Sources of Growth

Harvard Economics 1011B
Professor Gabriel Chodorow-Reich
Spring 2020

Overview of growth and income differences

- Kaldor facts.
- Solow model.
  - Growth from capital accumulation and exogenous technology.
- Neoclassical growth model.
  - Growth from equilibrium capital accumulation and exogenous technology.
  - Efficiency result.
- Confronting neoclassical growth theory with evidence.
- Other and deeper theories of cross-country growth differences.
- **Growth over time.**
- Cross-country welfare differences beyond GDP.

Outline

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1. Growth accounting
2. Measurement
3. Case study: East Asian miracle
4. Case study: U.S. Special century

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- Can extend to include human capital, different types of physical capital, etc.

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$$\text{Labor share:} \quad \frac{w_t L_t}{Y_t} = \frac{L_t F_L}{Y_t} = \frac{L_t (1-\alpha) Y_t / L_t}{Y_t} = 1 - \alpha,$$

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- Program: measure g_Y, g_K, g_K. Define:

$$\begin{aligned} \text{Capital contribution:} \quad & \alpha g_K, \\ \text{Labor contribution:} \quad & (1-\alpha) g_L, \\ \text{Solow Residual/TFP:} \quad & g_Y - \alpha g_K - (1-\alpha) g_L. \end{aligned}$$

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- Note: Should remind you of Hall and Jones cross-country exercise.

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Components

- Physical capital measured by accumulating investment and subtracting depreciation.
- Labor measured by total hours worked or total persons at work.
- Measuring output is harder because need to measure price changes...

Standard of living over time

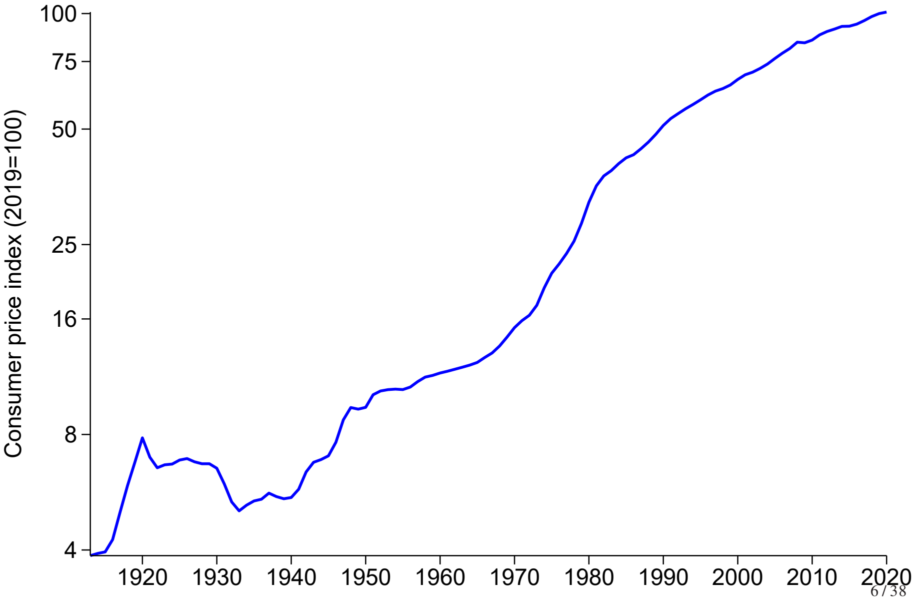
- At what level of income in 1970 would you be indifferent to living on \$60,000 today?

- 1970: car cost \$3,500. Today: \$26,000. But cars today are better (safer, more powerful).

- 1970: no cell phone, internet, high-tech medical imaging, etc.

- What about 1920? 1870?

BLS Consumer price index



Ideal consumer price index

- Definition: an ideal consumer price index tracks the minimum cost of purchasing goods and services that deliver 1 util.
- That is, given:

$$\begin{aligned} \text{Prices on } N \text{ goods:} &\qquad \mathbf{p}_t = \left(p_{1,t}, \ldots, p_{N,t}\right)', \\ \text{Consumption basket:} &\qquad \mathbf{c}_t = \left(c_{1,t}, \ldots, c_{N,t}\right)', \\ \text{Utility:} &\qquad U_t = u(\mathbf{c}_t), \end{aligned}$$

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- Remark 1: there is no t subscript on the $u(.)$ function. This only makes sense under stable preferences.

