Micro Data and Macro Technology

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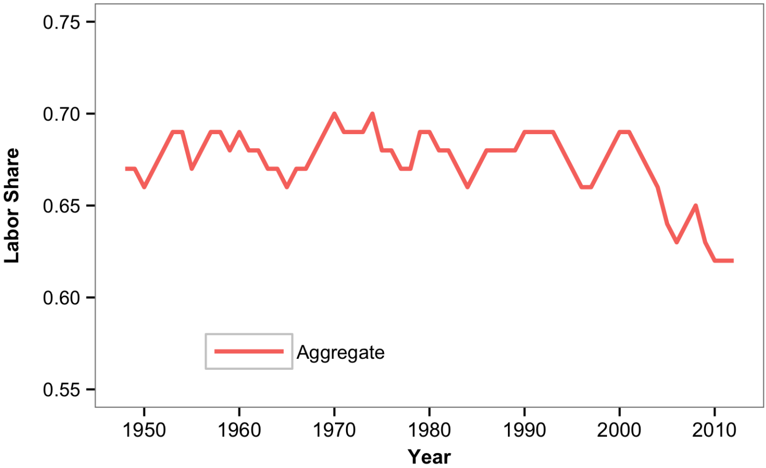
Labor's Share has Fallen



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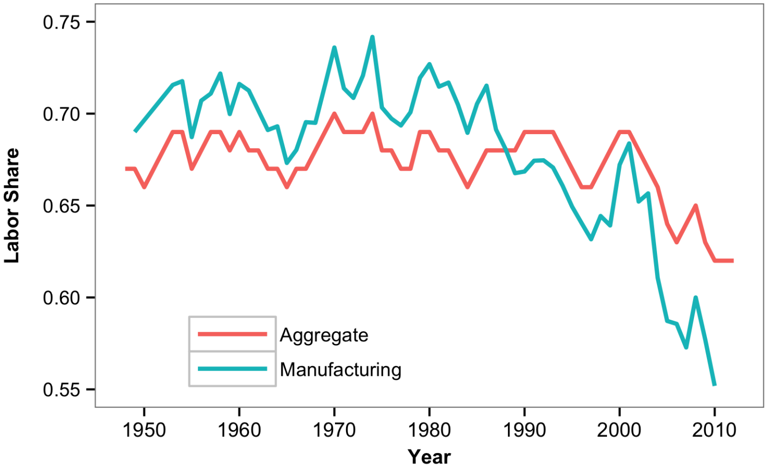

Why has the labor share fallen?

- Factor Prices
  - Fall in Investment Prices: Karabarbounis & Neiman (2014)
  - Capital Accumulation: Piketty (2014)
- Biased Technical Change
  - Offshoring/Trade: Elsby, et al (2013)
  - Automation/ IT
- Key is the Aggregate Elasticity of Substitution:

$$\sigma \equiv \frac{\partial \ln K/L}{\partial \ln w/r}$$

Aggregate Capital-Labor Elasticity of Substitution

- How do factor prices and technical change affect factor compensation?

- Important for many questions
  - How do tax policies impact investment and welfare?
  - How does trade affect factor compensation and factor prices?
  - What are the features of long run growth?

- Impossibility Theorem of Diamond, McFadden, & Rodriguez (1978)
  - Cannot identify σ or bias of tech. with time series of quantities and prices
  - Need variation in prices that is independent of technology

Two Approaches to Estimate Elasticity

1. Use time series of aggregate data
   - Strong assumptions about technical change
   - Estimates vary
     - Antras (2004): 0.5-1.0
     - Klump et al. (2007): 0.5-0.6
     - Karabarbounis & Neiman (2014): 1.25
     - Piketty (2014): 1.3-1.6
     - Herrendorf et al. (2014): 0.84
     - Leon-Ledesma et al (2010): Identification difficult even with assumptions.

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   - Typical estimate: 0.4-0.5
   - Identifies a micro elasticity of substitution

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   - Typical estimate: 0.4-0.5
   - Identifies a micro elasticity of substitution

- Houthakker (1955): Disconnect between micro and macro elasticities
  - If macro elasticity is necessary, are estimates of micro elasticity useful?

