Skills and Market Power

Empirical evidence and model results

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Overview

Research question

- Sweden's workforce is becoming better educated.
- Large manufacturing firms employ a more educated workforce.
- College premia and sales-to-variable-cost ratios evolve differently across firm sizes.

How does skill supply affect technology adoption, competition, and firm size?

How do markups affect technology adoption and wage inequality?

Firm heterogeneity and skill premia

- Markup heterogeneity and aggregate productivity:
  - De Loecker, Eeckhout, and Unger (2020), Baqaee and Farhi (2020), Edmond, Midrigan, and Xu (2023).
  - Abstracts from skill heterogeneity.
- Skill premia and skill-biased technical change:
  - Katz and Murphy (1992), Krusell et al. (2000), Autor, Goldin, and Katz (2020).
  - Abstracts from market power.

We propose a model that bridges the two.

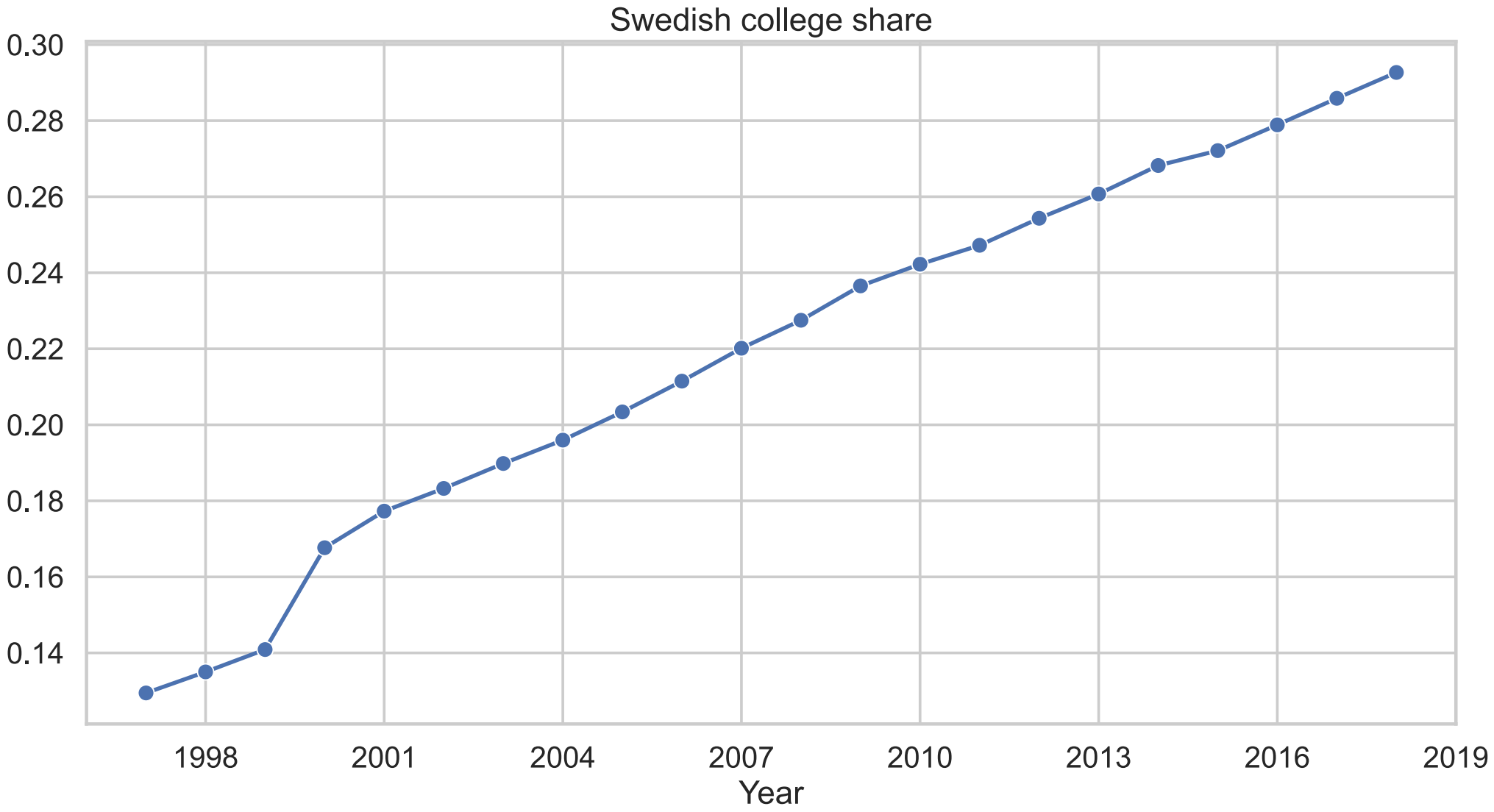
Reading guide

- **Empirical evidence:** Swedish education, wage premia, and firm cost ratios.
- **Model and calibration:** Firm technology choice with product and labor market power.
- **Counterfactuals:** Higher skill supply and the removal of markup heterogeneity.

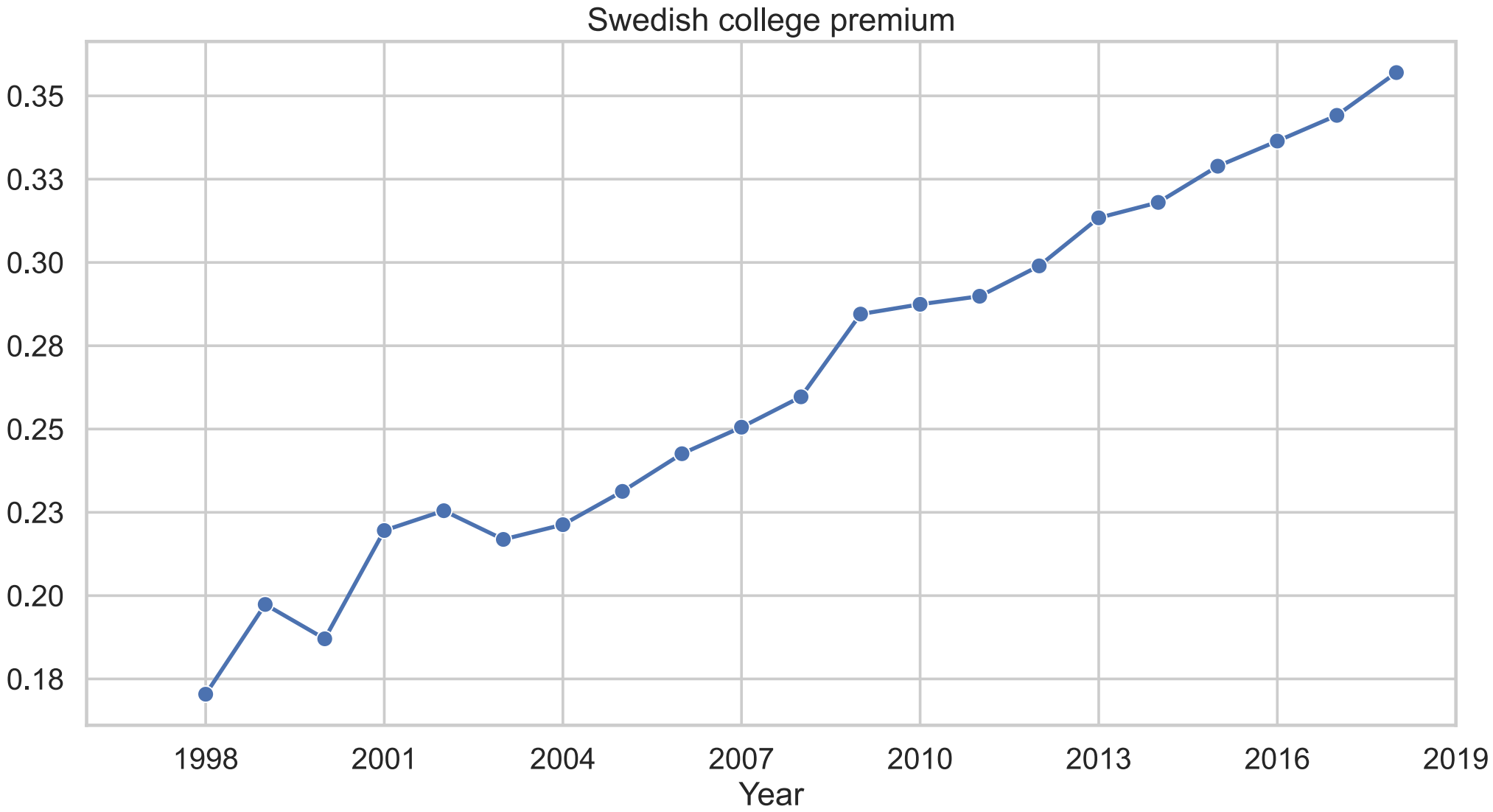
Work in progress. Empirical evidence from November 2025 and model results from March 2026.

Empirical facts

College share of employment



College premium



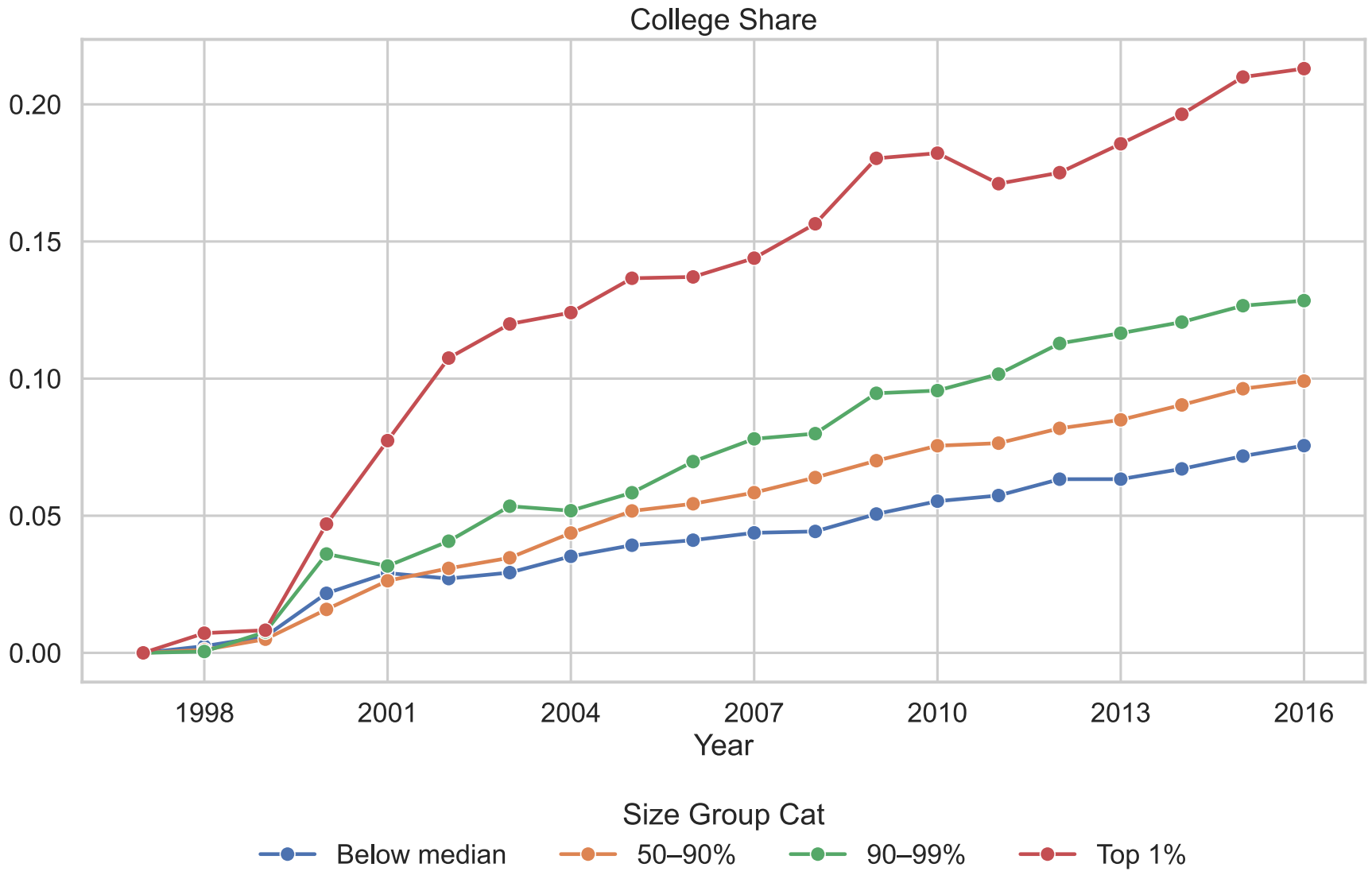
Measuring the college premium

- Data: Swedish employer-employee data.
- Sample: Males who ever worked in manufacturing.

