \frac{rK_i}{rK_i + wL_i} \quad \alpha \equiv \frac{rK}{rK + wL} \quad \alpha = \sum_{i \in I} \alpha_i \theta_i \quad \theta_i \equiv \frac{rK_i + wL_i}{rK + wL}$$

$$\sigma - 1 = \frac{\mathrm{d}\ln rK_i/wL_i}{\mathrm{d}\ln w/r} = \frac{\mathrm{d}\ln \alpha_i/(1-\alpha_i)}{\mathrm{d}\ln w/r} = \frac{1}{\alpha_i(1-\alpha_i)}\frac{\mathrm{d}\alpha_i}{\mathrm{d}\ln w/\boldsymbol{r}}$$

$$\sigma^{\mathrm{agg}} - 1 = \frac{\mathrm{d}\ln rK/wL}{\mathrm{d}\ln w/r} = \frac{\mathrm{d}\ln \alpha/(1-\alpha)}{\mathrm{d}\ln w/r} = \frac{1}{\alpha(1-\alpha)}\frac{\mathrm{d}\alpha}{\mathrm{d}\ln w/r}$$

$$\sigma^{\mathrm{agg}} - 1 = \frac{1}{\alpha(1-\alpha)}\sum_{i \in I} \alpha_i(1-\alpha_i)(\sigma - 1)\theta_i + \frac{1}{\alpha(1-\alpha)}\sum_{i \in I} \alpha_i \theta_i \frac{\mathrm{d}\ln \theta_i}{\mathrm{d}\ln w/r}$$

2.1 SIMPLE EXAMPLE

- Dixit–Stiglitz preference
- monopolistically competitive
- common elasticity of demand $\varepsilon > 1$

$$h_i(\mathbf{p}, u) = \frac{\partial e(\mathbf{p}, u)}{\partial p_i}$$

$$\left(\sum_{i \in I} D_i^{\frac{1}{\varepsilon}} Y_i^{\frac{\varepsilon - 1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon - 1}}$$

$$\frac{\mathrm{d} \ln \theta_i}{\mathrm{d} \ln w/r} = (\varepsilon - 1)(\alpha_i - \alpha)$$

2.1 SIMPLE EXAMPLE

$$\sigma^{\text{agg}} = (1 - \chi)\sigma + \chi\varepsilon$$

aggregate
EoS

plant level
EoS

plant level
elasticity of
demand

$$\chi \equiv \sum_{i \in I} \frac{(\alpha_i - \alpha)^2}{\alpha(1-\alpha)} \theta_i$$

σ: substitution within plants

$\boldsymbol{\sigma^{agg}}$: substitution across plants

ε: heterogeneity in capital intensity

X : proportional to variance of capital shares

2.2 BASELINE MODEL

$$F_{ni}(K_{ni}, L_{ni}, M_{ni}) = \left(\left[(A_{ni}K_{ni})^{\frac{\sigma n-1}{\sigma n}} + (B_{ni}L_{ni})^{\frac{\sigma n-1}{\sigma n}} \right]^{\frac{\sigma n-1}{\sigma n-1}\frac{n-1}{\zeta n}} + (C_{ni}M_{ni})^{\frac{\zeta n-1}{\zeta n}} \right)^{\frac{\zeta n}{Ln-1}}$$

$$Y \equiv \left[\sum_{n\in N} D_n^{\frac{1}{\eta}} Y_n^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \qquad Y_n \equiv \left(\sum_{i\in I_n} D_{ni}^{\frac{1}{\varepsilon n}} Y_{ni}^{\frac{\varepsilon n-1}{8n}} \right)^{\frac{\varepsilon n}{\varepsilon n-1}}$$

$$Y_{ni} = F_{ni}(K_{ni}, L_{ni}, M_{ni})$$

$$\max_{P_{ni}, Y_{ni}, K_{ni}, L_{ni}, M_{ni}} P_{ni}Y_{ni} - rK_{ni} - wL_{ni} - qM_{ni}$$

- Plant i in industry n produces with the production function
- elasticity of substitution between capital and labor : σn
- elasticity of substitution between materials and its capital-labor bundle : ζn
- Each plant in industry n faces a demand curve with constant elasticity εn
- q : price of materials, each plant maximizes profit
- subject to the technological constraint

2.2 BASELINE MODEL

Demand curve

$$Y_{ni} = Y_n (P_{ni}/P_n)^{-\varepsilon_n}$$

Price index for industry n

$$P_n \equiv \left(\sum_{i \in I_n} D_{ni} P_{ni}^{1-\varepsilon_n} \right)^{\frac{1}{1-\varepsilon_n}}$$

$$\sigma_n^N \equiv \frac{\mathrm{d} \ln K_n / L_n}{\mathrm{d} \ln w/r}$$

$$\alpha_{ni} = \frac{rK_{ni}}{rK_{ni} + wL_{ni}} \qquad \theta_{ni} = \frac{rK_{ni} + wL_{ni}}{rK_n + wL_n} \qquad s_{ni}^M \equiv \frac{qM_{ni}}{rK_{ni} + wL_{ni} + qM_{ni}}$$

2.3 PROPOSITIONS: 1 & 2

PROPOSITION 1: Under Assumption 1, the industry elasticity of substitution is

$$\sigma_n^N = (1-\chi_n)\sigma_n + \chi_n\left[\left(1-\bar{s}_n^M\right)\varepsilon_n + \bar{s}_n^M\zeta_n\right]$$

$$\chi_n = \sum_{i\in I_n}\frac{(\alpha_{ni}-\alpha_n)^2}{\alpha_n(1-\alpha_n)}\theta_{ni} \qquad \bar{s}_n^M = \frac{\sum_{i\in I_n}(\alpha_{ni}-\alpha_n)\left(\alpha_{ni}-\alpha^M\right)\theta_{ni}s_{ni}^M}{\sum_{i\in I_n}(\alpha_{ni}-\alpha_n)\left(\alpha_{ni}-\alpha^M\right)\theta_{ni}}$$

PROPOSITION 2: The aggregate elasticity between capital and labor

$$\sigma^{\text{agg}} = (1-\chi^{\text{agg}})\bar{\sigma}^N + \chi^{\text{agg}}\left[\left(1-\bar{s}^M\right)\eta + \bar{s}^M\bar{\zeta}^N\right]$$

$$\chi^{\text{agg}} \equiv \sum_{n\in N}\frac{(\alpha_n-\alpha)^2}{\alpha(1-\alpha)}\theta_n \qquad \bar{s}^M \equiv \sum_{n\in N}\frac{(\alpha_n-\alpha)\left(\alpha_n-\alpha^M\right)\theta_n}{\sum_{n'\in N}(\alpha_{n'}-\alpha)\left(\alpha_{n'}-\alpha^M\right)\theta_{n'}}s_n^M$$

$$\bar{\sigma}^N \equiv \sum_{n\in N}\frac{\alpha_n(1-\alpha_n)\theta_n}{\sum_{n'\in N}\alpha_{n'}(1-\alpha_{n'})\theta_n}\sigma_n^N \qquad \bar{\zeta}^N \equiv \sum_{n\in N}\frac{(\alpha_n-\alpha)\left(\alpha_n-\alpha^M\right)\theta_n s_n^M}{\sum_{n'\in N}(\alpha_{n'}-\alpha)\left(\alpha_{n'}-\alpha^M\right)\theta_{n'}s_{n'}^M}\zeta_n^N$$

