Artificial Intelligence and the Functional Distribution of Income

A General Equilibrium Model with Endogenous Automation and Labor Reallocation

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(with iterative guidance from Larry Santucci)

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The question

Who benefits from AI?

- Previous automation displaced **middle-skill routine** workers
  - Factory robots, ATMs, self-checkout
- Current AI displaces **skilled professional** tasks
  - Legal analysis, medical diagnosis, software engineering, financial modeling

$\Rightarrow$ Qualitatively different distributional pattern?

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We show the answer depends on exactly two parameters

Empirical motivation: AI hits the top, not the bottom

Hampole, Papanikolaou, Schmidt & Seegmiller (2025, NBER WP 33509)

Occupation group	**AI task exposure**	**% of emp.**
Business & Financial	−9.8	18.3
Architecture & Engineering	−6.6	9.2
Management	−2.1	19.0
Office & Administrative	+3.1	10.5
Construction & Extraction	+6.9	2.0
Personal Care & Service	+12.9	1.0
Cleaning & Maintenance	+14.8	0.4
Food Preparation	+13.3	2.6

⇒ AI substitutes for **skilled professional** labor, not manual/service work

This paper

A two-sector GE model where AI substitutes for skilled labor

1. **CES production**: AI and skilled labor combined with elasticity σ
2. **Roy sorting**: heterogeneous workers choose skilled vs. unskilled sector
3. **Endogenous AI investment**: zero-profit condition with cost $c(\gamma) = c_0\gamma^{\varepsilon_c}$
4. **Two-good demand**: CES preferences with elasticity ε

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Two parameters govern everything:

σ	AI–skill substitution elasticity	*who wins and loses*
ε_c	cost elasticity of AI deployment	*whether anything happens at all*

Preview of results

1. **Unskilled workers benefit robustly**

   Real wage rises for $\sigma < 30$ — the entire plausible range

   They are "accidental winners": cheaper skilled goods, no direct displacement

2. **Cost, not capability, is the binding constraint**

   When $\varepsilon_c = 1$: AI improvements are *exactly neutral*

   All effects scale as $(1 - \varepsilon_c)$ — track deployment costs, not benchmarks

3. **Automation need not reduce the labor share**

   Falls only if $\sigma > 1$ *and* $\varepsilon \geq 1$

   Common claim is a joint hypothesis about technology *and* demand

Model: production

Unskilled sector (numeraire):

$$Y_u = L_u^{\beta} K_u^{1-\beta}$$

Skilled sector (price p):

$$Y_s = \underbrace{E_s^{\alpha}}_{\text{labor composite}} K_s^{1-\alpha}$$

CES composite — the key object:

$$\boxed{E_s = \left[\phi L_s^{\rho} + (1-\phi)(\gamma K_{ai})^{\rho}\right]^{1/\rho}}, \qquad \sigma = \frac{1}{1-\rho}$$

Two channels in tension:

- **Within CES**: higher γ displaces L_s (strength: ρ)
- **Outer Cobb–Douglas**: higher E_s raises all marginal products (strength: α)

Model: workers and AI investment

Roy sorting

- Workers have ability $\eta \sim \text{Beta}(2,3)$
- Skilled sector pays $w_s \cdot \eta^2$; unskilled pays w_u
- Threshold η^*: $w_s(\eta^*)^2 = w_u$
- Workers above η^* enter skilled sector; below enter unskilled

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AI investment (zero-profit, competitive supply)

$$r_{ai} = (\delta + \iota)\, c_0\, \gamma^{\varepsilon_c}$$

Effective price of AI services:

$$q(\gamma) = \frac{c(\gamma)}{\gamma} = c_0\, \gamma^{\varepsilon_c - 1}$$

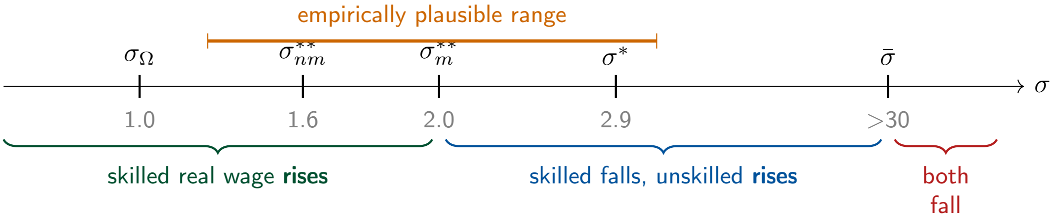
$$\begin{aligned}
\varepsilon_c < 1 \quad &\Rightarrow \quad \text{quality improvement reduces } q \\
\varepsilon_c = 1 \quad &\Rightarrow \quad \text{quality improvement } \textbf{leaves } q \textbf{ unchanged} \\
\varepsilon_c > 1 \quad &\Rightarrow \quad \text{quality improvement raises } q
\end{aligned}$$

Result 1: The threshold hierarchy

How does a 10% AI quality improvement affect wages?