- Remark 2: the N-vector of goods may include goods not available in some periods, in which case the associated prices are the "choke prices" at which the consumer would choose zero consumption (could be ∞).

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- It turns out that under some conditions, $\Pi_{t+1}^{Fisher} = \left(\Pi_{t+1}^{Laspyres} \Pi_{t+1}^{Paasche} \right)^{1/2}$ approximates ideal inflation.
- U.S. Bureau of Economic Analysis uses Fisher price indexes. Many statistical agencies use Paasche indexes. BLS uses Lasypres.

COMPLICATIONS: OBTAINING $p_{i,t+1}/p_{i,t}$

- Both the Laspyres and Paasche formulas have a term $p_{i,t+1}/p_{i,t}$.
- This is the change in price of good i. Hard to think about how to measure changes in the cost of living without starting from this.
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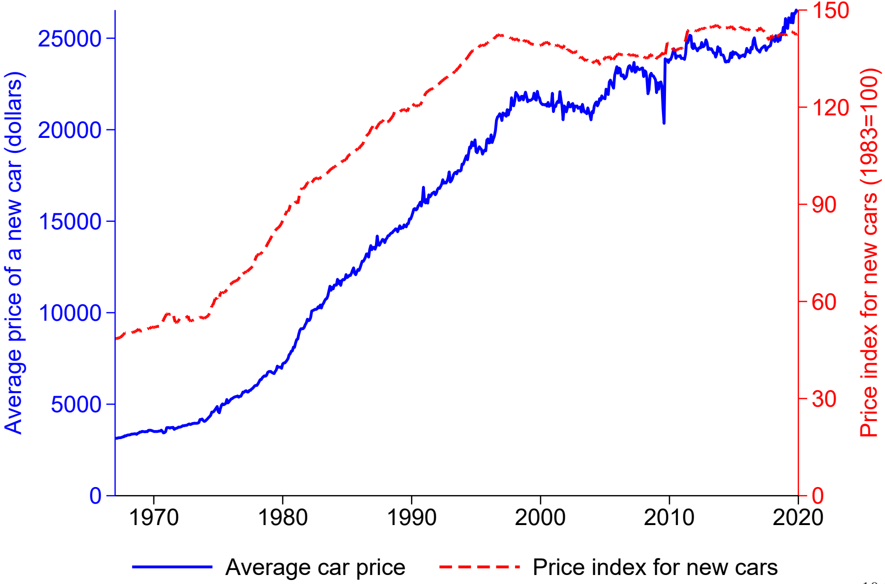
- Other new goods are radically different. E.g., iphone1.
- What is a good? Does buying the same product at Whole Foods deliver the same utility as buying it at Walmart?
- Small differences accumulate: if quality improvements or gains from variety under-valued by 0.5% per year and measured real income growth is 2% per year, then cumulative income gains mis-measured by $((1+0.02+0.005)/(1+0.02))^{40}-1=22\%$ after 40 years.

CAR PRICES



Average price of a new car (dollars)
0
5000
10000
15000
20000
25000
Price index for new cars (1983=100)
0
30
60
90
120
150
1970
1980
1990
2000
2010
2020
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Missing Growth from Creative Destruction†

By Philippe Aghion, Antonin Bergeaud, Timo Boppart, Peter J. Klenow, and Huiyu Li*

For exiting products, statistical agencies often impute inflation from surviving products. This understates growth if creatively-destroyed products improve more than surviving ones. If so, then the market share of surviving products should systematically shrink. Using entering and exiting establishments to proxy for creative destruction, we estimate missing growth in US Census data on non-farm businesses from 1983 to 2013. We find missing growth (*i*) *equaled about one-half a percentage point per year;* (*ii*) *arose mostly from hotels and restaurants rather than manufacturing; and* (*iii*) *did not accelerate much after 2005, and therefore does not explain the sharp slowdown in growth since then.* (*JEL* E23, E31, L14, L15, O30, O41)

View

The Big, Permanent Tax Increase Inside the Tax Cut Act

Let's talk about tax-bracket indexation.