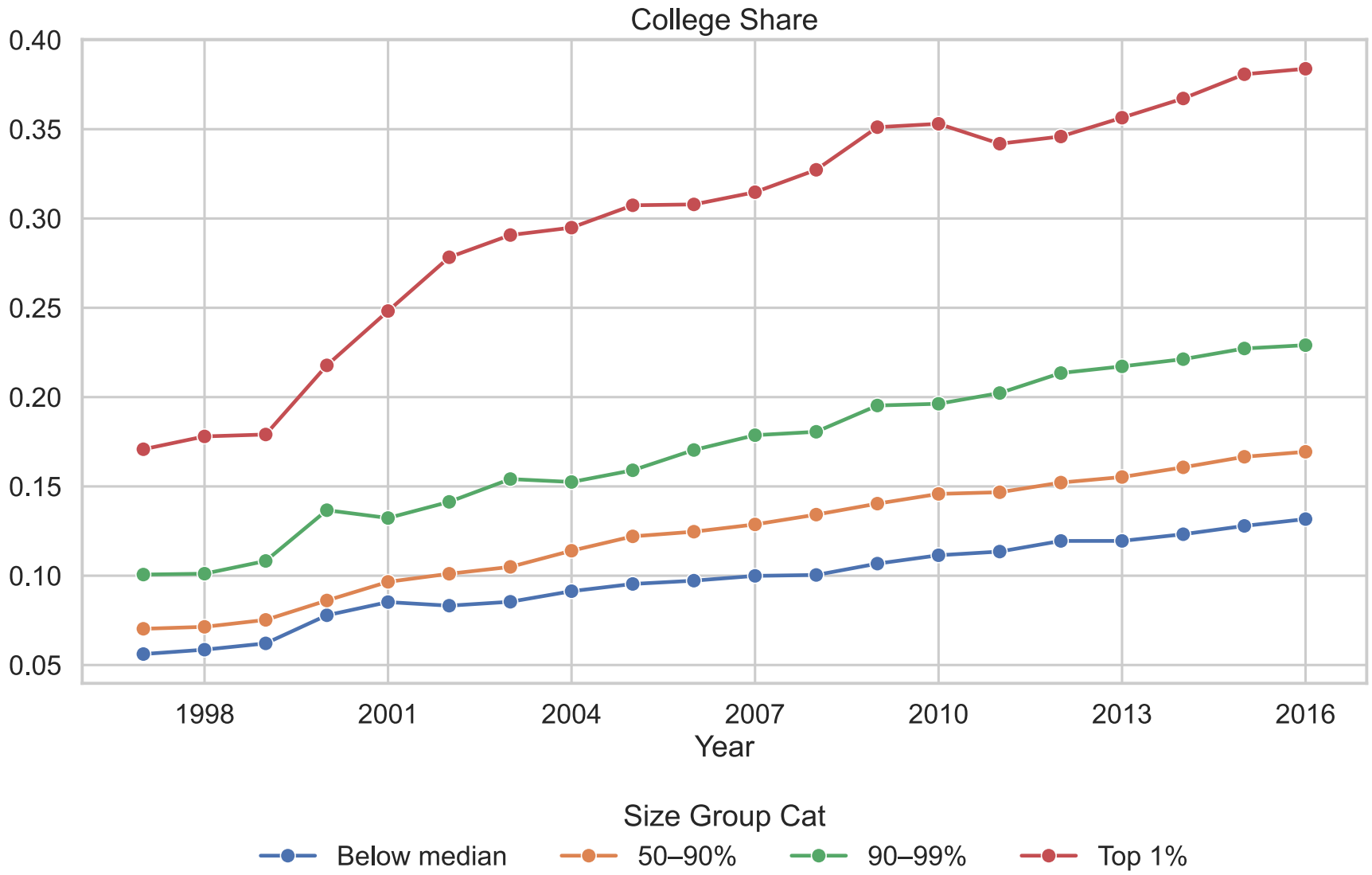
$$\log(\text{wage}_{it}) = \sum_{c}\sum_{y} \gamma_{cy} \mathbb{1}[\text{college}_i = c] \times \mathbb{1}[\text{year}_t = y] + \alpha_i + \delta_j + \epsilon_{it}$$

- α_i are worker fixed effects.
- δ_j are industry (SNI4) fixed effects.
- i indexes workers, t indexes time, j indexes industries.
- c indexes college status, y indexes years.

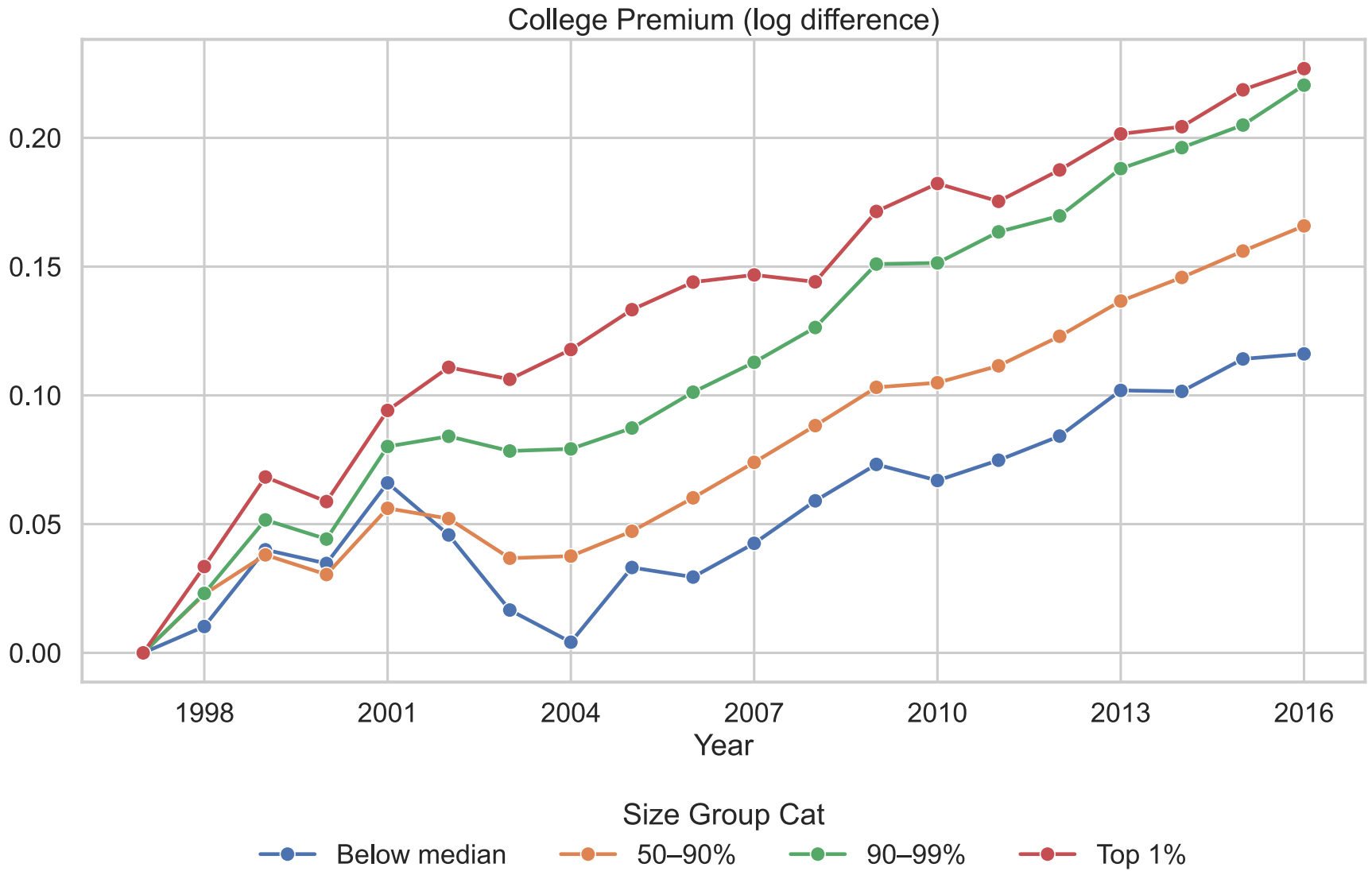
College share by firm size: change since 1997