BEFORE EMPIRICAL

Two Propositions throughout the whole article

$$\boldsymbol{\sigma_n^N = (1-\chi_n)\sigma_n + \chi_n\left[\left(1-\bar{s}_n^M\right)\varepsilon_n + \bar{s}_n^M\zeta_n\right]}$$

$$\boldsymbol{\sigma^{agg} = (1-\chi^{agg})\bar{\sigma}^N + \chi^{agg}\left[\left(1-\bar{s}^M\right)\eta + \bar{s}^M\bar{\zeta}^N\right]}$$

Elasticity: substitution elasticity, demand elasticity
Heterogeneity: capital intensive heterogeneity, intermediate production heterogeneity

BEFORE EMPIRICAL

Two Propositions throughout the whole article

$$\sigma_n^N = (1-\chi_n)\sigma_n + \chi_n\left[\left(1-\bar{s}_n^M\right)\varepsilon_n + \bar{s}_n^M\zeta_n\right]$$

Elasticity substitution elasticity demand elasticity

Heterogeneity capital intensive heterogeneity intermediate production heterogeneity

$$\sigma^{agg} = (1-\chi^{agg})\bar{\sigma}^N + \chi^{agg}\left[\left(1-\bar{s}^M\right)\eta + \bar{s}^M\bar{\zeta}^N\right]$$

DATA - MICRO DATA ON MANUFACTURING PLANTS

The U.S. Census of Manufactures

every 5 years, 1987 to 2007

- **Capital costs**
  - Perpetual inventory
  - Total stock of structures
  - Equipment capitals
  - External real rental rate of return: Harper, Berndt, Wood (1989)
- **Labor costs**
  - Total salaries and wages at the plant level

Annual Survey of Manufactures (ASM)

1977 to 2007

- **Capital Statistics**
  - Additionally include machinery rents
- **Labor costs**
  - Additionally include supplemental labor costs
    - Benefits
    - Payrolls
    - Taxes

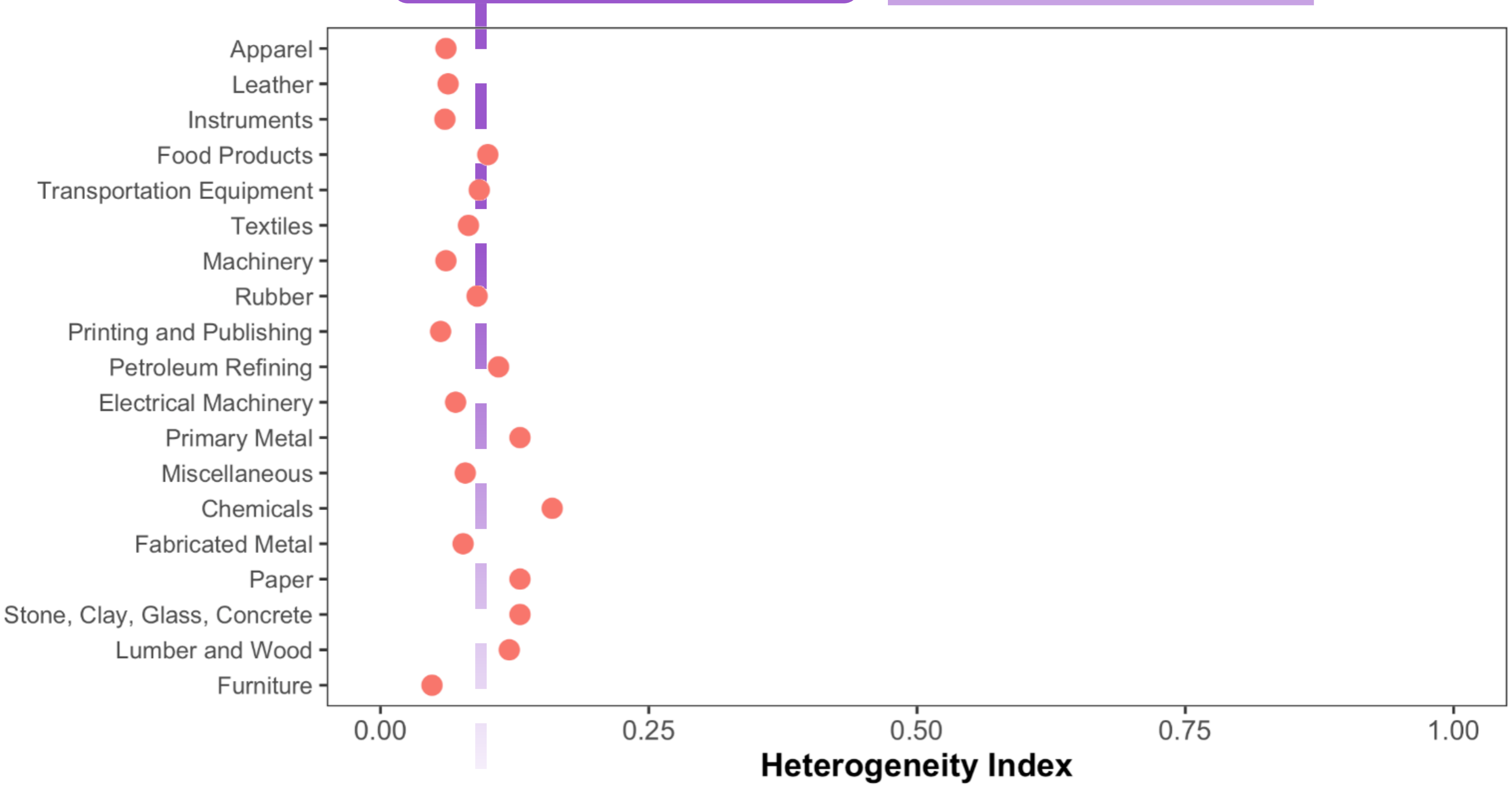
Industry definition: Changes from SIC to NAICS in 1997

3.2 MICRO HETEROGENEITY

$$\sigma_n^N = (1-\chi_n)\sigma_n + \chi_n\left[(1-\bar{s}_n^M)\varepsilon_n + \bar{s}_n^M\zeta_n\right]$$