Five thresholds, strict ordering:

$$\boxed{\sigma_\Omega < \sigma^{**}_{nm} < \sigma^{**}_{m} < \sigma^{*} < \bar{\sigma}}$$



Key property: all thresholds are *invariant* to the AI investment margin

Why does the hierarchy exist?

Partial equilibrium ($\sigma^* = 1/(1-\alpha) \approx 2.86$)

- Balance between CES displacement (ρ) and Cobb–Douglas complementarity (α)

General equilibrium pushes the threshold down to $\sigma_m^{**} \approx 2.0$:

Cheaper goods	Skilled output price p falls	protects real wage
Worker exit	Marginal workers leave skilled sector	raises w_s for stayers
AI investment	K_{ai} expands, absorbing shock	dampens displacement

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Unskilled workers benefit through a simple channel:

- AI makes skilled-sector goods cheaper
- Unskilled workers consume these goods
- Real purchasing power rises — for *any* plausible σ

Result 2: Cost elasticity as gatekeeper

What matters is quality-adjusted cost, not capability

Neutrality theorem: When $\varepsilon_c = 1$, a 10% smarter AI system that costs 10% more per unit has *zero* macroeconomic impact

- The economy contracts K_{ai} to exactly offset the quality gain
- γK_{ai} unchanged $\Rightarrow$ every price, wage, and quantity unchanged

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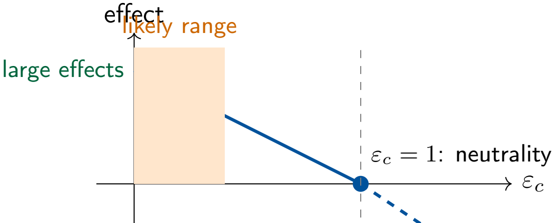
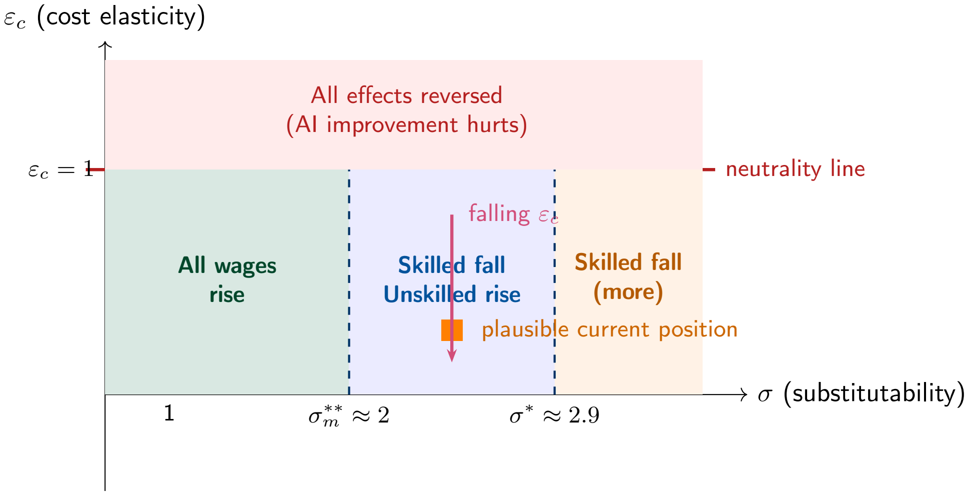
Scaling rule: all equilibrium effects satisfy

$$\boxed{\hat{X}(\sigma, \varepsilon, \varepsilon_c, \hat{\gamma}) \;\approx\; \hat{X}(\sigma, \varepsilon, 0, \hat{\gamma}) \;\times\; (1 - \varepsilon_c)}$$



The (σ, ε_c) parameter space



Two questions: (1) Where are we? (2) Which direction are we moving?

