Rising Skill Premium?

The Roles of Capital-Skill Complementarity and Sectoral Shifts in a Two-Sector Economy

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This paper...

- Documents three facts in the Japanese economy
  - **(1)** Declining skill premium
  - **(2)** Expanding sectoral wage gap
  - **(3)** Increasing unskilled labor share in non-manufacturing

- Considers a neoclassical two-sector model with
  - Two types of labor (skilled and unskilled)
  - Capital-skill complementarity

  to explain the three facts

- Estimates the key structural parameters by Bayesian methods

- Performs comparative statics exercises

- Provides supporting industry-level evidence

Stylized Facts

Fact 1 Skill premium has started to decline since the mid 90s.

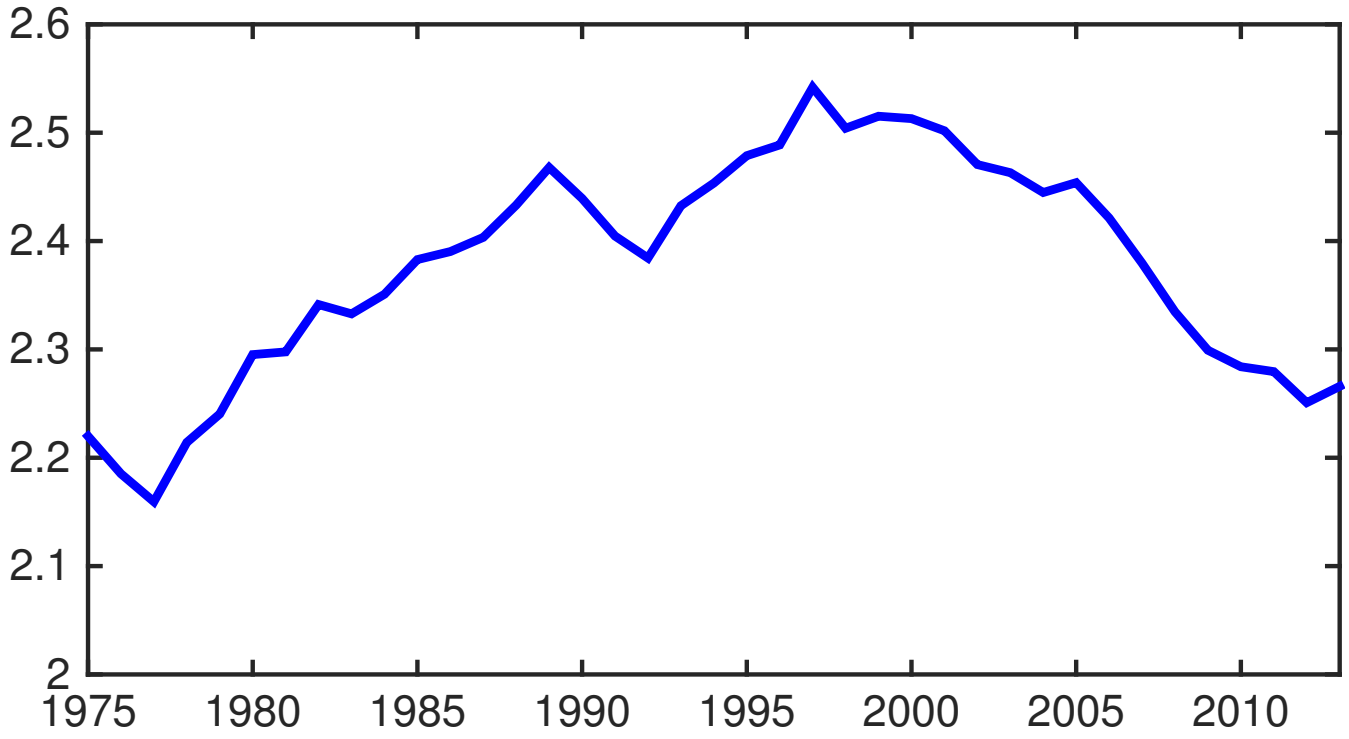

Figure: Skill Premium (W_s/W_u)

Stylized Facts

Fact 2 Sectoral wage gap ↑ since the mid 90s

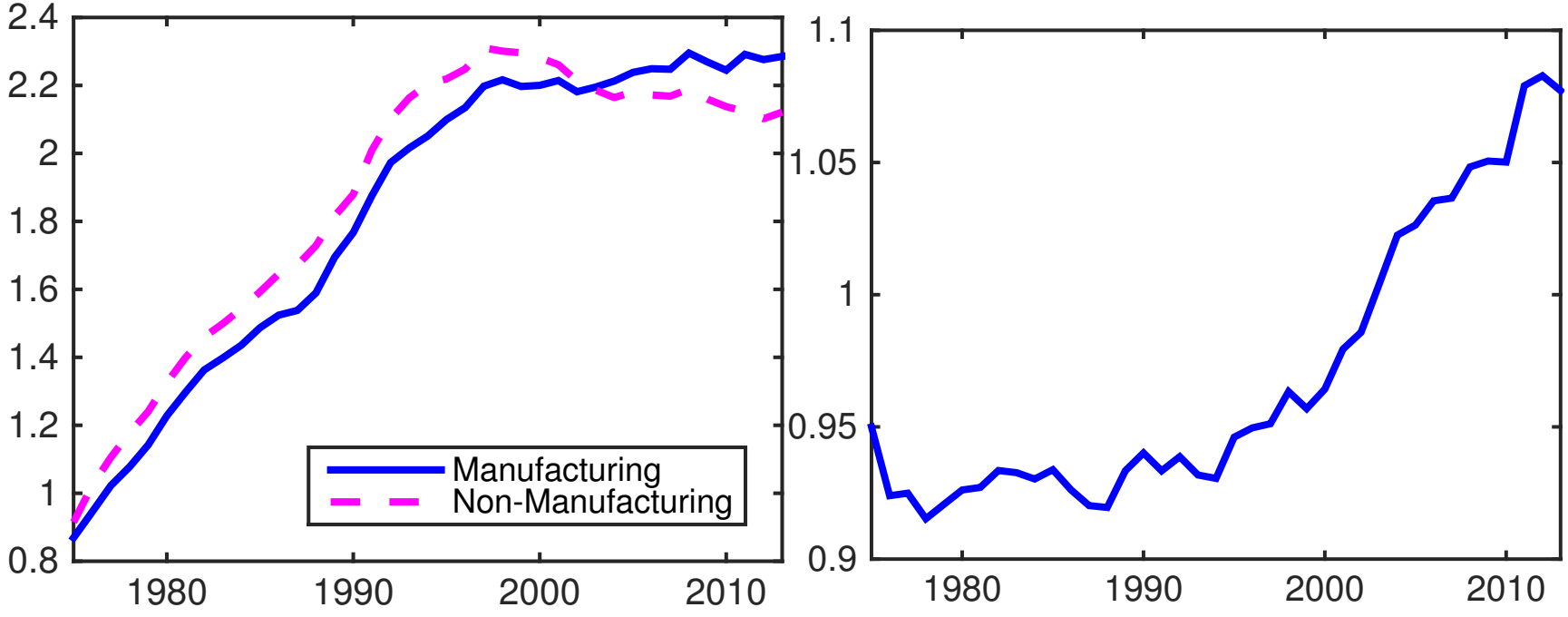

Figure: Sectoral Wages and Wage Gap

Note: Left panel shows hourly wages in thousands yen. Right panel illustrates the manufacturing wage relative to non-manufacturing.

