Skill-Biased Structural Change and the Skill Premium

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Motivating Trends

- Well-documented rise in the skill premium, e.g., +28 pp since 1977 in the US
  - Katz & Murphy (1992),..., Acemoglu & Autor (2011)
  - Will skill premium continue rising, plateau, revert?

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- Well-documented rise in the skill premium, e.g., +28 pp since 1977 in the US
  - Katz & Murphy (1992),..., Acemoglu & Autor (2011)
  - Will skill premium continue rising, plateau, revert?
- Skill-biased structural change (SBSC) in advanced economies:
  - rising value added share of skill-intensive sectors
  - rising relative price of skill-intensive sectors

This Paper

Complements the standard emphasis on skill-biased technical change (SBTC) to account for the rise in the skill premium by:

1. Documenting salient, pervasive skill-biased structural change (SBSC) patterns for advanced economies

2. Developing a two-sector model of skill-biased structural change and assessing its contribution to the rise of the skill premium

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Complements the standard emphasis on skill-biased technical change (SBTC) to account for the rise in the skill premium by:

1. Documenting salient, pervasive skill-biased structural change (SBSC) patterns for advanced economies

2. Developing a two-sector model of skill-biased structural change and assessing its contribution to the rise of the skill premium
   - Fits cross-country panel well, with common preferences, technological change
   - Contribution of SBSC: 27-33% in U.S.

Literature Review

- Theories explaining the rise of the skill premium, w/ emphasis on SBTC:
  - Katz & Murphy (1992), ..., Acemoglu & Autor (2011), Autor & Dorn (2013), Leonardi (2015)
- Structural change:
  - Baumol (1969),..., Kongsamut et al. (2001), Ngai & Pissarides (2007), Acemoglu & Guerrieri (2008), Buera & Kaboski (2012), Reshef (2013), Herrendorf et al. (2014)

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Skill-Biased Structural Change

- Standard theories of structural change focused on agriculture, manufacturing, services categories
- Recent theories emphasize technology or preference defining characteristics:
  - Capital intensity: Acemoglu & Guerrieri (2008)
  - Skill intensity: rise of services explained by growth of skill-intensive services, Buera & Kaboski (2012)

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Data Work

1. Document salient patterns in cross-country panel
   - Rising share of skill-intensive sector with per capita income
   - Substitution: Rising relative price of skill-intensive output with per capita income
2. Non-hometheticity: VA share of skill-intensive sector in expenditures rises with household income (U.S. cross-section)

Cross-Country Data

- EUKLEMS Basic Tables
  - Current-value VA by (1-2 digit) industry
  - Price indexes by industry
  - 1970-2005 for most countries
  - PPP data for 1997 for cross-country comparisons
- EUKLEMS Labour Input Data for advanced economies
  - Percentage distribution of labor payments and hours
  - broken out by education level, age, sex, and (1-2 digit) industry
  - 1970-2005, but years vary by country
- PWT 7.1 GDP per capita

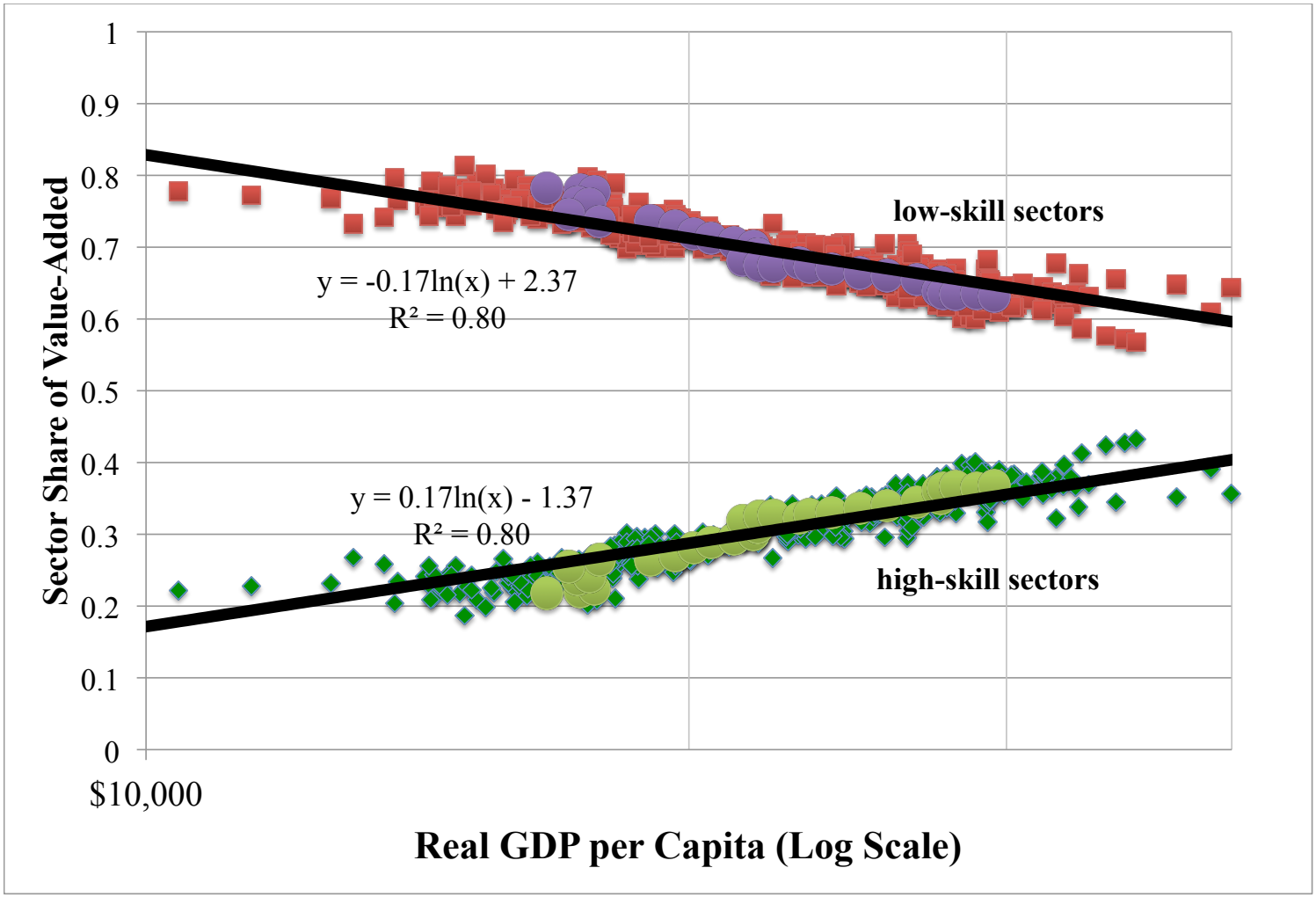
High vs. Low Skill-Intensive Industries

High Skill Share	1970
Education	0.74
Health and Social Work	0.49
Real Estate and Business Activities	0.39
Financial Intermediation	0.27
Chemical, Rubber, Plastics & Fuel	0.21
Electrical and Optical Equipment	0.21
...	...
Wood and of Wood and Cork	0.05
Private Households with Employed Persons	0.02

High vs. Low Skill-Intensive Industries

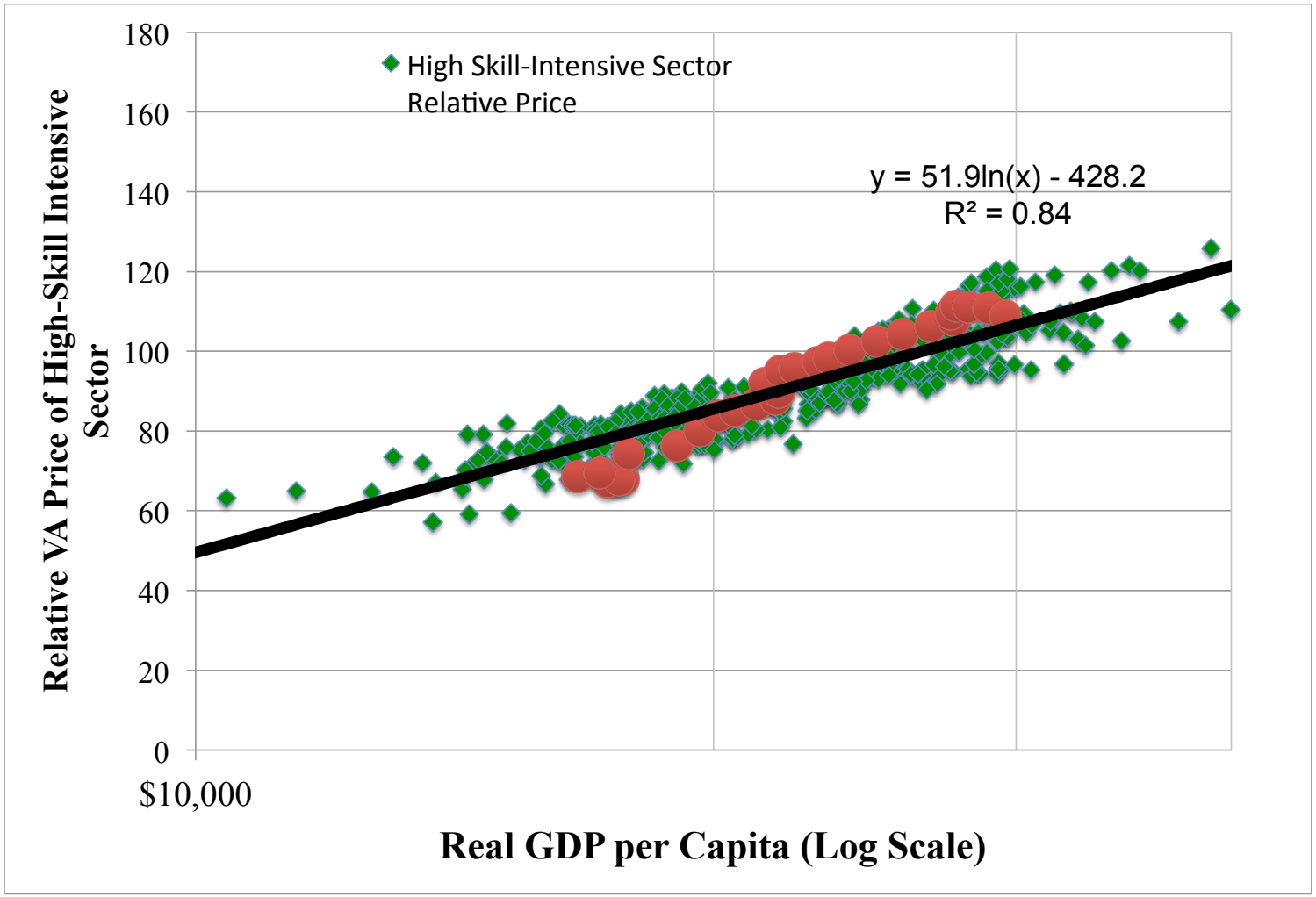
High Skill Share	1970	2005
Education	0.74	0.79
Health and Social Work	0.49	0.63
Real Estate and Business Activities	0.39	0.66
Financial Intermediation	0.27	0.62
Chemical, Rubber, Plastics & Fuel	0.21	0.46
Electrical and Optical Equipment	0.21	0.57
...	...	...
Wood and of Wood and Cork	0.05	0.18
Private Households with Employed Persons	0.02	0.14

Skill-Biased Structural Change: Value Added



EUKLEMS 1970-2005: Australia, Austria Denmark, France, Germany, Italy, Japan, the Netherlands, South Korea, Spain, UK, US. ▸ within manufacturing ▸ within services

Skill-Biased Structural Change: Relative Prices



U.S. Cross-Section Data

- CEX (2012) gives expenditures on final goods/services (except investment)
- Most models are value-added models (Herrendorf et al., 2014)
- Factor intensity is at value-added level (use EUKLEMS for cross-country comparability)

- Obtaining value-added content of consumer spending:
  1. Designate industry VA as high or low-skill intensive
  2. Get skill-intensive sector VA of one dollar of PCE categories by mapping through BEA I-O tables (BEA correspondence)
  3. Mapping CEX expenditures to PCE categories (BLS correspondence) to get VA content
- Regress household skill-intensive VA content on household observables (education instruments for income)

U.S. Cross-Section Evidence: Non-Homotheticity

Table: **Household High-Skill Intensive Expenditure Share vs. Income/Skill**

	OLS	**IV**	**OLS**
Ln Income	0.012***	0.049***	.
SE	0.001	0.002	.
High Skill Head	.	.	0.043***
SE	.	.	0.002
R^2	0.08	0.02	0.15
Observations	48,550	48,550	17,812

*** indicate significance at the 1 percent level.

Controls include: age; age squared; dummies for sex, race, state, urban, and month; number of boys (2-16 year); number of girls (2-16 years); number of men (over 16 years); number of women (over 16 years);and number of infants (less than 2 years). High skilled is defined as 16 years of schooling attained, while low skilled is defined as 12 years attained.

