The Romer Model: Policy Implications

Prof. Lutz Hendricks

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Policies have level effects

What are the effects of government policies?

We may expect policies to affect saving (s_K), R&D (s_A), or population growth (n).

Consider the case of $\phi < 1$, where growth is

$$g(A) = \frac{\lambda\ n}{1-\phi} \tag{1}$$

Main result: Policies that affect only saving or investment in R&D (s_A) do not affect long-run growth.

Note: For policies that do not affect R&D the model behaves exactly like the Solow model.

R&D Subsidies

Consider a permanent increase in s_A.

We must consider two equations:

$$g(A) = B \ (s_A L)^{\lambda} \ A^{\phi-1} \tag{2}$$

$$\dot{K} = s_K \ Y - d \ K \tag{3}$$

Note: Behavior of A is independent of K and Y.

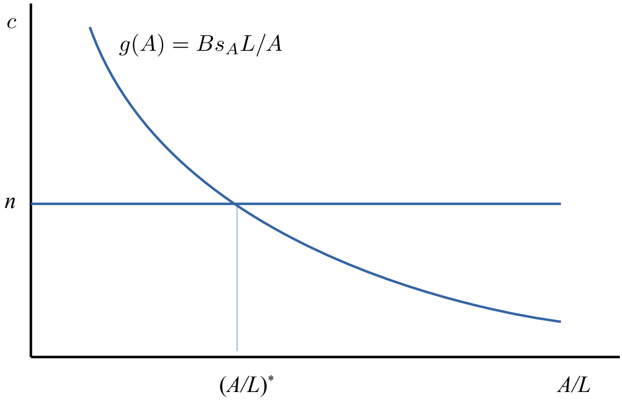
Simplify by assuming $\lambda = 1$ and $\phi = 0$ so that

$$g(A) = B \ s_A \ L \ / \ A \tag{4}$$

Balanced growth rate:

$$g(A) = n$$

R&D Subsidies



R&D Subsidies

On a **BGP**, (4) determines A/L:

$$g(A) = n = Bs_A L/A \tag{5}$$

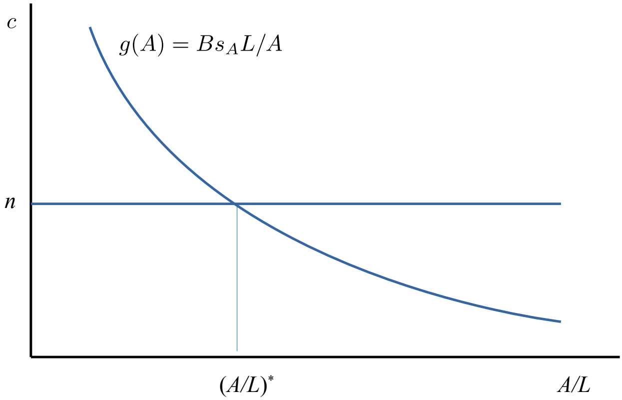
implies

$$(A/L)^* = \frac{B\ s_A}{n} \tag{6}$$

Transition:

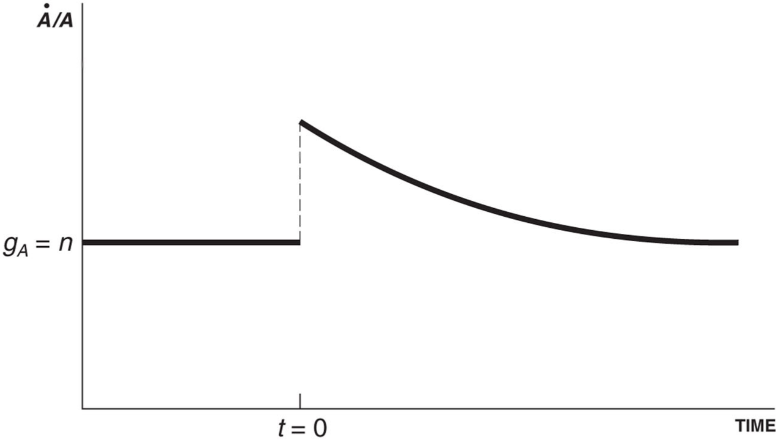
- As long as L/A is above BGP, $g(A) > n$ is above BGP.
- Therefore, $g(A)$ declines over time until it reaches n.
- The BGP is stable.