Related Literature

We build up from micro data

- Construct aggregate elasticity using theory and microdata

$$\sigma^{agg} \equiv \frac{\partial \ln K/L}{\partial \ln w/r}$$

We build up from micro data

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$$\underbrace{\sigma^{agg}}_{\substack{\text{aggregate}\\ \text{EoS}}} = (1-\chi)\underbrace{\sigma}_{\substack{\text{plant level}\\ \text{EoS}}} + \chi\underbrace{\varepsilon}_{\substack{\text{plant level}\\ \text{elasticity of demand}}}$$

We build up from micro data

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$$\underbrace{\sigma^{agg}}_{\text{aggregate EoS}} = (1-\chi)\underbrace{\sigma}_{\text{plant level EoS}} + \chi\underbrace{\varepsilon}_{\text{plant level elasticity of demand}}$$

  - σ: substitution within plants
  - ε: substitution across plants
  - χ: heterogeneity in capital intensity
    - proportional to variance of capital shares

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  - σ: substitution within plants
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- Our approach
  - Estimate σ and ε
  - Compute χ from the cross-section
  - σ^{agg} not a structural parameter

Cross-section in 1987 $\Rightarrow$ σ^{agg} in 1987

Roadmap

- Model
- US Manufacturing Sector
  - Micro Parameters
  - Aggregate Elasticity
  - Decline in Labor Share

Baseline Model

- Industries (indexed by $n \in N$) composed of plants (indexed by $i \in I_n$).

$$Y^{agg} = \left(\sum_{n \in N} D_n Y_n^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \qquad Y_n = \left(\sum_{i \in I_n} D_i Y_i^{\frac{\varepsilon_n - 1}{\varepsilon_n}} \right)^{\frac{\varepsilon_n}{\varepsilon_n - 1}}$$

- Plant i in n produces with CES production function with EoS σ_n:

$$Y_{ni} = \left[(A_{ni} K_{ni})^{\frac{\sigma_n - 1}{\sigma_n}} + (B_{ni} L_{ni})^{\frac{\sigma_n - 1}{\sigma_n}} \right]^{\frac{\sigma_n}{\sigma_n - 1}}$$

- For now, ignore adjustment costs, returns to scale, and extensive margin

Baseline Model

- Industry-level elasticity of substitution for industry n:

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

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- Heterogeneity Index

$$\chi_n \equiv \frac{\sum_{i\in I_n}(\alpha_{ni}-\alpha_n)^2\,\theta_{ni}}{\alpha_n(1-\alpha_n)}$$

- Nests nicely: Similar to go from industry to aggregate Details

Materials

$$Y_{ni} = \left[F_{ni}(K_{ni}, L_{ni})^{\frac{\zeta_n - 1}{\zeta_n}} + C_{ni} M_{ni}^{\frac{\zeta_n - 1}{\zeta_n}} \right]^{\frac{\zeta_n}{\zeta_n - 1}}$$

- Industry elasticity of substitution:

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

- $\bar{s}_n^M$ is weighted average of plants' materials shares

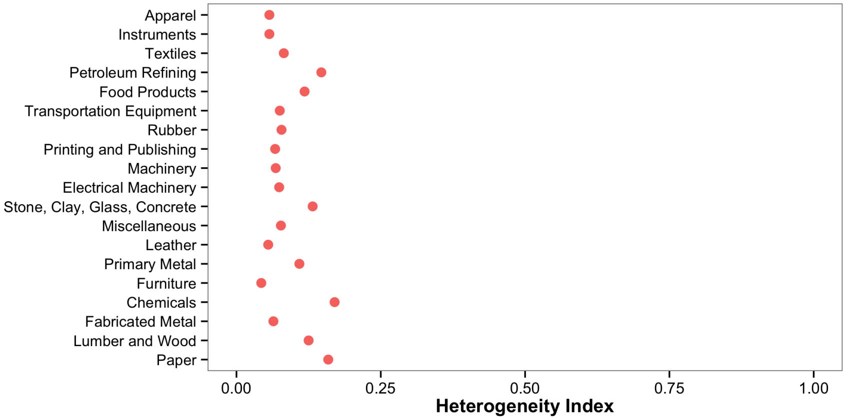
- Intuition:
  - $\bar{s}_n^M \searrow 0 \quad \Rightarrow$ plants grow/shrink
  - $\bar{s}_n^M \nearrow 1 \quad \Rightarrow$ substitute towards/away from materials