Quantitative Model

- Simple, standard structural change model incorporating two chief causes:
  1. (Low) substitution: relative productivity/prices
  2. Nonhomotheticity: "Stone-Geary"-like constant (or Boppart, 2014, extension)
- Static
- Closed economy
- High- and low-skilled workers, exogenous supply

Quantitative Model: Preferences

$$a_G c_G^{\frac{\varepsilon-1}{\varepsilon}} + (1-a_G)(c_S+\bar{c}_S)^{\frac{\varepsilon-1}{\varepsilon}}$$

- c_G: goods (and low-skill intensive services)
- c_S: high-skill intensive services
- ε: elasticity of substitution (if $\bar{c}_S = 0$)
- $\bar{c}_S > 0$: (high-skill intensive) services are luxuries

Quantitative Model: Technologies

For each sector $j = G, S$

$$Y_j = A_j \left[\alpha_j H_j^{\frac{\rho-1}{\rho}} + (1-\alpha_j) L_j^{\frac{\rho-1}{\rho}} + \right]^{\frac{\rho}{\rho-1}}$$

- A_j: skill-neutral, sector-biased technological parameter
- $\alpha_j,\ \alpha_S > \alpha_G$: skill-biased technological parameter
- ρ: elasticity of substitution

Equilibrium

1. Individuals with skill $i = L, H$

$$\max_{c_{Gi}, c_{Si}} a_G c_{Gi}^{\frac{\varepsilon-1}{\varepsilon}} + (1 - a_G)(c_{Si} + \bar{c}_S)^{\frac{\varepsilon-1}{\varepsilon}}$$

s.t.

$$p_G c_{Gi} + p_S c_{Si} = w_i$$

2. Firms in sector $j = G, S$

$$\max_{L_j, H_j} p_j A_j \left[\alpha_j H_j^{\frac{\rho-1}{\rho}} + (1 - \alpha_j) L_j^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} - w_H H_j - L_j$$

3. Markets clear

$$H_G + H_S = f_H, \quad L_G + L_S = 1 - f_H, ...$$

Equilibrium: Expenditure Share of Services

$$\frac{p_S c_{Si}}{w_i} = \frac{\left(\frac{1-a_G}{a_G}\right)^{\varepsilon}\left(\frac{p_S}{p_G}\right)^{1-\varepsilon} - \frac{p_S \bar{c}_S}{w_i}}{\left(\frac{1-a_G}{a_G}\right)^{\varepsilon}\left(\frac{p_S}{p_G}\right)^{1-\varepsilon} + 1}$$

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- Relative price: $\Delta \frac{p_S}{p_G} > 0$ & $\varepsilon < 1$ (Baumol, 1969; Ngai & Pissarides, 2007)

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- Income effect: $\bar{c}_S > 0$ & $\Delta \frac{w_i}{p_s} > 0$ (Engel, 1857, Kongsamut et al., 2001)
- Technological progress, either sector biased or neutral, drive these effects

$$p_j = \frac{1}{A_j}\left[(1-\alpha_j)^{\rho} + \frac{\alpha_j^{\rho}}{w_H^{(\rho-1)}}\right]^{1-\rho}.$$

High Skill Labor Market Clearing

$$\left[\frac{\alpha_S \hat{p}_S(w_H) A_S}{w_H}\right]^{\rho} \frac{\sum_{i=L,H} f_i \hat{c}_{Si}(w_H)}{A_S}$$
$$+ \left[\frac{(\alpha_G \hat{p}_G(w_H) A_G}{w_H}\right]^{\rho} \frac{\sum_{i=L,H} f_i \hat{c}_{Gi}(w_H)}{A_G} = f_H.$$

Quantitative Exploration: Roadmap

1. Given ε and ρ, we calibrate $\{\alpha_{jt}\}_{t=0}^{T}$, $\{A_{jt}\}_{t=0}^{T}$, a_G, and $\bar{c}_S$ to match high-skill intensities in each sector, relative prices, aggregate growth, and the value-added share of skill-intensive sector in 1977 and 2005 for U.S.

2. Data on skill premium and aggregate factor shares imply "effective" supply of skills

3. Examine U.S. fit over time

4. Examine out-of-sample fit in cross-country panel

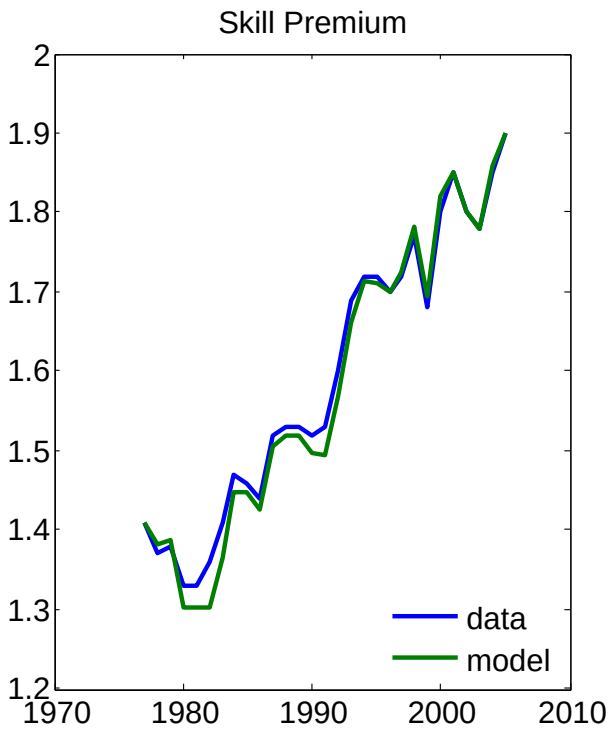
5. Perform counterfactuals to quantify the fraction of the U.S. change in the skill-premium explained by SBSC ($\approx 30\%$) vs. SBTC ($\approx 70\%$)

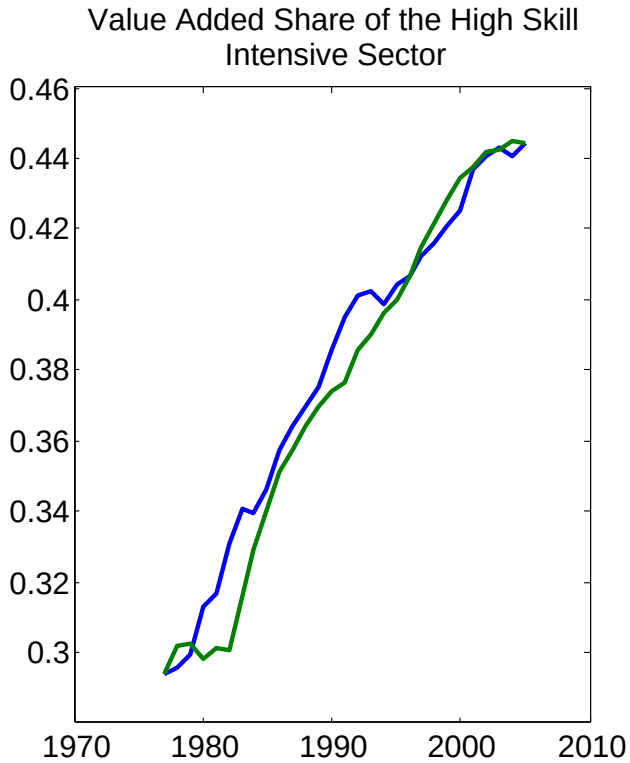
6. Analyze the sensitivity to alternative values of ε (not sensitive) and ρ (relatively insensitive)

Calibration, setting $\varepsilon = 0.2$ and $\rho = 1.4$

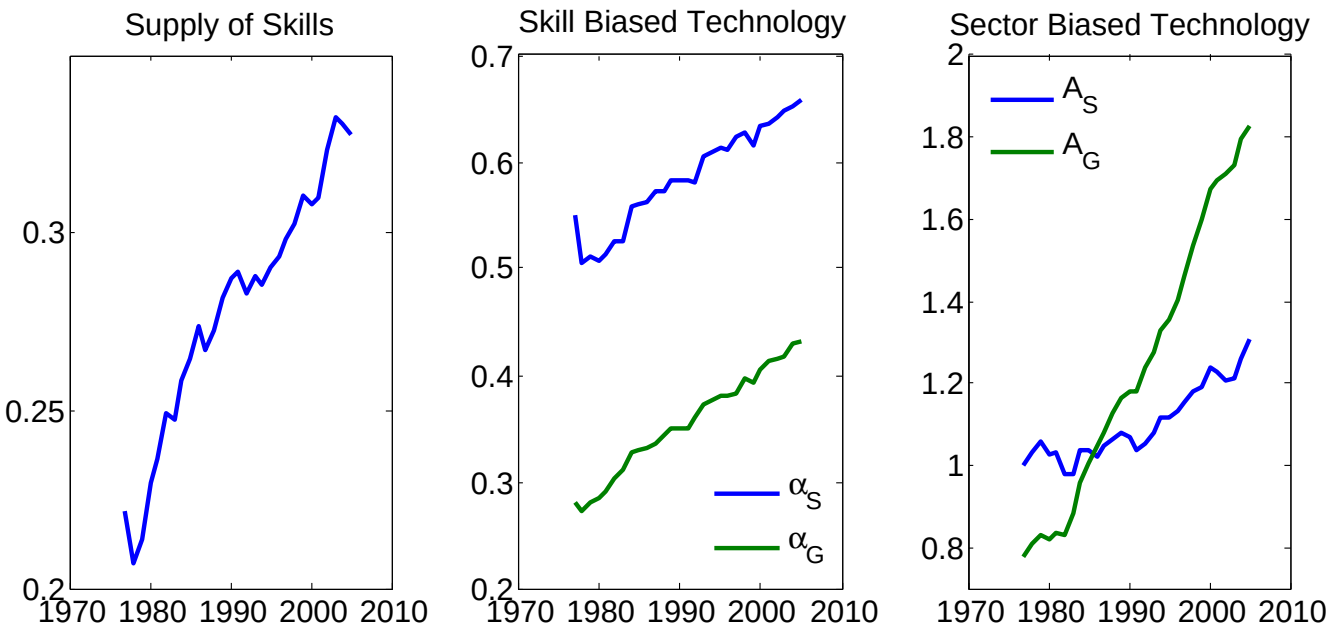
Parameters		Moments	
α_{G0}, α_{GT}	0.28, 0.43	$\frac{w_{Lt}L_{Gt}}{p_{Gt}Y_{Gt}}$	0.82, 0.66
α_{S0}, α_{ST}	0.55, 0.66	$\frac{w_{Lt}L_{St}}{p_{St}Y_{St}}$	0.46, 0.34
$\%\Delta \frac{A_G}{A_S}$	86%	$\%\Delta \frac{p_S}{p_G}$	62%
$\%\Delta A_G$	123%	$\%\Delta Y$	70%
a_G	0.71	$\frac{p_{S0}Y_{S0}}{Y_0}$	0.29
$\bar{c}_S$	0.14	$\Delta \frac{p_S Y_S}{Y}$	0.15 pp