College share by firm size: levels



College premium by firm size: change since 1997

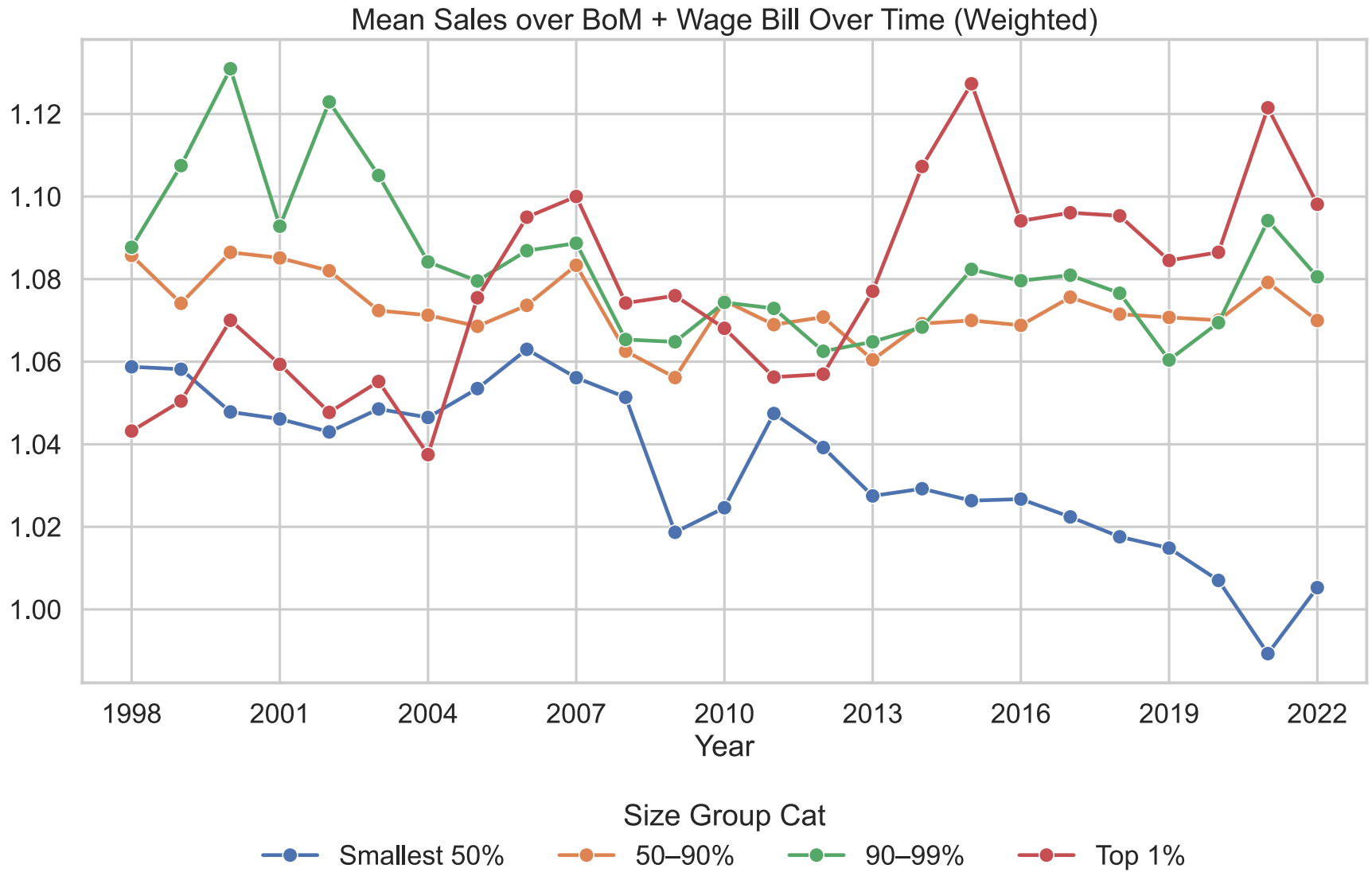


Measuring the college premium by firm size

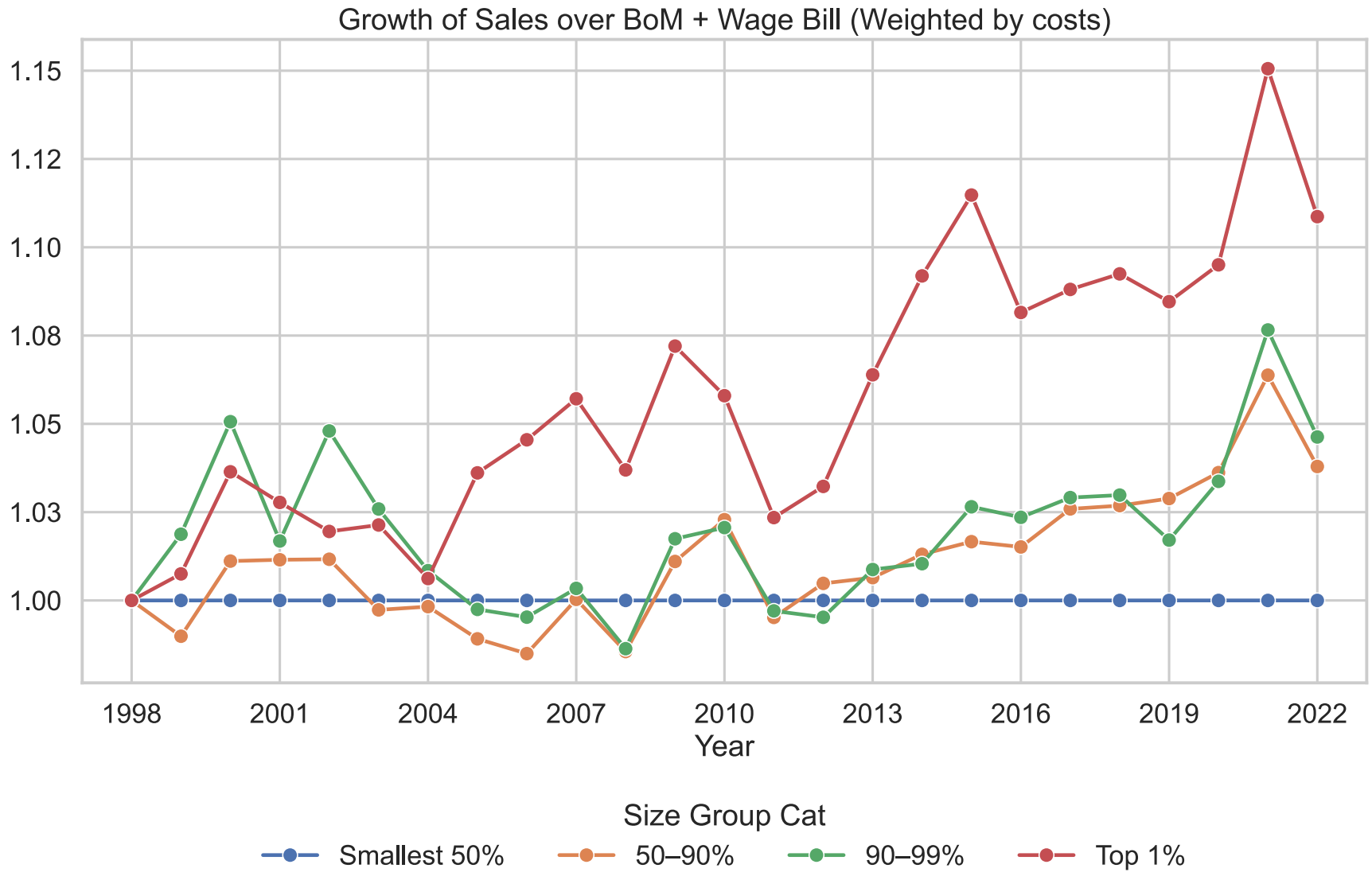
$$\log(\text{wage}_{it}) = \sum_{c}\sum_{y}\sum_{s} \gamma_{cys} \mathbb{1}[\text{college}_i = c] \times \mathbb{1}[\text{year}_t = y] \times \mathbb{1}[\text{sizebin}_{it} = s] + \alpha_i + \delta_j + \epsilon_{it}$$

- α_i are worker fixed effects.
- δ_j are industry (SNI4) fixed effects.
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- c indexes college status, y indexes years, s indexes size groups.

Sales to variable costs, levels



Sales to variable costs: growth relative to small firms



Interpreting sales to variable costs

- Lower returns to scale.
  - Fixed costs spread over greater volume.
- Rising markups.
- Higher capital share of sales.

$$\frac{\text{Sales}}{\text{Variable Costs}} = \left(\frac{\text{RTS}}{\text{Markup}} - \frac{\text{Cost of Capital}}{\text{Sales}} \right)^{-1}$$

Empirical motivation for the model

- Larger firms have higher college shares, with larger increases over time.
- College premia rise more in larger firms.
- Sales-to-variable-cost ratios rise more in the largest firms relative to small firms.

The model links skill-biased technology choice to firm size and markups.

These patterns motivate the mechanism. The counterfactuals quantify its implications under the model's assumptions.

Model

Setup

- Heterogeneous firms.
  - Ex-ante variation in total factor productivity (TFP).
  - Monopolistic: Markups.
  - Skill-biased technology (SBT) choice: Skill Premium.
- Households.
  - Two types of labor, skilled and unskilled.
  - Monopsonistic labor markets.
    - Firm type-specific wages and skill-premia.

Product market

- Monopolistic sectors $j \in J$ with continuous mass of n_j firms.
  - Free entry to learn firm-TFP, determines firm mass.
  - Fixed operating cost, determines productivity distribution cutoff.
- Demand as in Klenow and Willis (2016).
- Cobb Douglas final good aggregator across sectors: $Y = \prod_j Y_j^{\theta_j}$.

Klenow and Willis (2016) demand

Demand curve given by:

$$Y'\left(\frac{Y_{ij}}{Y_j}\right) = \frac{\bar{\sigma}-1}{\bar{\sigma}}\exp\left(\frac{1-\left(\frac{Y_{ij}}{Y_j}\right)^{\frac{\varepsilon}{\bar{\sigma}}}}{\varepsilon}\right), \bar{\sigma} > 1$$

- Demand elasticities vary with relative size.

$$\sigma\left(\frac{Y_{ij}}{Y_j}\right) = \bar{\sigma}\left(\frac{Y_{ij}}{Y_j}\right)^{-\frac{\varepsilon}{\bar{\sigma}}}$$

- Optimal markups increase with size:

$$\mu_i = \frac{\bar{\sigma}}{\bar{\sigma} - \left(\frac{Y_i^*}{Y_j^*}\right)^{\frac{\epsilon}{\bar{\sigma}}}}$$

Production technology

$$Y_i = \Omega_i K_i^{\alpha_k} M_i^{\alpha_m} \tilde{H_i}^{\alpha_h}$$

$$\tilde{H_i} = \left(E_i H_i^{\frac{\varrho-1}{\varrho}} + L_i^{\frac{\varrho-1}{\varrho}} \right)^{\frac{\varrho}{\varrho-1}}$$

- Ex-ante heterogeneity in TFP: Ω_i.
- Skill-specific technology E_i.
- Firms choose heterogeneous E_i, inducing skill-firm *sorting*.
  - Skill premium disproportionately higher in firms with high E_i.

Cost of SBT

$$f(E_i) = \gamma_0 + \frac{\gamma_1}{1+\gamma_2}\left(\frac{E_i}{\bar{E}} - 1\right)^{1+\gamma_2}$$

- Fixed cost, independent of output.
- $\gamma_0 > 0$. paid by all firms, determines TFP-cutoff.
- $\gamma_1 > 0$, cost increases in amount.
- $\gamma_2 > 0 \rightarrow$ convex in E_i.

Firm problem, step 1

Choose employment and intermediates, H_i, L_i, K_i, M_i, conditional on E_i:

$$\max_{H_i, L_i, K_i, M_i} P_i Y_i - W_{h,i} H_i - W_{l,i} L_i - K_i - M_i$$

subject to labor supply, product demand, and production function.

Firm problem, step 2

Choose E_i, taking as given optimal input choices conditional on E_i:

$$\max_{E_i} \Pi_i^*(E_i) - f(E_i)$$

Π_i^* denotes firm profits under optimal input choices for a given technology E_i.

Optimal skill technology adoption

Characterized by:

$$\left(1-\frac{1}{\mu_i^*}\right)\frac{d\log R_i^*}{d\log E_i}+\left(\frac{1}{\mu_i^*}\right)\frac{d\log \mu_i^*}{d\log E_i}=\frac{f'(E_i)E_i}{R_i^*}$$

→ Firms with high markups place greater weight on scale than margins.