Stylized Facts

Fact 3 Unskilled share in non-manufacturing ↑

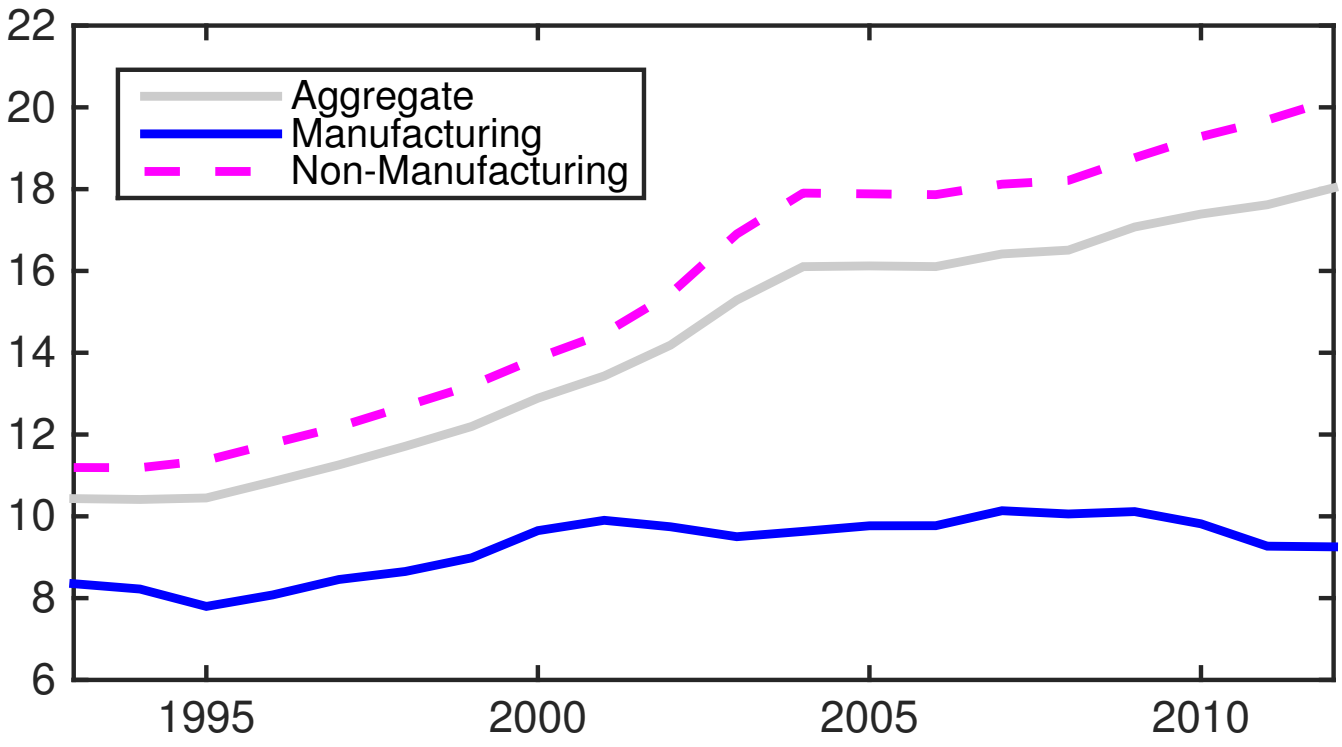

Figure: Unskilled Shares (%)

Alternative Stories for the Lower Skill Premium

- Skill-biased technological change (SBTC)
  - Sector-specific SBTC?
- Labor supply side story
  - Kawaguchi and Mori (2014) use college/high-school graduates to measure skilled and unskilled labor.
  - A reduction in the skill premium and an increase in the relative supply of skilled.

Skilled / Unskilled Labor

Regular workers

Those who are directly employed and work full time

Precise Def.

Part-time workers

Those who work less than the regular workers per day or per week

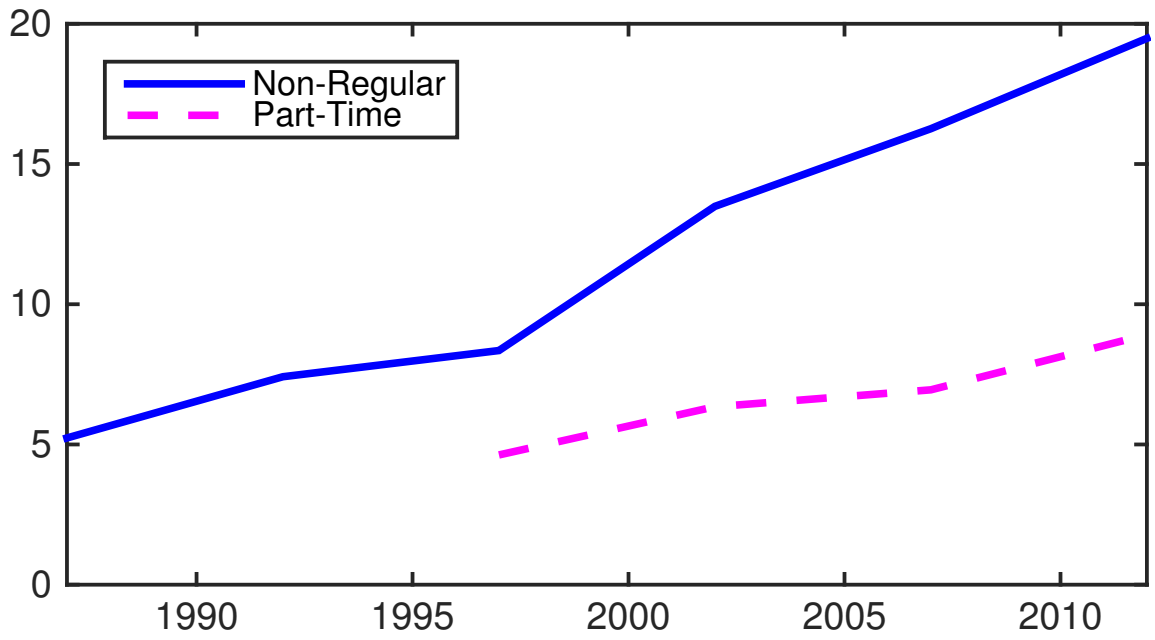

Figure: Fraction of Unskilled Jobs in College-Graduate Employments (%)

Preview of the Results

- Heterogeneity in capital-skill complementarity
- $\downarrow$ in the elasticity of substitution between unskilled labor and capital (lower capital-skill complementarity) in non-manufacturing explains the observations.
- Other possible scenarios can alter the skill premium. However, they cannot explain the widening sectoral wage gap.
- Rapidly growing medical and health care industry may account for the reduction in the elasticity of substitution.

Model Overview

- Two-sector neoclassical model
  – Manufacturing ($j = m$) and Non-manufacturing ($j = n$)
- Two types of labor
  – Skilled (S) and Unskilled (U)
- Production technology features capital-skill complementarity as in Krusell et al. (2000)

What We Need

- Define sectoral wage for $j = m, n$ as

$$w_j = (1 - \tau_j) w_s + \tau_j w_u, \tag{1}$$

where $\tau_j = \frac{U_j}{S_j + U_j}$.

- Changes in the sectoral wage gap is then expressed as

$$dw_m - dw_n = \underbrace{(\tau_n - \tau_m)}_{\substack{\text{typically} \\ > 0}} (dw_s - dw_u) + \underbrace{(w_u - w_s)}_{\substack{\text{typically} \\ < 0}} (d\tau_m - d\tau_n). \tag{2}$$

Firms

- Two sectors (manufacturing and non-manufacturing)

$$Y_{j,t} = A_{j,t}\Big[\mu_j(\psi_{u,t}U_{j,t})^{\sigma_j} + (1-\mu_j)\big\{\lambda_j(K_{j,t})^{\rho_j} + (1-\lambda_j)(\psi_{s,t}S_{j,t})^{\rho_j}\big\}^{\frac{\sigma_j}{\rho_j}}\Big]^{\frac{1}{\sigma_j}} \quad (3)$$

- σ controls the elasticity of substitution between K (or S) and U.
- ρ controls the elasticity of substitution between K and S.
- When $\sigma > \rho$, there exists capital-skill complementarity.
- As $\sigma \to 0$ and $\rho \to 0$, it becomes Cobb-Douglas.

Household

- Consumes C_t, which consists of manufacturing and non-manufacturing goods, and provides H_t
- Following Horvath (2000), the aggregate labor index H_t is given by

$$H_t = \left[(S_t)^{\frac{\theta+1}{\theta}} + (U_t)^{\frac{\theta+1}{\theta}} \right]^{\frac{\theta}{\theta+1}}, \tag{4}$$

  where θ is the elasticity of substitution between skilled and unskilled jobs.
- As $\theta \to \infty$, skilled and unskilled jobs become perfect substitutes.
- As $\theta \to 0$, there is no way to change the composition of two types of jobs.
- When $0 < \theta < \infty$, the household prefers having diversity of labor.

The Rest of the Model

- Budget constraint

$$C_{m,t} + p_t C_{n,t} + I_{m,t} + I_{n,t} \leq r_{m,t} K_{m,t} + r_{n,t} K_{n,t} + w_{s,t} S_t + w_{u,t} U_t, \quad (5)$$

- Sector specific capital accumulation ($j = m, n$)

$$K_{j,t+1} = I_{j,t} \left\{ 1 - \Phi \left(\frac{I_{j,t}}{I_{j,t-1}} \right) \right\} + (1 - \delta) K_{j,t}. \quad (6)$$

- Sectoral wages

$$w_{j,t} = (1 - \tau_{j,t}) w_{s,t} + \tau_{j,t} w_{u,t}, \quad (7)$$

where $\tau_{j,t} = \frac{U_{j,t}}{S_{j,t} + U_{j,t}}$.