Evolution of the Skill Premium and SBSC: Model vs. Data





Evolution of the Exogenous Shocks

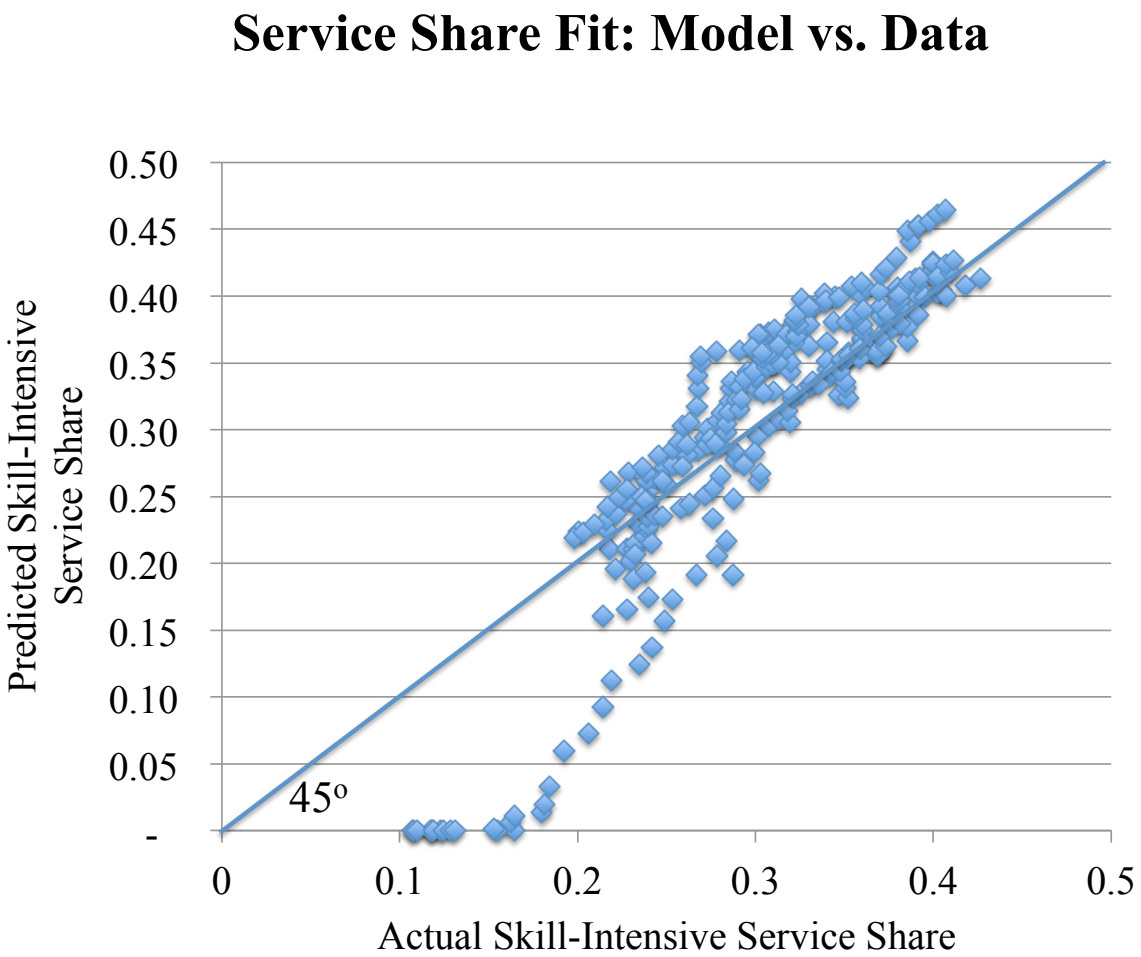


Examining Fit in Cross-Country Panel

Approach:

1. Keep preferences and technology parameters the same as U.S.
2. Use countries' income share, relative price, and aggregate growth data as targets
3. Examine fit for sector shares, skill premium
4. Examine imputed exogenous processes

Panel Results: Skill-Intensive Sector Fit



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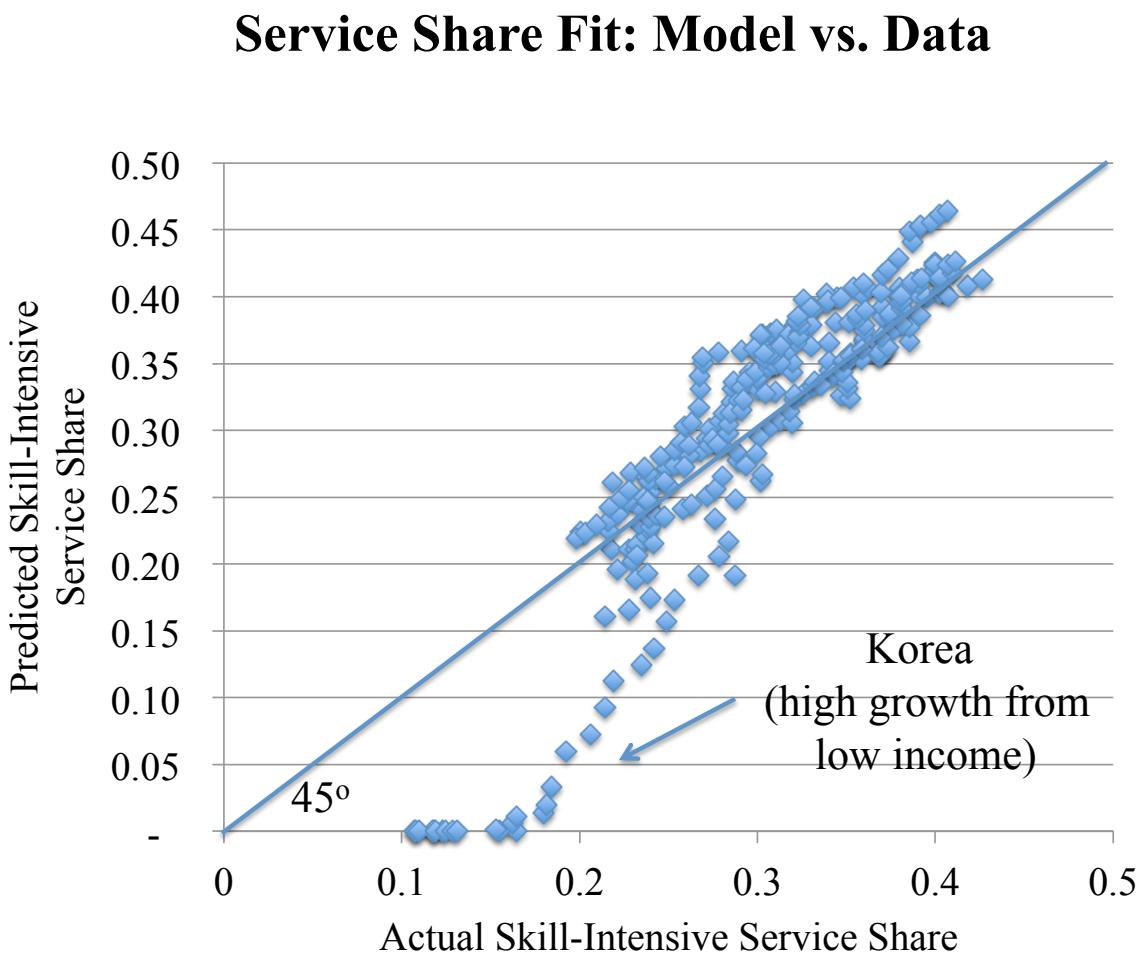
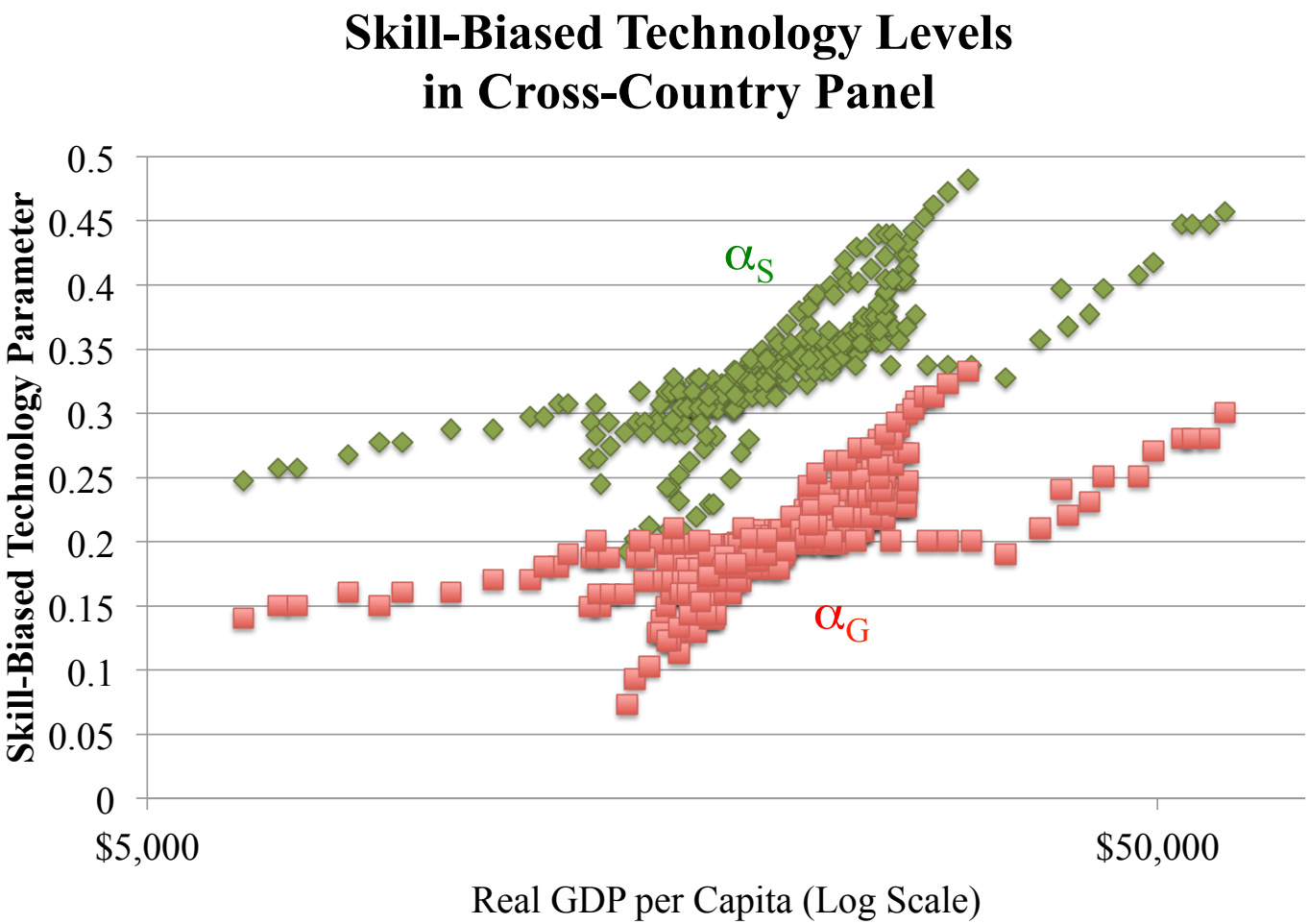