Labor market

- Isoelastic monopsonistic labor supply to firm i, sector j.
- Enables firm-level wages.
- $$\frac{H_i}{H} = \left(\frac{W_{h,i}}{W_h} \right)^{\eta}$$
- $$\frac{L_i}{L} = \left(\frac{W_{l,i}}{W_l} \right)^{\eta}$$

Equilibrium labor shares

- $\frac{W_{l,i}L_i}{R_i} = \lambda \mu_i^{-1} \cdot \left(1 - \frac{E_i}{E_i + \left(\frac{W_{h,i}}{W_{l,i}}\right)^{\varrho-1}}\right)$
- $\frac{W_{h,i}H_i}{R_i} = \lambda \mu_i^{-1} \cdot \frac{E_i}{E_i + \left(\frac{W_{h,i}}{W_{l,i}}\right)^{\varrho-1}}$

Markups:

→ influence the output elasticities.

→ depress the unskilled labor share.

→ ambiguously affect the skilled labor share.

Equilibrium

Equilibrium

- Goods market clearing: $\mathrm{Y} = \mathrm{M} + \mathrm{K} + \text{Entry costs} + \text{SBT costs} + \text{Fixed Op. cost.}$
- High skill labor market clearing: $\bar{\mathrm{H}} = \sum_{\mathrm{j}} \int_{0}^{\mathrm{n_j}} \mathrm{H_i}\,\mathrm{di}.$
- Low skill labor market clearing: $\bar{\mathrm{L}} = \sum_{\mathrm{j}} \int_{0}^{\mathrm{n_j}} \mathrm{L_i}\,\mathrm{di}.$
- Free entry condition: $\text{Entry Cost}_{\mathrm{j}} = \mathbb{E}\left[\Pi_{\mathrm{ij}}\right]$
- Zero (operating) profit condition: $\Pi_{\mathrm{ij}} = 0$ for the marginal active firm.
- Firms choose inputs and SBT to maximize profits.
- Households maximize utility.

Calibration

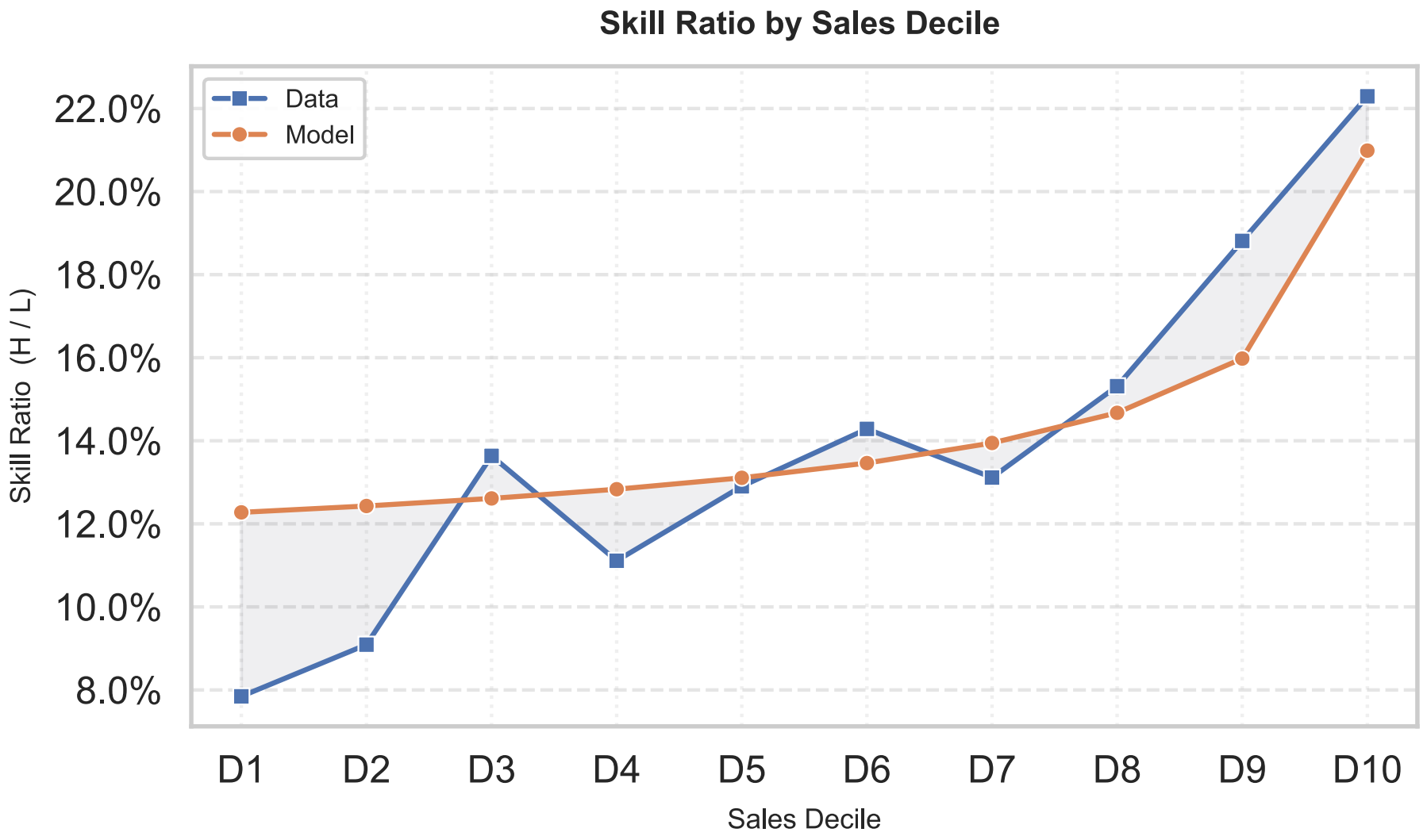
Parameter values

Name	Description	Value	Method
$\bar{\sigma}$	Demand param.	9	Edmond, Midrigan, Xu (2023)
$\frac{\varepsilon}{\bar{\sigma}}$	Super Elasticity param.	0.16	Edmond, Midrigan, Xu (2023)
ϱ	Skill E.o.S	2	Assigned
$\bar{E}$	Min. SBT	0.316	Min. SP = 1
γ_1	Linear SBT cost	1.27	Model Estimate
γ_2	Curvature of SBT cost	2.876	Model Estimate
α	TFP Pareto Shape	4.735	Model Estimate
ζ	Entry Cost	0.188	Free Entry Residual
γ_0	Min. Fixed Op. Cost	0.012	Zero Min. Profit Residual

Moment fit

Moment	Data	Model	Model − Data
Skill share, top sales decile	0.223	0.210	-0.013
Skill share, median sales decile	0.129	0.131	0.002
Skill premium (W_H/W_L)	1.150	1.150	0.001
Sales share of top 5%	0.560	0.558	-0.002
Average absolute error			0.004

Skill intensity fit



Aggregate skill ratio (model): 0.200

Counterfactuals

Two counterfactual experiments

- Increasing the skilled population share.
  - Effects on firm-size and markups distribution.
- Undoing markups heterogeneity.
  - Effects on skill premium and SBT-adoption.

Higher Skill Share

Higher Skill Share

- Keep parameters from baseline.
- Exogenous change in population composition.
  - From: $\mathrm{H/L} = 0.2$.
  - To: $\mathrm{H/L} = 0.3$.
- Compare three economies.
  1. Baseline.
  2. New equilibrium.
  3. New equilibrium, holding fixed SBT from baseline.

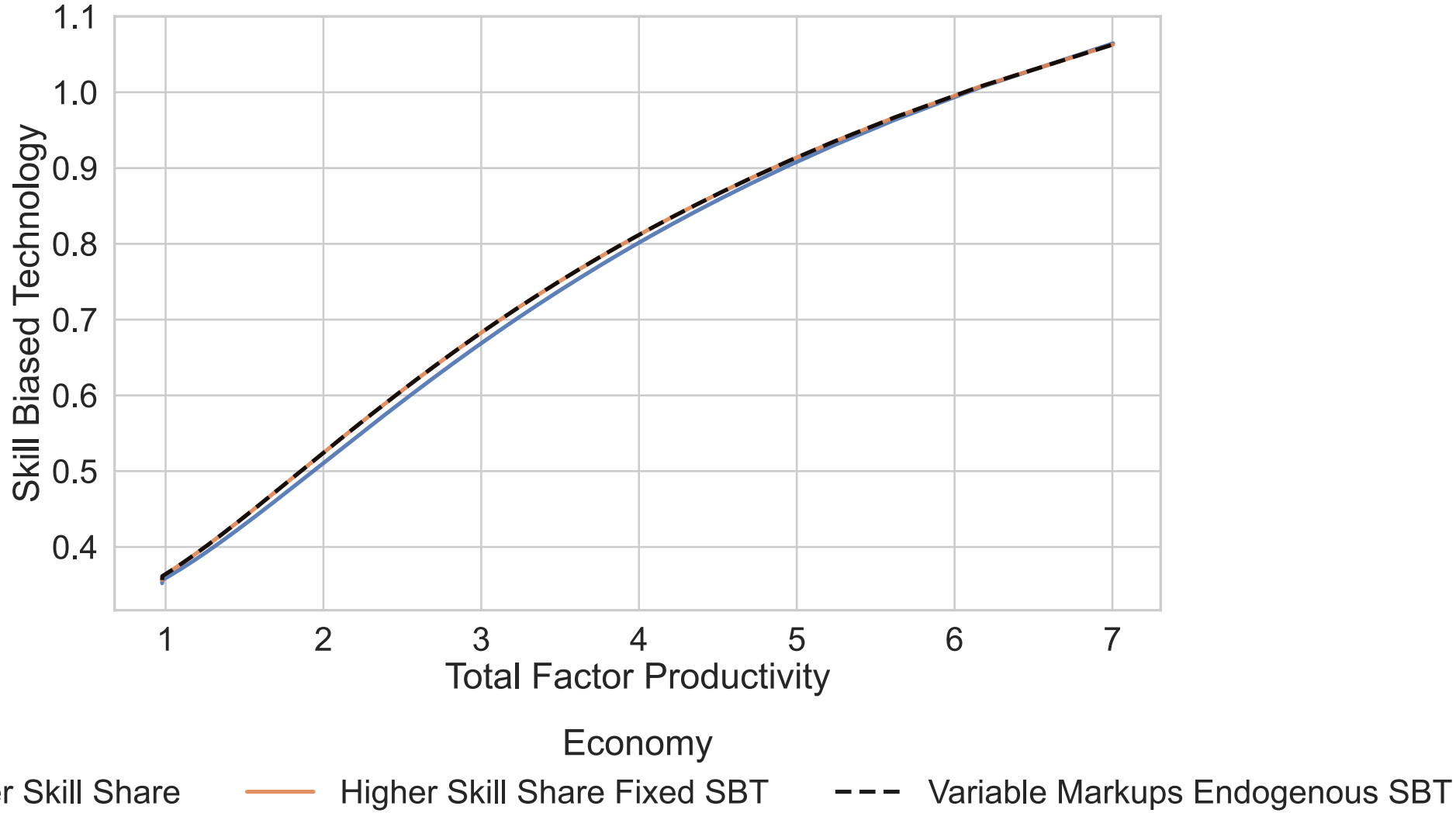
Convergence

	Baseline	Increased Skill Ratio	Increased Skill Ratio, Fixed SBT
Final Good Output	1.2267	1.3562	1.3575
Final Good Consumption	1.2267	1.3562	1.3575
Low Skill Labor Demand	0.8333	0.7692	0.7692
Low Skill Labor Supply	0.8333	0.7692	0.7692
High Skill Labor Demand	0.1667	0.2308	0.2308
High Skill Labor Supply	0.1667	0.2308	0.2308
Min. Profit	-0.0000	-0.0000	-0.0000
FEC Residual	0.0000	0.0000	-0.0000