- Market clearing conditions

$$S_t = S_{m,t} + S_{n,t} \qquad Y_{m,t} = C_{m,t} + I_{m,t} + I_{n,t}$$
$$U_t = U_{m,t} + U_{n,t} \qquad Y_{n,t} = C_{n,t}$$

Estimation Setup

- We augment our log-linearized model with sectoral investment-specific technology shocks and skill-specific wage markup shocks.
- Seven observables
  - Output growth (manufacturing and non-manufacturing)
  - Growth rate of total hours worked (skilled and unskilled)
  - Wage inflation (manufacturing and non-manufacturing)
  - Relative price inflation

Details

- Sample: 1975:Q1 – 1995:Q4

Fig. 2

- Imposed steady-state shares

$$w_s/w_u = 2.45 \qquad S_m/U_m = 13.85 \qquad \alpha_{k_m} = 0.46$$
$$\frac{S_m}{S_m+S_n} = 0.36 \qquad S_n/U_n = 7.06 \qquad \alpha_{k_n} = 0.54$$

Prior Distributions

Table: Prior Distributions

Parameter		Dist.	Prior Mean	Prior Std Dev
κ	Elasticity of substitution b/w goods and services	G	1.143	0.4
$\frac{1}{\eta}$	Inverse Frisch labor supply elasticity	N	2	0.75
σ	Controlling elasticity of substitution b/w K and U	B	0.2	0.2
α	Capital-skill complementarity ($\alpha \equiv \sigma - \rho$)	G	0.5	0.5
φ	Investment adjustment cost parameter	G	4	1
ρ_x	Persistence of shocks	B	0.75	0.1
σ_x	Std Dev of shocks	IG	0.025	∞

Posterior Distribution

Table: Selected Posterior Distributions

Parameter		Posterior Distribution		
		Mean	90% Interval	
κ	Elasticity of substitution b/w goods and services	4.5705	3.7134	5.4186
$\frac{1}{\eta}$	Inverse Frisch labor supply elasticity	1.6710	1.1827	2.1474
σ_m	Controlling elasticity of substitution b/w K_m and U_m	0.6254	0.5469	0.7011
σ_n	Controlling elasticity of substitution b/w K_n and U_n	0.0025	0.0000	0.0065
α_m	Capital-skill complementarity in manufacturing	4.5644	3.1990	5.8114
α_n	Capital-skill complementarity in non-manufacturing	0.4034	0.2879	0.5127
φ	Investment adjustment cost parameter	1.7129	0.7033	2.7524

Note: $\alpha_j \equiv \sigma_j - \rho_j$

Other Post Dist

Some Comments on the Estimated Results

- The elasticities of substitution between K and U are quite different across sectors (2.7 vs. 1).
- Capital-skill complementarity differs across sectors.
- The implied elasticities of substitution between K and S are different as well (0.2 vs. 0.7).
- The elasticity of substitution between goods and services is greater than unity.
  - This suggests that the data may not support the story of Ngai and Pissarides (2007) for the sectoral reallocation of labor.

Comparative Statics Setup

- Given the imposed values of $\frac{w_s}{w_u}$, $\frac{S_m}{U_m}$, $\frac{S_n}{U_n}$, and $\frac{S_m}{S_m+S_n}$, pin down the value of θ.
- Given the estimated parameter values, back out μ_m, μ_n, γ, and $\frac{\psi_u}{\psi_s}$ by using the steady-state relationship.
- Numerically investigate how different parameter values affect the steady-state skill premium and sectoral wages.

Changes in the Skill Premium

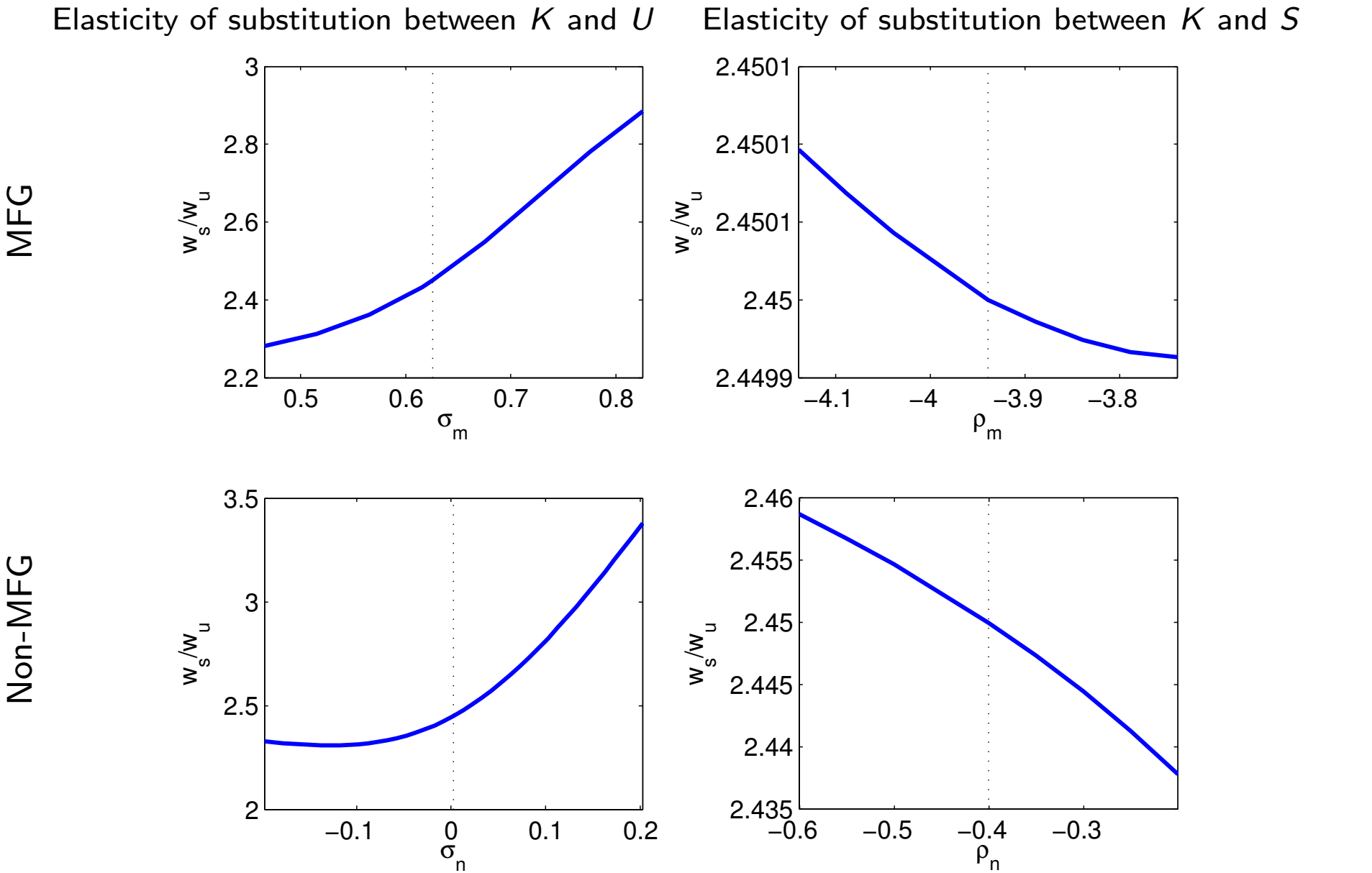

Figure: Changes in Skill Premium (Dashed vertical lines indicate posterior means.)