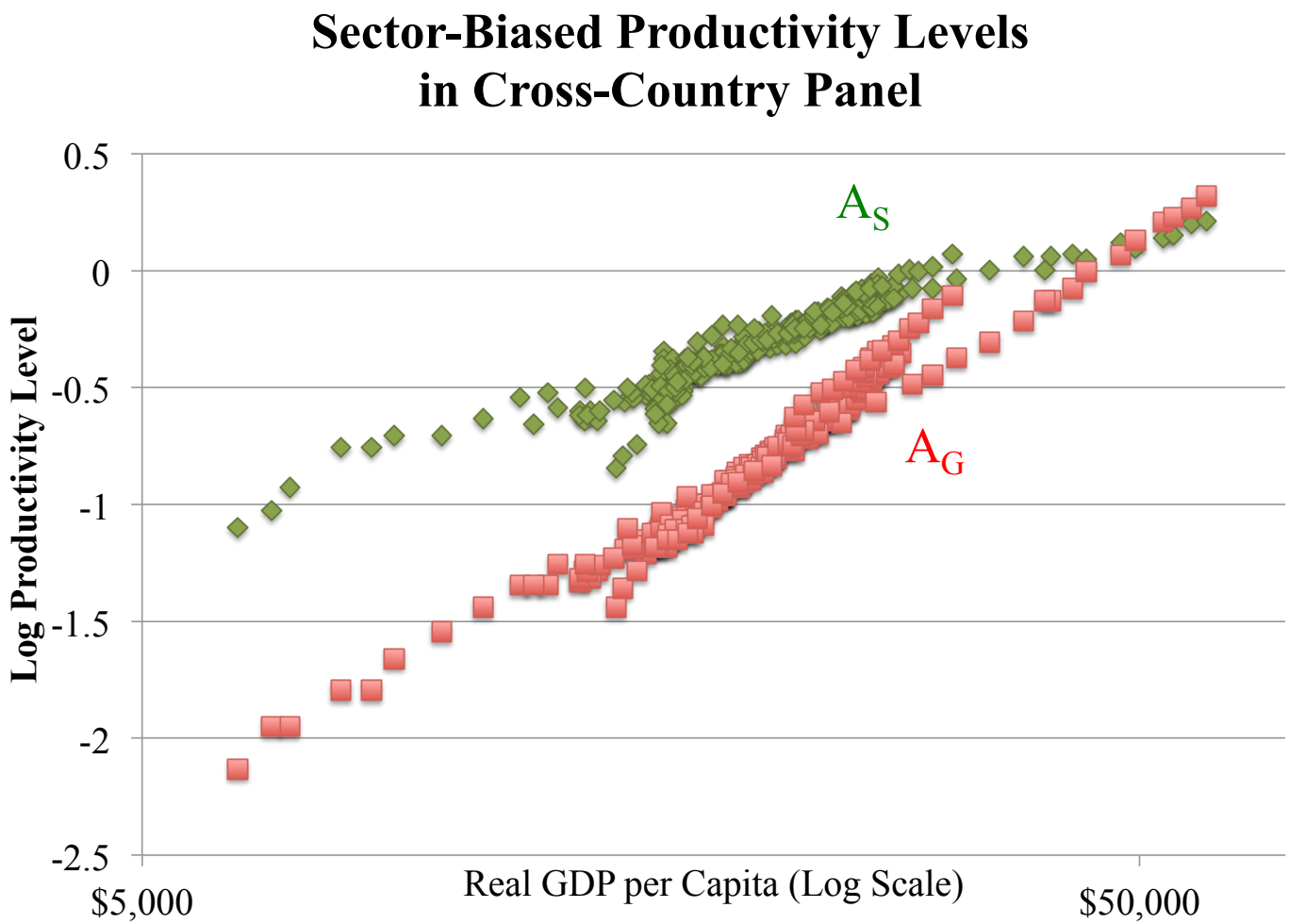
▸ Raw Results

Panel Results: Skill-Biased Technology Levels



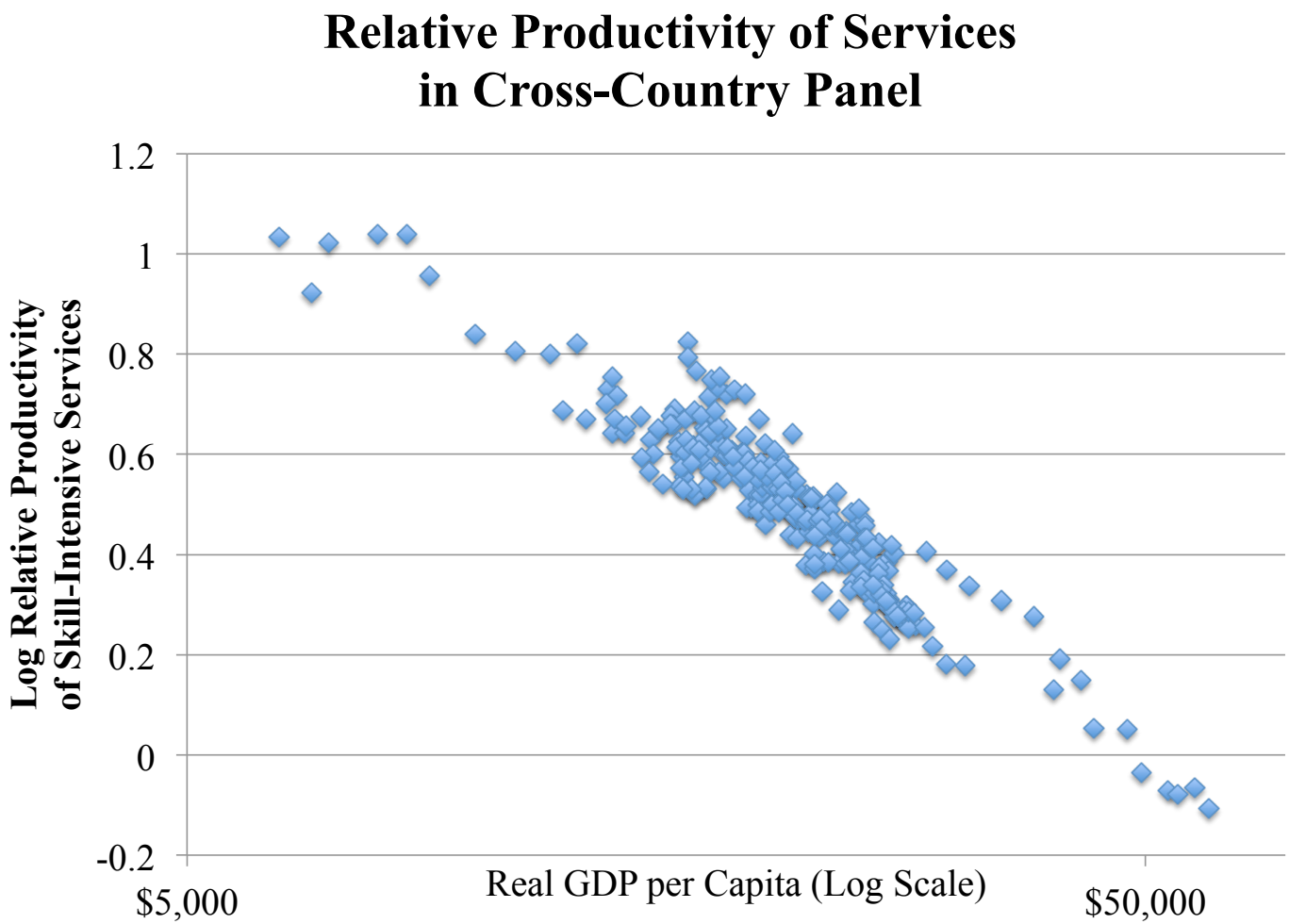
▸ Raw Results

Panel Results: Sector-Biased Technology Levels



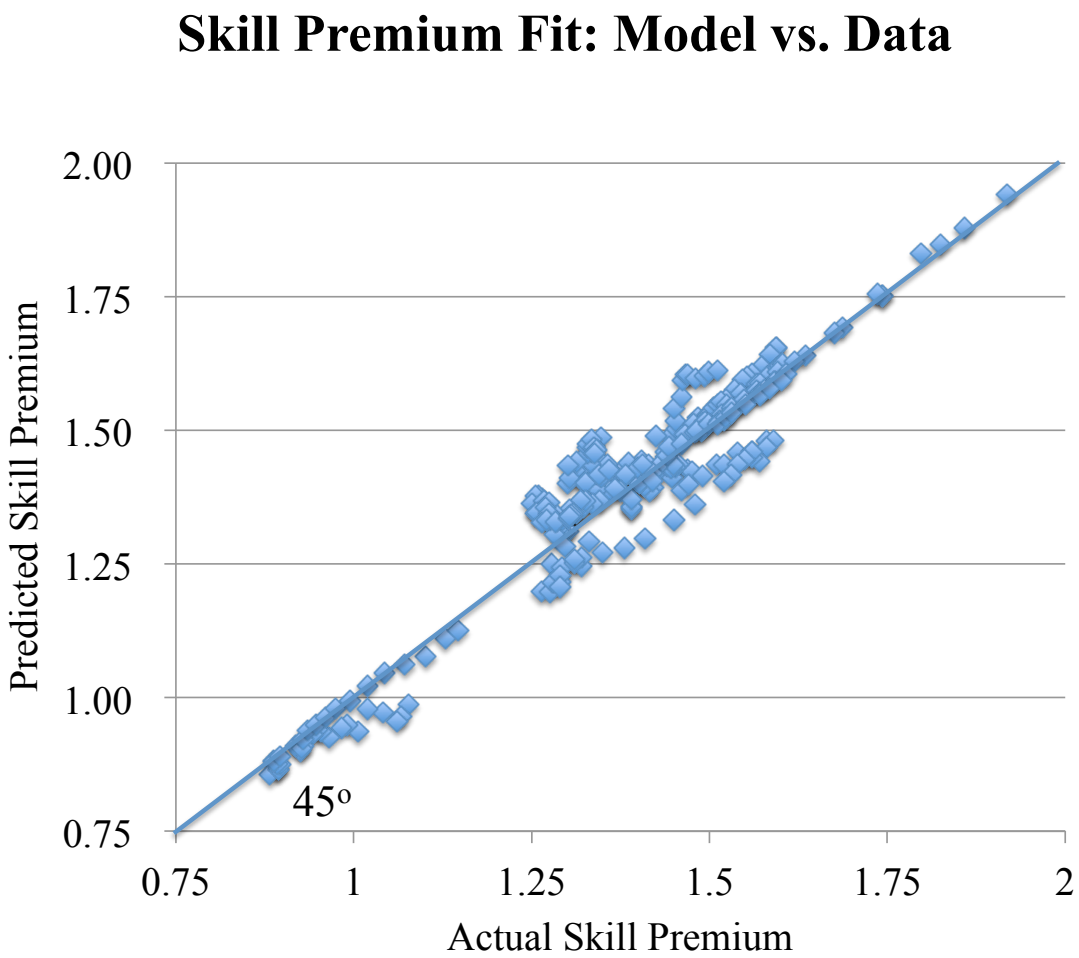
▸ Raw Results

Panel Results: Relative Sectoral Productivity Levels



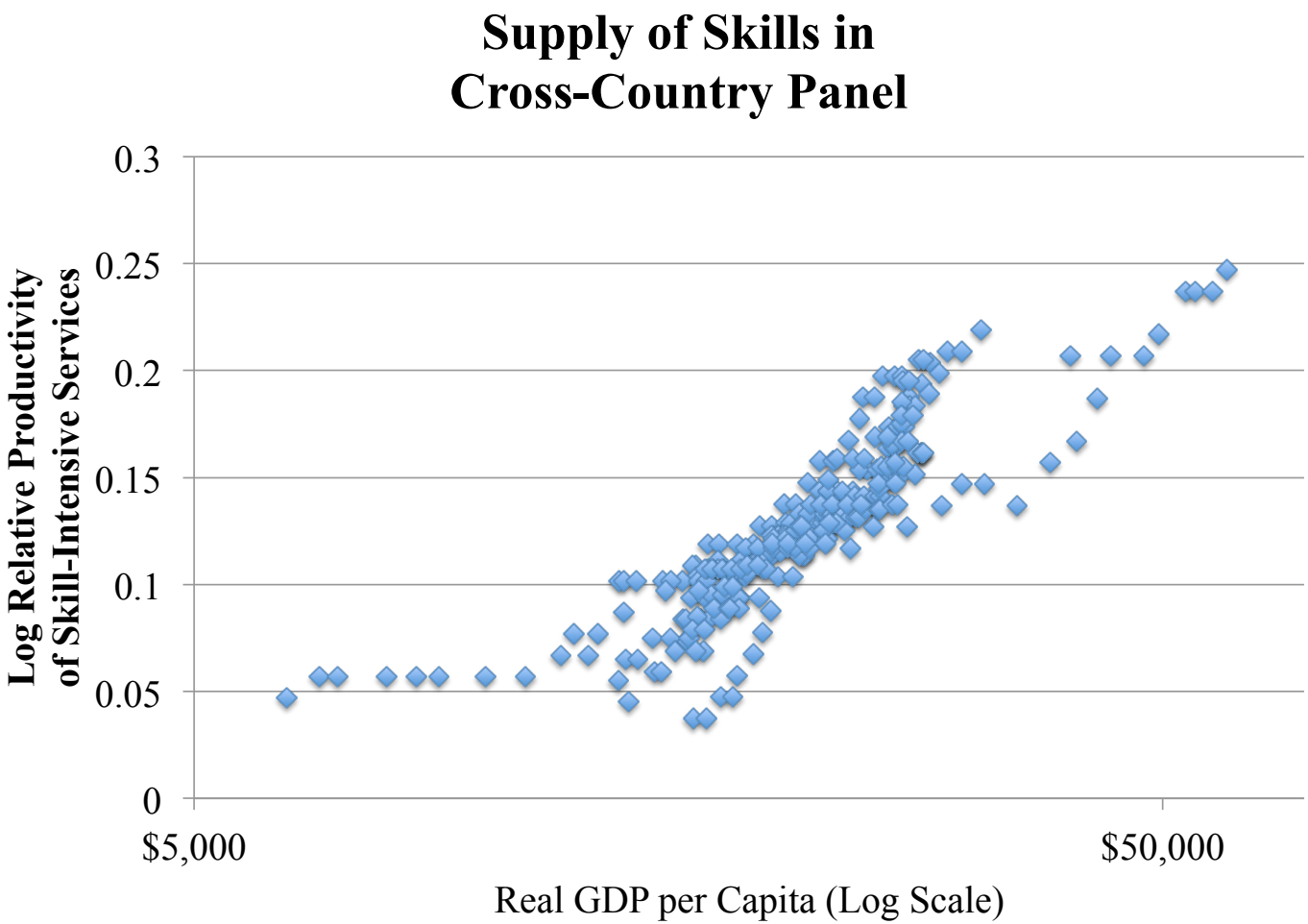
▸ Raw Results

Panel Results: Skill Premium Fit



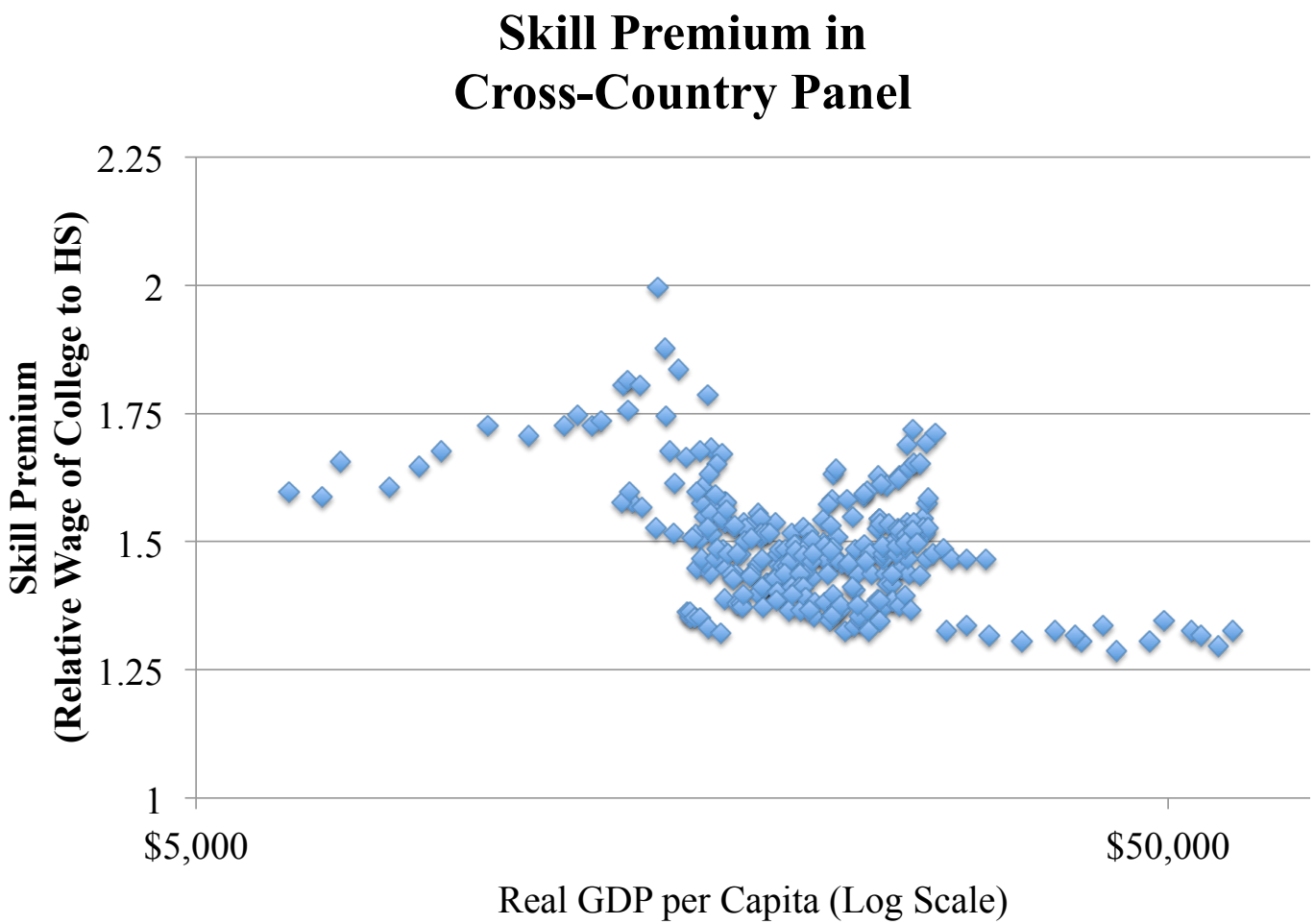
▸ Raw Results

Panel Results: Supply of Skills



▸ Raw Results

No Clear Skill Premium Patterns in Data

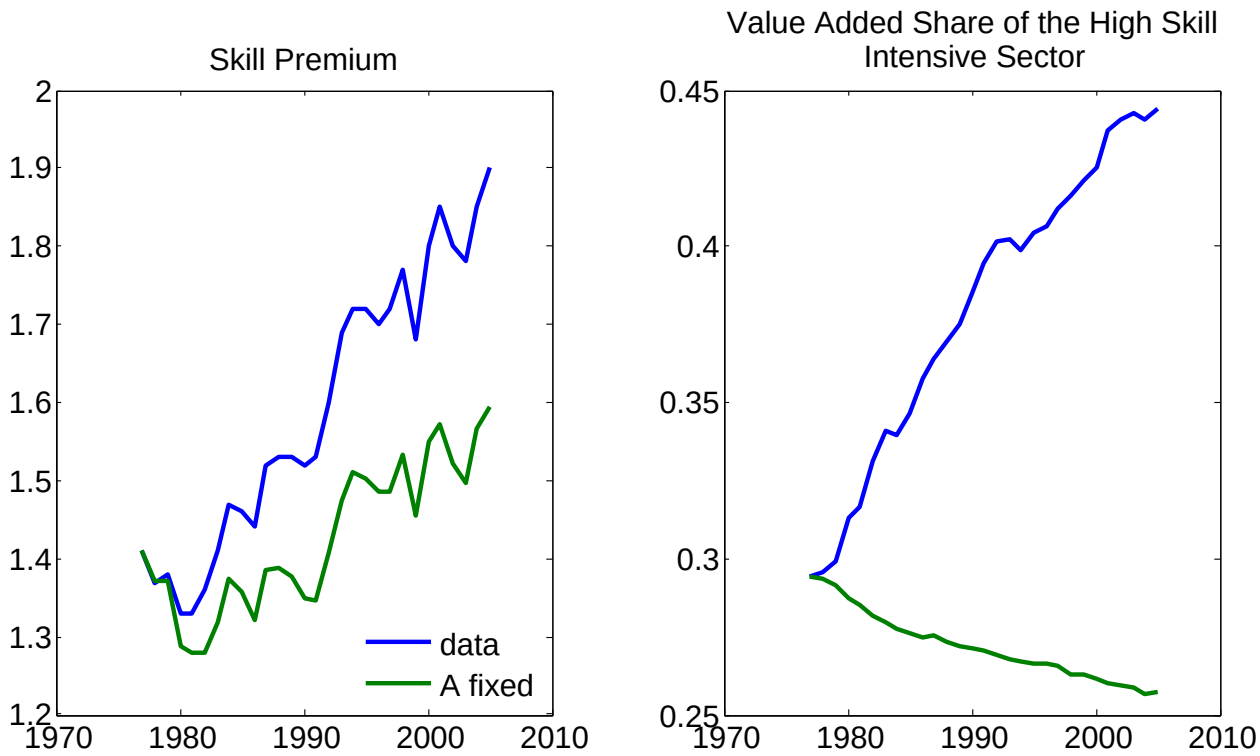


▸ Raw Results

Taking Stock

- Model fits U.S. data well
- Model fits cross-country panel
  - Variation in skill premia, stock of skills, SBTC, but...
  - Salient sectoral productivity patterns emerge
- Now return to the U.S. for counterfactuals

Counterfactual Dynamics: Fixed A_G and A_S



Accounting for the Rise in the Skill-Premium, 1977-2005

$\Delta(w_H/w_L - 1)$ (percentage points)	