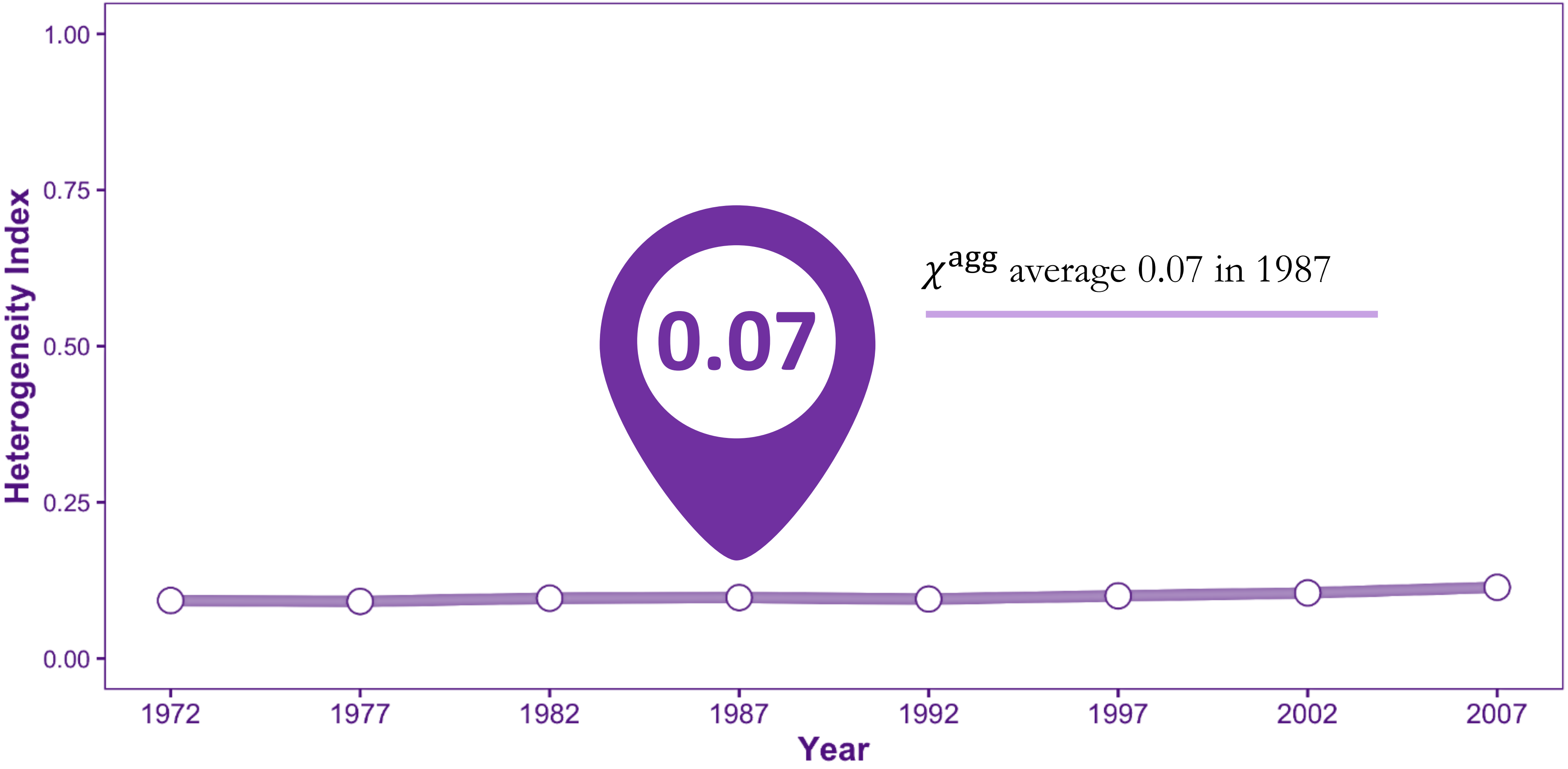
0.1

χ_n average 0.1 in 1987



3.2 MICRO HETEROGENEITY

$$\sigma_n^N = (1-\chi_n)\sigma_n + \chi_n\left[\left(1-\bar{s}_n^M\right)\varepsilon_n + \bar{s}_n^M\zeta_n\right]$$



3.3 PLANT-LEVEL ELASTICITY OF SUBSTITUTION

Regression model

$$\log \frac{rK_{nic}}{wL_{nic}} = \beta_n \log w_c + \gamma_n X_{nic} + \epsilon_{nic}$$

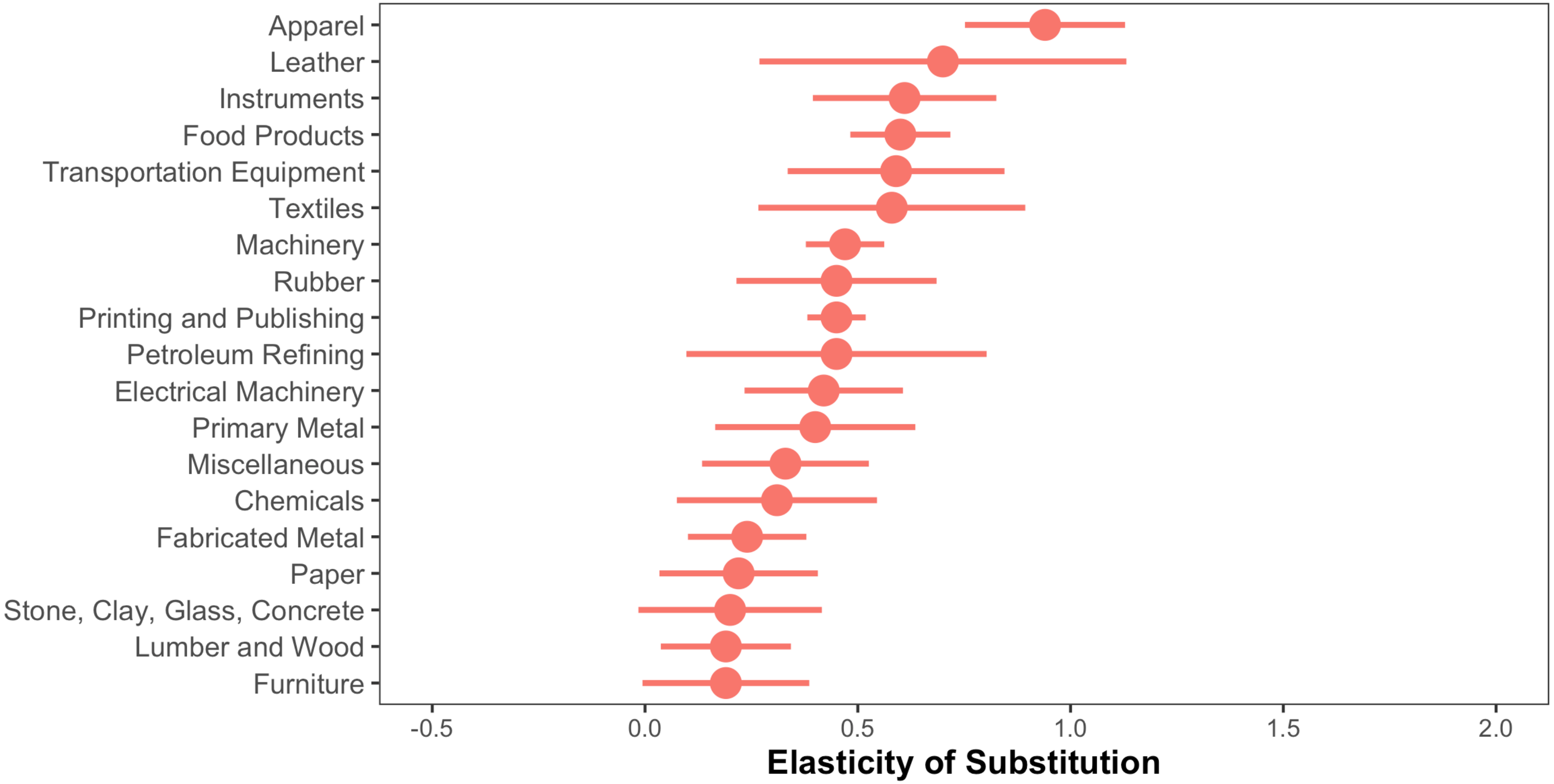
$$\beta_n = \frac{\mathrm{d} \log \frac{rK_{nic}}{wL_{nic}}}{\mathrm{d} \log \frac{w_c}{r_c}} = \sigma_n - 1$$