Quantitative results: forward-looking economy

10% AI quality improvement, AI = 30% of skilled effective labor, $\varepsilon = 1$, $\varepsilon_c = 0$

σ	$\widehat{w_s/P}$ (%)	$\widehat{w_u/P}$ (%)	$\hat{p}$ (%)	$\hat{K}_{ai}$ (%)	$\Delta\lambda_L$ (pp)	$\widehat{\text{GDP}_r}$ (%)
0.50	+0.82	+0.48	−0.76	−4.3	+0.23	0.28
lightgray 1.00	+0.68	+0.68	−1.24	0.0	0.00	0.68
2.00	−0.02	+1.11	−2.35	+6.1	−0.63	1.73
lightgray 3.00	−0.96	+1.42	−3.27	+8.9	−1.17	2.68
5.00	−2.45	+1.72	−4.26	+10.2	−1.68	3.79

- Unskilled real wage **always rises** — accidental winners
- Skilled real wage flips sign at $\sigma_m^{**} \approx 2$
- GDP gains are substantial: 1.7–3.8% at $\sigma = 2$–5

The cost elasticity matters enormously

Same shock ($\hat{\gamma} = 10\%$), varying ε_c. $\sigma = 3$, current economy ($s_L = 0.92$)

ε_c	$\widehat{w_s/P}$ (%)	$\widehat{w_u/P}$ (%)	$\hat{K}_{ai}$ (%)	$\widehat{\text{GDP}_r}$ (%)	Regime
-0.50	-0.21	$+0.25$	$+37.0$	0.52	Amplified
0.00	-0.13	$+0.16$	$+19.6$	0.33	Normal
0.50	-0.06	$+0.08$	$+4.3$	0.16	Attenuated
lightgray **1.00**	**0.00**	**0.00**	**$-$9.1**	**0.00**	**Neutral**
1.50	$+0.06$	-0.07	-20.8	-0.15	Reversed

- At $\varepsilon_c = 1$: **exact zero** on every variable (except K_{ai}, which adjusts inversely)
- Effects are **almost perfectly linear** in $(1 - \varepsilon_c)$
- The entire distributional debate is moot if $\varepsilon_c \geq 1$

Result 3: the labor share is not a foregone conclusion

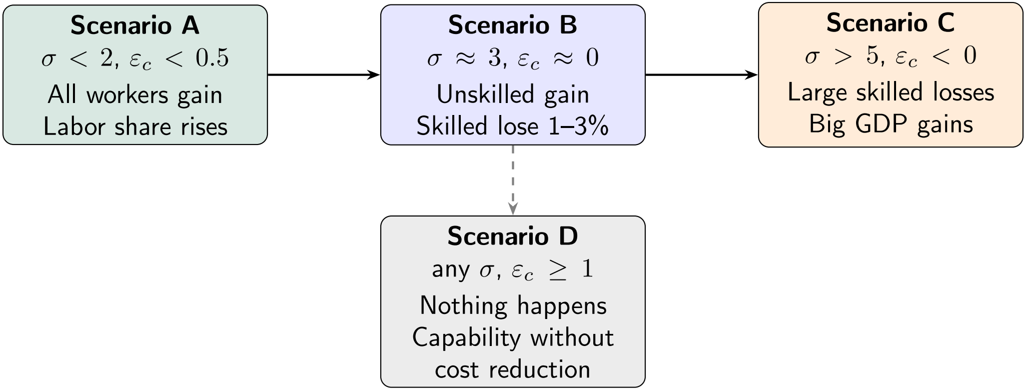
$$d\lambda_L = \underbrace{(\alpha s_L - \beta)\, ds_{\text{rev}}}_{\text{between-sector}} + \underbrace{\alpha\, s_{\text{rev}}\, ds_L}_{\text{within-sector}}$$

	$\varepsilon > 1$ (elastic demand)	$\varepsilon < 1$ (inelastic demand)
$\sigma > 1$ (substitutes)	λ_L falls ✓	ambiguous
$\sigma < 1$ (complements)	ambiguous	λ_L rises ✓

- "Automation reduces the labor share" requires **both** $\sigma > 1$ and $\varepsilon \geq 1$
- With AI–skill complementarity or inelastic demand: labor share can *rise*

$\Rightarrow$ Empirical work should estimate demand elasticities, not just production parameters

What this teaches us about possible futures



Current evidence (HPSS 2025, API pricing trends) suggests **Scenario B**:
$\sigma \in [2, 3]$, ε_c well below 1