	$\varepsilon = 0.2$
Data	49
Model	49
Counterfactuals:	
No SBSC or SBTC (Δf_H only)	-49
Implied total Δ from technology	98
No SBSC (Δf_H and $\Delta \alpha_j$ only)	18
Implied SBSC contribution (ΔA_j)	31
SBSC as percent of total	31%

Sensitivity to ε

$\Delta(w_H/w_L - 1)$ (percentage points)

	$\varepsilon = 0.5$	$\varepsilon = 0.2$	$\varepsilon = 0.1$
Data	49	49	49
Model	49	49	49
Counterfactuals:			
No SBSC or SBTC (Δf_H only)	-46	-49	-49
Implied total Δ from technology	95	98	98
No SBSC (Δf_H and $\Delta \alpha_j$ only)	20	18	18
Implied SBSC contribution (ΔA_j)	29	31	31
SBSC as percent of total	31%	31%	31%

Sensitivity to ρ

$\Delta(w_H/w_L - 1)$ (percentage points)

	$\rho = 0.8$	$\rho = 1.4$	$\rho = 2.5$
Data	49	49	49
Model	49	49	49
Counterfactuals:			
No SBSC or SBTC (Δf_H only)	-76	-49	-34
Implied total Δ from technology	125	98	63
No SBSC (Δf_H and $\Delta \alpha_j$ only)	-5	18	27
Implied SBSC contribution (ΔA_j)	54	31	17
SBSC as percent of total	44%	31%	22%