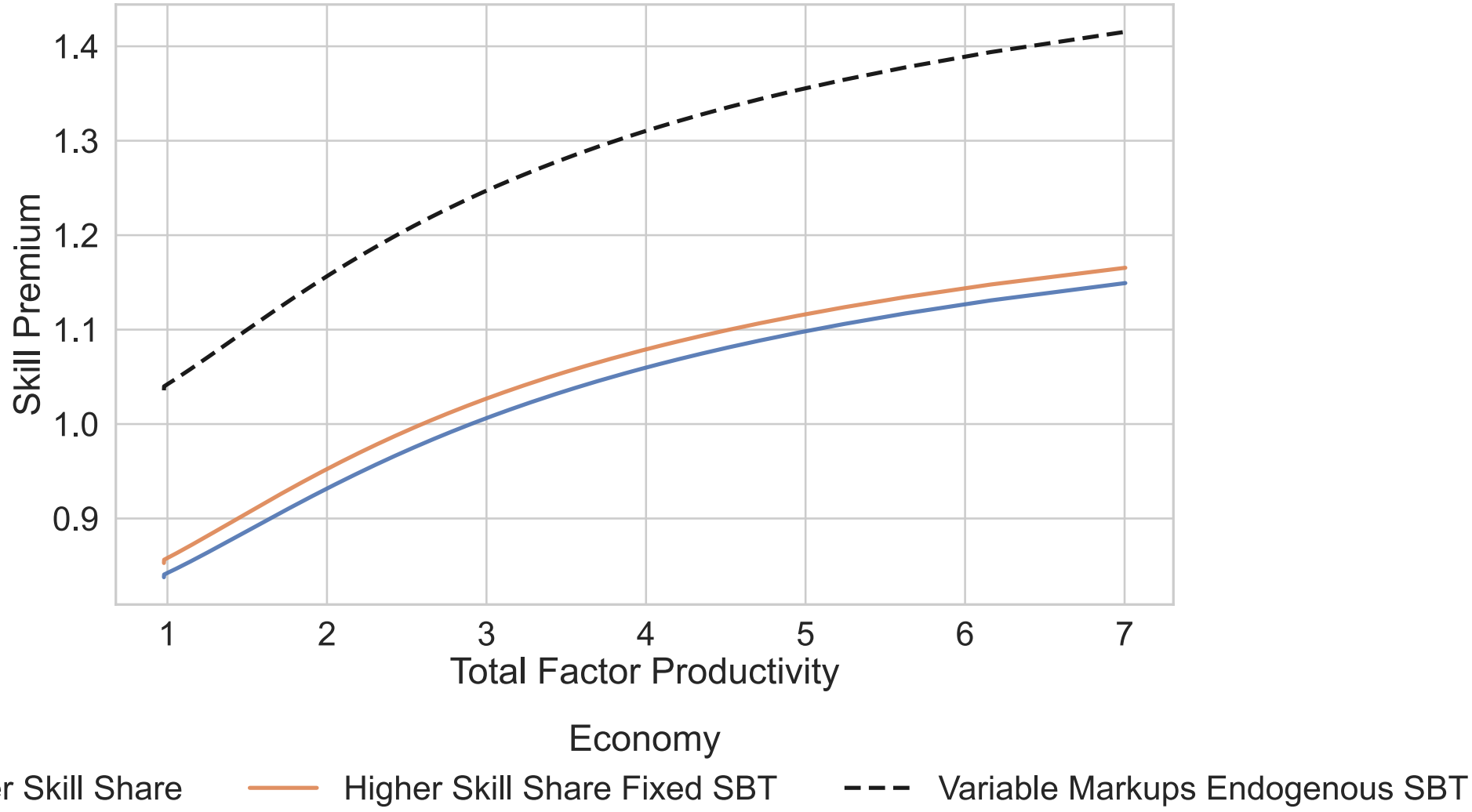
Macro overview

	Baseline	Increased Skill Ratio	Increased Skill Ratio, Fixed SBT
Gross Output	1.227	1.356	1.357
Labor Income	0.241	0.266	0.266
Skill Premium	1.150	0.931	0.950
High Skill Wage Index	0.215	0.200	0.203
Low Skill Wage Index	0.187	0.215	0.214
Active Firms, %	100.0	103.5	102.7
Unsuccessful Entry, %	10.0	17.3	17.2
TFP Cutoff	1.000	1.018	1.018