Data from US manufacturing censuses

- US Census of Manufactures
  - Every five years - we use 1987 and 1997
  - We exclude small plants with less than five employees: no capital data
  - Each census: More than 180,000 plants
- Annual Survey of Manufactures (ASM)
  - Survey of 50,000 plants every year in a limited panel
  - Allows us to construct perpetual inventory measures of capital
  - Includes benefits, payroll taxes

Heterogeneity Indices

$$(1 - \chi_n)\sigma_n + \chi_n[(1 - \bar{s}_n^M)\varepsilon_n + \bar{s}_n^M \zeta]$$



Back

Plant capital-labor elasticity of substitution

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

- Approach (Raval, 2014): Exploit geographic variation in wages

$$\ln\left(\frac{rK}{wL}\right)_{ni} = (\sigma_n - 1)\ln w_{ni}^{MSA} + CONTROLS + \epsilon_{ni}$$

- w_{ni}^{MSA}: wage in i's MSA from Population Censuses 5% sample
  - MSA wage controlling for education, experience, and occupation
- Wage differences are persistent $\Rightarrow$ σ is long-run elasticity

Plant capital-labor elasticity of substitution

$$\ln\left(\frac{rK}{wL}\right)_{ni} = (\sigma_n - 1)\ln w_{ni}^{MSA} + CONTROLS + \epsilon_{ni}$$

	Separate OLS	Single OLS	Bartik Instrument	Equipment Capital	Firm FE
1987	0.52	0.52 *(0.04)*	0.49 *(0.05)*	0.53 *(0.03)*	0.49 *(0.05)*
1997	0.52	0.46 *(0.03)*	0.52 *(0.08)*		0.48 *(0.08)*

- Wages driven by local productivity, skills?
- Capital produced locally?
- Credit constraints?

- Chirinko et al. (2011): $\sigma = 0.4$

Bartik Industry Estimates

Scale Elasticity

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

- Demand Elasticity, ε_n: Average estimate: 3.9. Range: 3-5.
  - Back out from average revenue-cost ratio Alternative Strategy

$$\frac{P_i Y_i}{wL_i + rK_i + qM_i} = \frac{\varepsilon_n}{\varepsilon_n - 1}$$

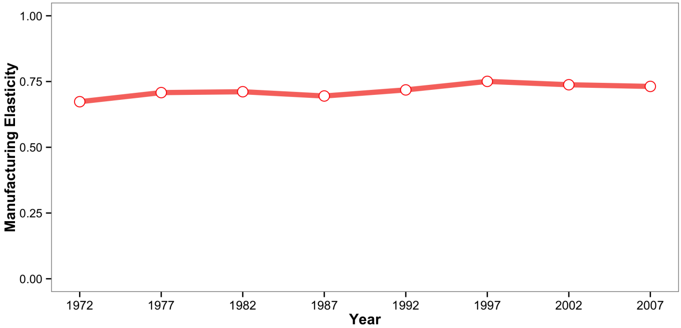
- Materials / K-L Elasticity, $\zeta_n = 0.90$:
  - Exploit geographic variation in wages
  - How does $\frac{qM_i}{rK_i+wL_i}$ vary with local wage? Details

- Materials shares, $\bar{s}_n^M$: Average 0.59 Figure

- Cross-industry substitution, η: 1.0 Estimate

Aggregate Elasticity of Substitution

Estimate in 1987 : $\sigma^{agg} = 0.70$



- Robustness
  - Extensive margin Details, Sorting Details
  - Returns to scale Details, Non-CES production Details
  - Adjustment costs Details, Misallocation Details
  - Demand elasticity Alternative Strategy, Demand System Details

Industry elasticities

Decomposition of Labor Share Decline

$$ds^{v,L} = \underbrace{\frac{\partial s^{v,L}}{\partial \ln w/r} d \ln w/r}_{\text{prices}} + \underbrace{ds^{v,L} - \frac{\partial s^{v,L}}{\partial \ln w/r} d \ln w/r}_{\text{``bias of tech. change''}}$$

- Use σ^{agg} to measure contribution of factor prices
- "Bias of technical change" is residual

