Income and inequality under asymptotically full automation

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Will AI make workers irrelevant?

Automation: tasks performed using capital instead of labor

AI: All tasks eventually (asymptotically) automated?

Full (asymptotic) automation $\overbrace{\rightarrow}^{?}$ fundamental change in economy

[?] Labor irrelevant / Capital dominant

[?] Affluent rentiers vs impoverished workers

[?] Role of financial markets if labor income vanishes

This paper

Analyze what standard economic forces say about these questions

Take the march of automation as given

Wages, capital returns, savings, work decisions all standard

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Closest: Aghion, Jones, Jones (2019): saving+work exogenous, rep agent

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Simple condition for capital dominance and economic-transformation

Task complementarity (Baumol) is key economic force

Policy: tax-and-redistribute dominates automation-retardation

Capital dominance condition maps to observables:
Current rate of automation too slow for capital dominance

Preferences, capital accumulation

Preferences

$$\int_0^\infty e^{-\rho t} \frac{1}{1-\gamma} \left(C_{i,t}^{\frac{\eta-1}{\eta}} + \omega \left(1 - L_{i,t}\right)^{\frac{\eta-1}{\eta}} \right)^{\frac{1-\gamma}{1-\frac{1}{\eta}}} dt$$

$\eta =$ elasticity of substitution between cons $C_{i,t}$ and leisure $1 - L_{i,t}$

Focus on $\eta < 1$, leisure ↑ as cons ↑

Capital accumulation ($K_{i,t} \geq 0$)

$$\dot{K}_{i,t} = \overbrace{R_t K_{i,t}}^{\text{capital income}} + \overbrace{W_t L_{i,t}}^{\text{labor income}} - \delta_i K_{i,t} - C_{i,t}$$

Agents either capitalists ("o(wners)") or workers (w), worse at investment

$$\delta_w > \delta_o$$

Considerable evidence of heterogeneous investment returns

Also, isomorphic to difference in time preference

Technology

Continuum of fundamental "tasks"

At date t a fraction α_t have been automated

$$Y_t = F(K_t, L_t; \alpha_t) = \left(\alpha_t \left(A_K \frac{K_t}{\alpha_t} \right)^{\frac{\sigma-1}{\sigma}} + (1-\alpha_t) \left(A_L \frac{L_t}{1-\alpha_t} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

Note: $F(K_t, L_t; \alpha_t = 1) = A_K K_t$

$\sigma =$ elasticity of substitution between tasks

Baumol: Tasks are complements, $\sigma < 1$

Equivalently: Continuum of goods enter preferences

Automation: Advances at rate θ

$$\dot{\alpha}_t = \theta (1 - \alpha_t)$$

Capitalists and workers

Euler equation	$\frac{\partial}{\partial t} \ln MU_{C,i} \leq -(R - \delta_i - \rho)$
Intratemporal optimality	$\frac{MU_{1-L,i}}{MU_{C,i}} \leq W$

Consumption grows without bound →

Leisure+consumption complements → leisure approaches upper bound

$$\frac{\partial}{\partial t} \ln MU_{C,i} \quad \rightarrow \quad -\frac{1}{\eta} g_{C_i}$$

Hence

for agents who hold capital	$\lim g_{C_i} = \eta (R - \delta_i - \rho)$
for agents who work	$g_{C_i} = \eta\, g_W$

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Can't keep both at equality $\rightarrow$ must have some segmentation

Workers always work

Capitalists always hold capital

Capital dominance vs stable labor share

Capital dominance $\equiv$ capital takes over the economy, capital share$\rightarrow 1$

(Aside: “capitalism” might be a better term, but already taken)

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$$g_L + g_W < g_K + g_R = g_K$$

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Automation: labor-augmenting $\rightarrow$ automation vs capital accumulation