Transition path after an increase in s_A



Time path of the growth rate of ideas

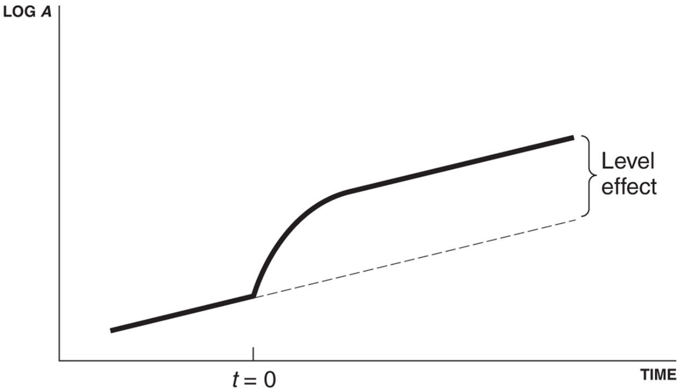
FIGURE 5.2 $\dot{A}/A$ OVER TIME



A period of faster innovation builds up more ideas.

Time path of A

FIGURE 5.3 THE LEVEL OF TECHNOLOGY OVER TIME



Eventually growth levels off, but the higher level of A remains forever.

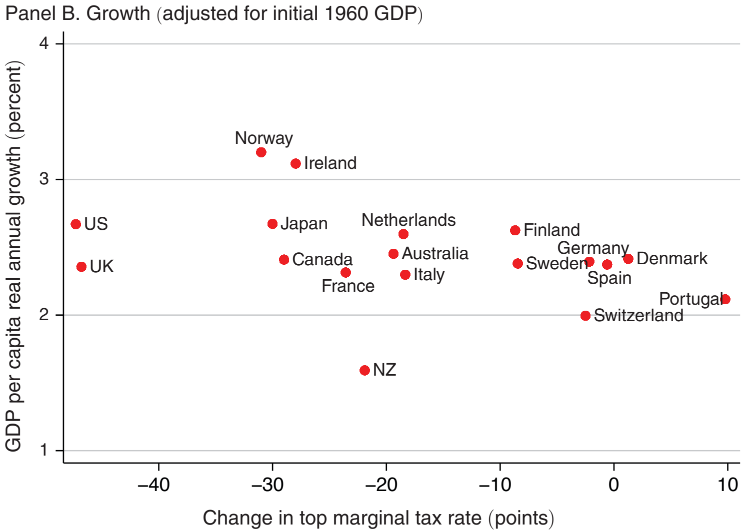
Policy implications

- Patent protection, R&D subsidies, and other policies affect s_A.
- These policies can raise the growth rate of output, although not in the long run.
- Policies do affect long-run levels of Y/L.

How could the hypothesis that taxes do not change long-run growth be tested?

- it's surprisingly tricky...
- regress growth rates on tax rates?

Empirical evidence



Source: Piketty et al. (2014)

Is Growth Sustainable?

Outlook for U.S. growth

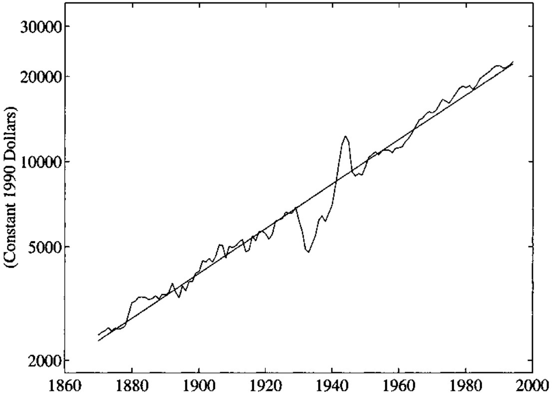


FIGURE 1. U.S. GDP PER CAPITA, LOG SCALE

Source: Jones (2002)

U.S. growth has been constant for a long time.
But are we on a balanced growth path?

Will growth level off?

The basic idea of Jones (2002):

- Over the past 100 years, inputs that improve productivity have been rising: years of schooling; R&D spending / output.
- Eventually, these must level off.
- Then output growth must slow down.
- By how much?