- **Cross-sectional data**
- **Same cost of capital**
- **Residual wage**

3.3 PLANT-LEVEL ELASTICITY OF SUBSTITUTION

0.3 - 0.7

range between **0.3-0.7**



3.3.1 IV

Bartik Instrument

Heterogeneity of industrial composition

Industry expanding in employment → labor demand → w_c

$$g_n(t) = \frac{1}{10}\ln\left(\frac{L_n(t)}{L_n(t-10)}\right)$$

$$Z_j(t) = \sum_{n \in N^S} \omega_{j,n}(t-10)\, g_n(t)$$

$$\frac{d(\text{Labor demand})}{d(\text{Local expanding in employment})}$$

3.3.1 IV

Beaudry, Green, Sand version

Heterogeneity of industrial composition

Industry wage premium → labor supply → w_c

$$\frac{d(\text{Labor supply})}{d(\text{Local wage premium})}$$

$$\sum_{n \in N^S} \hat{\omega}_{j,n}(t)[v_n(t) - v_n(t-10)]$$

$$\sum_{n \in N^S} v_n(t)[\hat{\omega}_{j,n}(t) - \omega_{j,n}(t-10)]$$

3.3.1 IV

This paper's version

<u>Short-coming</u> of previous IV: Ignorant of input-output linkages

Better Amenities → lower wage

IV: Measures of local amenities based on **<u>climate</u>** and **<u>geography</u>**

3.3.1 IV

$$\sigma_n^N = (1 - \chi_n)\sigma_n + \chi_n\left[\left(1 - \bar{s}_n^M\right)\varepsilon_n + \bar{s}_n^M \zeta_n\right]$$

IV ESTIMATES OF THE PLANT CAPITAL-LABOR SUBSTITUTION ELASTICITY

Year	OLS		Bartik	BGS	Amenities		All
1987	0.44 *(0.04)*	0.54 *(0.03)*	0.52 *(0.04)*	0.45 *(0.09)*	0.45 *(0.07)*	0.48 *(0.06)*	0.51 *(0.04)*
1992	0.47 *(0.03)*	0.52 *(0.03)*	0.45 *(0.04)*	0.48 *(0.04)*	0.57 *(0.06)*	0.55 *(0.05)*	0.50 *(0.03)*
1997	0.29 *(0.05)*	0.48 *(0.04)*	0.41 *(0.11)*	0.36 *(0.08)*	0.28 *(0.09)*	0.40 *(0.07)*	0.41 *(0.05)*
2002	0.31 *(0.06)*	0.48 *(0.05)*	0.31 *(0.10)*	0.37 *(0.06)*	0.33 *(0.13)*	0.42 *(0.11)*	0.42 *(0.06)*
2007	0.45 *(0.04)*	0.58 *(0.03)*	0.51 *(0.05)*	0.56 *(0.05)*	0.49 *(0.09)*	0.53 *(0.07)*	0.54 *(0.04)*
Wage	Pop Census	LBD	LBD	LBD	Pop Census	LBD	LBD

+0.13 → **0.3 - 0.6** ↔

3.3.2 OTHER THREATS TO IDENTIFICATION

Rental rate

- Reflect wage
- Difference in creditworthiness
- Different capital taxes and subsidies

3.3.2 OTHER THREATS TO IDENTIFICATION

ROBUSTNESS CHECKS FOR PLANT CAPITAL-LABOR SUBSTITUTION ELASTICITY

	(1) Separate OLS	(2) Singe OLS **(Baseline)**	(3) Equipment Capital	(4) Firm FE	(5) State FE	(6) ASM Only	(7) Book Value Capital
1987	0.43	0.44 *(0.04)*	0.45 *(0.03)*	0.57 *(0.07)*	0.39 *(0.04)*	0.40 *(0.08)*	0.42 *(0.04)*
1992	0.48	0.47 *(0.03)*	0.47 *(0.03)*	0.65 *(0.06)*	0.31 *(0.03)*	0.67 *(0.07)*	0.39 *(0.03)*
1997	0.34	0.29 *(0.05)*		0.66 *(0.06)*	0.32 *(0.05)*	0.42 *(0.09)*	0.27 *(0.05)*
2002	0.34	0.31 *(0.06)*		0.59 *(0.06)*	0.41 *(0.07)*	0.52 *(0.09)*	0.22 *(0.07)*
2007	0.38	0.45 *(0.04)*		0.55 *(0.07)*	0.48 *(0.05)*	0.37 *(0.07)*	0.39 *(0.04)*

-0.05 +0.08 +0.21

- Firm-wide wage setting procedures compress wage differences within firms
- Measure error in plant-level capital stock

3.4 AGGREGATION

$$\sigma_n^N = (1-\chi_n)\sigma_n + \chi_n\left[\left(1-\bar{s}_n^M\right)\varepsilon_n + \bar{s}_n^M\zeta_n\right]$$

ζ_n **Plant elasticity of substitution between materials and non-materials input**

Same regression model

$$\log\frac{rK_{nic} + wL_{nic}}{qM_{nic}} = (1-\zeta)(1-\alpha_{nic})\log w_c + \gamma_n X_{nic} + \epsilon_{nic}$$