By Justin Fox
December 20, 2017, 3:30 PM EST

The CPI-E: A Better Option for Calculating Social Security COLAs

The 2017 Social Security Trustees Report, released in July 2017, projects a modest 2.2 percent cost-of-living-adjustment (COLA) for 2018. The National Committee is disappointed and not convinced that these estimates –with some more recent projections pointing to an even smaller COLA – accurately reflects the inflation affecting today's seniors. We believe that Social Security's COLA needs to be strengthened.

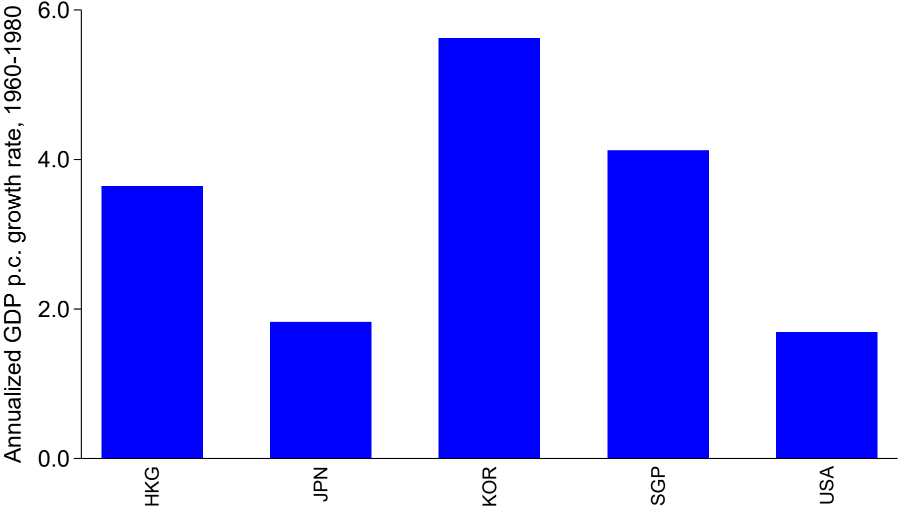
Over the past eight years, the current COLA formula has led to average increases of just over 1 percent, with three of those years seeing no increase at all. The 2017 COLA was a mere 0.3 percent. For the average senior, this COLA provided an extra $4.00 per month, barely the average cost of one Lipitor pill, a prescription drug frequently prescribed to seniors. We urge the adoption of a consumer price index (CPI) for the elderly, or CPI-E, as a more accurate means of calculating Social Security COLAs. An in-depth examination of the CPI-E follows.

Other considerations

- "Free" goods.
- Social infrastructure.
- Environment.
- Life expectancy.

Outline

Why do some countries grow more than others?



THE TYRANNY OF NUMBERS: CONFRONTING THE STATISTICAL REALITIES OF THE EAST ASIAN GROWTH EXPERIENCE*

ALWYN YOUNG

This paper documents the fundamental role played by factor accumulation in explaining the extraordinary postwar growth of Hong Kong, Singapore, South Korea, and Taiwan. Participation rates, educational levels, and (excepting Hong Kong) investment rates have risen rapidly in all four economies. In addition, in most cases there has been a large intersectoral transfer of labor into manufacturing, which has helped fuel growth in that sector. Once one accounts for the dramatic rise in factor inputs, one arrives at estimated total factor productivity growth rates that are closely approximated by the historical performance of many of the OECD and Latin American economies. While the growth of output and manufacturing exports in the newly industrializing countries of East Asia is virtually unprecedented, the growth of total factor productivity in these economies is not.

I. INTRODUCTION

This is a fairly boring and tedious paper, and is intentionally so. This paper provides no new interpretations of the East Asian experience to interest the historian, derives no new theoretical implications of the forces behind the East Asian growth process to

TABLE V
Total Factor Productivity Growth: Hong Kong

Time period	Annual growth of: Output	Raw capital	Weighted capital	Raw labor	Weighted labor	TFP	Labor share
61–66	0.109	0.169	0.162	0.032	0.025	0.035	0.643
66–71	0.065	0.075	0.078	0.025	0.024	0.023	0.660
71–76	0.081	0.075	0.080	0.033	0.024	0.039	0.662
76–81	0.099	0.093	0.098	0.051	0.064	0.022	0.617
81–86	0.058	0.078	0.079	0.019	0.027	0.009	0.593
86–91	0.063	0.062	0.066	0.005	0.022	0.024	0.609
66–91	**0.073**	**0.077**	**0.080**	**0.026**	**0.032**	**0.023**	**0.628**

Raw inputs are the arithmetic sum of subcomponents, with no adjustment for hours of work. Weighted inputs are translog indices of factor input growth, with labor services measured by hours of work.