Changes in Sectoral Wages

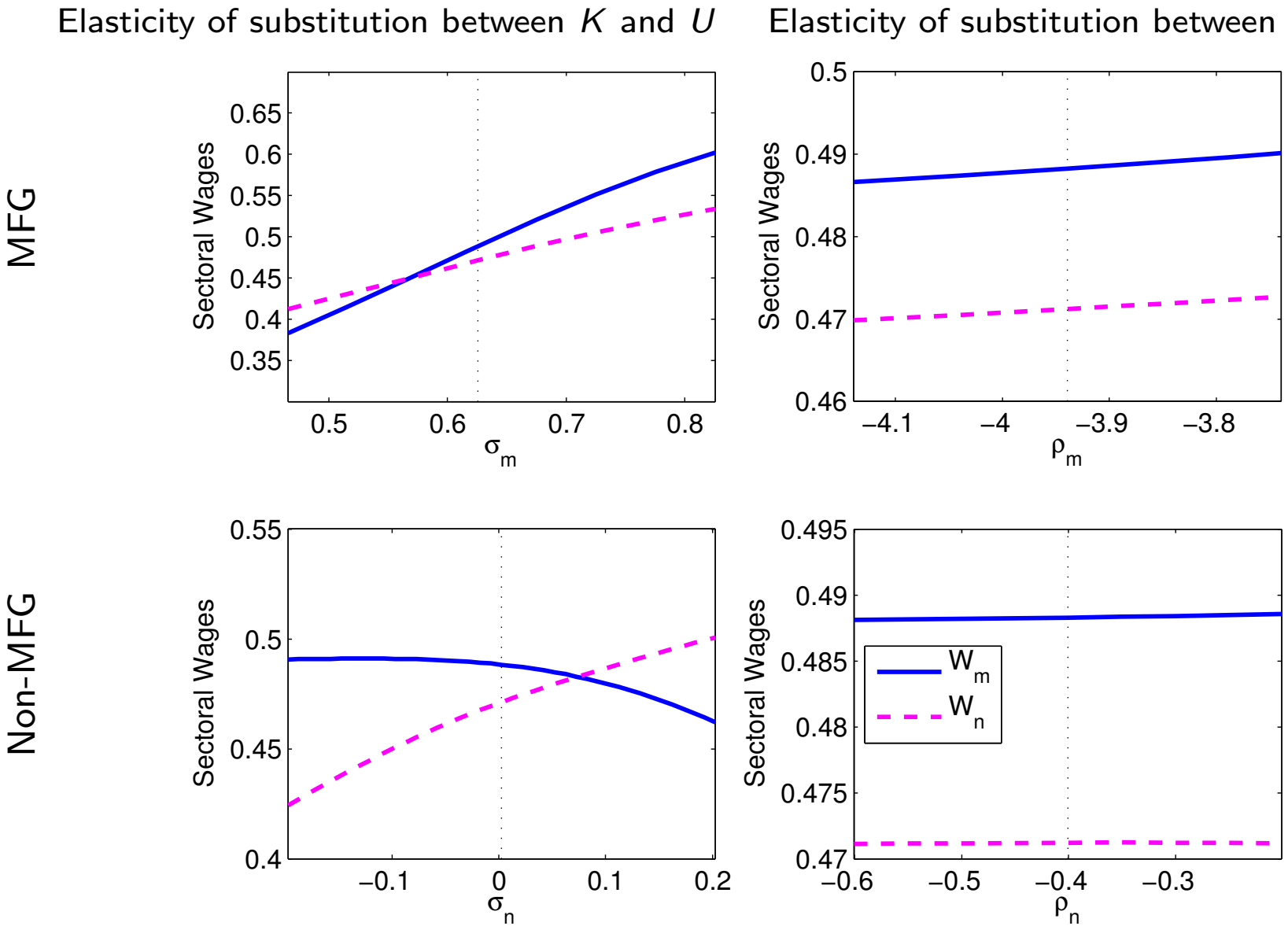

Figure: Changes in Sectoral Wages (Dashed vertical lines indicate posterior means.)

Changes in Unskilled Shares

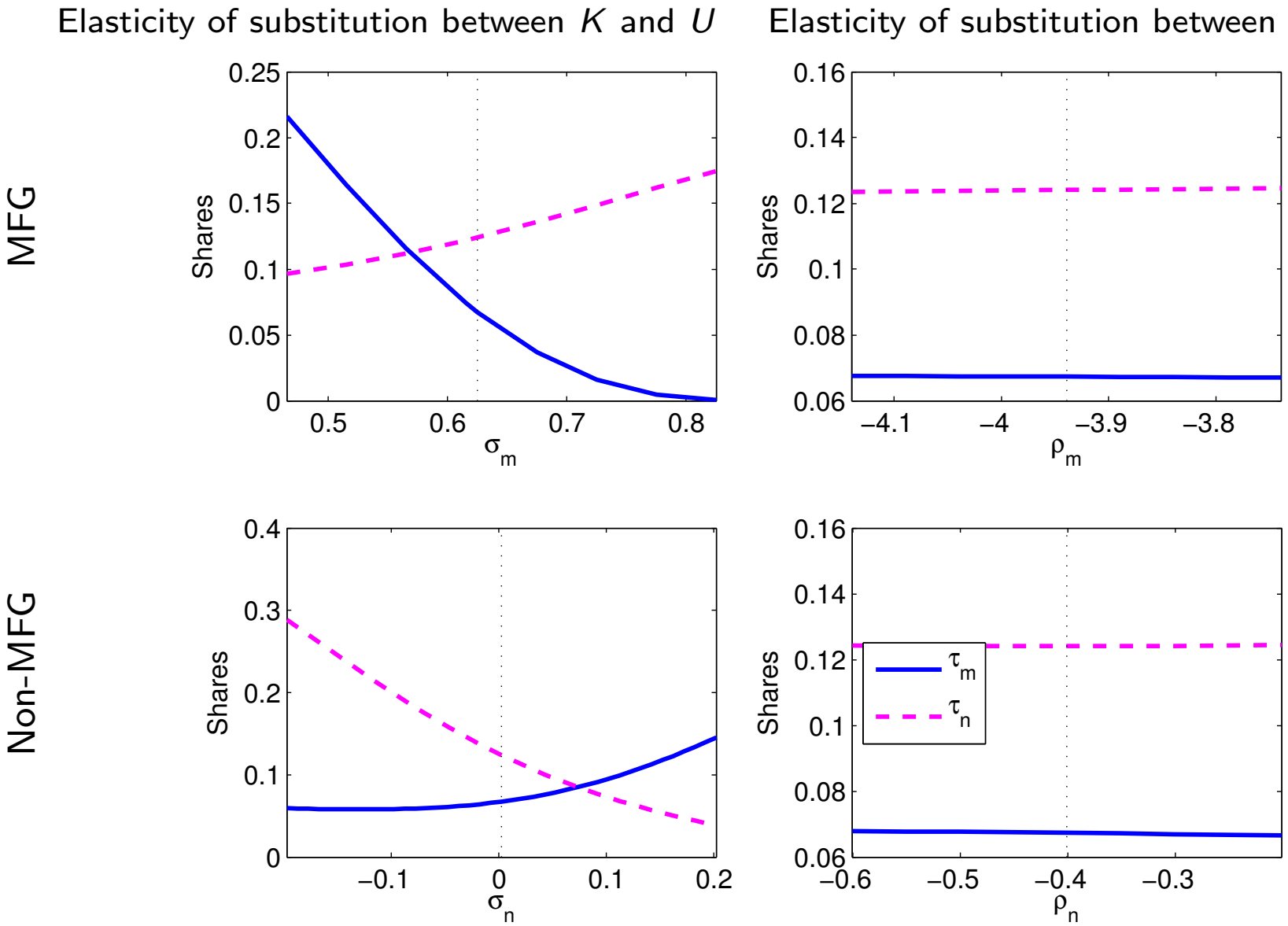

Figure: Changes in Unskilled Shares (Dashed vertical lines indicate posterior means.)

More Productive Unskilled Labor?

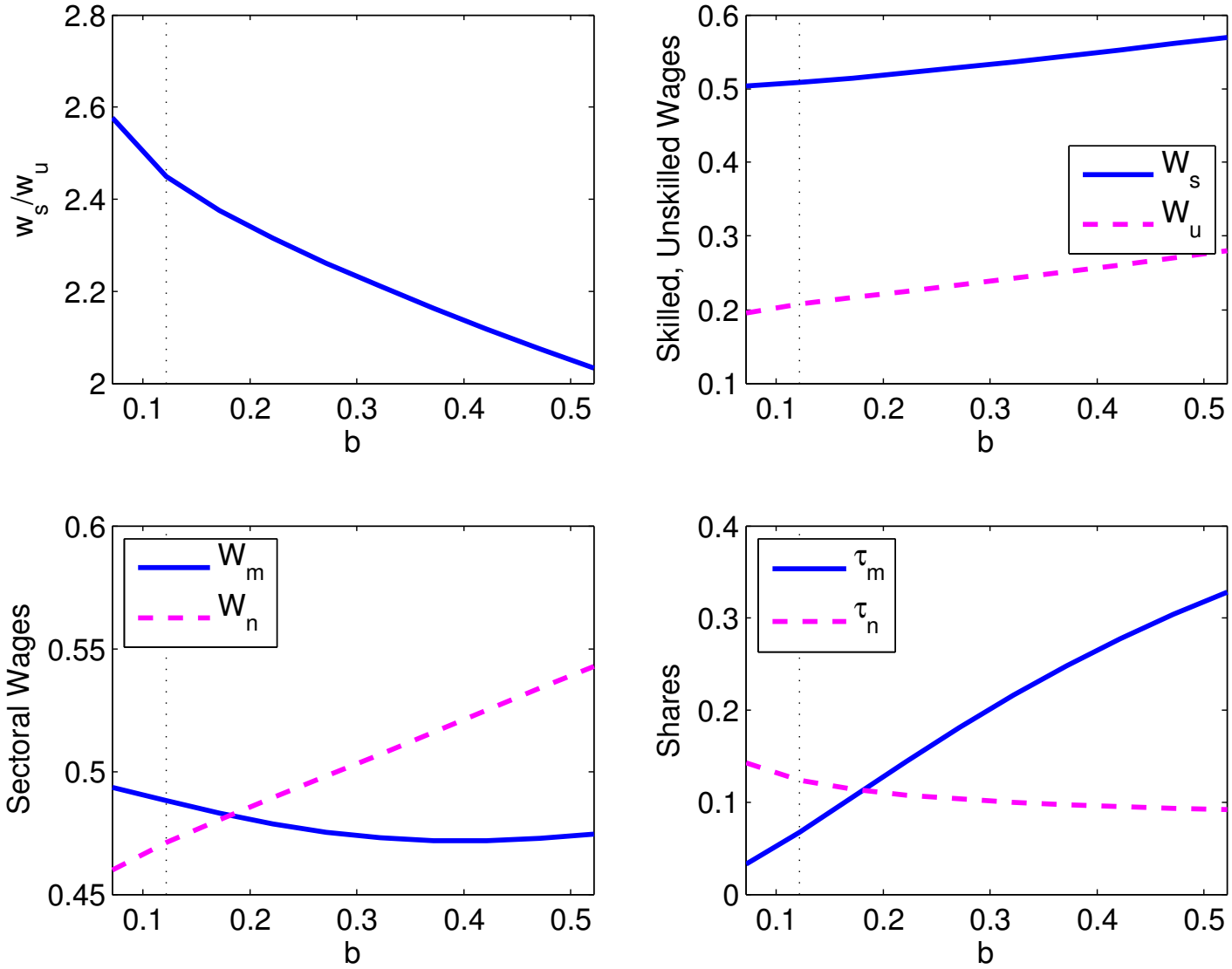

Figure: Changes in b (Dashed vertical lines indicate the baseline case.)