PLANT-LEVEL ELASTICITIES OF SUBSTITUTION

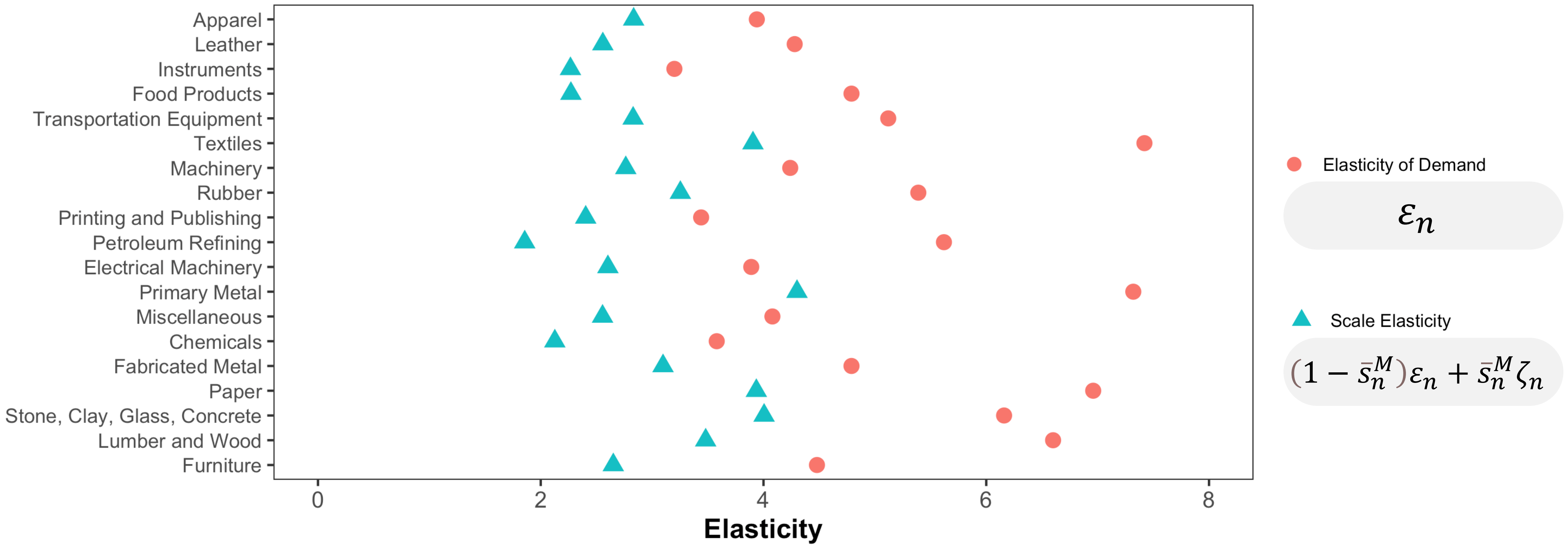
1987	1.03 *(0.12)*
1992	0.83 *(0.10)*
1997	0.69 *(0.07)*
2002	0.78 *(0.08)*
2007	0.57 *(0.06)*

3.4 AGGREGATION

$$\sigma_n^N = (1-\chi_n)\sigma_n + \chi_n\left[(1-\bar{s}_n^M)\varepsilon_n + \bar{s}_n^M \zeta_n\right]$$

ε_n **Optimal price setting behavior: Profit maximization**

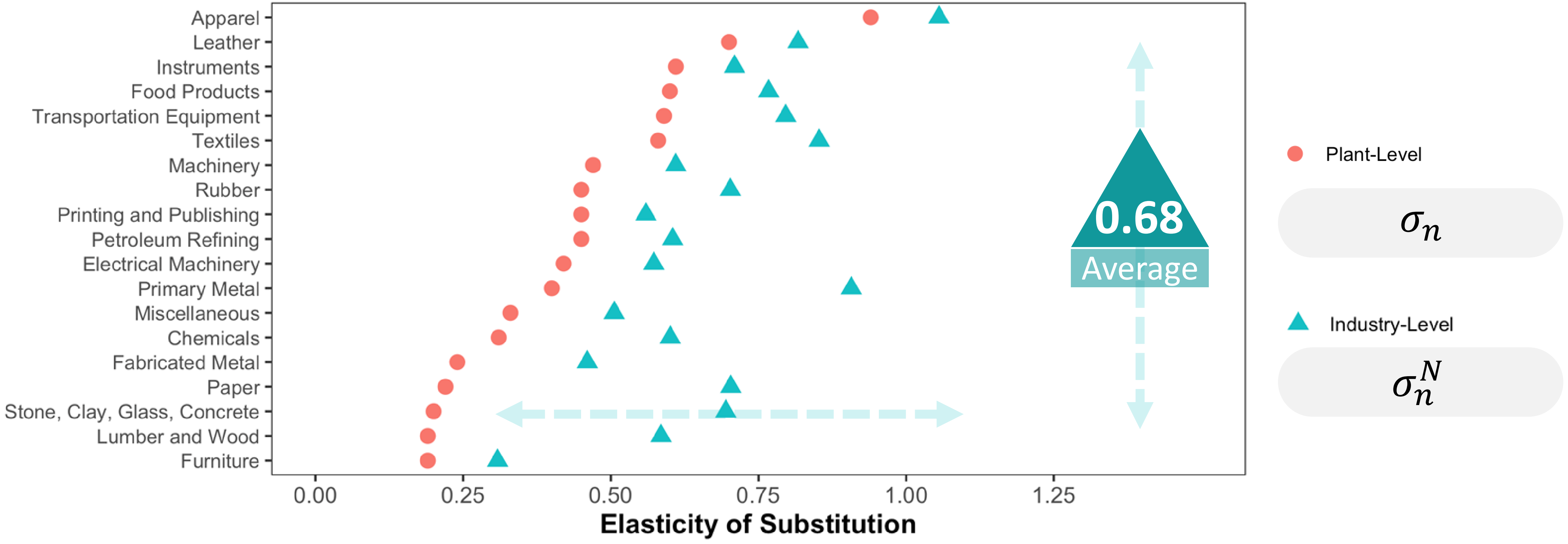
$$\frac{\varepsilon}{\varepsilon - 1} = \frac{P}{MC}$$



3.4 AGGREGATION

$$\sigma_n^N = (1-\chi_n)\sigma_n + \chi_n\left[(1-\bar{s}_n^M)\varepsilon_n + \bar{s}_n^M \zeta_n\right]$$

σ_n^N Aggregation of industrial elasticity of substitution



3.4 AGGREGATION

$$\sigma^{agg} = (1-\chi^{agg})\bar{\sigma}^N + \chi^{agg}[(1-\bar{s}^M)\eta + \bar{s}^M\bar{\zeta}^N]$$

$$\log q_{n,t} = -\eta \log p_{n,t} + \alpha_n + \beta_t + Controls + \varepsilon_n$$