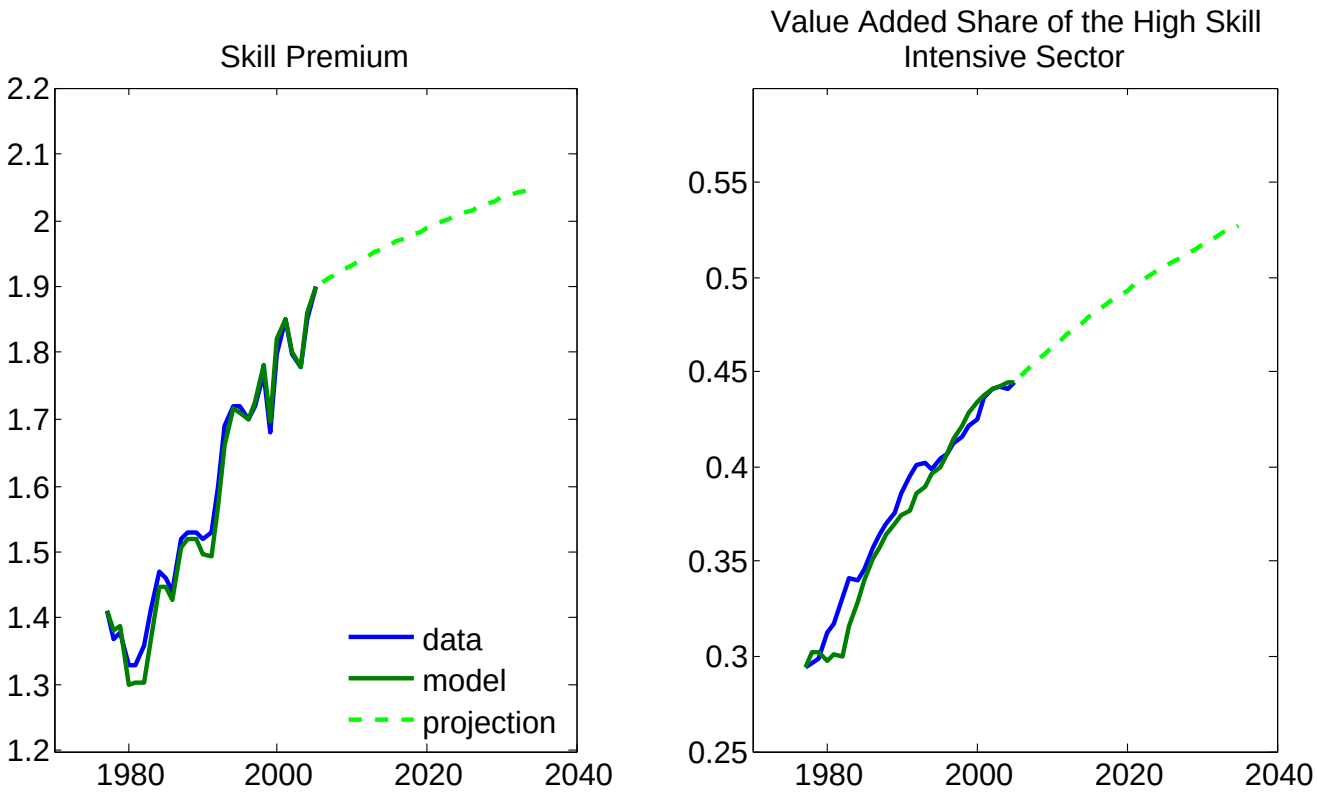
Accounting for Changes in the Skill-Premium, OECD

SBSC contribution / Total technology contribution (%)	
Australia	18
Austria	40
Denmark	11
Spain	32
Germany	37
Italy	54
Japan	22
Netherlands	27
United Kingdom	36

Projecting the Evolution of SBSC

- Assume A_G and A_S follow previous trends
- Assume α_G, α_S and f_H remain at 2005 values

Projecting the Evolution of SBSC



Conclusions

- With development consumption shifts toward high-skill intensive industries, increasing the relative demand for high skill workers (SBSC)
- This trend is pervasive across advanced economies

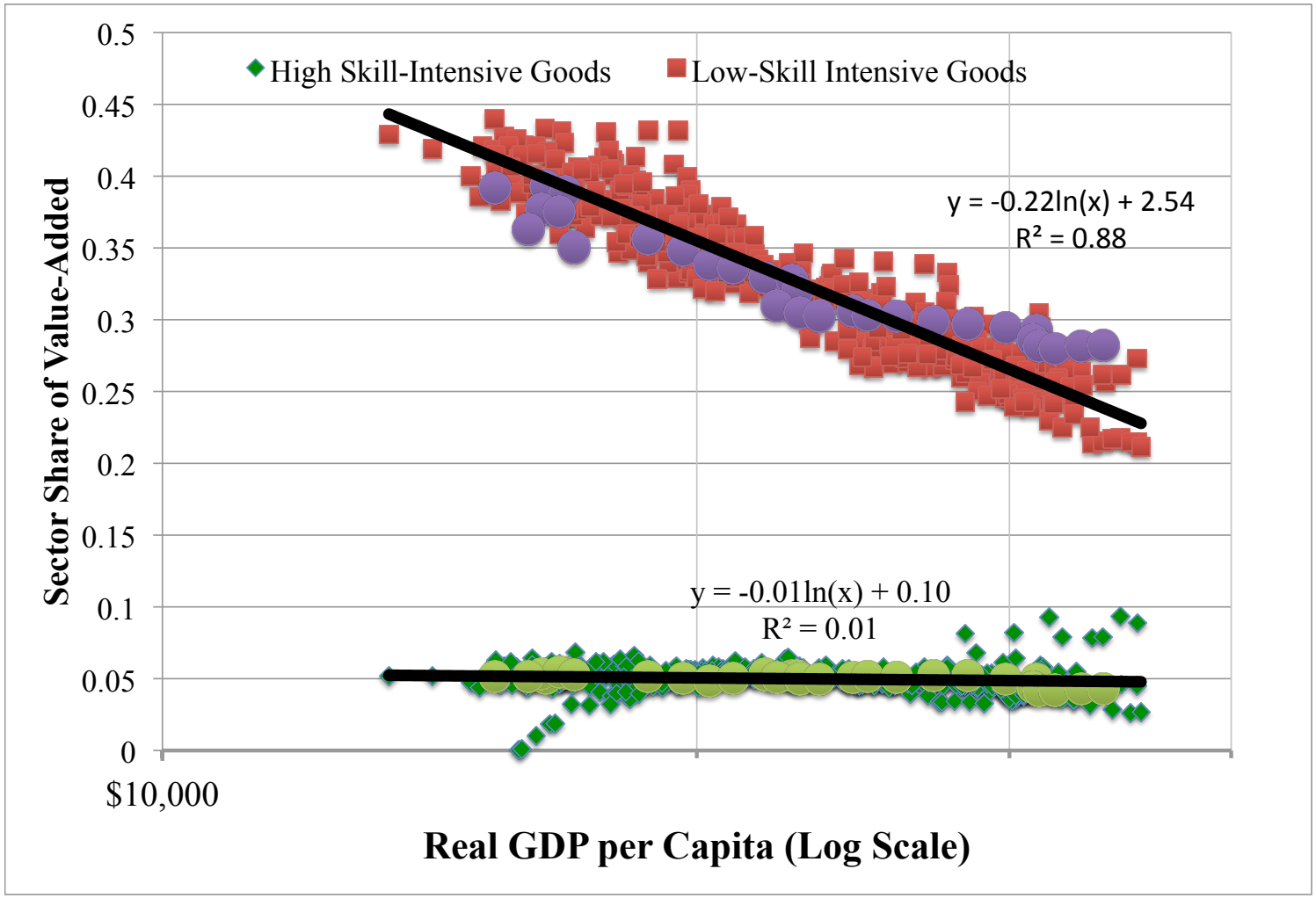
- This leads to a substantial, and persistent, rise in the skill-premium, even without skill-biased technological progress (SBTC)

Decomposing Relative Productivity and Non-Homotheticity

$\Delta \frac{p_S Y_S}{Y}$ (percentage points), 1977-2005 U.S.

	$\varepsilon = 0.5$	$\varepsilon = 0.2$	$\varepsilon = 0.1$
Data	15	15	15
Model	15	15	15
Counterfactuals:			
No productivity growth (no ΔA_j)	-3	-4	-4
Implied total Δ from technology	18	19	19
No relative productivity change (no $\Delta A_S/A_G$)	11	4	2
Implied relative productivity contrib. (ΔA_j)	4	11	13
Rel. prod. as % of total prod.	24%	58%	68%

Skill-Biased Structural Change within Manufacturing



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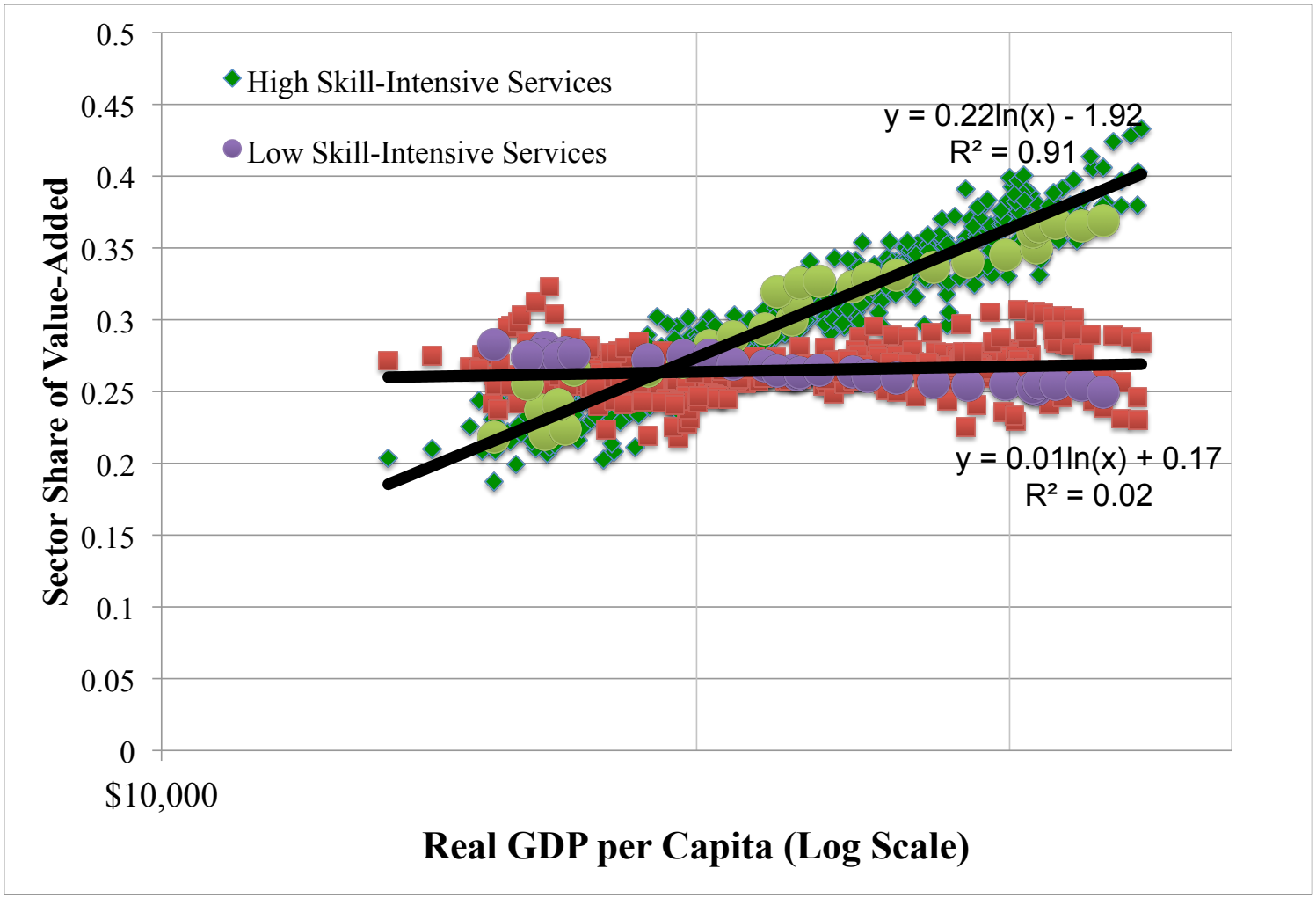
Skill-Biased Structural Change within Services