Summary of Comparative Statics

- Lower capital-skill complementarity can explain the declining skill premium.

- $\downarrow$ in σ_n mainly accounts for the three observations:
  - **(i)** Lower skill premium
  - **(ii)** Wider sectoral wage gap between manufacturing and non-manufacturing
  - **(iii)** Higher unskilled share in non-manufacturing

- Varying other parameter values do not replicate changes in sectoral wages. Others

- When we let $\sigma_n = -0.087$, we have

$$\frac{w_s}{w_u} = 2.3 \quad \text{and} \quad \frac{w_m}{w_n} = 1.0847$$

Our Interpretation

- What does the lower σ_n really mean?
- We interpret this as some evidence for sectoral shifts within non-manufacturing.
- Shifts from sectors with high substitutability between unskilled and capital to those with less substitutability.

Estimating Relative Demand for Skilled

- From the FOCs, the demand for skilled relative to unskilled is given by

$$\frac{S_{i,t}}{U_{i,t}} = \left(\frac{\mu_i}{(1-\mu_i)(1-\lambda_i)}\right)^{\frac{1}{\sigma_i-1}} \left(\frac{w_{s,t}}{w_{u,t}}\right)^{\frac{1}{\sigma_i-1}} \left(\frac{\psi_{s,t}}{\psi_{u,t}}\right)^{\frac{-\sigma_i}{\sigma_i-1}} \times \left[\lambda_i \left(\frac{K_{i,t}}{\psi_{i,t} S_{i,t}}\right)^{\rho_i} + (1-\lambda_i)\right]^{\frac{\rho_i-\sigma_i}{\rho_i(\sigma_i-1)}} \quad (8)$$

- Suggesting the following estimation equation

$$\log\left(\frac{S_{i,t}}{U_{i,t}}\right) + \log\left(\frac{\psi_{s,t}}{\psi_{u,t}}\right) = a_i + b_i \left\{\log\left(\frac{w_{s,t}}{w_{u,t}}\right) - \log\left(\frac{\psi_{s,t}}{\psi_{u,t}}\right)\right\} + c_i \log\left(\frac{K_{i,t}}{\psi_{s,t} S_{i,t}}\right) + \epsilon_{i,t} \quad (9)$$

where

$$b_i = \frac{1}{\sigma_i - 1}$$

Data

- We estimate Eq. (9) by pooling non-manufacturing data from the JIP database.
- Use $\{\hat{\psi}_{s,t}, \hat{\psi}_{u,t}\}$ from the structural estimation.
- Sample:
  - $t = 1975, 1980, 1985, 1990, 1995$
  - Due to availability of $S_{i,t}/U_{i,t}$ and $\{\hat{\psi}_{s,t}, \hat{\psi}_{u,t}\}$
  - 40 non-manufacturing industries (10 groups)
- Impose restrictions that coefficients are the same within each industry group.
- Use capital-labor ratios in the previous year as instruments.

Estimation Results

Table: Estimated Elasticities of Substitution between Capital and Unskilled

	$\frac{1}{1-\sigma_i}$	Std. Err.
Utility	1.3644*	(0.1937)
Information Technology	1.3841*›	(0.0558)
Transportation	1.0440	(0.0580)
Retail and Wholesale	1.0482	(0.4904)
Finance, Insurance, and Real Estate	0.9605	(0.0441)
Education and Professional Services	0.9973	(0.0935)
Accommodations and Food	1.1615	(0.2115)
Personal and Amusement Services	0.8681	(0.0861)
Medical and Health Care	0.7288*›	(0.0444)
Other Services	1.0507	(0.0526)

Note: Heteroskedasticity-robust standard errors are reported in parentheses. ***, **, and * indicate that the corresponding coefficient is significant at 1%, 5%, and 10% level, respectively. The null hypothesis is $\frac{1}{1-\sigma_i} = 1$.

Changes in Relative Shares

Elasticity of Substitution

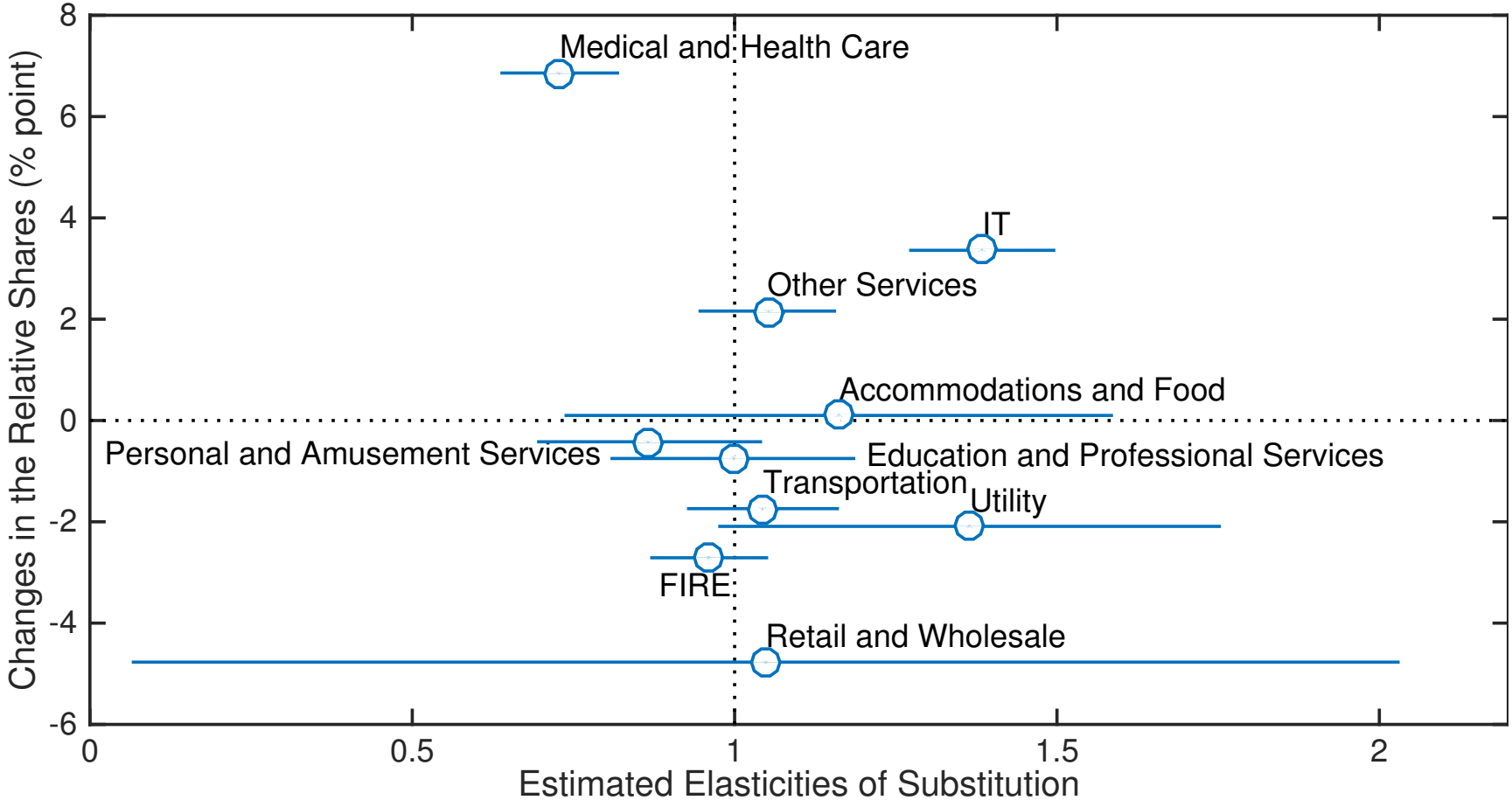

Figure: Estimated Elasticities of Substitution and Changes in Shares

Note: Dots correspond to point estimates. Horizontal lines indicate two-standard-error intervals. Vertical axis measures changes in the relative shares within non-manufacturing.

Remarks

- Disaggregated analysis suggest that rapid growth of medical and health care can account for the reduction in σ_n.
- Generated regressor problem must be addressed.
  - Standard errors ignore uncertainty related to the generated regressor.
- A fix (to be implemented):
  - We have $\{\hat{\psi}_{s,t}^{(k)}, \hat{\psi}_{u,t}^{(k)}\}$ for $k = 1, \cdots, K$ from MH draws.
  - Use these to correctly account for distributions of $\hat{\psi}_{s,t}$ and $\hat{\psi}_{u,t}$.