IV: Avg cost as supply shifter

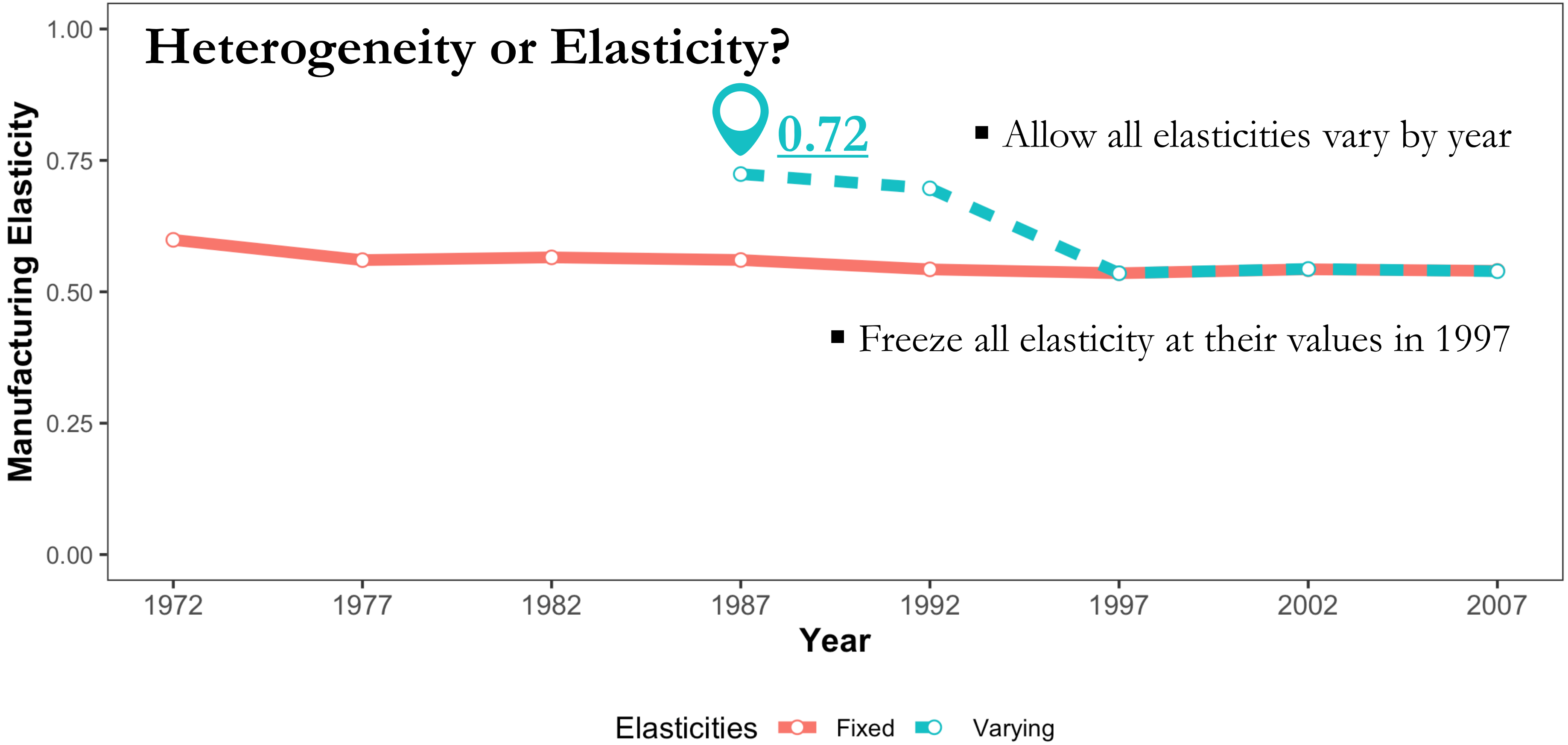
Results: η **around 1, set to 1**

	Industry Definition				
Instrument	4-Digit			2-Digit	
None	0.87 *(0.02)*	0.87 *(0.02)*	0.46 *(0.03)*	0.97 *(0.05)*	-0.07 *(0.04)*
APL	1.23 *(0.01)*	1.28 *(0.01)*	2.67 *(0.05)*	1.14 *(0.04)*	1.85 *(0.34)*
Avg Cost	1.17 *(0.01)*	1.13 *(0.01)*	1.89 *(0.03)*	1.16 *(0.04)*	0.65 *(0.09)*
Industry-Year Controls	None	3-Digit FE	6-Digit Trends	None	3-Digit Trends

3.4 AGGREGATION

$$\sigma^{agg} = (1-\chi^{agg})\bar{\sigma}^N + \chi^{agg}[(1-\bar{s}^M)\eta + \bar{s}^M\bar{\zeta}^N]$$

σ^{agg} **Manufacturing sector-level elasticity of substitution**



ε_n 5.0 → **3.3**

σ_n 0.48 → **0.34**

4 ADDITIONAL MARGINS OF ADJUSTMENT

Entry and Exit

$$\sigma^{\text{agg}} = (1-\chi)\left[\sigma + \frac{\int(\alpha_\tau - \alpha)\frac{\mathrm{d}E_\tau}{\mathrm{d}\ln w/r}\theta_\tau \mathrm{d}T(\tau)}{\int \alpha_\tau(1-\alpha_\tau)\theta_\tau \mathrm{d}T(\tau)}\right] + \chi[(1-\bar{s}^M)\varepsilon + \bar{s}^M\bar{\zeta}^N]$$

Upper bound: Baseline Model

$$\frac{\varepsilon}{\varepsilon-1}\frac{Variable\ Costs}{Variable\ Costs+Overhead\ Costs}=\frac{\hat{\varepsilon}}{\hat{\varepsilon}-1}$$

Lower bound: Long-run elasticity$=\frac{\beta}{1-\rho_5-\rho_{10}}$

$$\log\frac{K_{itc}}{L_{itc}} = \rho_5 \log\frac{K_{itc}}{L_{itc}} + \rho_{10}\log\frac{K_{itc}}{L_{itc}} + \beta\log\frac{w_{tc}}{r_t} + \eta_i + \delta_t + \epsilon_{nic}$$

4 ADDITIONAL MARGINS OF ADJUSTMENT

Entry and Exit

$$\sigma^{\text{agg}} = (1-\chi)\left[\sigma + \frac{\int (\alpha_\tau - \alpha)\frac{\mathrm{d}E_\tau}{\mathrm{d}\ln w/r}\theta_\tau \mathrm{d}T(\tau)}{\int \alpha_\tau(1-\alpha_\tau)\theta_\tau \mathrm{d}T(\tau)}\right] + \chi[(1-\bar{s}^M)\varepsilon + \bar{s}^M\bar{\zeta}^N]$$