- Factor Prices Details
  - w: from NIPA, use Jorgenson to control for changes in skill
  - r: price indices from NIPA, tax rates/depreciation allowances from Jorgenson

Biased Technical Change Drives Labor Share Decline

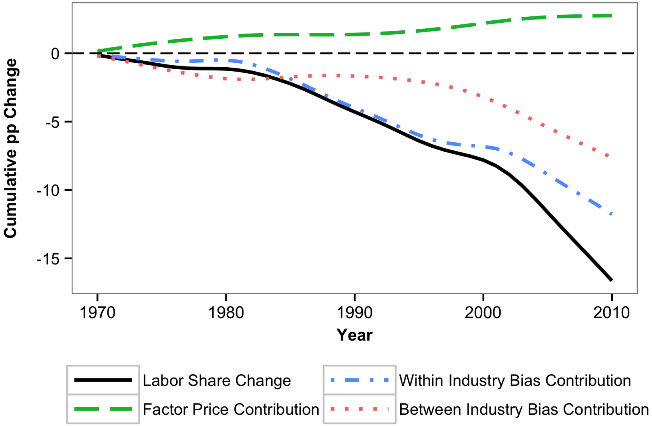
		Contributions from:	
Period	Labor Share Change	Factor Prices	Bias
1970-1999	-0.25%	0.07%	-0.32%
2000-2010	-0.79%	0.05%	-0.84%

- Contribution of factor prices approximately constant and small
  - Casts doubt on explanations that work solely through factor prices
- Stagnant wages?
  - Before 1970, real wage growth $1.9pp$ higher
  - Can only explain 1/6 of decline
- Candidates: offshoring, automation, IT investment, decline of unions...

Aggregate Time Series

Within and Between Contributions to Labor Share Decline

$$s^{v,L} = \sum_n \frac{VA_n}{VA} s_n^{v,L}$$



Annualized Changes

Conclusion

- We develop approach to estimate aggregate elasticity
  - Function of micro parameters and statistics of micro heterogeneity
- Aggregate elasticity of substitution in US Manufacturing sector
  - σ^{agg} has been relatively stable since 1970 ≈ 0.7
- We used estimate to assess decline of labor share
  - Little role for factor prices
  - Within-industry bias of technical change most important
  - Shift in industry composition played role since 2000
- Future work
  - Assess causes of decline in labor share
  - Decompose increase in skill premium

Manufacturing Sector

- Assume nested CES demand

$$Y^{agg} = \left(\sum_{n \in N} D_n Y_n^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \qquad Y_n = \left(\sum_{i \in I_n} D_i Y_i^{\frac{\varepsilon_n - 1}{\varepsilon_n}} \right)^{\frac{\varepsilon_n}{\varepsilon_n - 1}}$$

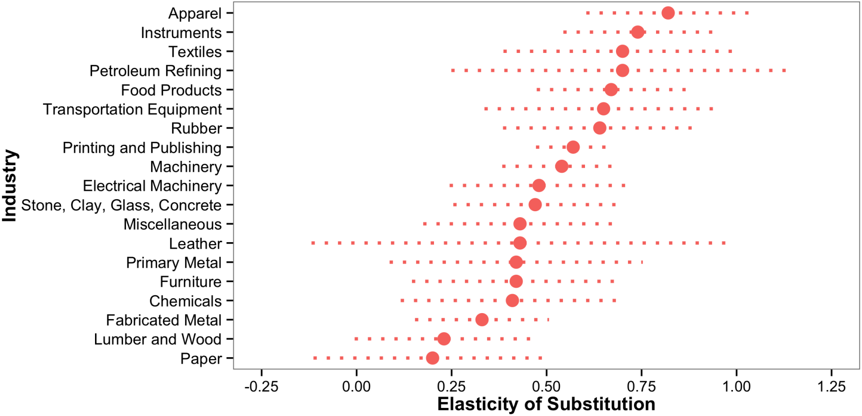
- Aggregate elasticity of substitution

$$\sigma^{agg} = \left(1 - \chi^{agg}\right) \bar{\sigma}^N + \chi^{agg} \eta$$

$$\bar{\sigma}^N = \sum_{n \in N} \omega_n^N \sigma_n^N \qquad \chi^{agg} = \sum_{n \in N} \frac{(\alpha_n - \alpha)^2}{\alpha(1-\alpha)} \theta_n$$

Back

Plant-level elasticities range between 1/4 and 3/4



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Endogeneity of wages?