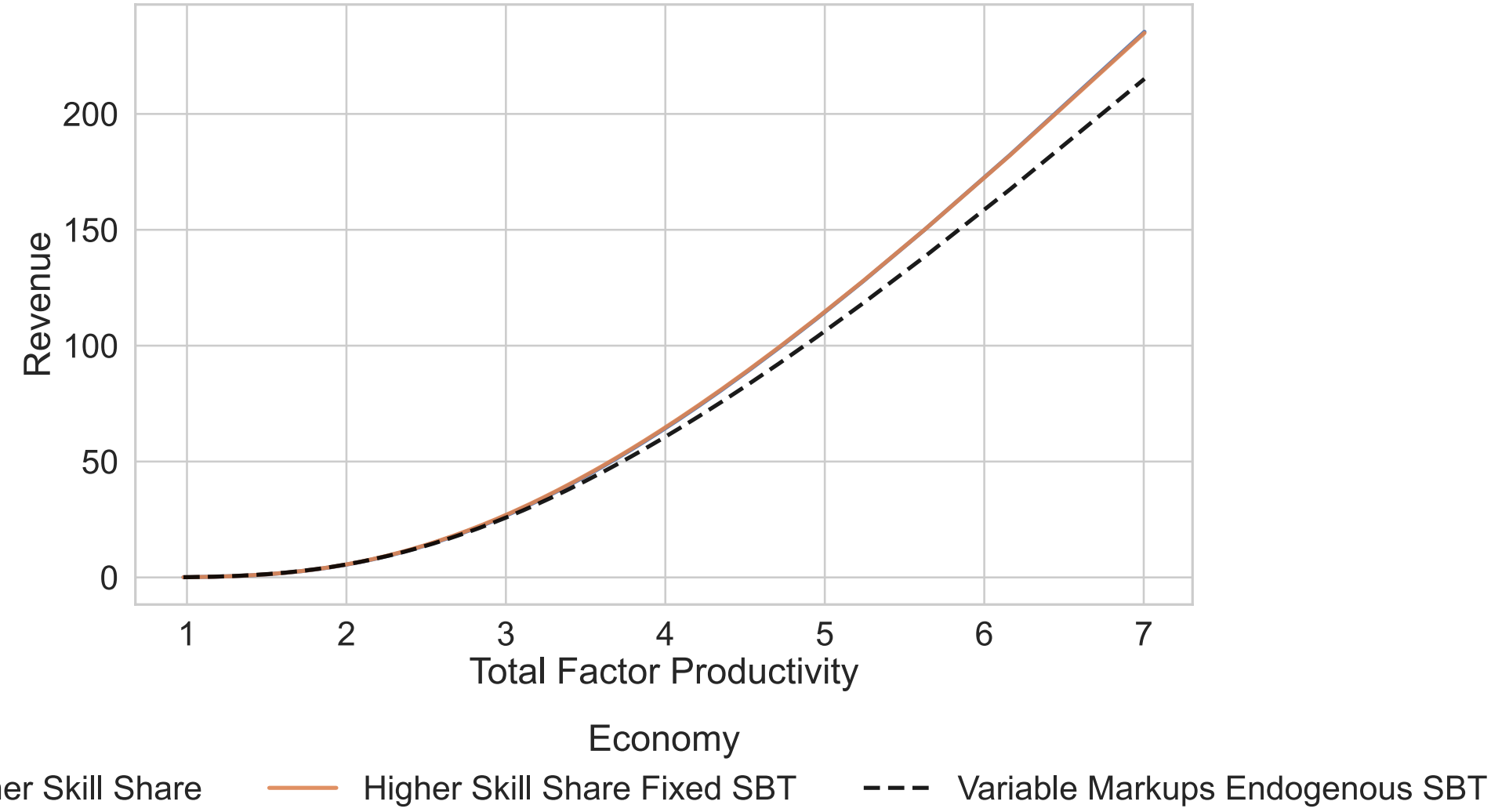
SBT-distribution



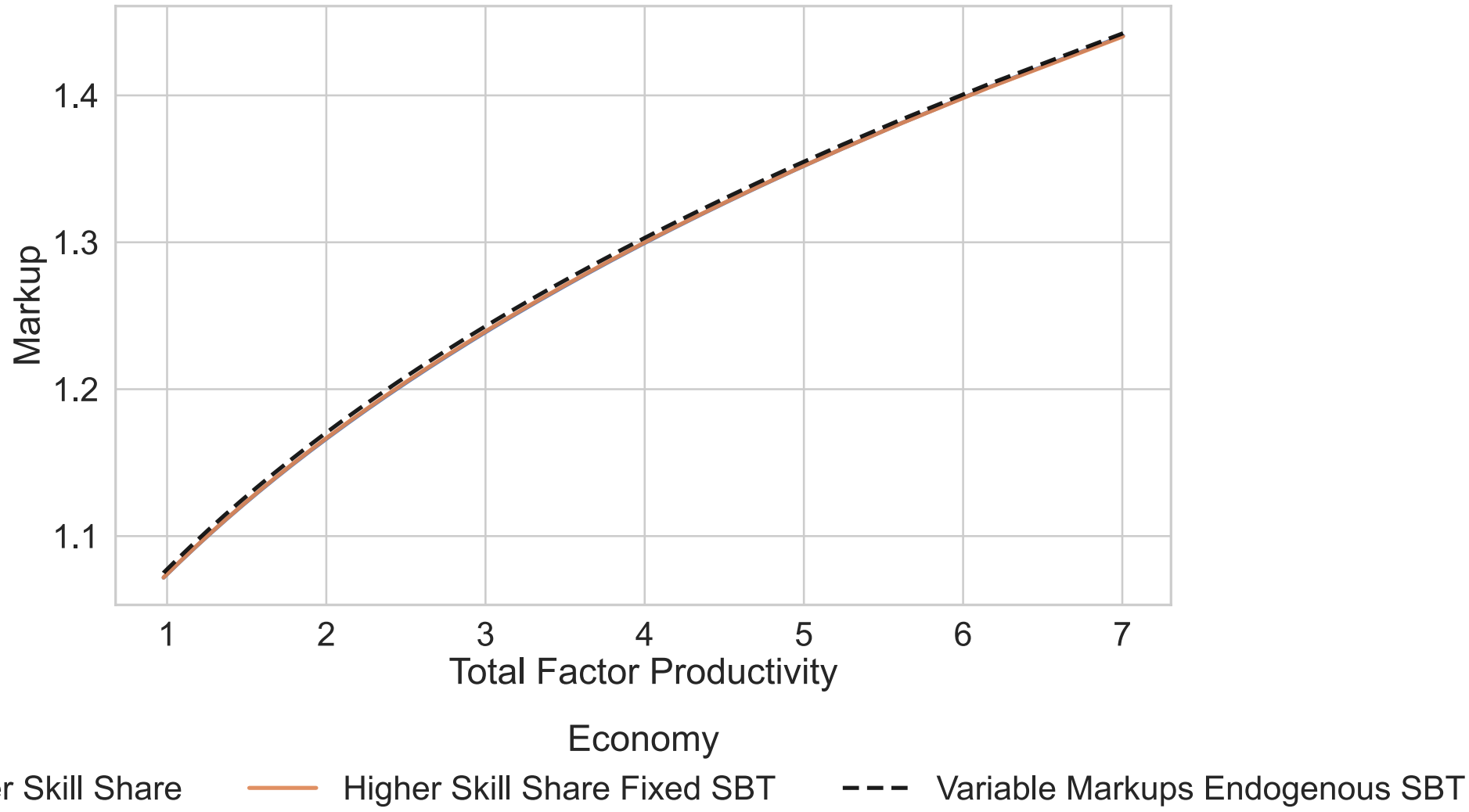
Skill Premium



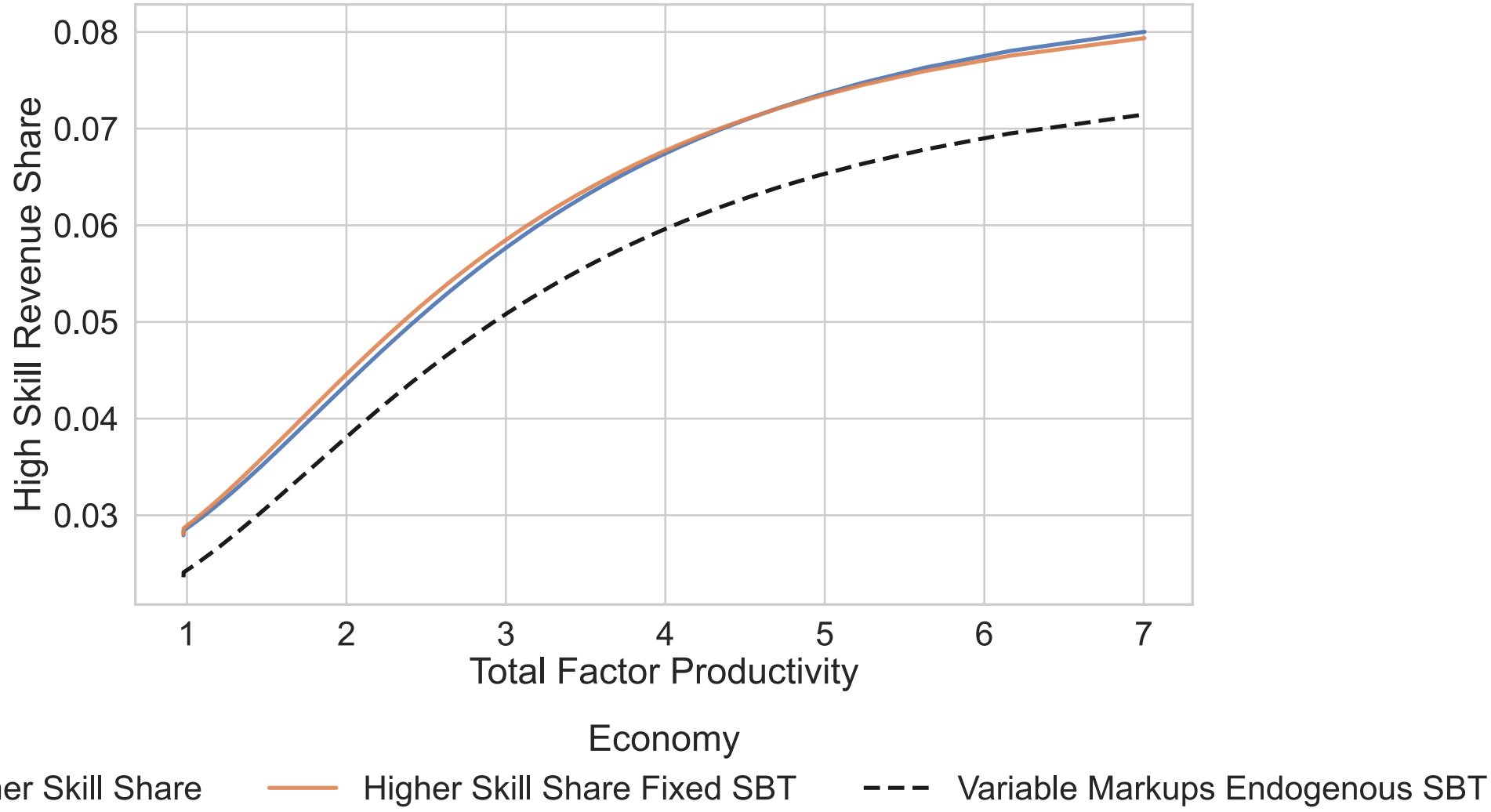
Firm size


Revenue
200
150
100
50
0
1
2
3
4
5
6
7
Total Factor Productivity
Economy
Higher Skill Share
Higher Skill Share Fixed SBT
Variable Markups Endogenous SBT

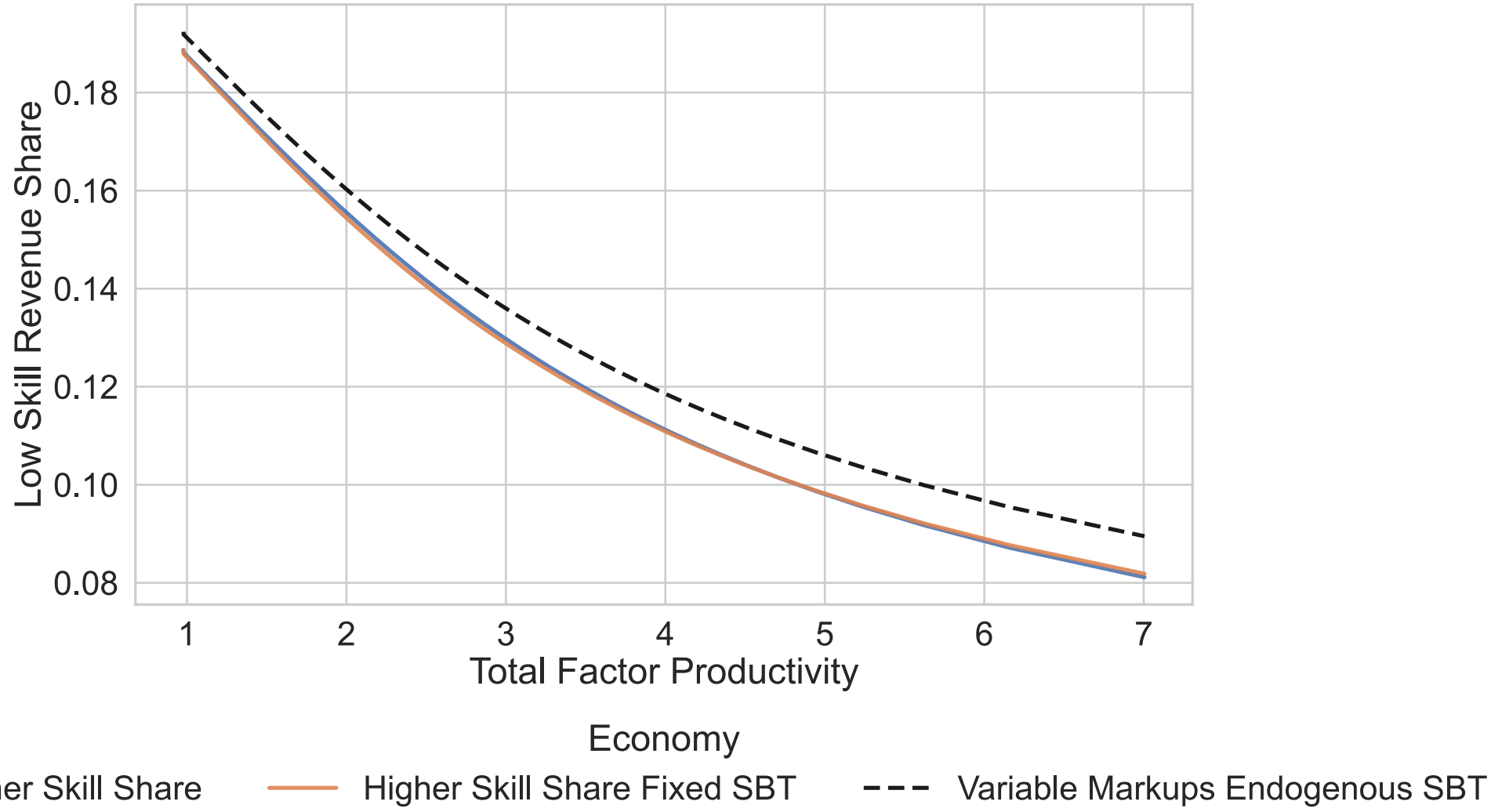
Markups


1.4
1.3
1.2
1.1
Markup
1
2
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High Skill Revenue Share



Low Skill Revenue Share



Undoing markup heterogeneity

Experiment

Are markups important for the choice of technology adoption?

- Size-dependent firm-subsidies like Edmond, Midrigan, and Xu (2023).
  - Paid for by household taxes.
- Compare baseline against two economies without markup heterogeneity:
  - Optimal SBT-choice: firms choose their SBT freely.
  - Fixed SBT: Firms' SBT is fixed to baseline.