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Automation: labor-augmenting $\to$ automation vs capital accumulation

$$\theta \overbrace{>}^{?} (1-\sigma)\left(A_K - \delta_o - \rho\right)$$

Equilibrium consumption growth

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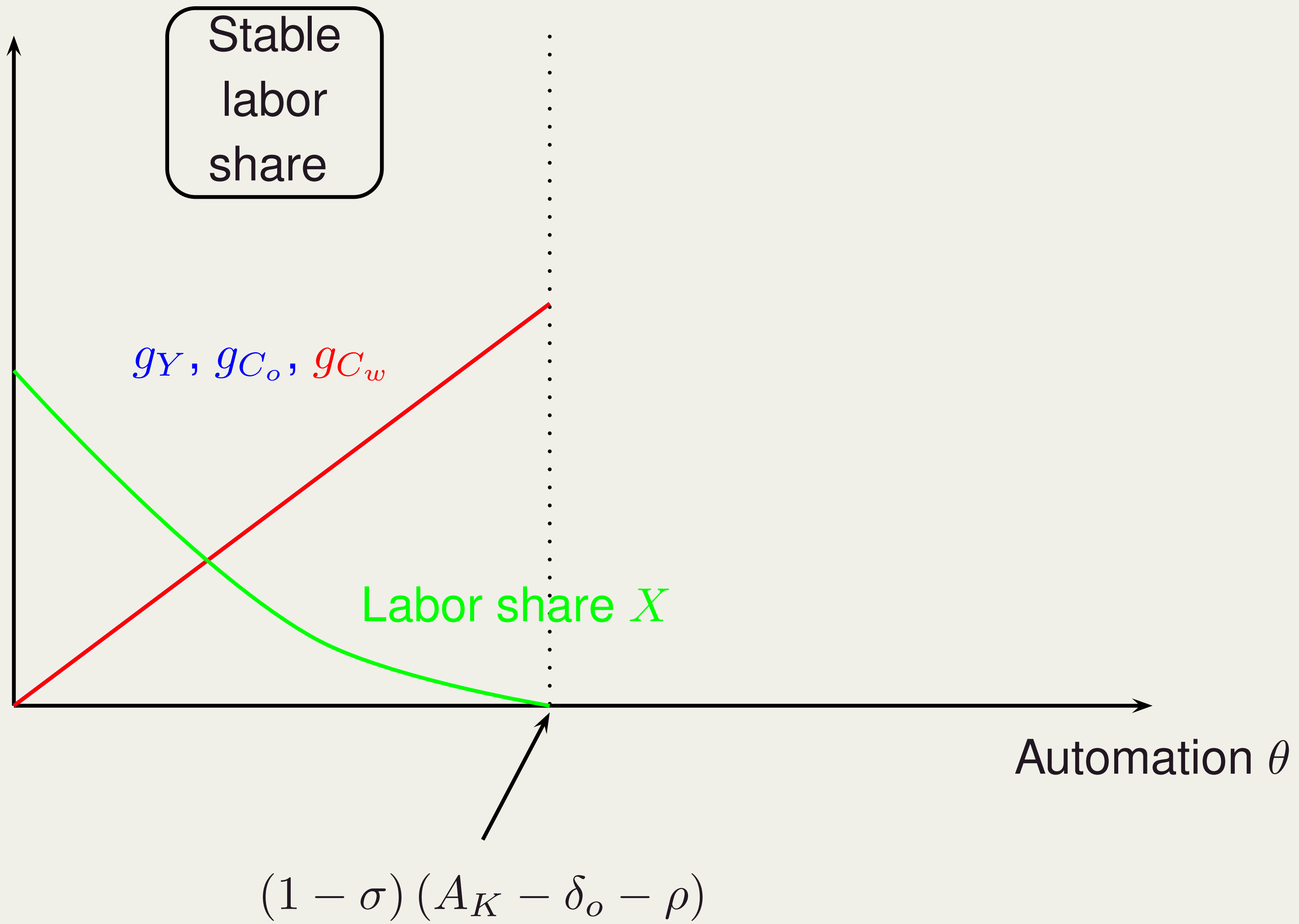