- Instrument using shock to local labor demand (Bartik (1991))
- Interaction between:
  - 10 year change in national employment of 4-digit service industry
  - local MSA exposure to the industry

$$Z_j = \sum_{n \in N^{service}} \underbrace{\omega_{j,n}(t-10)}_{\substack{\text{share of } L_j \\ \text{in industry } n}} \times \underbrace{g_{n(t)}}_{\substack{\text{national growth in} \\ \text{industry n}}}$$

- Estimate: 0.49 (compared to 0.52 in baseline)

Back to Micro

Alternative Estimate of Demand Elasticity

- Adapt method of Foster, Haltiwanger, Syverson (2008)
  - For some products, Census provides prices and quantities
  - Homogenous products only: units are meaningful
- Trace out demand curve
  - Regress quantity on price
  - Use average cost as instrument
- Average of Industry-level elasticities:

$$\bar{\sigma}^N = .54 \text{ (Baseline)}, \qquad \bar{\sigma}^N = .52 \text{ (IV)}, \qquad \bar{\sigma}^N = .54 \text{ (FHS)}$$

Back to Micro Back to Macro

Elasticity of Substitution between M and K-L bundle

$$\ln \frac{qM_i}{rK_i + wL_i} = (\zeta - 1)(1 - \alpha_i) \ln w_j + \epsilon_{ij}$$

	No Local Content	Local Content
1987	0.90 *(0.06)*	0.87 *(0.07)*
1997	0.67 *(0.04)*	0.63 *(0.05)*
N	$\approx 140,000$	

- No local content: implicit assumption that materials market is national
- Local content: some materials are sourced locally affected
  - Materials price would be affected by local wage
  - Local content: fraction of materials produced within 100 miles
  - Use Commodity Flow Survey and I/O tables to proxy for local content

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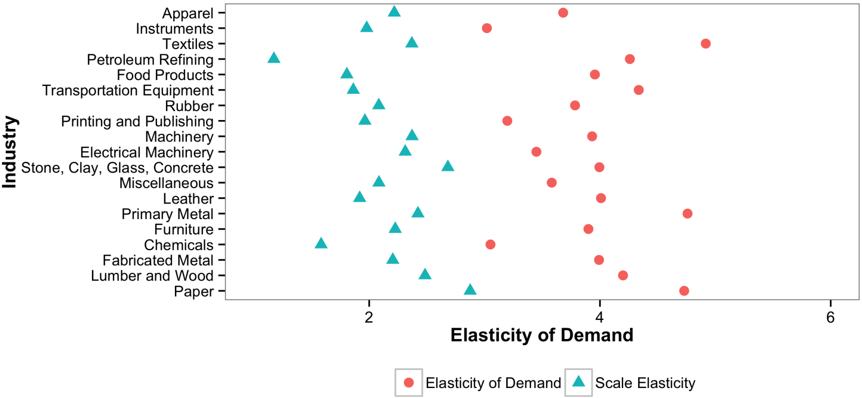
Scale Elasticity

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



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Industry elasticity of demand

$$\sigma^{agg} = (1 - \chi^{agg})\,\bar{\sigma}^N + \chi^{agg}\eta$$

- Panel of two-digit manufacturing industries

$$\log y_n = -\eta \log p_n + CONTROLS + \epsilon$$

- Instrument for price using average cost per unit produced for industry

Instrument	(1)	(2)
None	0.91 *(0.03)*	0.37 *(0.05)*
APL	1.14 *(0.04)*	1.05 *(0.06)*
Avg Cost	1.04 *(0.03)*	0.77 *(0.05)*
Industry-Year Controls	None	Trends

Back

Returns to Scale

- i produces with $\qquad Y_i = G_i(K, L, M)^{\gamma}$
  - G_i is constant returns to scale, $\gamma < \frac{\varepsilon}{\varepsilon - 1}$

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

where x satisfies $\frac{x}{x-1} = \frac{1}{\gamma}\frac{\varepsilon}{\varepsilon - 1}$.