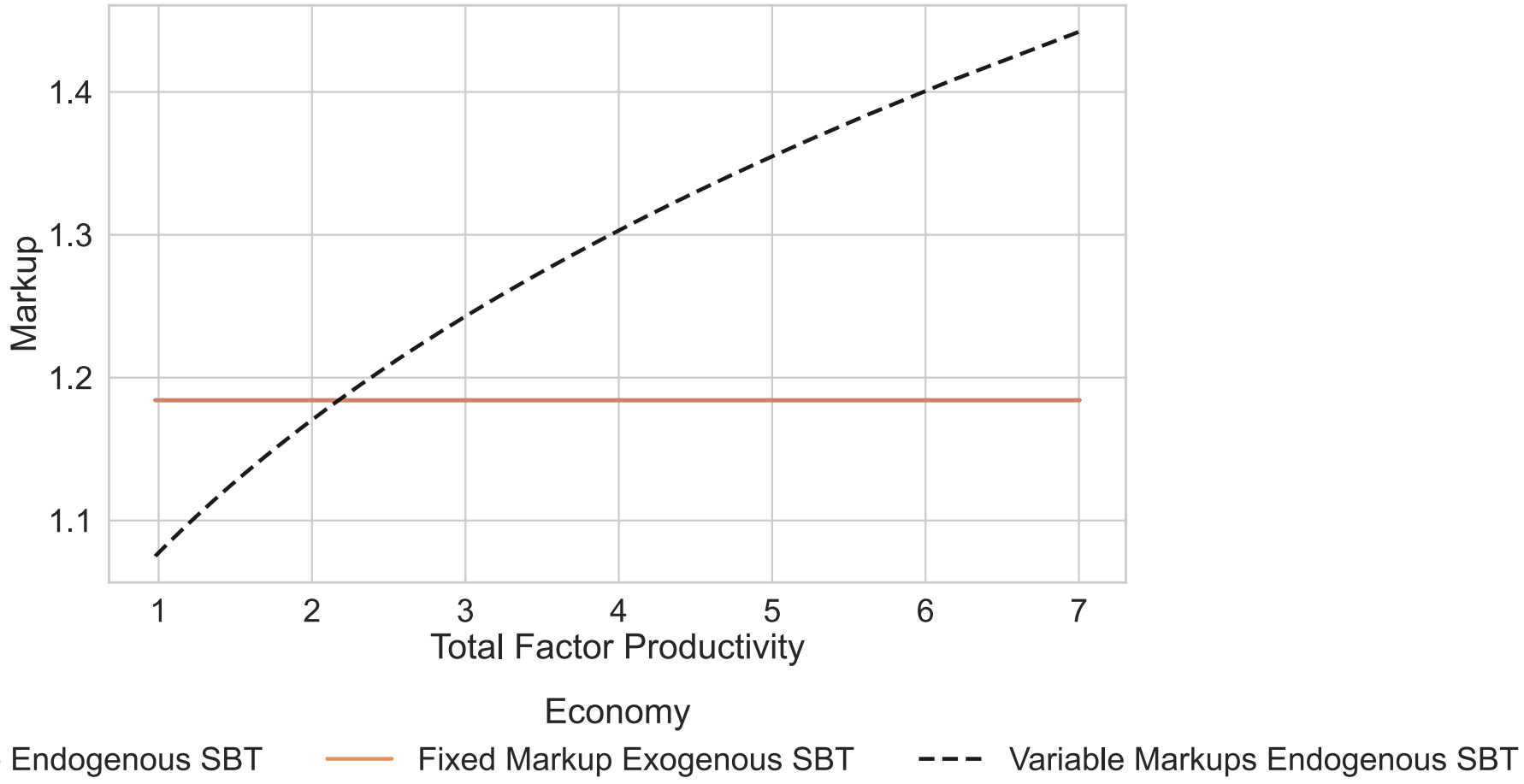
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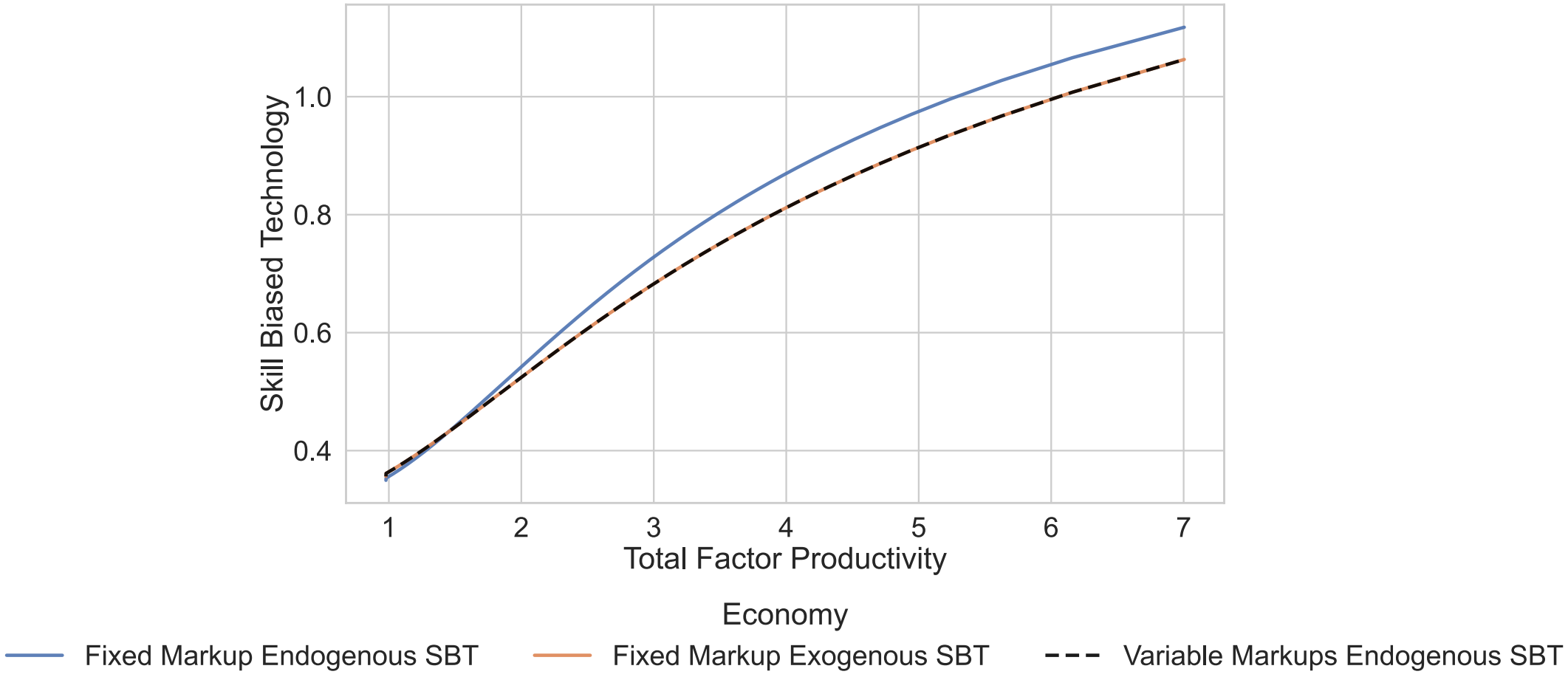
Macro overview

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Gross Output	1.227	2.282	2.241
Labor Income	0.241	0.447	0.439
Skill Premium	1.150	1.371	1.313
High Skill Wage Index	0.215	0.420	0.402
Low Skill Wage Index	0.187	0.307	0.306
Active Firms, %	100.0	123.2	124.4
Unsuccessful Entry, %	10.0	39.5	39.8
TFP Cutoff	1.000	1.087	1.088
Markups	Variable	Constant	Constant
SBT	Endogenous	Endogenous	Assigned