Capital-Skill Complementarity in Non-Manufacturing

Table: Estimated Degree of Capital-Skill Complementarity

	c_i	Std. Err.
Utility	0.2512^{***}	(0.0876)
Information Technology	0.2702^{***}	(0.1164)
Transportation	-0.0924^{***}	(0.0260)
Retail and Wholesale	-0.1016	(0.3728)
Finance, Insurance, and Real Estate	-0.1230^{***}	(0.0168)
Education and Professional Services	-0.0863	(0.0703)
Accommodations and Food	0.0213	(0.0927)
Personal and Amusement Services	-0.2532^{***}	(0.0443)
Medical and Health Care	-0.3595^{***}	(0.0363)
Other Services	-0.0660^{*}	(0.0396)

Note: Heteroskedasticity-robust standard errors are reported in parentheses. ***, **, and * indicate that the corresponding coefficient is significant at 1%, 5%, and 10% level, respectively.

Changes in Relative Shares

Capital-Skill Complementarity

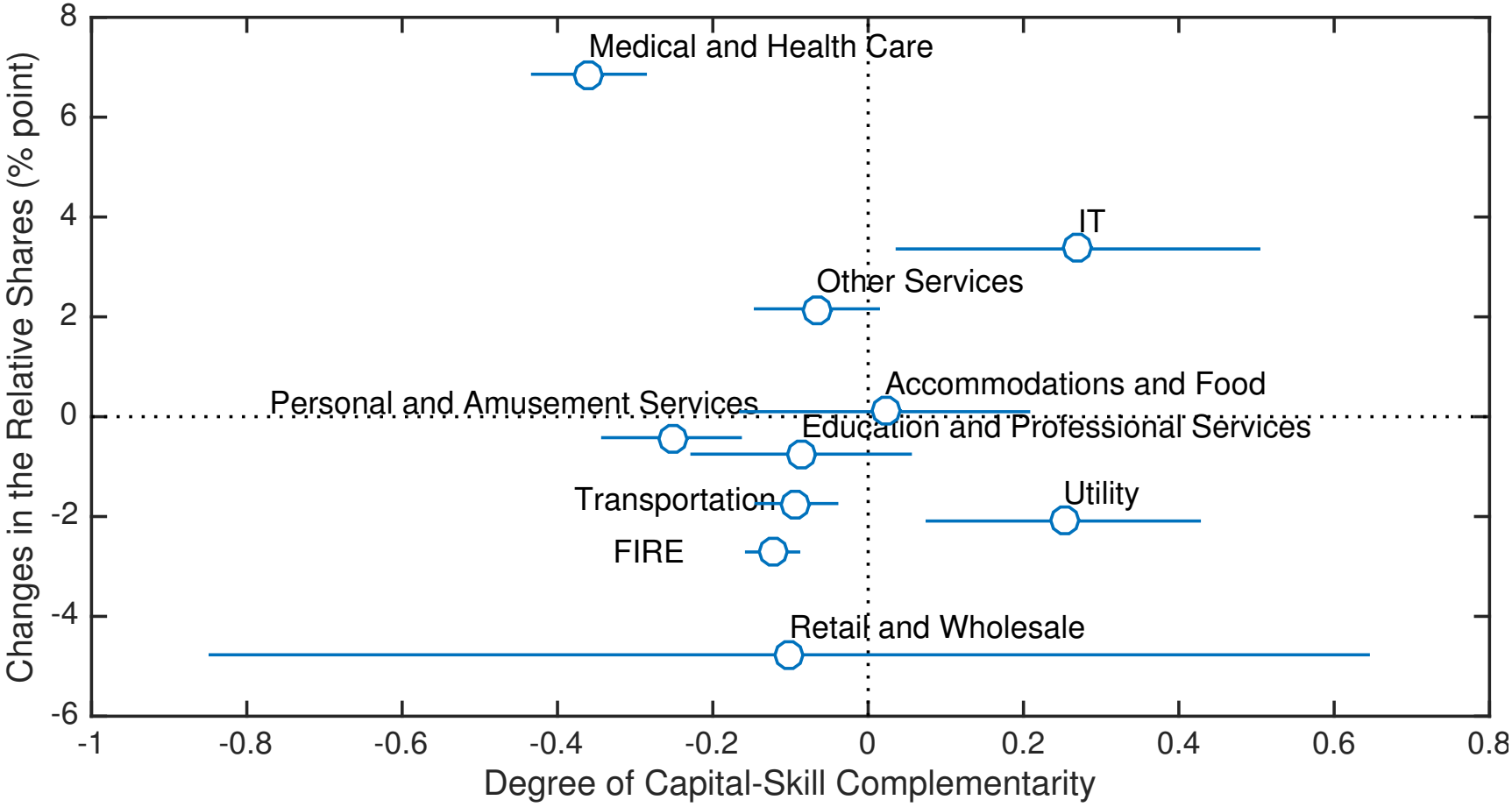

Figure: Estimated Degree of Capital-Skill Complementarity and Changes in Shares

Note: Dots correspond to point estimates. Horizontal lines indicate two-standard-error intervals. Vertical axis measures changes in the relative shares within non-manufacturing.

Conclusion

- Document (i) the declining skill premium, (ii) wider sectoral wage gap, and (iii) increasing unskilled share in non-manufacturing.
- The estimated parameter values suggest that there is significant difference in sectoral characteristics with respect to capital-skill complementarity.
- The lower elasticity of substitution between unskilled and capital in non-manufacturing accounts for the observed changes in the labor market in Japan.
- From the industry-level analysis, this can be attributed to the rapidly growing medical and health care industry, which is estimated to have low elasticity of substitution between capital and unskilled.

Definition of Regular Workers

Regular workers Those who satisfy one of the following conditions:

(1) Persons hired for an indefinite period or for longer than one month

(2) Persons hired by the day or for less than one month and who were hired for 18 days or more in each month of the two preceding months

Skill Premiums in Other Countries

- Typically, skill premiums have been increasing over time.
- Parro (2013) looks at 26 countries.
  - Average skill premium growth rates $= 7.25\%$
    (e.g., Germany: 14% 1990–2005, US: 3% 1990–2007) Table 1
  - However, there are countries experiencing declining skill premiums, such as Austria, Canada, Chile, Denmark, France, Greece, Japan, and Korea.

Changes in the Skill Premium

TABLE 1—CHANGE IN THE SKILL PREMIUM DURING THE LAST TWO DECADES

	Observed change in the skill premium (%)	Period	Definition of skill premium
Argentina	2.1	1990–1999	college/high school wage ratio
Austria	−9.9	1990–2005	college/high school wage ratio
Brazil	5.6	1996–2007	nonproduction/production workers wage ratio
Canada	−1.2	1990–2004	college/high school wage ratio
Chile	−5.0	1990–2000	college/high school wage ratio
China	40.2	1992–2006	college/high school wage ratio
Colombia	26.4	1990–2000	nonproduction/production workers wage ratio
Denmark	−2.3	1990–2005	college/high school wage ratio
Finland	1.4	1990–2005	college/high school wage ratio
France	−16.8	1990–2005	college/high school wage ratio
Germany	14.4	1990–2005	college/high school wage ratio
Greece	−2.4	1990–2005	college/high school wage ratio
India	11.9	1987–2004	college/high school wage ratio
Italy	29.8	1990–2005	college/high school wage ratio
Japan	−3.4	1990–2005	college/high school wage ratio
Korea	−6.6	1990–2005	college/high school wage ratio
Mexico	12.5	1990–2001	nonproduction/production workers wage ratio
Peru	23.9	1994–2000	nonproduction/production workers wage ratio
Portugal	12.3	1992–2005	college/high school wage ratio
Philippines	5.0	1988–2006	college/high school wage ratio
Spain	8.2	1990–2005	college/high school wage ratio
Sweden	9.0	1990–2002	college/high school wage ratio
Thailand	17.2	1990–2004	college/high school wage ratio
United Kingdom	2.0	1990–2005	college/high school wage ratio
United States	3.1	1990–2007	nonproduction/production workers wage ratio
Uruguay	11.1	1990–1999	college/high school wage ratio

Figure: Table 1 from Parro (2013, AEJ Macro)

Related Literature

- Lee and Wolpin (2006, Econometrica):
  - Two-sector model with three types of labor
  - OLG
  - Mobility costs
  - SMM
- Reshef (2013, RED):
  - Two-sector model with two types of labor
  - No capital
  - Inelastic labor supply
  - NLS

Household

- Preferences

$$u(C_t, H_t) = \log(C_t) - \varphi \frac{\eta}{1+\eta} H_t^{\frac{\eta+1}{\eta}}, \tag{10}$$

where η is the Frisch elasticity of aggregate labor supply.