Upper bound: Baseline Model

$$\frac{\varepsilon}{\varepsilon-1}\frac{Variable\ Costs}{Variable\ Costs+Overhead\ Costs}=\frac{\hat{\varepsilon}}{\hat{\varepsilon}-1}$$

Interval [0.35,0.65]

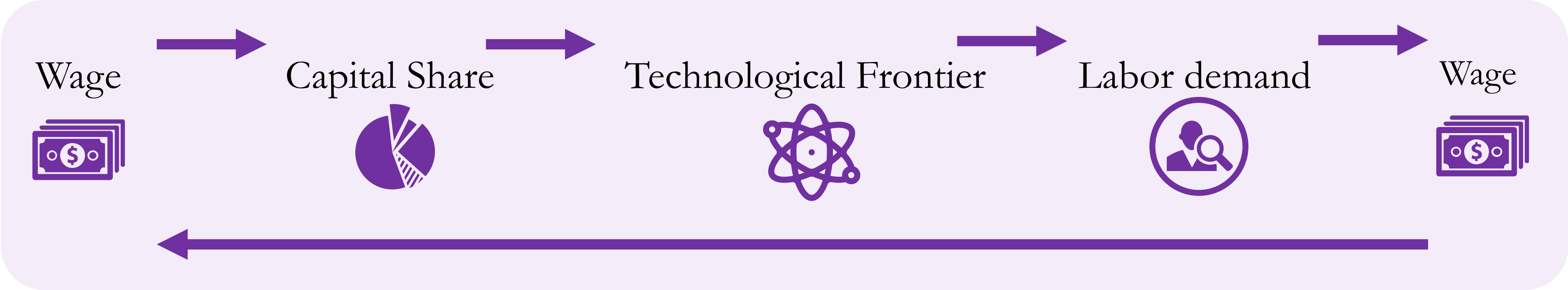
0.35 - 0.65

Lower bound: Long-run elasticity$=\frac{\beta}{1-\rho_5-\rho_{10}}$

$$\log\frac{K_{itc}}{L_{itc}} = \rho_5 \log\frac{K_{itc}}{L_{itc}} + \rho_{10}\log\frac{K_{itc}}{L_{itc}} + \beta\log\frac{w_{tc}}{r_t} + \eta_i + \delta_t + \epsilon_{nic}$$

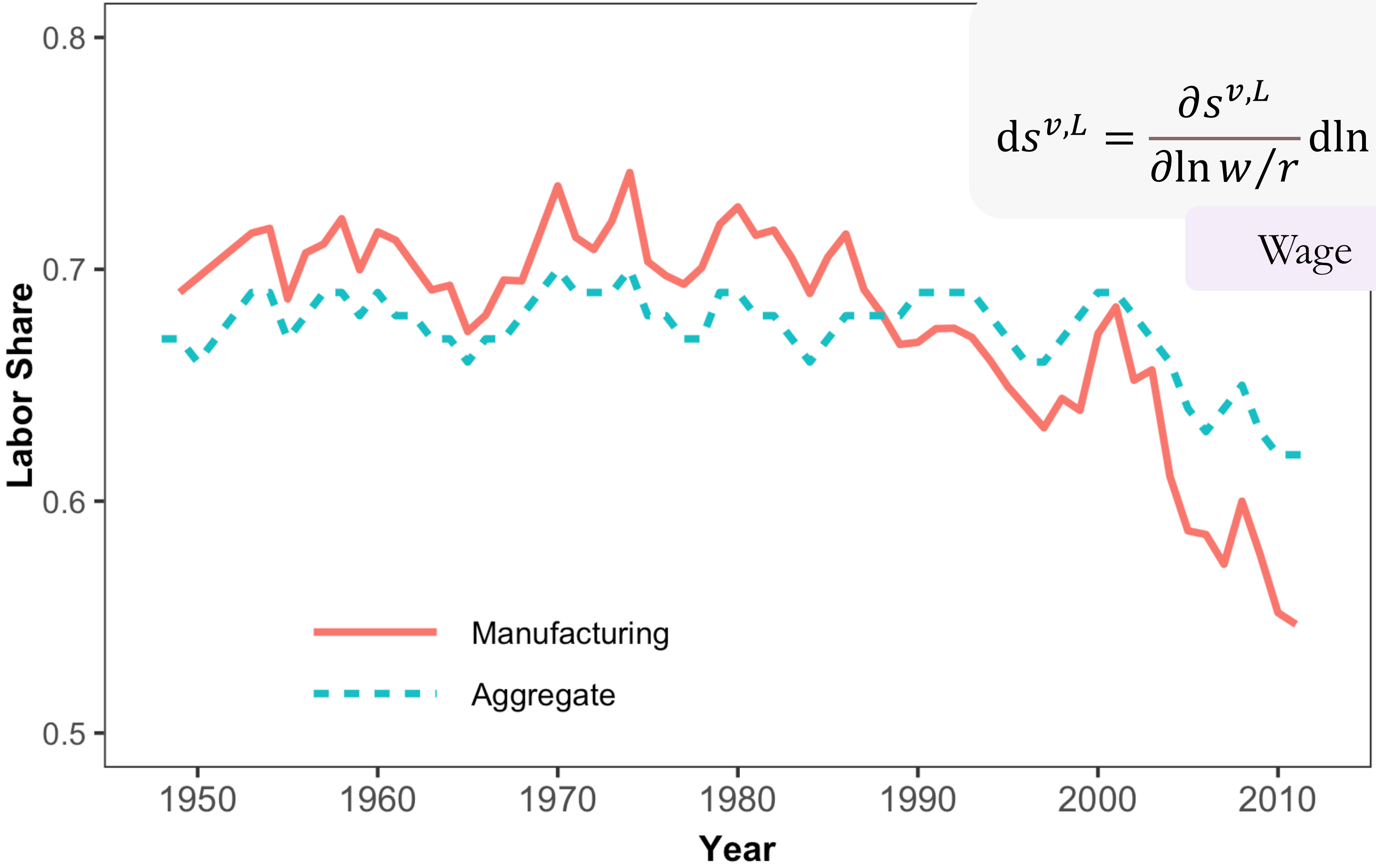
4 ADDITIONAL MARGINS OF ADJUSTMENT

- **Adjustment and Friction**
  - Adjustment cost
  - Misallocation frictions
- **Shifts in the technological frontier**