Inputs that increase productivity are rising

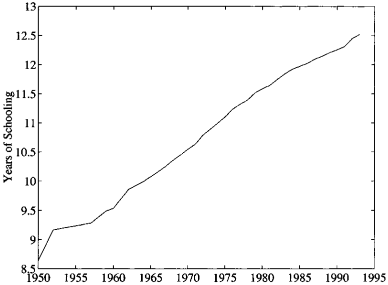


FIGURE 3. AVERAGE U.S. EDUCATIONAL ATTAINMENT, PERSONS AGED 25 AND OVER

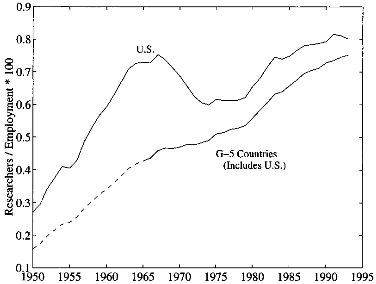


FIGURE 4. RESEARCH INTENSITY IN THE G-5 COUNTRIES

What happens when these inputs stop growing?

A Model

Extend the Romer model to incorporate:

1. Human capital in the production of output.
2. Human capital in R&D.

Output production:

$$Y_t = A_t^{\sigma} K_t^{\alpha} (h_t L_{Yt})^{1-\alpha} \tag{7}$$

Then

$$y_t = Y_t / L_t = (K_t / Y_t)^{\alpha/(1-\alpha)} l_{Yt} h_t A_t^{\sigma/(1-\alpha)} \tag{8}$$

where $l_Y = L_Y / L$ is the fraction of workers in this sector.

Derivation I

$$Y = A^{\sigma} K^{\alpha} (hl_y L)^{1-\alpha} \tag{9}$$

$$= A^{\sigma} \left(\frac{K}{L}\right)^{\alpha} (hl_y)^{1-\alpha} L \tag{10}$$

$$Y/L = A^{\sigma} \left(\frac{K}{hl_y L}\right)^{\alpha} hl_y \tag{11}$$

$$Y/K = A^{\sigma} \left(\frac{K}{hl_y L}\right)^{\alpha-1} \tag{12}$$

$$\left(\frac{K}{hl_y L}\right)^{\alpha} = (K/Y)^{\frac{\alpha}{1-\alpha}} A^{\frac{\sigma\alpha}{1-\alpha}} \tag{13}$$

Derivation II

Substitute this back into (11) and note that

$$A^{\sigma} A^{\sigma\alpha/(1-\alpha)} = A^{\sigma/(1-\alpha)} \tag{14}$$

because $1 + \frac{\alpha}{1-\alpha} = \frac{1}{1-\alpha}$. Then we get (8).

Output growth

What does

$$y_t = (K_t/Y_t)^{\alpha/(1-\alpha)} l_{Yt} h_t A_t^{\sigma/(1-\alpha)} \tag{15}$$

imply for growth of output per worker?

Along the transition:

$$g(y) = \underbrace{\frac{\alpha}{1-\alpha} g(k/y) + g(l_Y)}_{\text{about } 0} + \underbrace{g(h)}_{>0} + \underbrace{\frac{\sigma}{1-\alpha} g(A)}_{>0} \tag{16}$$

We expect $g(A)$ above balanced growth

- because R&D inputs are rising over time

Balanced growth

K/Y and l_y must be constant over time (they are bounded)

Assume long-run $g(h) = 0$ because schooling levels off (strong assumption).

Normalize $\sigma = 1 - \alpha$. (why can I do this?)

Then

$$g(y) = g(A) \tag{17}$$

We expect the balanced growth rate to be lower even than past TFP growth.

- $g(A)$ will slow down when R&D inputs stop growing.

R&D sector

$$\dot{A}_t = B\left(l_{At}h_tL_t\right)^{\lambda}A_t^{\phi} \tag{18}$$

so that

$$g\left(A\right) = \frac{\left(h_tl_{At}L_t\right)^{\lambda}}{A_t^{1-\phi}} \tag{19}$$

Balanced growth with $g\left(h\right) = g\left(l_A\right) = 0$:

$$g\left(A\right) = \frac{\lambda}{1-\phi}n \tag{20}$$

(just like in our textbook model)

BGP output growth

$$g(y) = g(A) = \underbrace{\frac{\lambda}{1-\phi}}_{\gamma} n \tag{21}$$

Key point

Transitional growth has several sources:

- $g(h)$,
- growth of A in excess of balanced growth γn, and
- balanced A growth of γn.