TABLE VI

Total Factor Productivity Growth: Singapore

Time period	Output	Raw capital	Weighted capital	Raw labor	Weighted labor	TFP	Labor share
	Annual growth of:						
Economy:							
66–70	0.130	0.119	0.134	0.054	0.033	0.046	0.503
70–80	0.088	0.122	0.140	0.050	0.058	−0.009	0.517
80–90	0.069	0.091	0.084	0.036	0.066	−0.005	0.506
66–90	**0.087**	**0.108**	**0.115**	**0.045**	**0.057**	**0.002**	**0.509**
Manufacturing:*							
70–80	0.103	0.123	0.130	0.086	0.089	−0.009	0.423
80–90	0.067	0.090	0.094	0.021	0.051	−0.011	0.385
70–90	**0.085**	**0.107**	**0.112**	**0.054**	**0.070**	**−0.010**	**0.404**

TABLE VII
Total Factor Productivity Growth: South Korea

Time period	Annual growth of: Output	Raw capital	Weighted capital	Raw labor	Weighted labor	TFP	Labor share
Economy—excluding agriculture:							
60–66	0.077	0.069	0.070	0.062	0.072	0.005	0.690
66–70	0.144	0.167	0.194	0.095	0.103	0.013	0.690
70–75	0.095	0.121	0.118	0.052	0.055	0.019	0.661
75–80	0.093	0.158	0.178	0.040	0.052	0.002	0.694
80–85	0.085	0.102	0.099	0.031	0.047	0.024	0.729
85–90	0.107	0.105	0.108	0.061	0.072	0.026	0.739
66–90	**0.103**	**0.129**	**0.137**	**0.054**	**0.064**	**0.017**	**0.703**
Manufacturing:							
60–66	0.123	0.105	NA	0.115	0.115	0.013	0.504
66–70	0.204	0.205	NA	0.104	0.108	0.048	0.504
70–75	0.165	0.133	NA	0.084	0.088	0.053	0.477
75–80	0.127	0.207	NA	0.047	0.062	−0.007	0.503
80–85	0.106	0.075	NA	0.019	0.039	0.051	0.547
85–90	0.118	0.147	NA	0.069	0.,082	0.008	0.572
66–90	**0.141**	**0.151**	**NA**	**0.063**	**0.074**	**0.030**	**0.521**
Other industry:							

TABLE VIII
TOTAL FACTOR PRODUCTIVITY GROWTH: TAIWAN

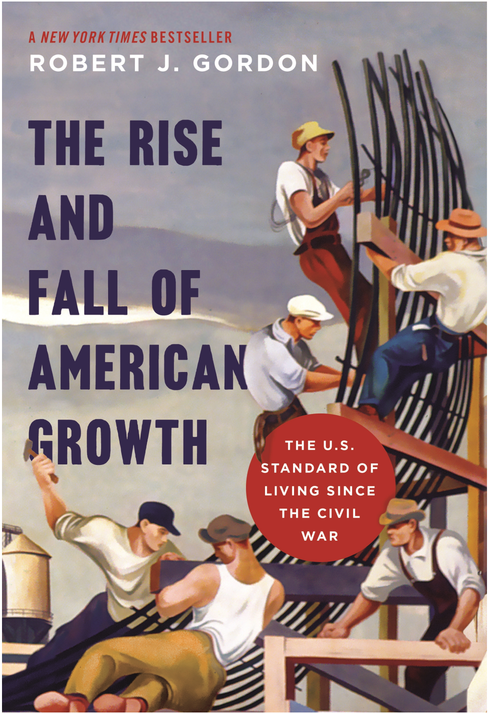
Time period	Output	Aggregate capital	Weighted capital	Aggregate labor	Weighted labor	TFP	Labor share
	Annual growth of:						
Economy—excluding agriculture:							
66–70	0.111	0.152	0.171	0.043	0.044	0.034	0.739
70–80	0.103	0.137	0.144	0.068	0.068	0.015	0.739
80–90	0.078	0.085	0.083	0.024	0.032	0.033	0.749
66–90	**0.094**	**0.118**	**0.123**	**0.046**	**0.049**	**0.026**	**0.743**
Manufacturing:							
66–70	0.168	0.207	0.214	0.078	0.075	0.031	0.558
70–80	0.121	0.145	0.146	0.100	0.101	0.001	0.566
80–90	0.072	0.078	0.079	0.012	0.021	0.028	0.613
66–90	**0.108**	**0.128**	**0.130**	**0.059**	**0.063**	**0.017**	**0.579**
Other industry:							
66–70	0.104	0.177	0.190	0.100	0.096	−0.020	0.702
70–80	0.112	0.165	0.169	0.063	0.066	0.013	0.691
80–90	0.059	0.058	0.060	0.012	0.018	0.027	0.692
66–90	**0.088**	**0.122**	**0.127**	**0.048**	**0.051**	**0.014**	**0.695**
Services:							
66–70	0.087	0.145	0.162	0.018	0.023	0.040	0.828
70–80	0.094	0.134	0.139	0.049	0.050	0.029	0.827