- **Other considerations**
  - Intangible capital
  - Endogenous location choice

5 THE DECLINE OF THE LABOR SHARE



Decomposition of the decline

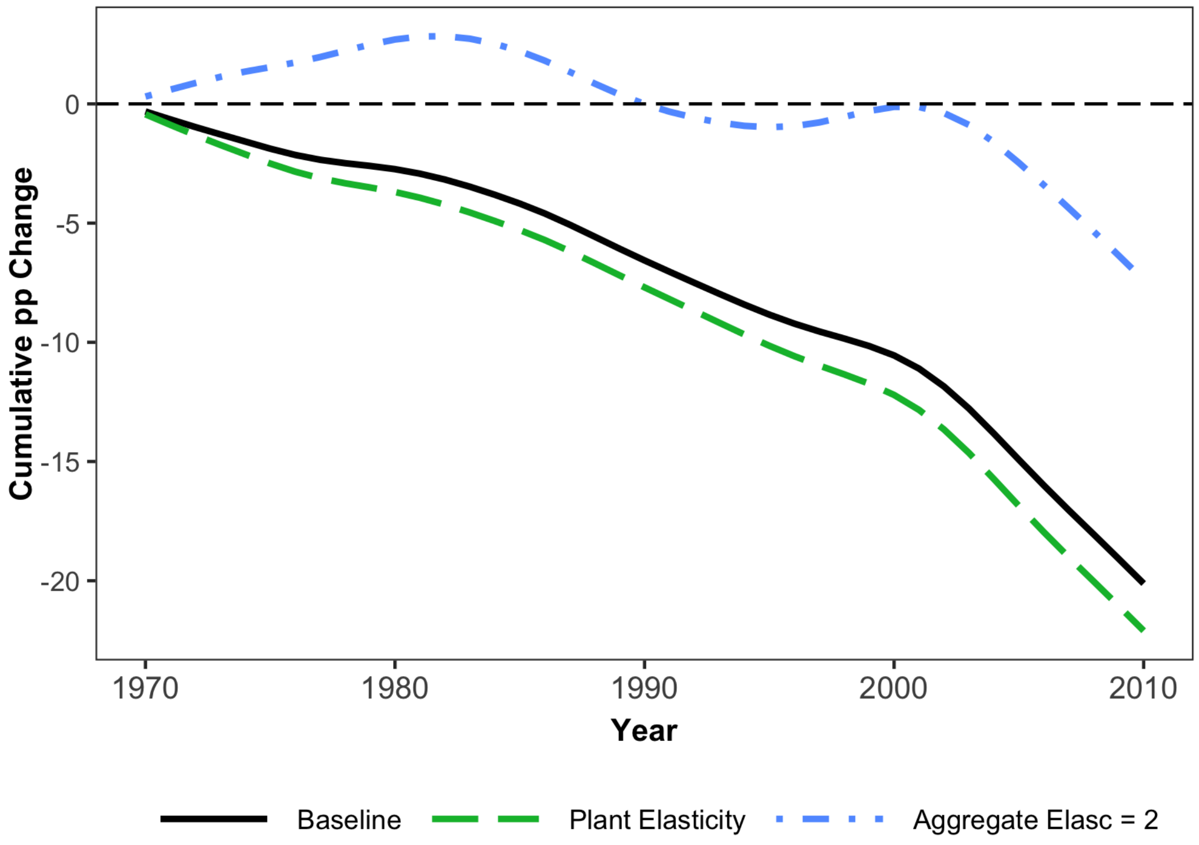
$$\mathrm{d}s^{v,L} = \frac{\partial s^{v,L}}{\partial \ln w/r} \mathrm{d}\ln w/r + \left(\mathrm{d}s^{v,L} - \frac{\partial s^{v,L}}{\partial \ln w/r} \mathrm{d}\ln w/r \right)$$

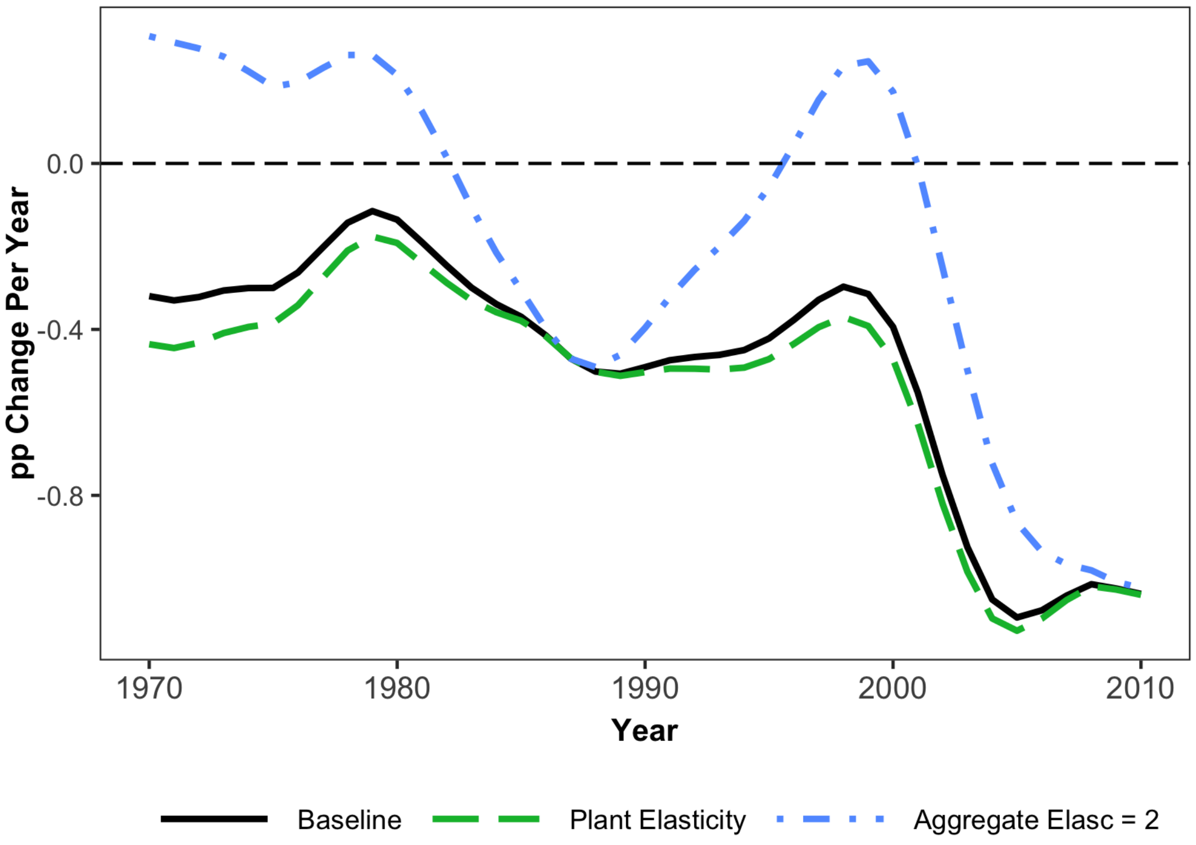
Wage

Tech

5 THE DECLINE OF THE LABOR SHARE

Technical change impacts the labor share





Micro Data

Macro Technology

THANK YOU

易诗凯
洪伟励
邹洺昊
曾子昂
孙菁桐