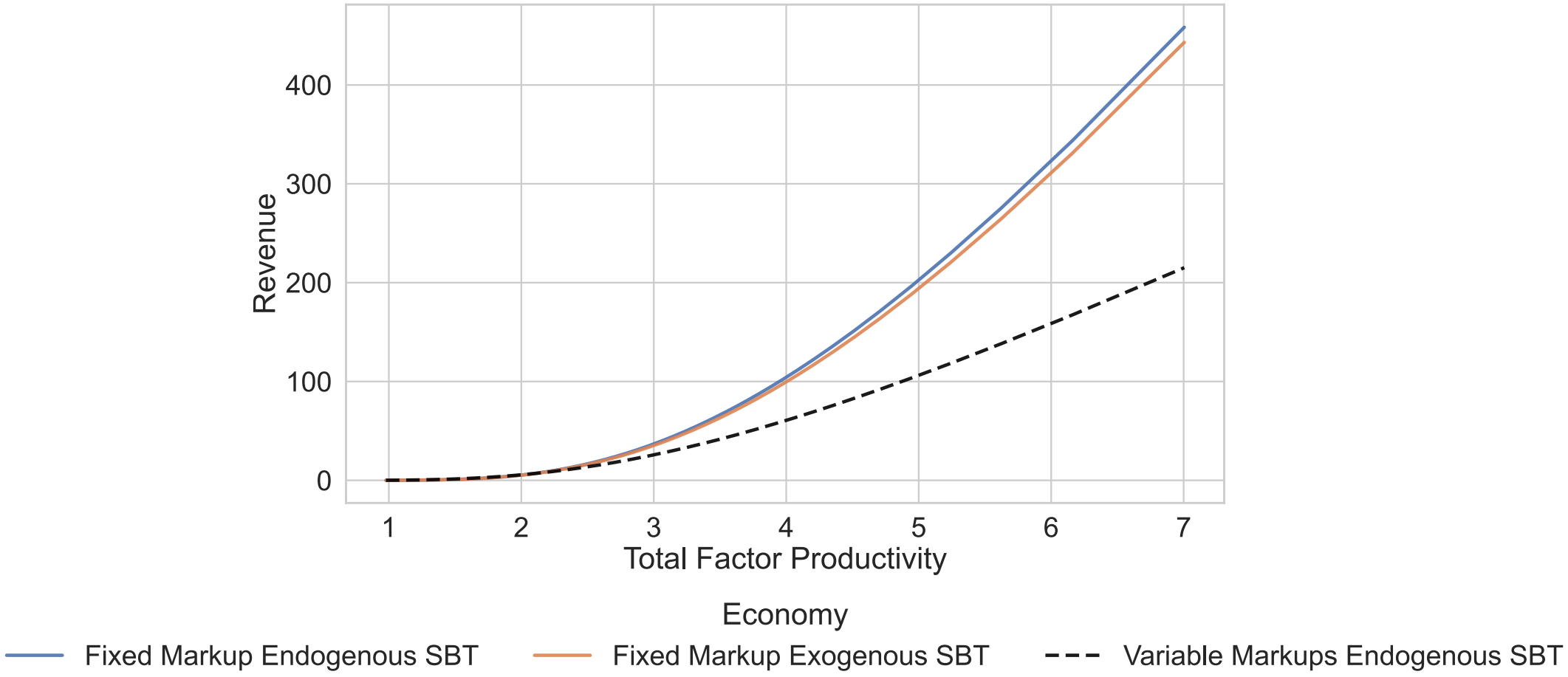
Markups


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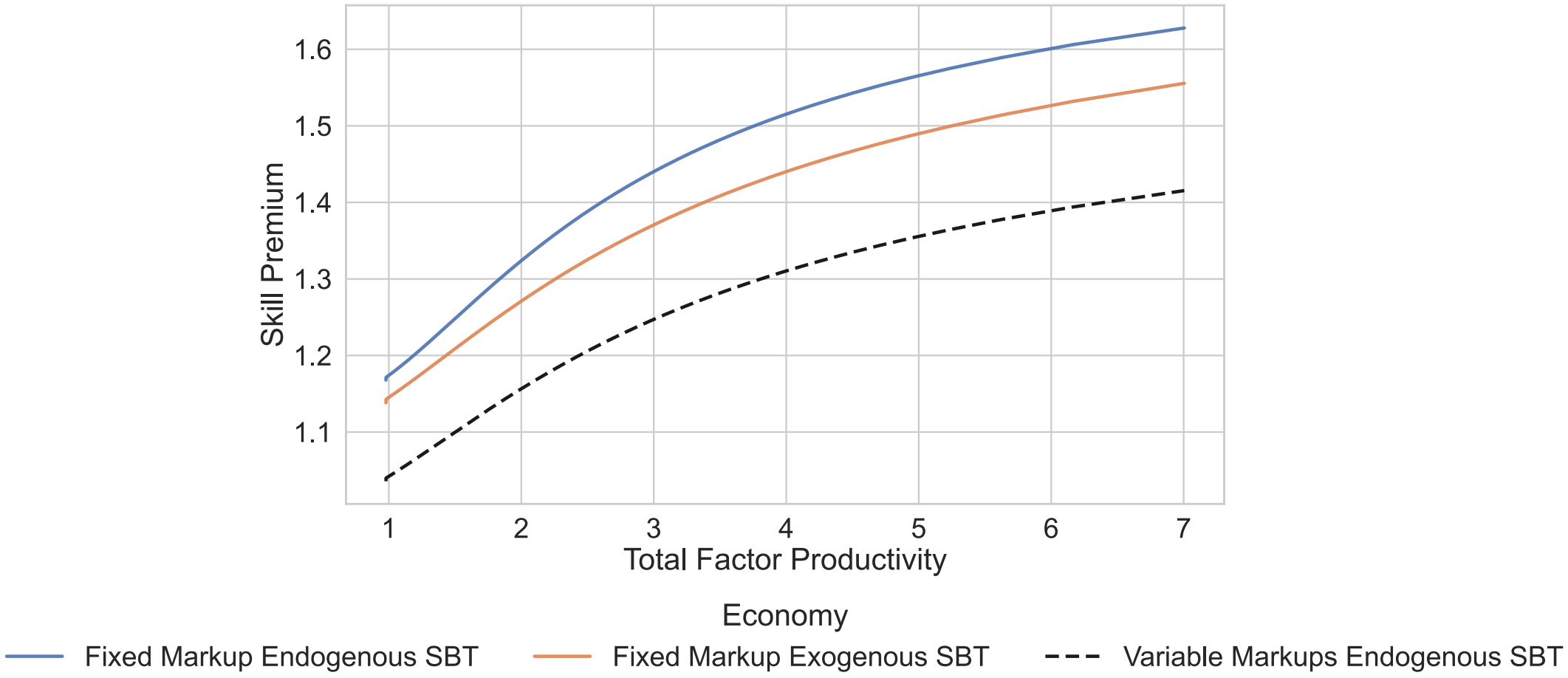
SBT-distribution



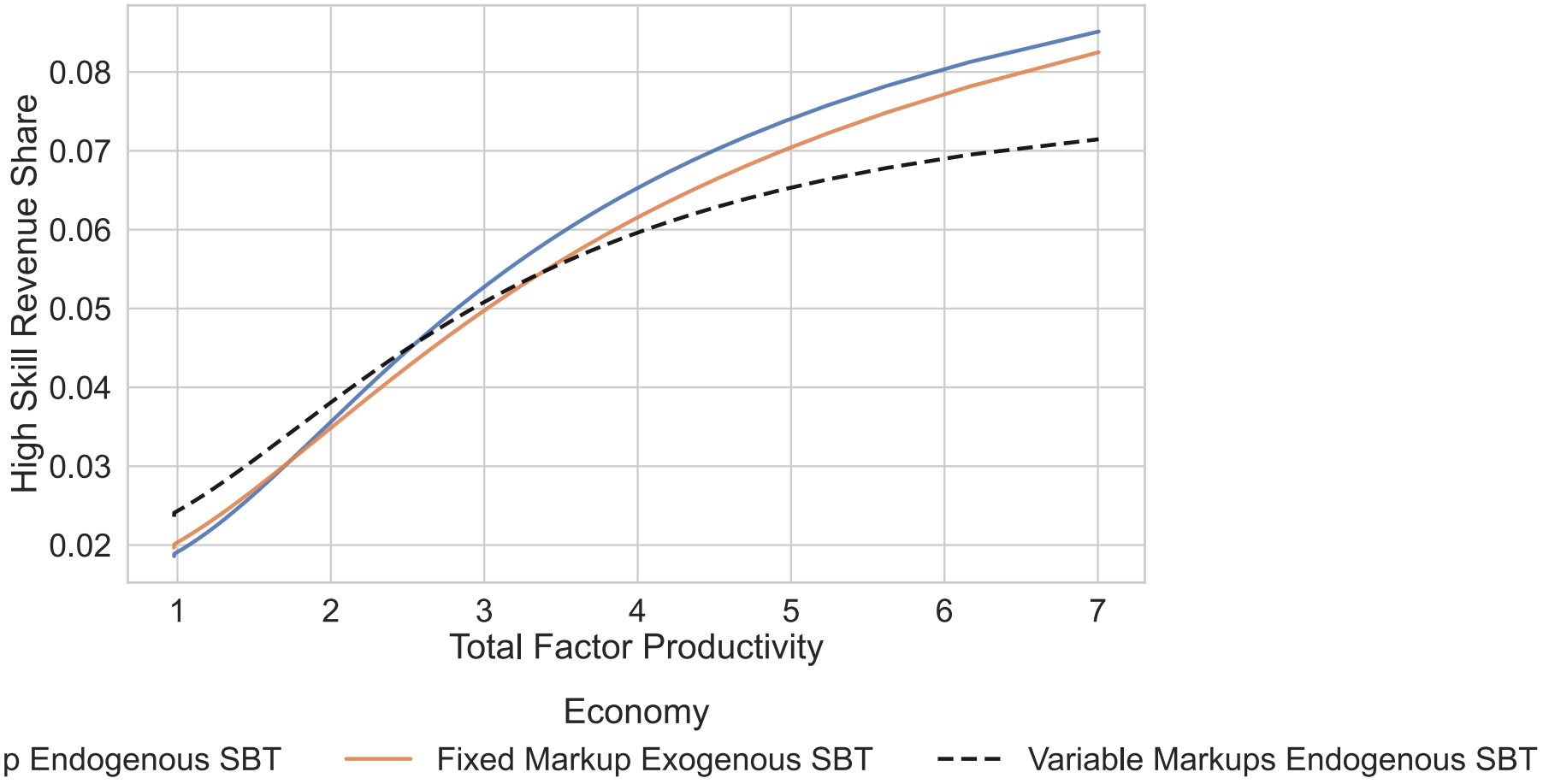
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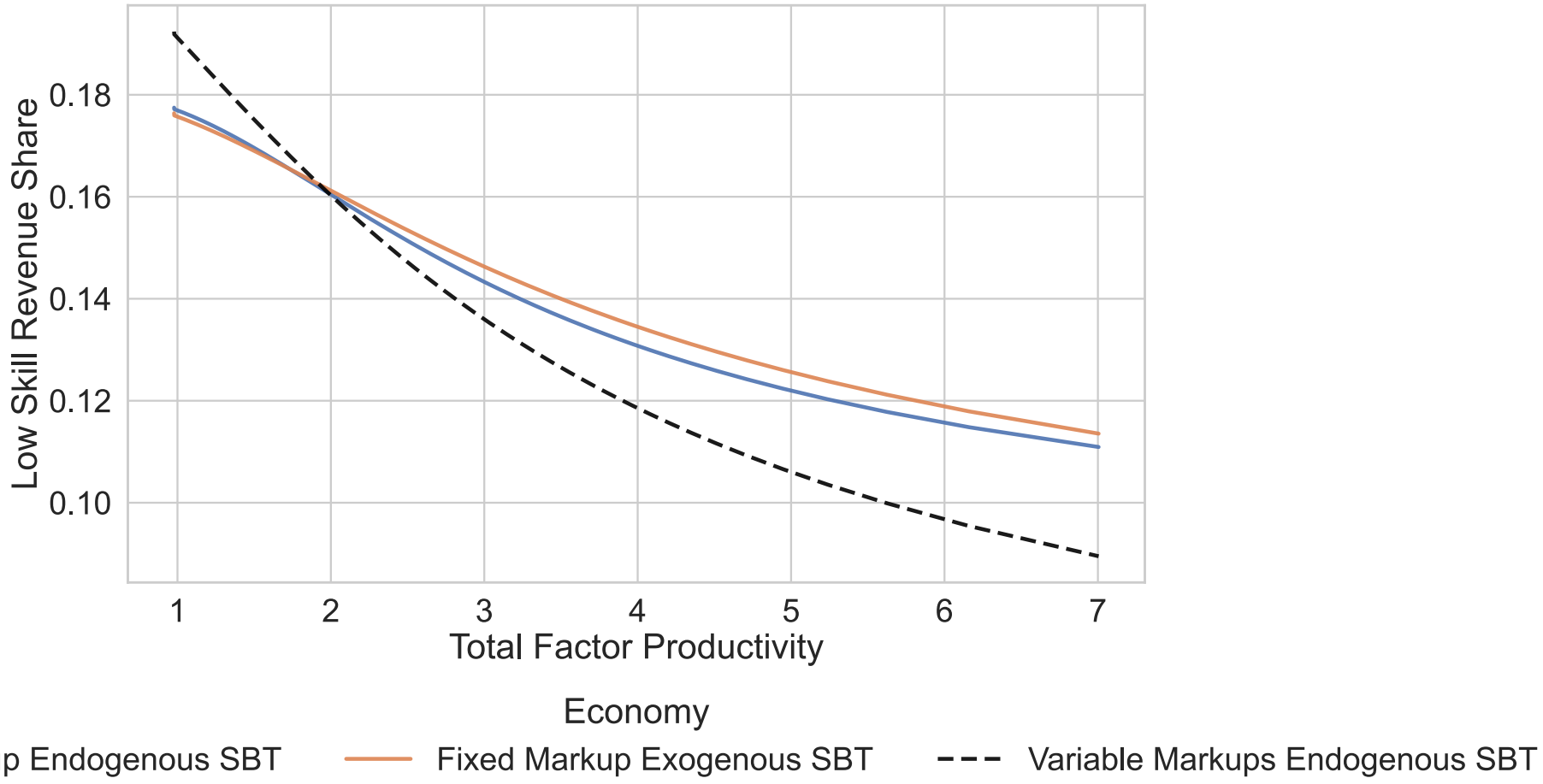
Skill premium



High Skill Revenue Share



Low Skill Revenue Share



References

Autor, David, Claudia Goldin, and Lawrence F Katz. 2020. “Extending the Race Between Education and Technology.” In *AEA Papers and Proceedings*, 110:347–51. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203.

Baqaee, David Rezza, and Emmanuel Farhi. 2020. “Productivity and Misallocation in General Equilibrium.” *The Quarterly Journal of Economics* 135 (1): 105–63.

De Loecker, J., J. Eeckhout, and G. Unger. 2020. “The Rise of Market Power and the Macroeconomic Implications.” *Quarterly Journal of Economics* 135 (2): 561–644.

Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu. 2023. “How Costly Are Markups?” *Journal of Political Economy* 131 (7): 1619–75.

Katz, Lawrence F, and Kevin M Murphy. 1992. “Changes in Relative Wages, 1963–1987: Supply and Demand Factors.” *The Quarterly Journal of Economics* 107 (1): 35–78.

Klenow, Peter J, and Jonathan L Willis. 2016. “Real Rigidities and Nominal Price Changes.” *Economica* 83 (331): 443–72.

Krusell, Per, Lee E Ohanian, José-Víctor Ríos-Rull, and Giovanni L Violante. 2000. “Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis.” *Econometrica* 68 (5): 1029–53.