- C_t consists of goods $C_{m,t}$ and services $C_{n,t}$

$$C_t = \left[\gamma \left(C_{m,t}\right)^{\frac{\kappa-1}{\kappa}} + (1-\gamma)\left(C_{n,t}\right)^{\frac{\kappa-1}{\kappa}}\right]^{\frac{\kappa}{\kappa-1}}, \tag{11}$$

where

$\gamma \in [0,1]$ is a share parameter

κ is the elasticity of substitution between C_m and C_n

Details of Data

- No sectoral output data is available at quarterly frequency.
- Assume that manufacturing produces goods that are used for
  - Durable goods consumption
  - Business fixed investment
  - Residential investment
- Similarly, we assume that output from non-manufacturing is consumed as
  - Non-durable consumption
  - Services

Posterior Distribution

Table: Posterior Distributions

Parameter		Posterior Distribution		
		Mean	90% Interval	
ρ_{a_m}	Persistence of TFP in MFG sector	0.66	0.52	0.81
ρ_{a_n}	Persistence of TFP in non-MFG sector	0.95	0.92	0.98
ρ_{ψ_s}	Persistence of skilled-specific shock	0.66	0.54	0.79
ρ_{ψ_u}	Persistence of unskilled-specific shock	0.77	0.67	0.88
ρ_{ξ_m}	Persistence of inv.-specific shock in MFG sector	0.76	0.59	0.92
ρ_{ξ_n}	Persistence of inv.-specific shock in non-MFG sector	0.92	0.87	0.98
ρ_{μ_s}	Persistence of wage markup shock for skilled	0.94	0.91	0.98
ρ_{μ_u}	Persistence of wage markup shock for unskilled	0.81	0.72	0.89

Posterior Distribution

Table: Posterior Distributions

Parameter		Posterior Distribution		
		Mean	90% Interval	
σ_{a_m}	Std Dev of TFP shock in MFG sector	0.023	0.020	0.027
σ_{a_n}	Std Dev of TFP shock in non-MFG sector	0.009	0.008	0.010
σ_{ψ_s}	Std Dev of skilled-specific shock	0.031	0.025	0.035
σ_{ψ_u}	Std Dev of unskilled-specific shock	0.175	0.127	0.223
σ_{ξ_m}	Std Dev of inv.-specific shock in MFG sector	0.020	0.006	0.031
σ_{ξ_n}	Std Dev of inv.-specific shock in non-MFG sector	0.037	0.020	0.053
σ_{μ_s}	Std Dev of wage markup shock for skilled	0.024	0.020	0.028
σ_{μ_u}	Std Dev of wage markup shock for unskilled	0.055	0.048	0.063

Changes in Skilled and Unskilled Wages

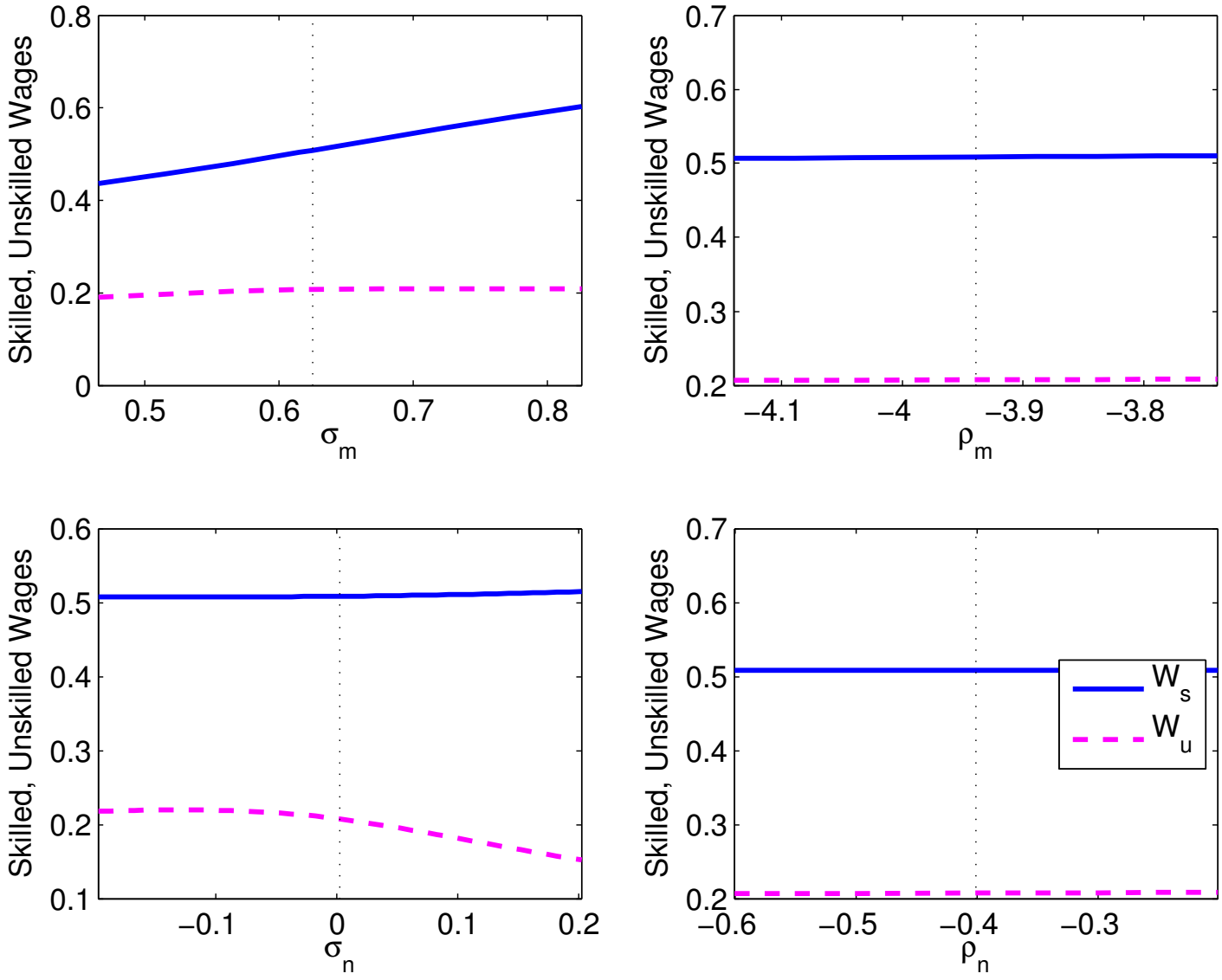

Figure: Changes in Skilled and Unskilled Wages (Dashed vertical lines indicate posterior means.)