Young's conclusion

As Table XV readily shows, the results of this paper derive from a confluence of small effects, each serving to chip away at the performance of the NICs, with no one estimate, in particular, being essential to the argument. One might dispute the estimates for the impact of increases in educational attainment; one might dispute the weighting of capital; or one might dispute the adjustment of Taiwanese public sector output. And yet, one must recognize that participation rates have risen; that output per worker grew more slowly in the nonagricultural sector than in the aggregate economy; that the educational attainment of the working population has risen rapidly; and that investment, particularly in machinery, has skyrocketed...

The results of this paper should be heartening to economists and policy-makers alike. If the remarkable postwar rise in East Asian living standards is primarily the result of one-shot increases in output brought about by the rise in participation rates, investment to GDP ratios, and educational standards and the intersectoral transfer of labor from agriculture to other sectors (e.g., manufacturing) with higher value added per worker, then economic theory is admirably well equipped to explain the East Asian experience. Neoclassical growth theory, with its emphasis on level changes in income and its well-articulated quantitative framework, can explain most of the difference between the performance of the NICs and that of other postwar economies.

Outline


A NEW YORK TIMES BESTSELLER
ROBERT J. GORDON
THE RISE AND FALL OF AMERICAN GROWTH
THE U.S. STANDARD OF LIVING SINCE THE CIVIL WAR

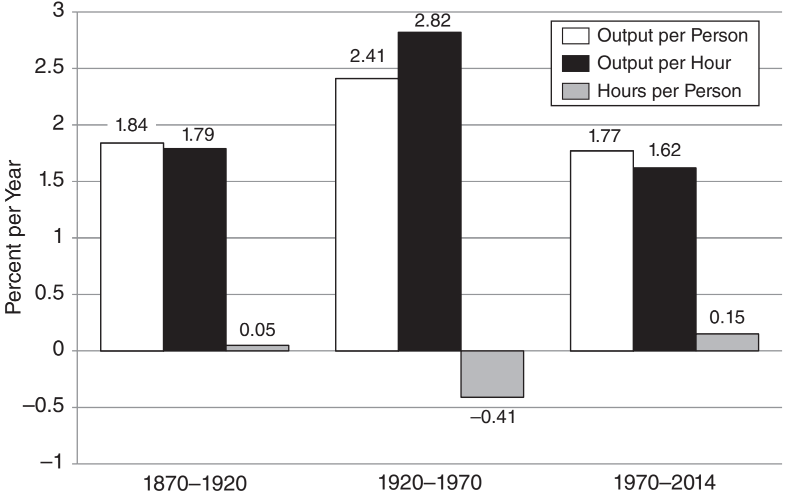


Figure 1–1. Annualized Growth Rate of Output per Person, Output per Hour, and Hours per Person, 1870–2014

Source: See Data Appendix.

