Lecture 6: AI in the Solow Model

ECON 30020: Intermediate Macroeconomics

Prof. Eric Sims

University of Notre Dame

Spring 2026

AI

How ought we to think about generative artificial intelligence (AI) in the Solow model?

It's not obvious. Options:

1. A permanent increase in A
2. A particular kind of capital-biased technological change
3. A productivity shock that impacts different kinds of labor differently (skill-biased technological change)

A Change in A

Cobb-Douglas production function, inelastic supply of labor ($N_t = 1$):

$$K_{t+1} = sAK_t^{\alpha} + (1-\delta)K_t$$

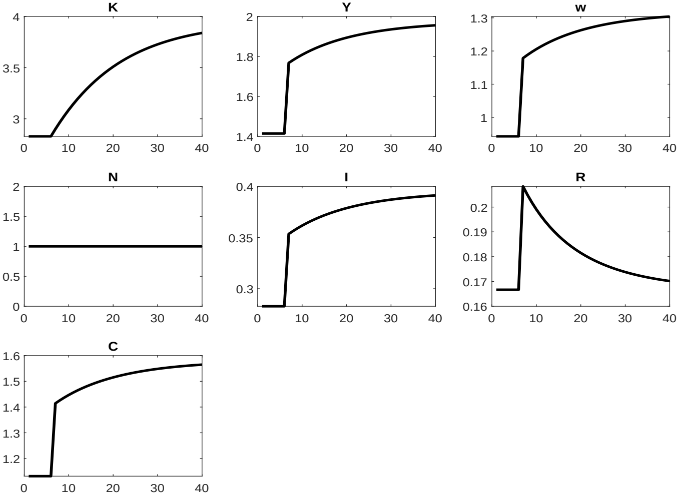
This is easy!

Assume $\alpha = 1/3$, $s = 0.2$, $\delta = 0.1$, and A goes from 1 to 1.25

Output, wages, and the rental rate on capital go up and transition to a new, higher steady state

Labor benefits (i.e., $w_t \uparrow$), both immediately and in the long run

Dynamic Responses to $\uparrow A$



Will AI Be Bad for Labor?

AI isn't coming for jobs—it's already replacing them by the thousands, report shows

The rise of generative AI has resulted in over 10,000 job cuts in July and more than 27,000 since 2023 in the US. Younger workers in entry-level roles are particularly affected, with a 15% decline in available positions.

Aman Gupta
Updated • 4 Aug 2025, 02:18 PM IST

Capital-Biased Technological Change

Alternative story: AI makes capital (computers, machines, equipment) more productive relative to labor

Simple way to model this: one-time, permanent increase in α

- Think of this as making machines more effective substitutes for labor

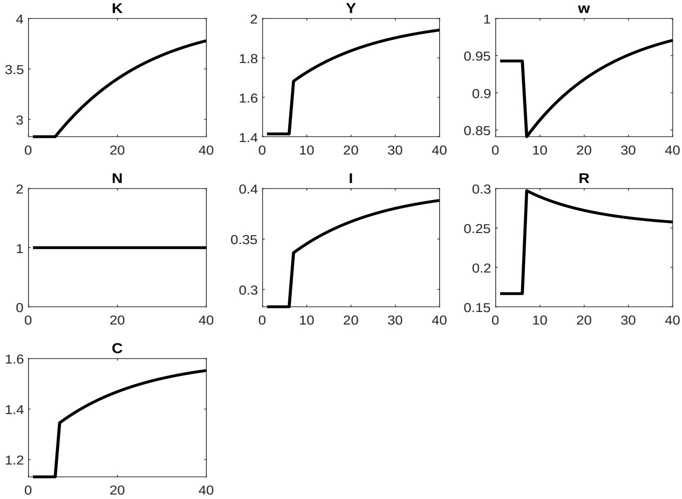
Marginal products:

$$R_t = \alpha A \left(\frac{K_t}{N_t} \right)^{\alpha - 1}$$
$$w_t = (1 - \alpha) A \left(\frac{K_t}{N_t} \right)^{\alpha}$$

Short run: $\uparrow R_t$, $\downarrow w_t$

Long run: $\uparrow K_t$, could result in $\uparrow w_t$

Dynamic Responses to $\uparrow \alpha$ (from 1/3 to 1/2)



Capital-Biased Technological Change

In the short run, AI is bad for labor (wages fall)

But in the long run, the AI boom leads to new investment, which becomes new capital, which raises the productivity of labor

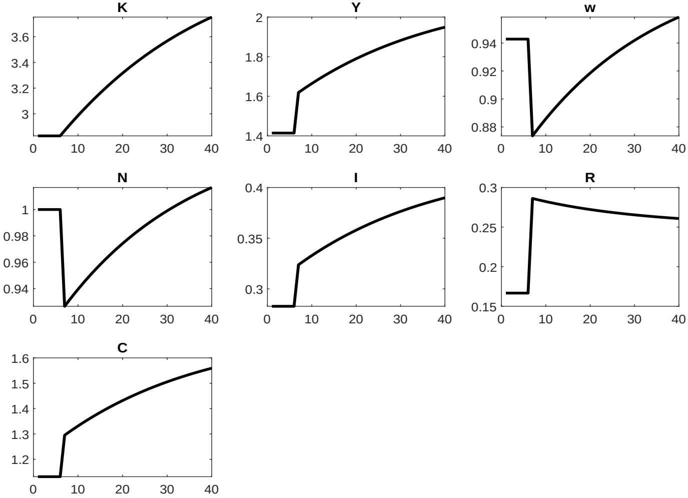
Wages can ultimately rise (relative to their pre-AI level)