Only the γn part is sustainable!

Quantifying the slowdown

We observe: $g(y) = 2\%$ per year

Balanced growth: γn where $n = 1.2\%$ per year.

So the value of γ determines the slowdown.

How big is γ?

Key idea (roughly):

$$g(A) = \frac{(h_t l_{At} L_t)^{\lambda}}{A_t^{1-\phi}} \tag{22}$$

- We observe $g(A), h$, and $L_{A,t} = l_{A,t} L_t$.
- If $g(A)$ was constant over time (roughly true), the we can estimate $\gamma = \lambda / (1 - \phi)$.

Result: $\gamma \approx 1/3$.

Key implication

Only 1/3 of past TFP growth is sustainable once transitory increases of h and l_A comes to an end.

Growth accounting implications

Post-war average growth $g(y) = 0.02$

$n = 0.012$

Balanced growth $= \gamma n = (1/3) \times 1.2\% = 0.4\%$

Transition dynamics

We can simulate the model path to find out how rapidly growth slows down.

Result: Growth slows by half (relative to γn) every 40 years.

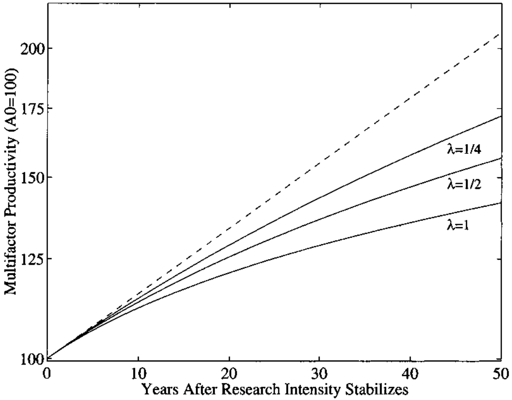


FIGURE 5. THE TRANSITION OF MULTIFACTOR PRODUCTIVITY TO STEADY STATE

Discussion

How seriously should we take this analysis?

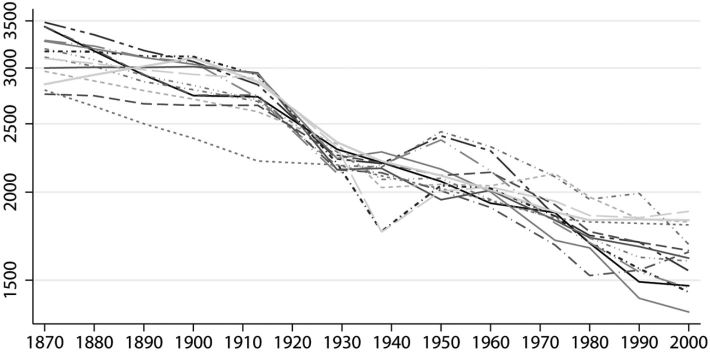
What Does the Model Contribute?

1. It can make an intuitive argument precise.
   The idea: long-run growth should be lower than past growth because R&D input growth must slow down
2. It can give an idea of magnitudes.
   The model is very simple. Assumptions have weak empirical support.
   Read as: "This could be a big deal."

Does Growth Cost Jobs?

How do we think about this question?