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- Revenue-cost no longer gives markup:

$$\frac{P_i Y_i}{rK_i + wL_i + qM_i} = \frac{1}{\gamma} \frac{\varepsilon}{\varepsilon - 1} = \frac{x}{x - 1}$$

Back

Misallocation

1. Suppose i pays idiosyncratic factor prices $r_i = T_{Ki} r$ and $w_i = T_{Li} w$
   - If σ^{agg} is defined to satisfy
   $$\sigma^{agg} - 1 = \frac{d \ln \left(\sum r_i K_i / \sum w_i L_i \right)}{d \ln w/r}$$
   - Then formulas are unchanged as long as we define
   $$\alpha_i = \frac{r_i K_i}{r_i K_i + w_i L_i} \qquad \theta_i = \frac{r_i K_i + w_i L_i}{\sum_j r_j K_j + w_j L_j}$$
2. If prices differ from shadow costs, need alternative

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Adjustment Costs

- Target capital K_i^* and target L_i^*
- Deviations do not affect estimate of micro elasticity
  - Need deviations from K_i^*, L_i^* to be uncorrelated with MSA wage
  - Satisfied if MSA wage is persistent
- Deviations matter for impact of heterogeneity
  - Likely less important for large plants
- What if all heterogeneity reflected adjustment costs?
  - 1987: $\sigma^{agg} = 0.70$ (baseline 0.70)
  - 1997: $\sigma^{agg} = 0.93$ (baseline 0.77)

Back

Demand System

- Industry Demand Y satisfies

$$1 = \sum_i H_i \left(\frac{Y_i}{Y} \right)$$

  - Homothetic
  - Arbitrary demand elasticities
  - Imperfect pass-through

- Industry elasticity

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

- x is weighted average of $b_i \varepsilon_i$
  - ε_i: local demand elasticity
  - b_i: local pass-through rate

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Relax CES Assumption

- Plant i produces using CRS production function $F_i(K, L)$
- σ_i is i's local elasticity of substitution

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- σ_i is i's local elasticity of substitution
- Industry elasticity of substitution is

$$\sigma_n^N = (1 - \chi_n)\bar{\sigma}_n + \chi_n \varepsilon_n$$

$$\bar{\sigma}_n \equiv \sum_{i \in I_n} \omega_i \sigma_i \qquad \omega_i \equiv \frac{\alpha_i(1-\alpha_i)\theta_i}{\sum_{i' \in I_n} \alpha_{i'}(1-\alpha_{i'})\theta_{i'}}$$

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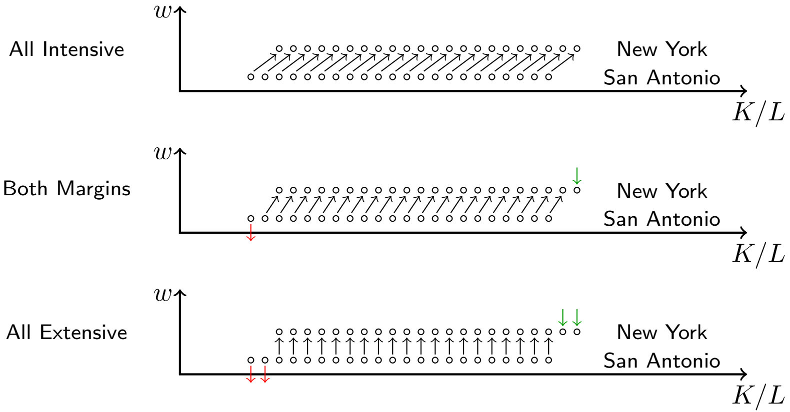
Extensive Margin



- Our estimate of σ is combination of intensive and extensive margin
  - Can't distinguish between extensive and intensive margins
  - But do not need to

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Micro Elasticities

- Raval (2013): On average, $\sigma \approx 0.5$
- Potential problem:
  - If plants sort across locations $\Rightarrow$ we overstate true σ
  - But, industries where moving is difficult (e.g., concrete) look similar to others
- Chirinko, Fazzari, Meyer (2011): $\sigma \approx 0.4$
  - Focuses on long run elasticity
  - Variation in cost of capital
  - Only includes intensive margin