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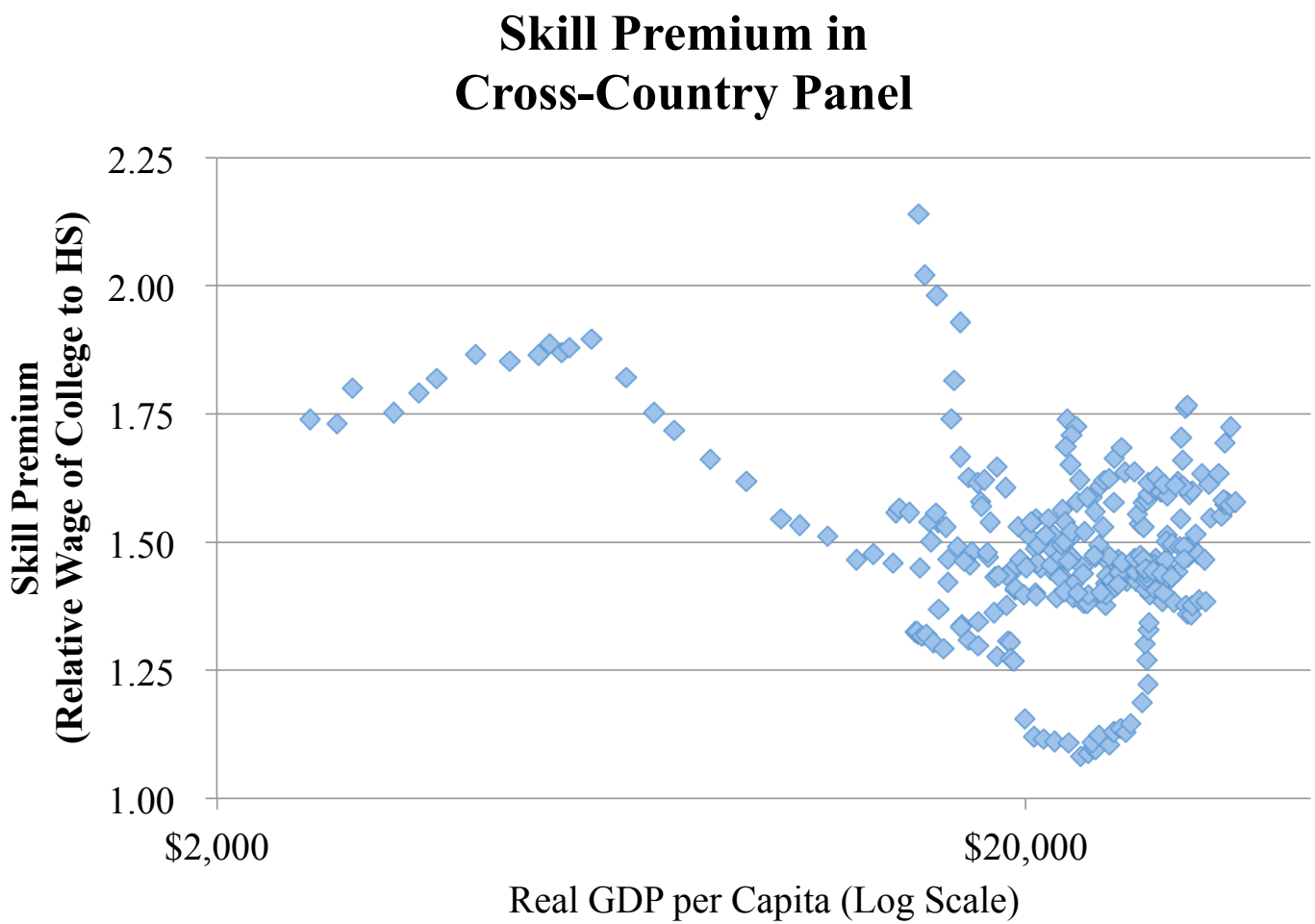
No Clear Pattern in Skill Premium: Raw Data



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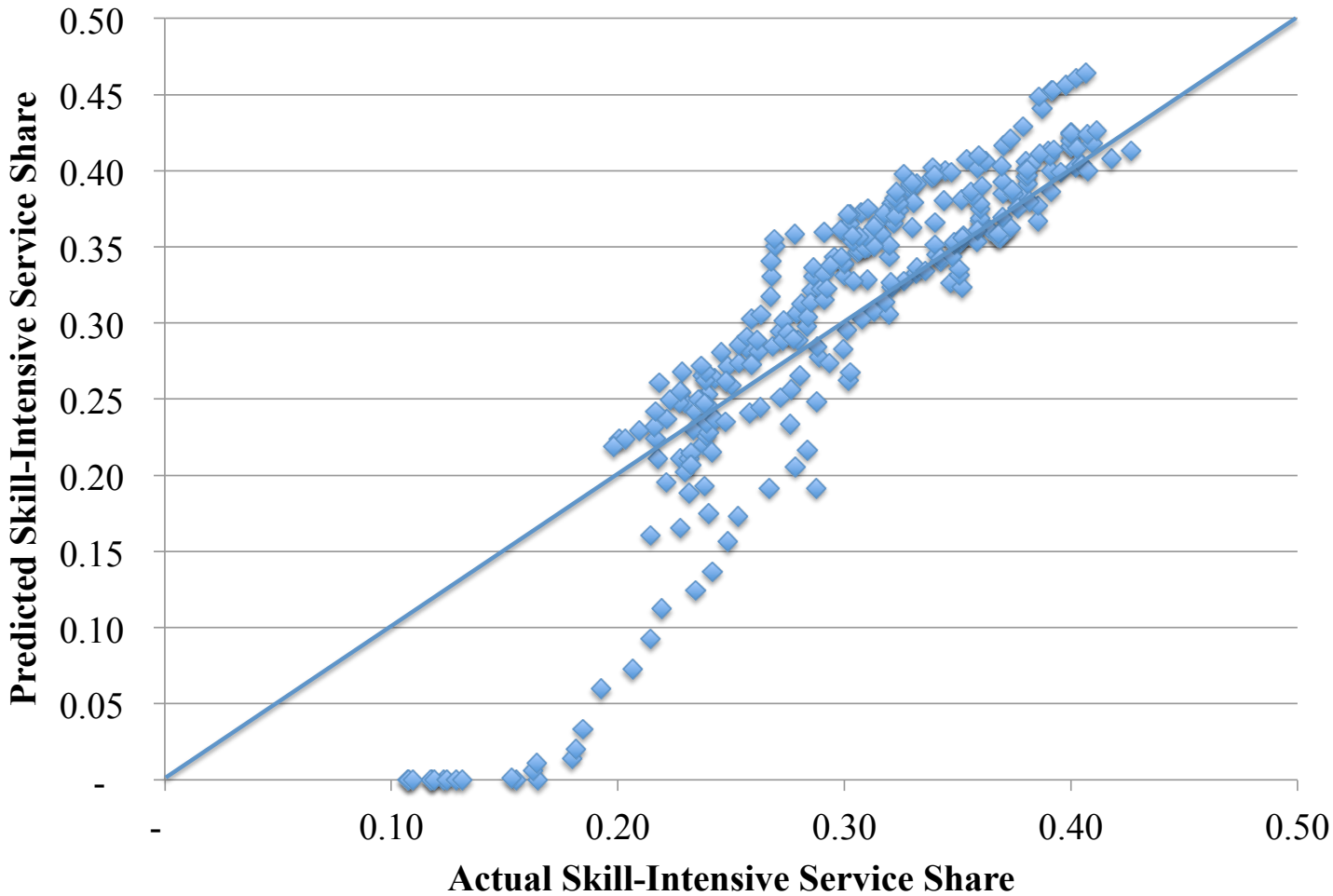
Service Share Fit: Raw Results



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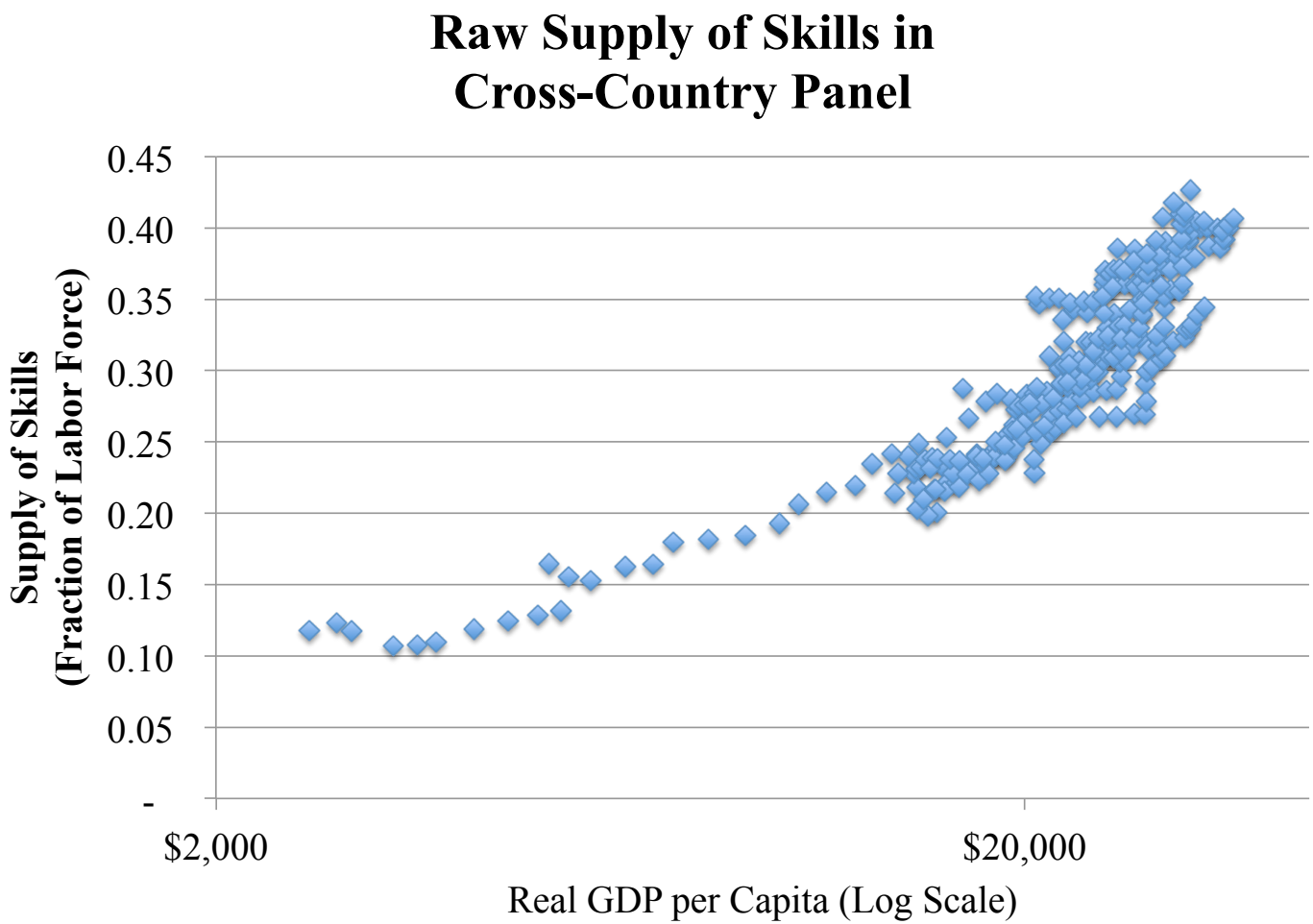
Supply of Skills: Raw Data