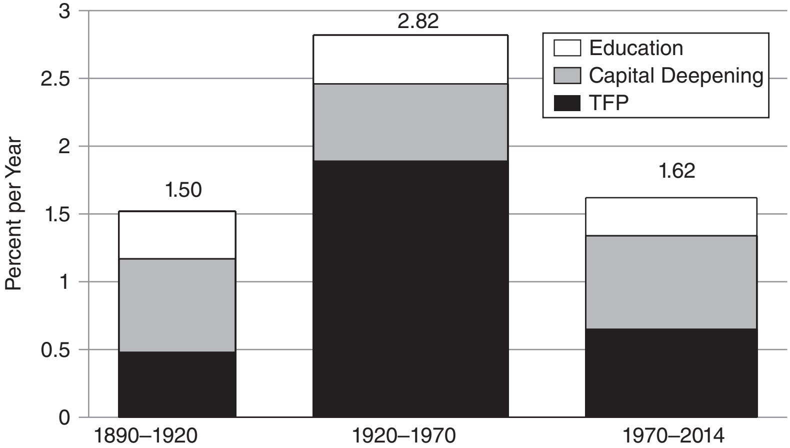


Figure 1–2. Average Annual Growth Rates of Output per Hour and Its Components, Selected Intervals, 1890–2014

Source: See Data Appendix.

The special century

The century of revolution in the United States after the Civil War was economic, not political, freeing households from an unremitting daily grind of painful manual labor, household drudgery, darkness, isolation, and early death. Only one hundred years later, daily life had changed beyond recognition. Manual outdoor jobs were replaced by work in air-conditioned environments, housework was increasingly performed by electric appliances, darkness was replaced by light, and isolation was replaced not just by travel, but also by color television images bringing the world into the living room. Most important, a newborn infant could expect to live not to age forty-five, but to age seventy-two. The economic revolution of 1870 to 1970 was unique in human history, unrepeatable because so many of its achievements could happen only once.

Starting point

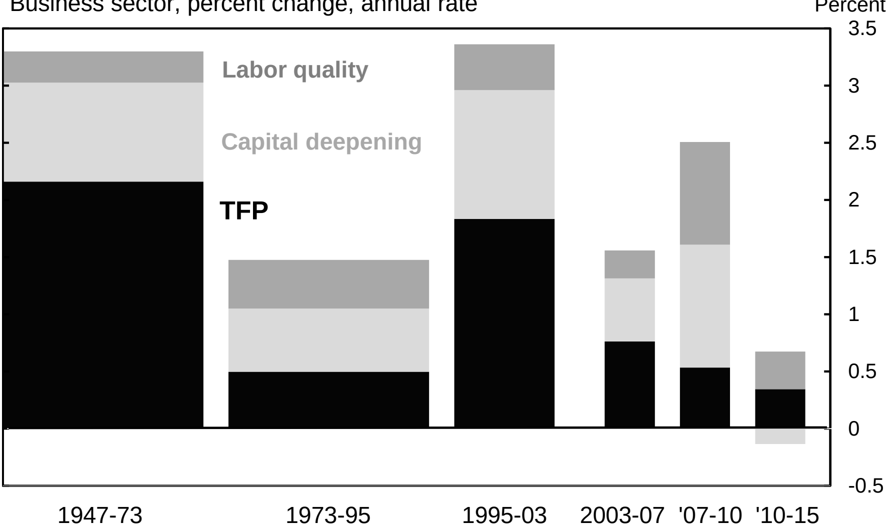
In 1870, farm and urban working-class family members bathed in a large tub in the kitchen, often the only heated room in the home, after carrying cold water in pails from the outside and warming it over the open-hearth fireplace. All that carrying and heating of water was such a nuisance that baths were not a daily or even weekly event; some people bathed as seldom as once per month. Similarly, heat in every room was a distant dream—yet became a daily possibility in a few decades, between 1890 and 1940.

Major inventions during special century

- Spread of electricity.
- Electric machines.
- Elevator.
- Cars and airplanes.
- Networked home: electricity, gas, telephone, radio and television, water, sewer.
- Refridgerators and freezers.
- Processed food.
- Anesthesia, X-rays, antibiotics...