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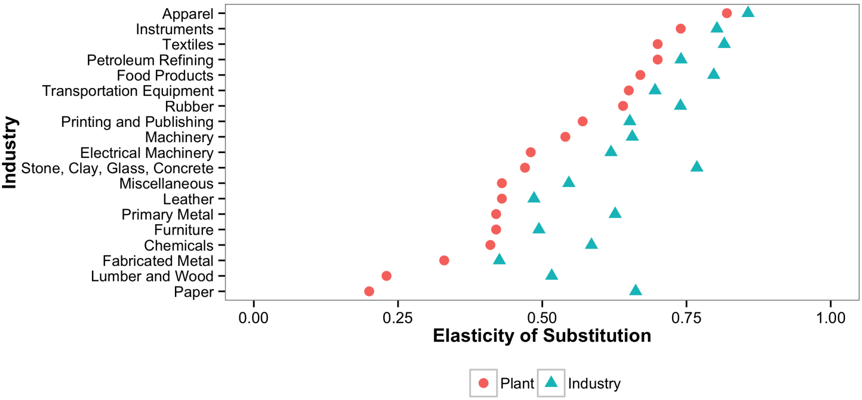
Industry-level Elasticity of Substitution



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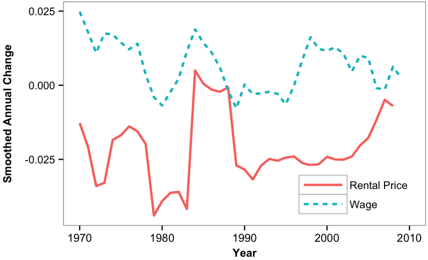
Factor Prices

- Wages
  - NIPA: $\frac{\text{Labor compensation}}{\text{Employees}}$ for manufacturing sector, includes benefits
  - Adjust for changes in skill using series from Jorgenson

- User cost of capital
  - Capital prices from NIPA by type
  - Real rental rate of 3.5%
  - Tax rates and depreciation allowances from Jorgenson



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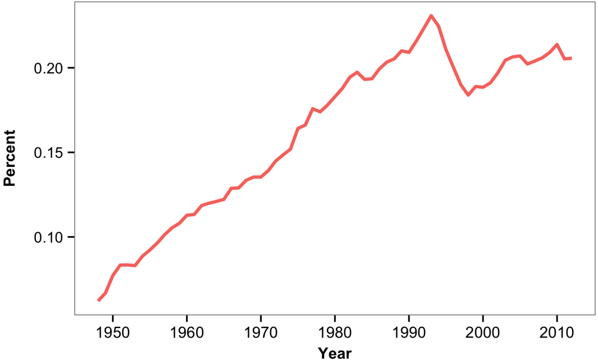
Benefits



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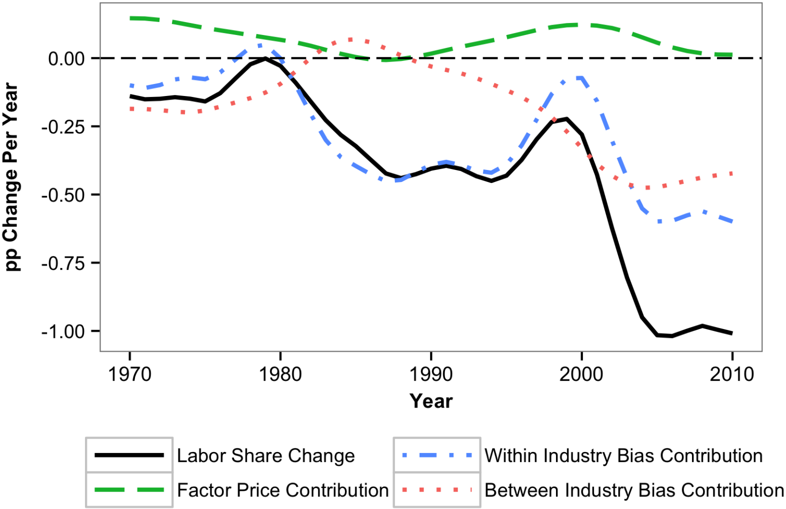
Within and Between Contributions to Labor Share Decline