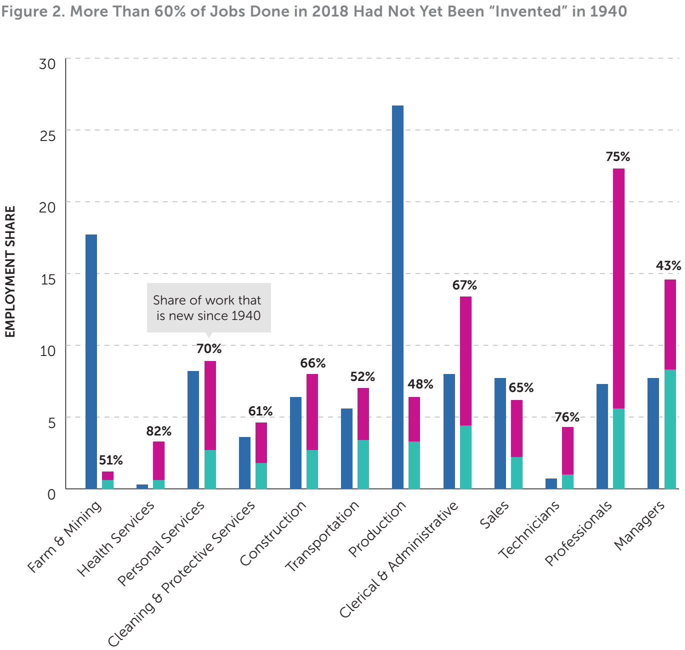
Falling hours worked



Source: Boppart and Krusell (2019). See also the VoxEU summary.

Is this evidence of job loss?

Technologies create new jobs



Middle income jobs are automated

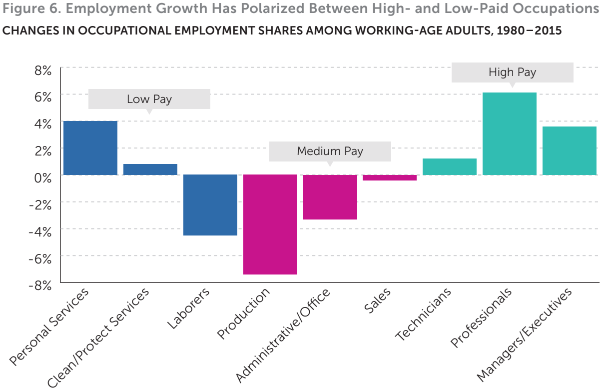
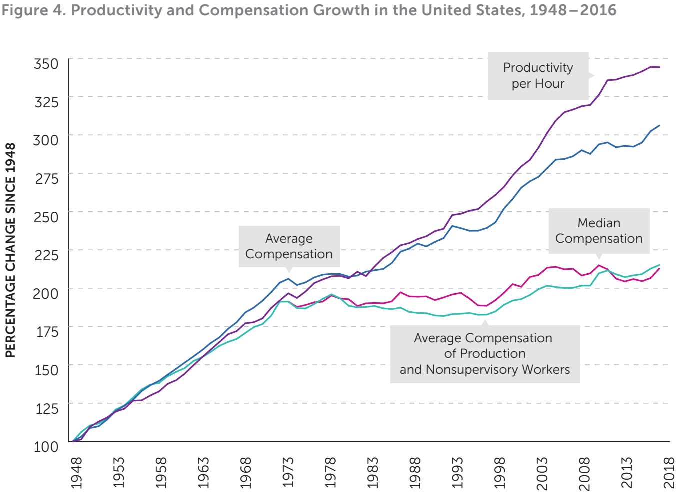


Figure is constructed using U.S. Census of Population data for 1980, 1990, and 2000, and pooled American Community Survey (ACS) data for years 2014 through 2016, sourced from IPUMS (Ruggles et al., 2018). Sample includes working-age adults ages 16 – 64 excluding those in the military. Occupational classifications are harmonized across decades using the classification scheme developed by Dorn (2009).

Source: Autor (2020)

Labor income lags output growth



Source: Autor (2020)

Does growth cost jobs?

What is the overall answer?

- We do not see large numbers of working age persons unable to find jobs.
- But we see displacement of middle skill jobs.

Future automation could render many workers obsolete.

Autor (2020): "No economic law dictates that the creation of new work must equal or exceed the elimination of old work. Still, history shows that they tend to evolve together."

Summary

- Innovations are produced just like regular goods, but they are non-rival.
- Therefore, we have scale effects: larger markets support more rapid innovation.
- The growth rate of Y/L is proportional to the population growth rate.
- A one-time increase in R&D effort (higher L_A) raises the rate of innovation permanently.
  - But this is not enough to sustain higher long-run growth.
- Policies only have level effects.

Final Example

What is the effect of a permanent increase in

1. research productivity (easy)
2. population (holding k fixed or not)
3. population growth (Europe)

Reading

- Jones (2013b), ch. 5.
- The section on the outlook for US growth is based on Jones (2002).

Optional:

- Romer (2011), ch. 3.1-3.4
- Jones (2013a), ch. 6

Advanced Reading

- Jones (2005) talks in some detail about the economics of ideas.
- Lucas (2009) and McGrattan and Prescott (2009) on openness and growth

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