If you want to think about what happens to N_t, assume simple labor supply function:

$$N_t = \theta w_t^{\chi}$$

Let $\chi = 1$, choose θ to be consistent with steady-state $N = 1$

Dynamic Responses to $\uparrow \alpha$ with Variable N_t



Substitutability Between Labor and Capital

The Cobb-Douglas production function is a special case of a more general constant elasticity of substitution (CES) production function:

$$Y_t = A \left[\alpha K_t^{\rho} + (1-\alpha) N_t^{\rho} \right]^{\frac{1}{\rho}}, \qquad \rho \leq 1$$

$\sigma = \frac{1}{1-\rho}$ is the elasticity of substitution:

$$\sigma = \frac{d \ln \left(K_t / N_t \right)}{d \ln \left(w_t / R_t \right)} = \frac{1}{1-\rho}$$

In words, how you adjust relative inputs in response to relative factor prices

Perfect Substitutes and Complements

Special cases:

- $\rho = 1$: perfect substitutes

$$Y_t = A_t \left[\alpha K_t + (1-\alpha) N_t\right]$$

- $\rho = 0$: Cobb-Douglas

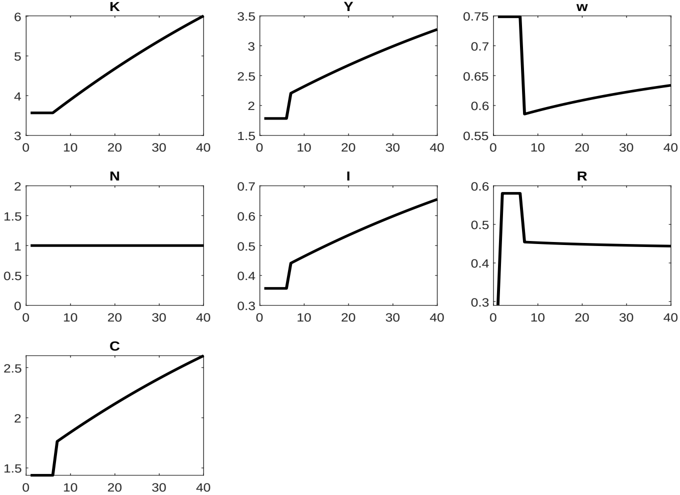
$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$$

- $\rho \to -\infty$: perfect complements

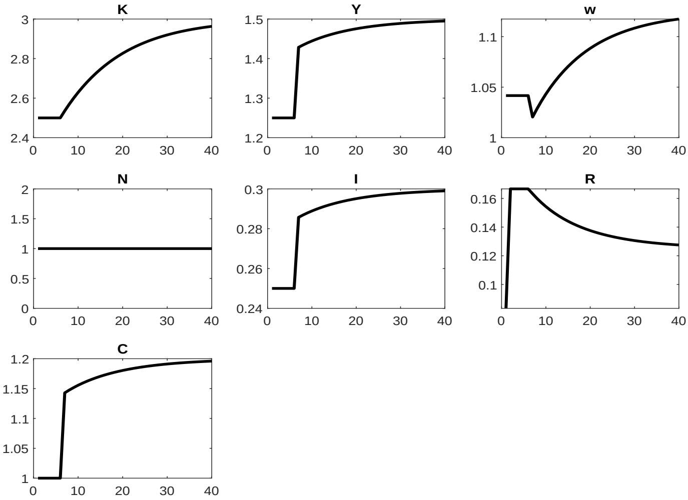
$$Y_t = A_t \min(K_t, N_t)$$

Re-do these experiments with different values of ρ

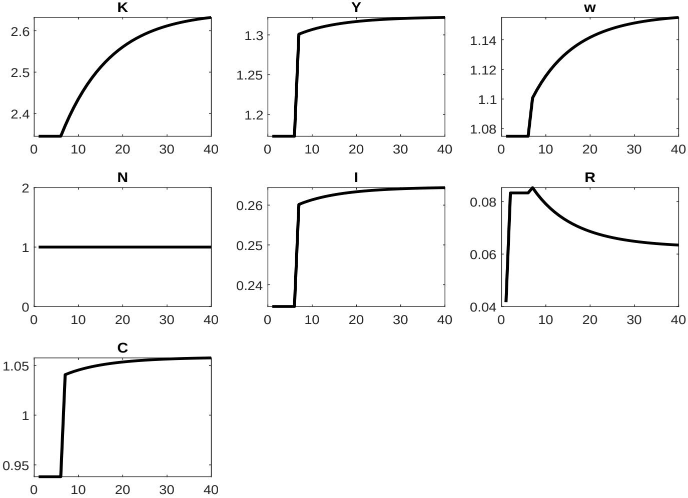
Dynamic Responses to $\uparrow \alpha$: Strong Substitutes ($\rho = 0.8$)