Three messages for policymakers

1. **Don't panic about unskilled workers — yet**
   - They benefit from cheaper professional services
   - Threshold for harm ($\bar{\sigma} > 30$) is nowhere near current estimates
   - *Caveat*: assumes unskilled sector remains non-automatable
2. **Track costs, not capabilities**
   - A smarter AI that costs proportionally more changes nothing
   - Quality-adjusted cost $q = c(\gamma)/\gamma$ is the sufficient statistic
   - If scaling laws hit diminishing returns, effects attenuate automatically
3. **The labor share depends on demand, not just technology**
   - Estimate ε (demand elasticity across sectors), not just σ
   - Policy that shifts demand composition can affect factor shares

Limitations and next steps

What the model cannot do:

- Transition dynamics — how fast do effects materialize?
- Within-group inequality — representative consumer precludes this
- Unskilled-sector automation — if AI reaches manual/service tasks
- Multi-sector heterogeneity — different industries, different σ

Most important next step: estimate σ and ε_c

- Firm-level AI adoption $\times$ occupation-level wage responses
- AI benchmark–cost panels: $\ln c_t = \alpha + \varepsilon_c \ln \gamma_t + u_t$
- The model provides the mapping from estimates to predictions

Summary

The distributional consequences of AI depend on
two numbers: σ and ε_c

σ	determines *who* wins and loses
ε_c	determines *whether* anything happens
(σ, ε_c) jointly	give you *everything*: wages, labor share, GDP

The model provides the complete map.
The empirical work is the frontier.

Thank you

Backup: threshold formulas

Partial equilibrium: $\sigma^* = \dfrac{1}{1-\alpha}$

Nominal GE: $\sigma_\Omega = \dfrac{\varepsilon}{\varepsilon(1-\alpha)+\alpha}$

Real GE, no mobility: $\sigma^{**}_{nm} = \dfrac{\varepsilon}{\varepsilon(1-\alpha)+\alpha(1-\omega_s)}$

Real GE, with mobility: σ^{**}_m solves $\Omega(\sigma)B + CD = 0$

Unskilled real wage: $\bar{\sigma}$ solves $\Omega(\bar{\sigma})B_u + CD = 0$

where $\Omega = (1-s_L)[\alpha(1-1/\varepsilon)-\rho]$

Invariance: all thresholds are independent of the AI investment margin

Backup: current economy ($s_L = 0.92$)

10% AI quality shock, $\varepsilon = 1$, $\varepsilon_c = 0$

σ	$\widehat{w_s/P}$ (%)	$\widehat{w_u/P}$ (%)	$\hat{p}$ (%)	$\hat{K}_{ai}$ (%)	$\Delta\lambda_L$ (pp)	$\widehat{\text{GDP}_r}$ (%)
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Effects are 3–$8\times$ smaller than forward-looking economy at $\sigma \approx 3$

Non-monotone in σ: at high σ, equilibrium AI share falls below 8%, attenuating effects

Backup: key identity and threshold invariance

CES-Cobb–Douglas identity:

$$\Delta' + \lambda' = 1$$

where

$$\begin{aligned}\Delta' &= (1-\alpha) + s_L(\alpha-\rho) + \alpha(1-s_L)/\varepsilon \\ \lambda' &= \rho s_L + \alpha(1-s_L)(1-1/\varepsilon)\end{aligned}$$

Why this matters: when you solve the zero-profit condition for $\hat{K}_{ai}$ and substitute into the wage equation, the investment-margin terms cancel:

$$\tilde{B} + \frac{CF_1}{\Delta'} = B$$

The threshold $\Omega B + CD = 0$ is the same whether K_{ai} is fixed or endogenous.

$\Rightarrow$ Qualitative predictions do not require knowing the investment response

Backup: neutrality proof intuition

When $c(\gamma) = c_0\gamma$:

1. Effective price of AI services: $q = (\delta + \iota)c_0\gamma/\gamma = (\delta + \iota)c_0$ (independent of γ)
2. Every equilibrium condition depends on AI only through $Z = \gamma K_{ai}$ and q
3. Since q is unchanged, equilibrium in (Z, η^*, p, K_s, K_u) is unchanged
4. $K_{ai} = Z/\gamma$ adjusts inversely: $\hat{K}_{ai} = -\hat{\gamma}$

Interpretation: a 10% smarter AI that costs 10% more is the same technology from the economy's perspective