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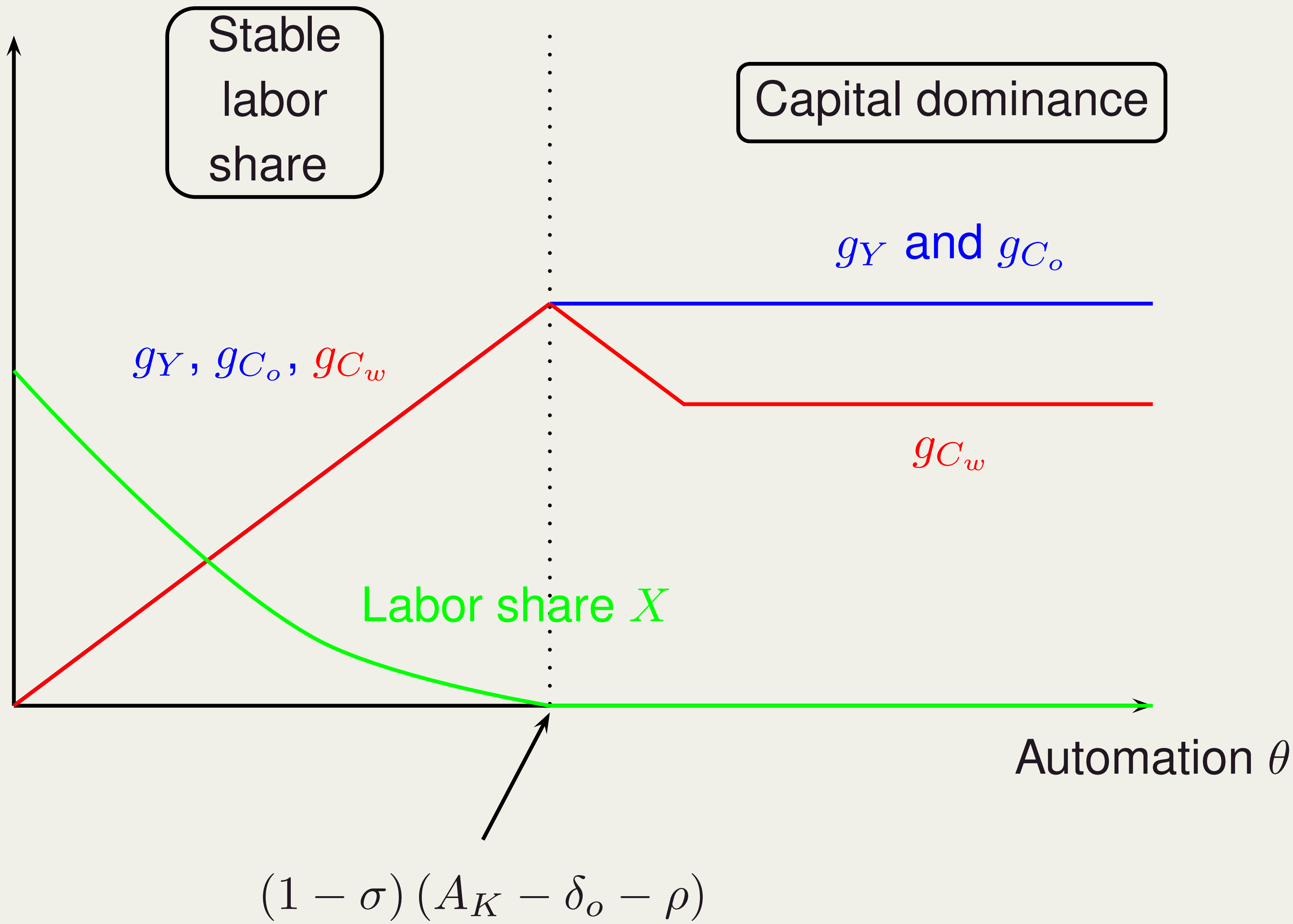
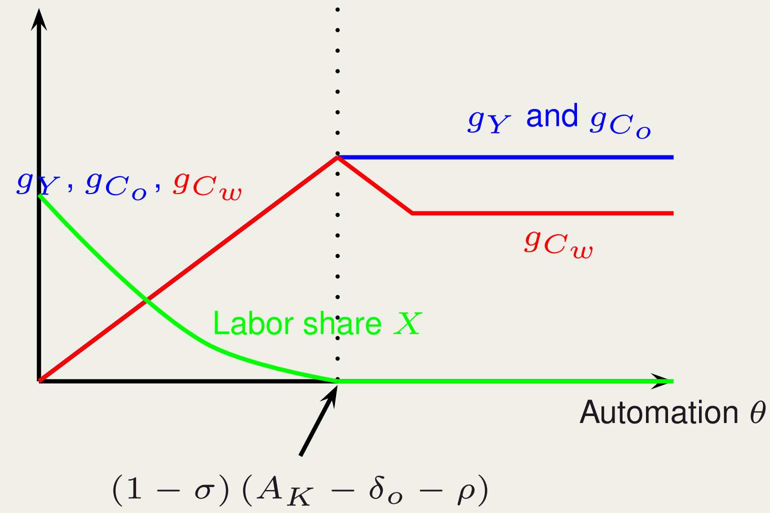