Dynamic Responses to $\uparrow \alpha$: Complementary ($\rho = -1$)



Dynamic Responses to $\uparrow \alpha$: More Complementary ($\rho = -2$)



Taking Stock

Capital-biased technological change could be bad or good for labor

Depends on how substitutable capital and labor are

The more substitutable: the worse for labor

Empirically: probably close to Cobb-Douglas ($\rho \approx 0$): short-run pain, long-run gain for labor

Different Types of Labor

Assume the aggregate production function is Cobb-Douglas:

$$Y_t = AK_t^{\alpha} H_t^{1-\alpha}$$

H_t is a composite of two (or more) types of labor:

$$H_t = \left[\beta N_{1,t}^{\rho} + (1-\beta) N_{2,t}^{\rho}\right]^{\frac{1}{\rho}}$$

As in the earlier example, ρ governs the substitutability between $N_{1,t}$ and $N_{2,t}$. β governs relative weight of each type

Labor Markets

Wages equal marginal products:

$$w_{1,t} = (1-\alpha)\beta A K_t^{\alpha} H_t^{-\alpha} \left[\beta N_{1,t}^{\rho} + (1-\beta) N_{2,t}^{\rho}\right]^{\frac{1-\rho}{\rho}} N_{1,t}^{\rho-1}$$

$$w_{2,t} = (1-\alpha)(1-\beta) A K_t^{\alpha} H_t^{-\alpha} \left[\beta N_{1,t}^{\rho} + (1-\beta) N_{2,t}^{\rho}\right]^{\frac{1-\rho}{\rho}} N_{2,t}^{\rho-1}$$

In long run, assume wages are equal and $N_1 + N_2 = 1$. Implies:

$$N_2 = \left(1 + \left(\frac{\beta}{1-\beta}\right)^{\frac{1}{1-\rho}}\right)^{-1}$$

$$N_1 = \left(\frac{\beta}{1-\beta}\right)^{\frac{1}{1-\rho}} \left(1 + \left(\frac{\beta}{1-\beta}\right)^{\frac{1}{1-\rho}}\right)^{-1}$$

Assume $\beta = 1/2$ initially, implying $N_1 = N_2 = 1/2$ in steady state

Experiment and Transition

Assume that economy sits in steady state, then β increases (to 2/3)

In steady state, this involves reallocating labor from N_2 to N_1

Assume $N_{2,t}$ adjusts immediately to new steady state implied by the higher β. But $N_{1,t}$ adjusts slowly – takes a while to "re-train" workers:

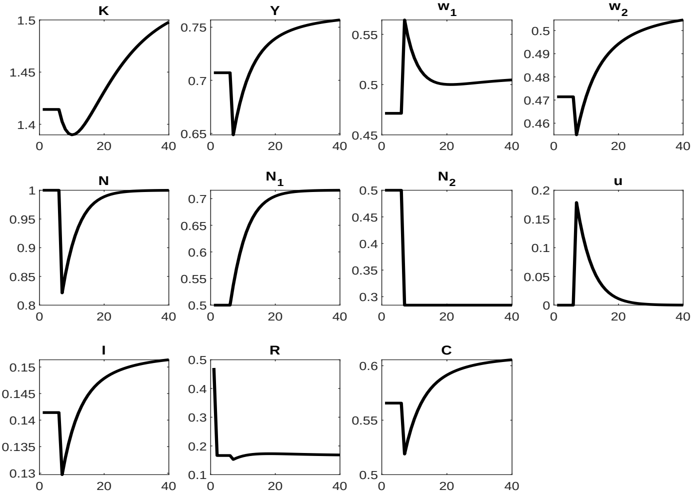
$$N_{1,t} = N_1^{\gamma} N_{1,t-1}^{1-\gamma}, \quad 0 < \gamma < 1$$

If γ is big, labor reallocates quickly; if γ small, it takes a while, and there is some short-term unemployment:

$$u_t = 1 - N_{1,t} - N_{2,t}$$

Assume $\rho = 0.25$ and $\gamma = 0.2$

Dynamic Responses to $\uparrow \beta$



Experiment and Transition

Eventually, output, capital, consumption are higher: but some short-run pain

Workers in the sector with higher productivity ($N_{1,t}$) benefit immediately (higher wages)

The losers: people who leave $N_{2,t}$ (short-term unemployment) and people who stay (short-run decline in wage)

But in the long run, <u>everyone</u> is better off

My Own Take

Caveat: AI is new, it's really hard to make a forecast. But . . .

We've lived through technological revolutions before (e.g., cotton gin, railroads, personal computers). Materially, we always end up better off

But there is sometimes some short-term pain and gains are unevenly distributed

In all three versions of Solow model I consider here, in long-run we are better off

But in two out of three, there is some short-term pain and/or unequal distribution of benefits. This is my guess as to what AI revolution will be like