Changes in γ

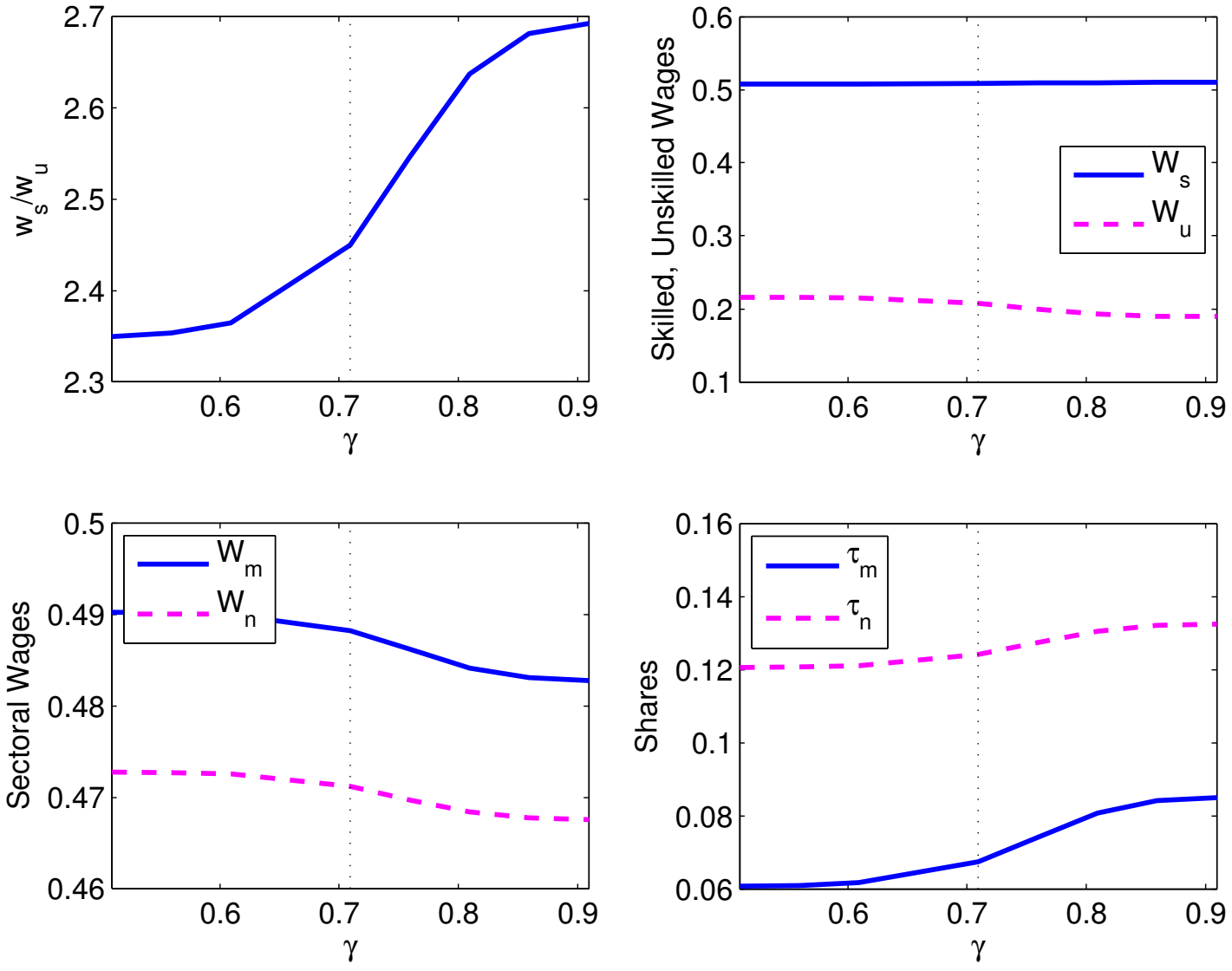

Figure: Changes in γ

Changes in κ

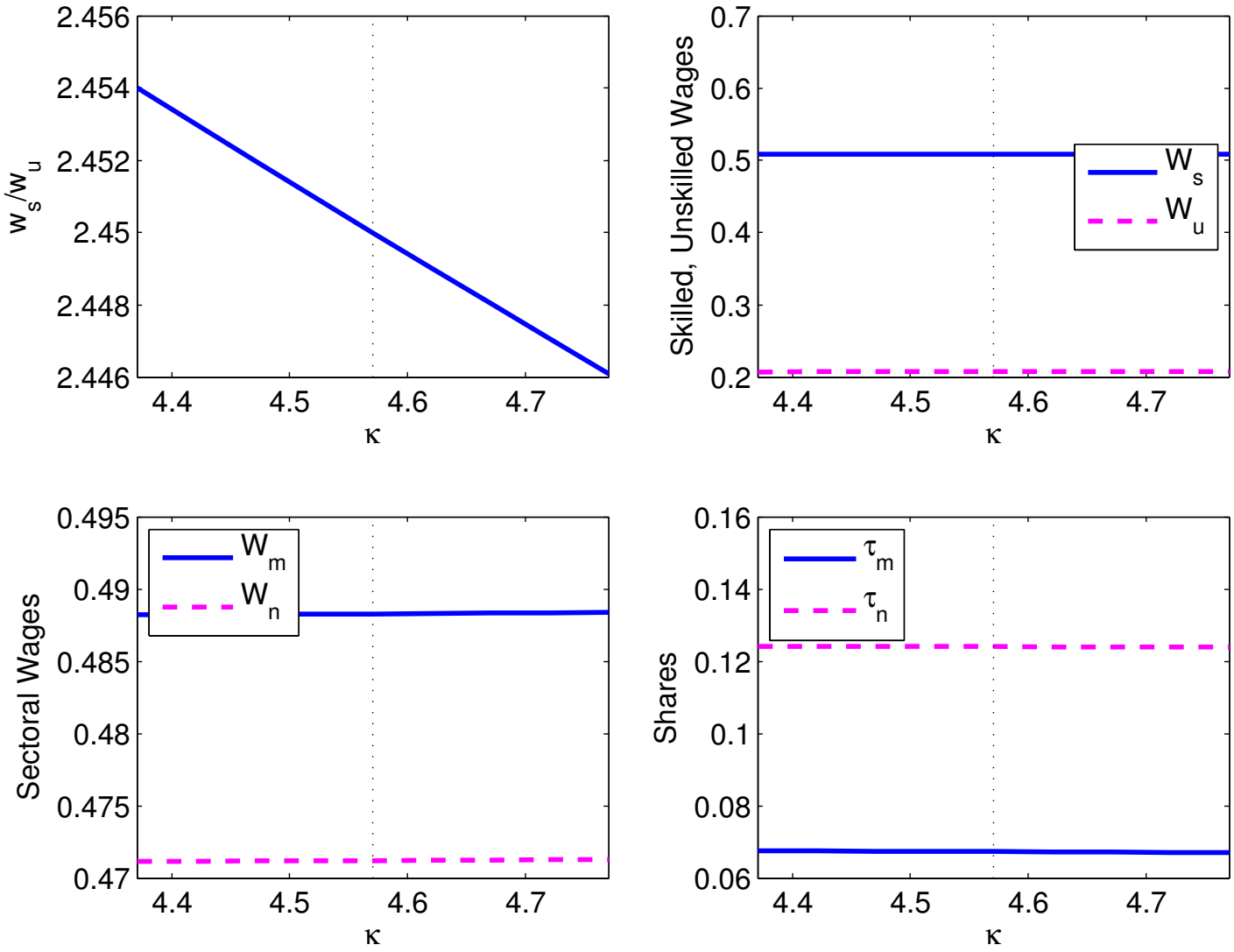

Figure: Changes in κ (Dashed vertical lines indicate posterior means.)

Changes in θ

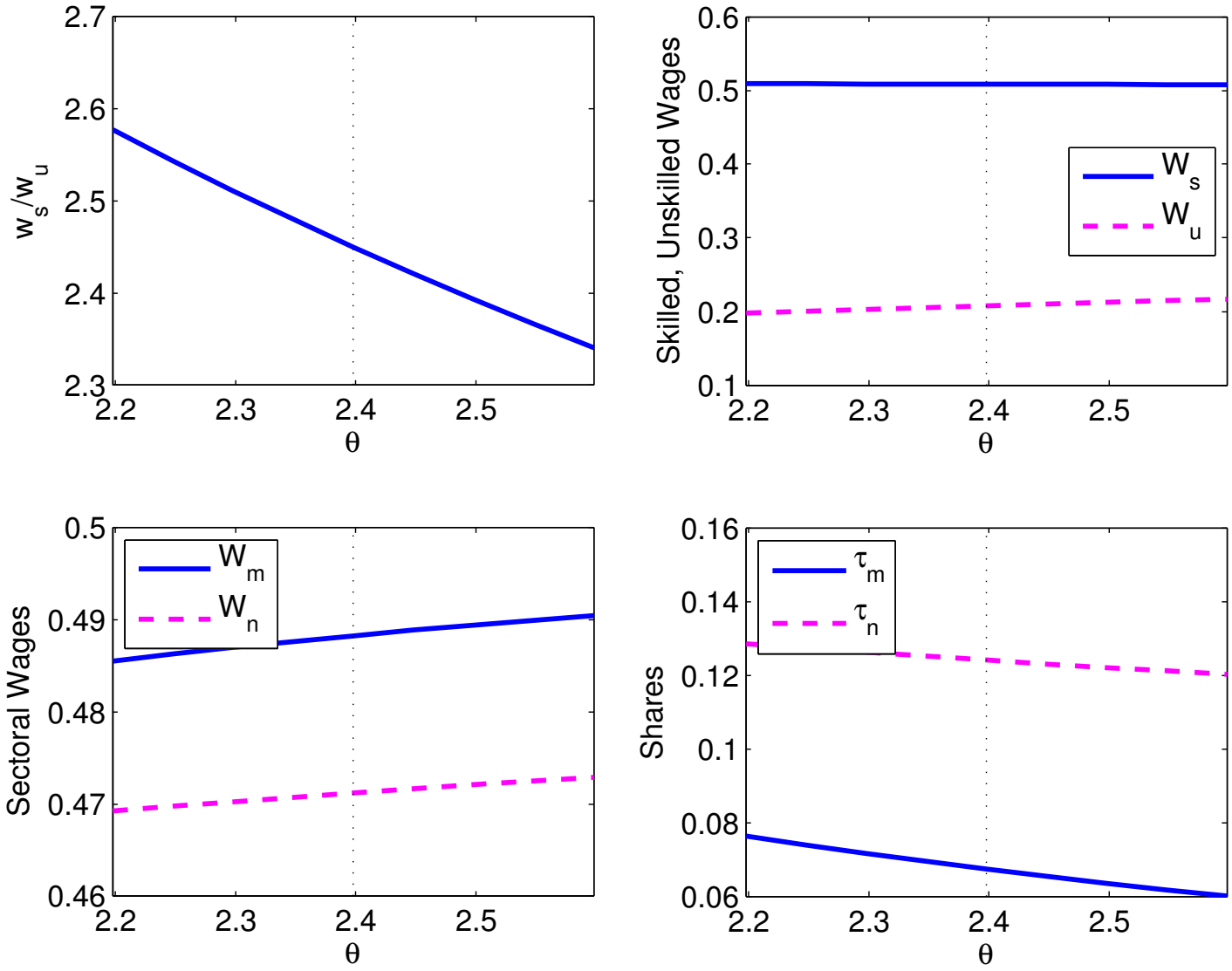

Figure: Changes in θ