Determinants and consequences of capital dominance

Capital dominance more likely if:

- automation faster
- capital accumulation slower
- tasks more substitutable



Workers benefit from moderate automation ...

...but correct to fear faster automation.

If automation fast enough,

workers invest in capital,

but wedge $\delta_o - \delta_w$ (financial frictions)
$\rightarrow$ slower cons growth

Policy: Tax-and-redistribute vs automation retardation

Suppose automation above capital dominance threshold

Govt wants to safeguard workers, ensure that

$$\frac{\text{worker cons}}{\text{national income}} \geq \mathcal{X}$$

Focus on case in which almost all households are worker-households

Compare:

Tax and redistribute

Deliberately slow automation

Both policies distort economy, reduce growth

Tax-and-redistribute

Tax capital at rate τ such that

$$\tau K_t = \mathcal{X} Y_t \rightarrow \mathcal{X} A_K K_t$$

So

$$\tau = A_K \mathcal{X}$$

(Alternatively: tax capital return at rate $\mathcal{X}$)

Aside: K-taxation slows K-accumulation $\rightarrow$ capital dominance more likely

Growth rate is now

$$g_Y = \eta \left(A_K (1 - \mathcal{X}) - \delta_o - \rho \right)$$

Automation retardation

Slow automation θ to below capital dominance threshold

$$\begin{aligned} \text{capital share} &= \left(\frac{\lim R}{A_K}\right)^{1-\sigma} \\ g_Y &= \eta\left(\lim R - \delta_o - \rho\right) \end{aligned}$$

Hence

$$1 - \mathcal{X} = \left(\frac{\delta_o + \rho + \frac{g_Y}{\eta}}{A_K}\right)^{1-\sigma}$$

or equivalently

$$g_Y = \eta\left(A_K\left(1 - \mathcal{X}\right)^{\frac{1}{1-\sigma}} - \delta_o - \rho\right)$$

Compare

$$g_Y^{\text{tax}} = \eta\left(A_K\left(1 - \mathcal{X}\right) - \delta_o - \rho\right)$$

Provided tasks are at least somewhat substitutable ($\sigma \neq 0$), tax-and-redistribute better

Is current automation above or below capital dominance threshold?