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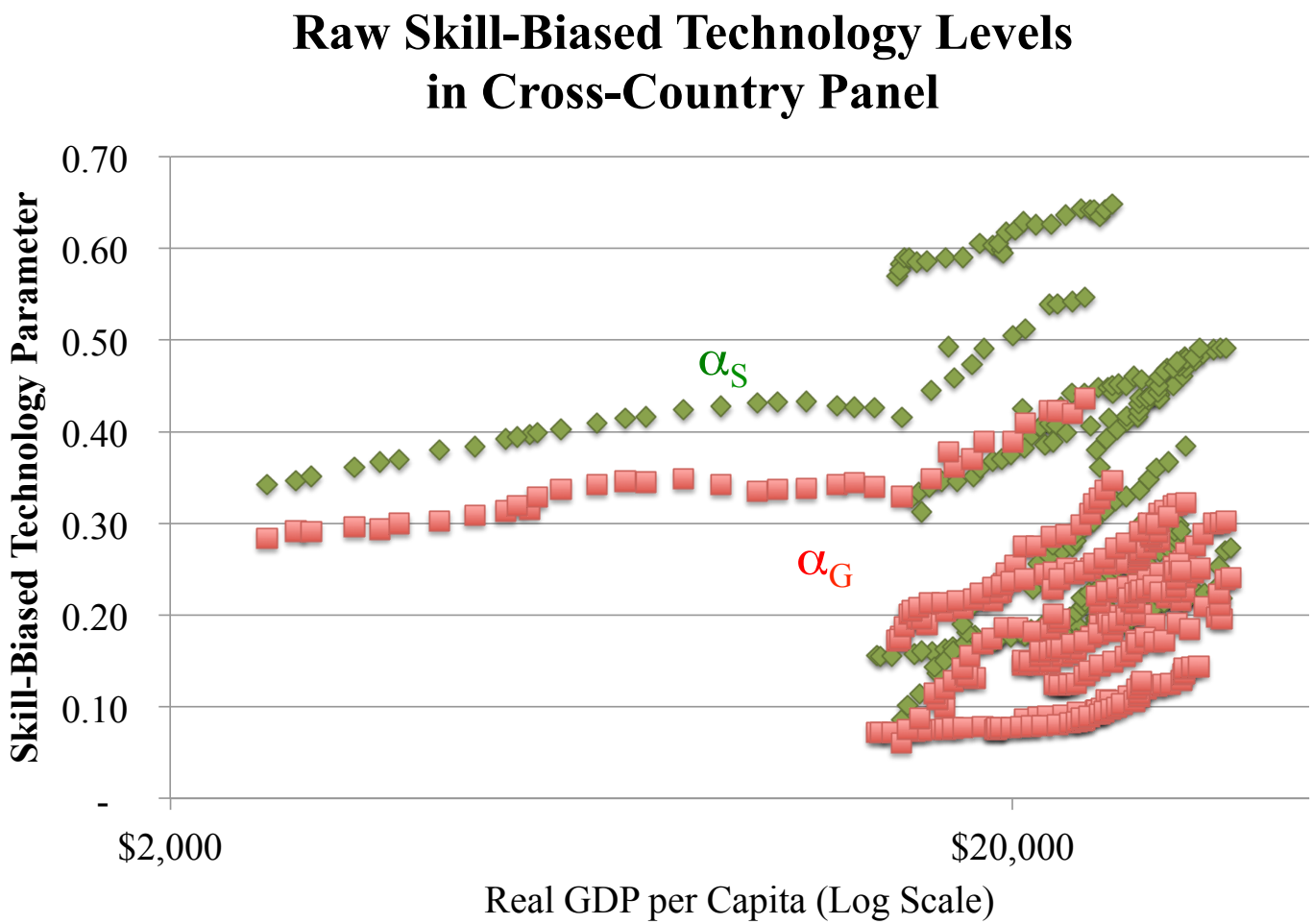
Skill-Biased Technology Levels: Raw Results



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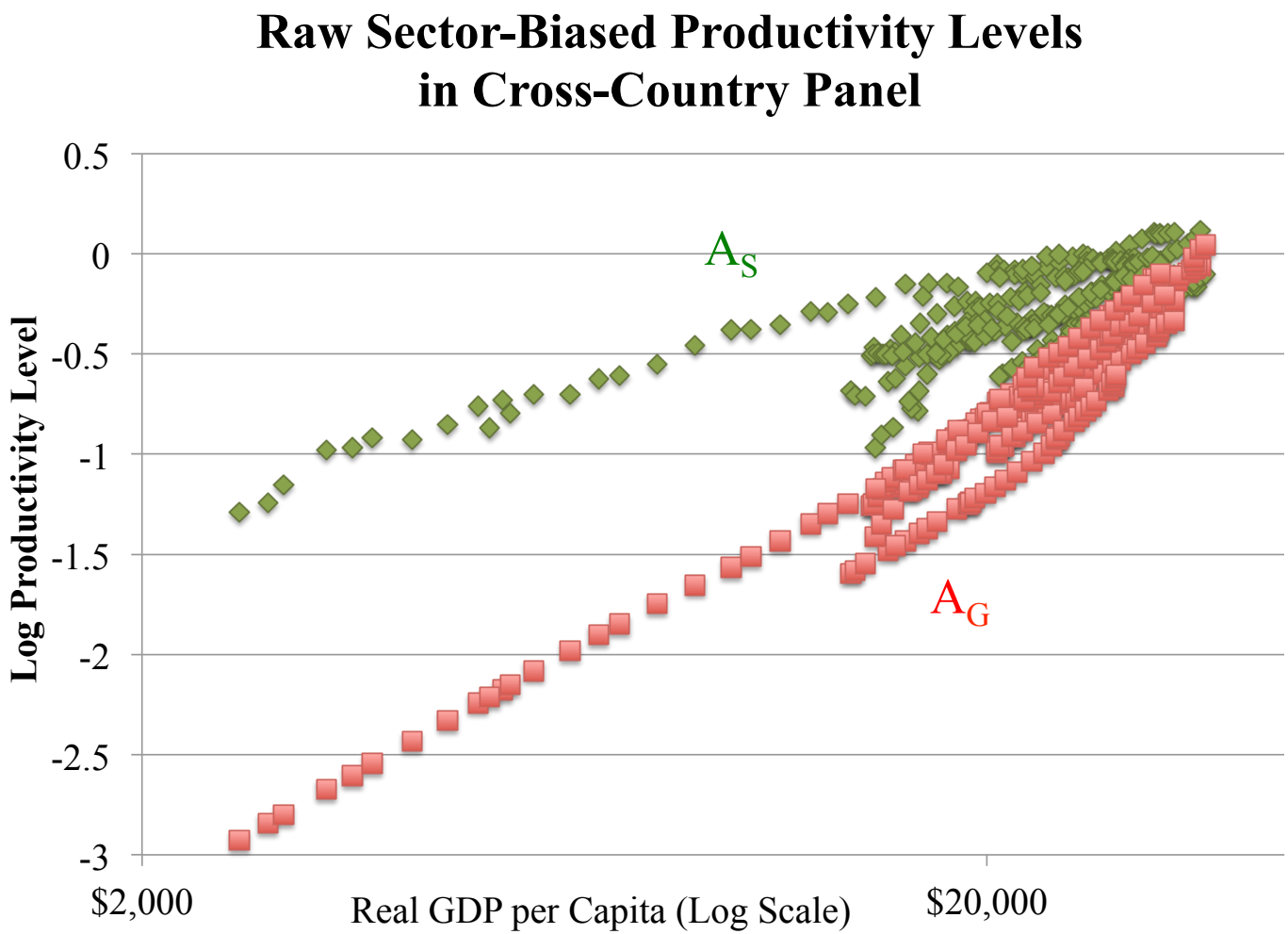
Sector-Biased Technology Levels: Raw Results



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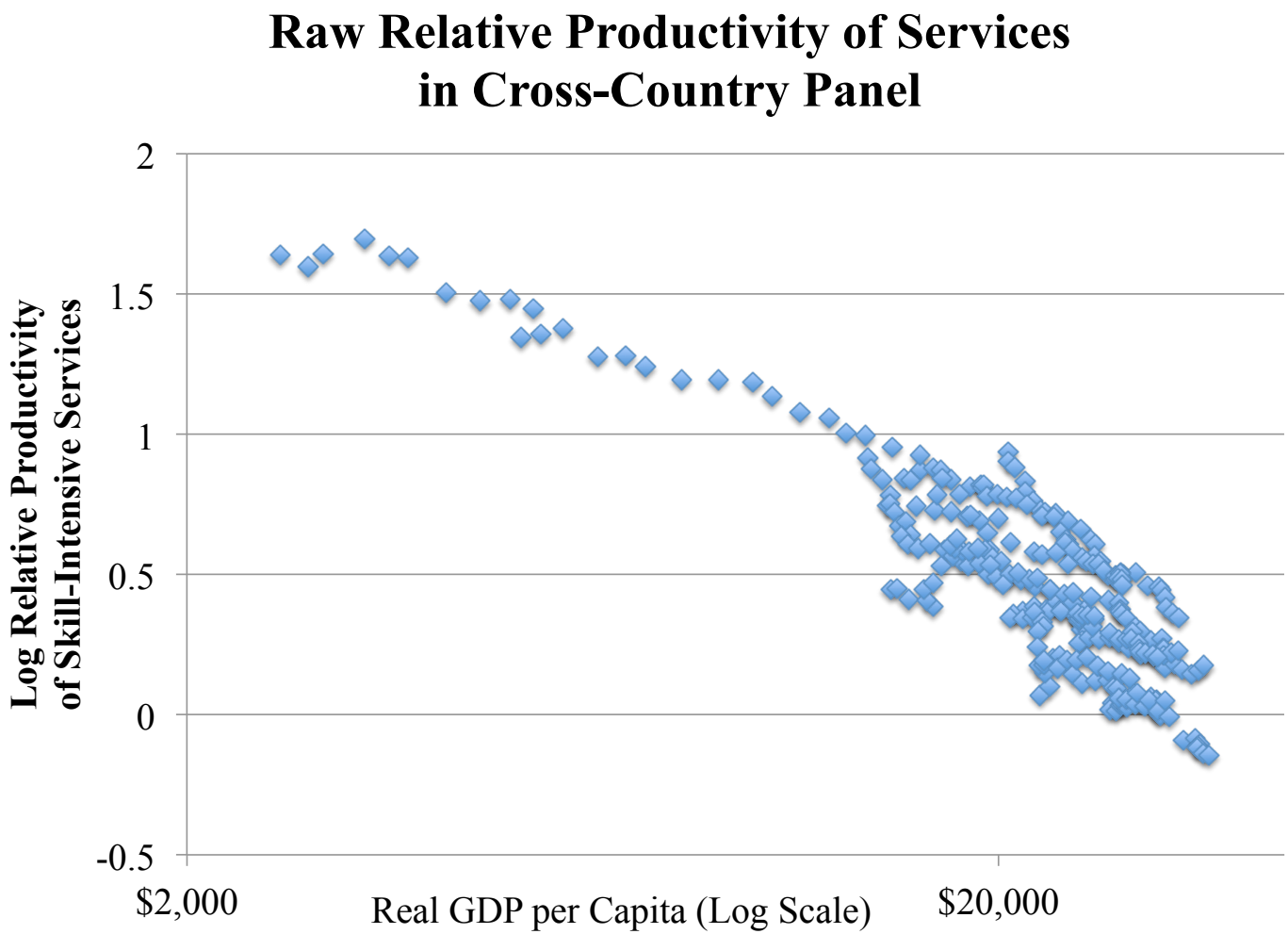
Relative Sectoral Productivity Levels: Raw Results



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