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Related Literature

- Micro vs. Macro elasticity
  - Houthakker (1955): Pareto distributed productivities
  - Jones (2005); Lagos (2006); Luttmer (2012)
  - Levhari (1968): Distributional assumptions are critical
  - Our approach builds on two good case of Sato (1967)
- Impact of factor prices, accumulation on distribution of income
  - Karabarbounis & Neiman (2014); Piketty (2014); Elsby, et al (2013)
  - Krusell, et al (2000); Acemoglu (2002,2003,2010); Burstein, et al (2014); Autor, et al (2003); Autor, et al (2014)

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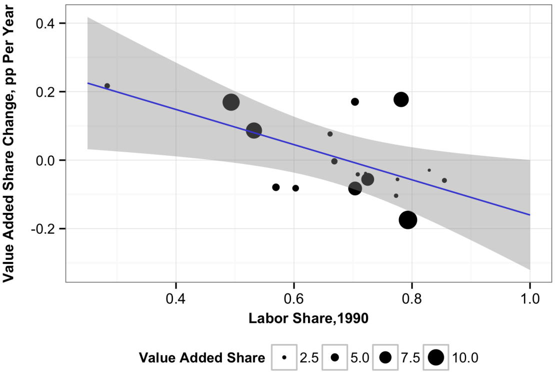
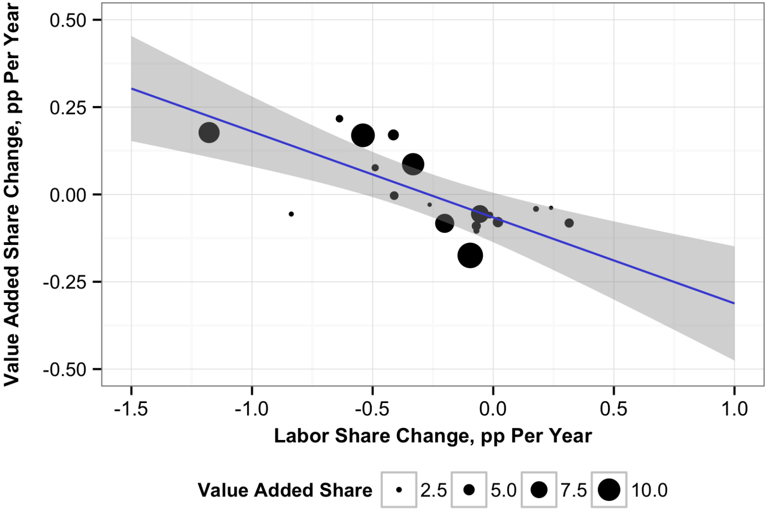
Shift in Composition Across Industries?

$$s^{v,L} = \sum_n \frac{VA_n}{VA} s_n^{v,L}$$



Correlation in Changes

Decline of the Labor Share



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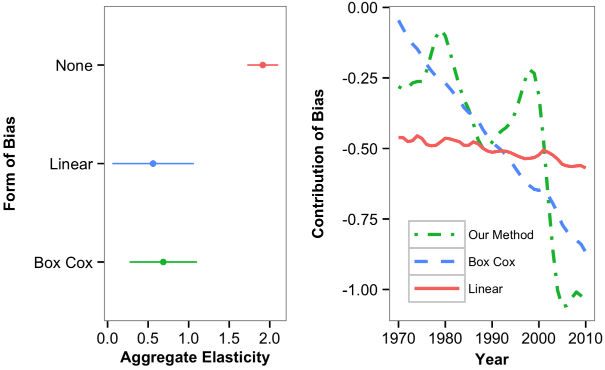
The Aggregate Time Series Approach

- How does our approach compare to literature?

$$\frac{s_l}{1-s_l} = \beta_0 + (\sigma^{agg} - 1)\ln\frac{r}{w} + \ln\phi + \epsilon$$



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Preview of Results

- 1987: plant-level elasticity 0.5, aggregate elasticity 0.7
- Aggregate elasticity relatively stable since 1972, close to 0.7

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- 1987: plant-level elasticity 0.5, aggregate elasticity 0.7
- Aggregate elasticity relatively stable since 1972, close to 0.7
- Decline of labor share: Small role for factor prices
  - Not consistent with: investment specific tech. change, capital accumulation
  - Consistent with: changes in automation, offshoring, collective bargaining
- Biased technical change within industries? Shift in composition?
  - 1970-2000: within-industry more important
  - Since 2000: both within and between are important