$$\frac{\theta}{1-\sigma} \overbrace{>}^{?} A_K - \delta_o - \rho$$

Task substitutability $\sigma \leftrightarrow$ capital-labor substitutability

Many estimates, consensus is $0.4 - 0.7$
(Chirinko (2008), Oberfield-Raval (2021), Nordhaus (2021))

$$g_{\text{labor share},t} = \frac{1-\sigma}{\sigma}\left(g_{Y,t} - g_{L,t}\right) - \frac{\theta}{\sigma}$$

Over period 1970-2019:

$$g_{\text{labor share},t} = -.17\% \text{ and } g_{Y,t} - g_{L,t} = 1.55\%$$

For $\sigma \approx 0.5$, inferred $\theta \approx 0.9\%$, matching inference from Acemoglu (2024):
5% of GDP AI-automated in next 10yrs

Inferred $\frac{\theta}{1-\sigma} \approx 1.72\%$ (rises to 1.94% for $\sigma = 0.7$)

Is current automation above or below capital dominance threshold?

Still need an estimate of $A_K - \delta_o - \rho$

$$A_K \geq F_{K,t} = \frac{\text{capital share}}{\frac{K_t}{Y_t}} \approx \frac{0.4}{3.63} = 11.1\%$$

Depreciation = 4.32%

$\rho =$ time preference $= 2\%$

Hence $A_K - \delta_o - \rho > 4.79\%$

Conclusion: $\frac{\theta}{1-\sigma} < A_K - \delta_o - \rho$, automation below threshold speed

Robustness: growth in A_L; capital productivity instead of labor productivity; measure expenditure on new automation

Strong complementarities and multiple equilibria

Both task-complementarity and cons-leisure complementarity strong ($\sigma + \eta < 1$),

$\rightarrow$ capital dominant and stable labor share equilibria may coexist

Rough economics:

Capital dominance $\rightarrow$ worker cons $\downarrow$

$\rightarrow$ worker leisure $\downarrow$, workers work more

$\rightarrow$ capital is relatively scarce, capital dominance more likely

With strong complementarities ($\sigma + \eta < 1$), new threshold for capital dominance as one possible equilibrium

$$\frac{\theta}{1-\sigma} + \frac{1-\sigma-\eta}{1-\sigma}\left(\delta_w - \delta_o\right) > A_K - \delta_o - \rho$$

Consumption-leisure complementarity η and the wedge $\delta_w - \delta_o$

Worker optimization

$$g_{C,t} - g_{1-L,t} = \eta g_{W,t}$$

Can infer η from micro-estimates of Frisch elasticity of labor supply (≈ 0.32), income-to-cons ratio (≈ 1.1), IES (?), & labor-to-leisure ratio (?)

$\eta \approx 0.5$ consistent with reasonable inputs.
Even aggressive inputs for IES (low) and $\frac{L}{1-L}$ (≈ 2) deliver $\eta < 1$

Lower estimates of η consistent with strong complementarity condition

Risk-adjusted estimates of $1\% - 3\%$ for $\delta_w - \delta_o$
(Fagereng et al 2020, Smith et al 2022)

Capital dominance as one of several equilibria?

$$\frac{\theta}{1-\sigma} + \overbrace{\frac{1-\sigma-\eta}{1-\sigma}(\delta_w - \delta_o)}^{\leq \delta_w - \delta_o} \overbrace{>}^{?} \overbrace{A_K - \delta_o - \rho}^{\geq 4.79\%}$$

Capital dominance equilibrium exists only for aggressive assumptions on complementarity and/or financial frictions:

- Very low η (≈ 0.025) *and* high (but not too high) σ ($0.8 < \sigma < 1 - \eta$)
- Low η (< 0.28) *and* high frictions ($\delta_w - \delta_o \approx 4.5\%$)

Capital dominance unlikely even considering multiplicity region

Conclusion

Will asymptotically full automation make capital dominant?

Take the march of automation as given

Wages, capital returns, savings, work decisions all standard

No heterogeneity in labor productivity but:

1. Automation shifts income to capital
2. Heterogeneity in capital market outcomes

Enodogenous segmentation into workers and capitalists

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