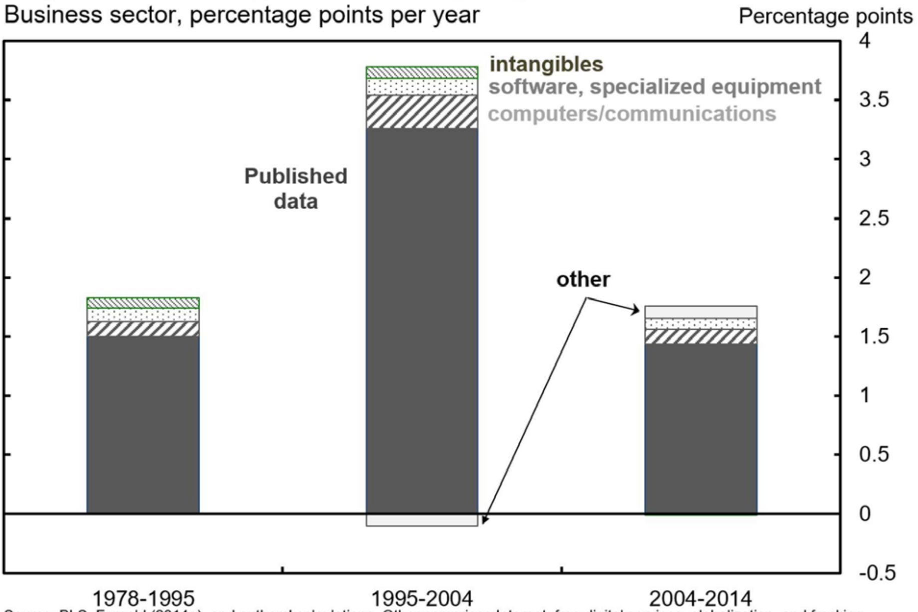
Contributions to growth in U.S. output per hour

Business sector, percent change, annual rate



Source: Fernald (2014a). Quarterly; samples end in Q4 of years shown except 1973 (ends Q1). Capital deepening is contribution of capital relative to quality-adjusted hours. Total factor productivity measured as a residual.

Adjustments to growth in output per hour



Source: BLS, Fernald (2014a), and authors' calculations. Other comprises Internet, free digital services, globalization, and fracking.

What drives growth at the frontier?

- In models: A!
- What drives A? Solow and neoclassical growth models do not have much to say here.
- *Endogenous growth theory*: A depends on the generation of new ideas.
- Ideas are special input into production, because they are non-rival.
- Require protection to incentivize idea generation, such as patents.
- Or natural monopoly (e.g. Facebook).
- Or government investment (e.g. National Institute of Health).

Production function for ideas

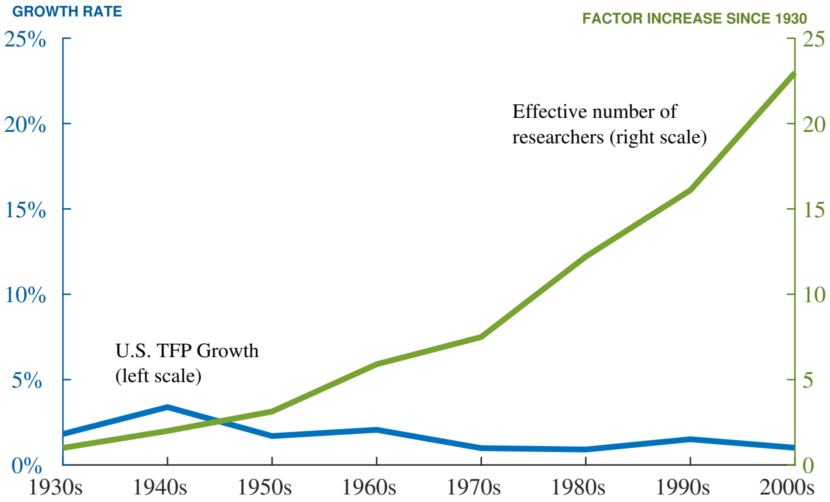
- Suppose for S_t researchers, A grows at:
$$\frac{dA_t}{dt} = BS_t^{\gamma} A_t^{\theta}.$$

- The growth rate of A, g_A, is:
$$\frac{d \ln A_t}{dt} = \frac{dA_t}{A_t dt} = BS_t^{\gamma} A_t^{\theta - 1}.$$

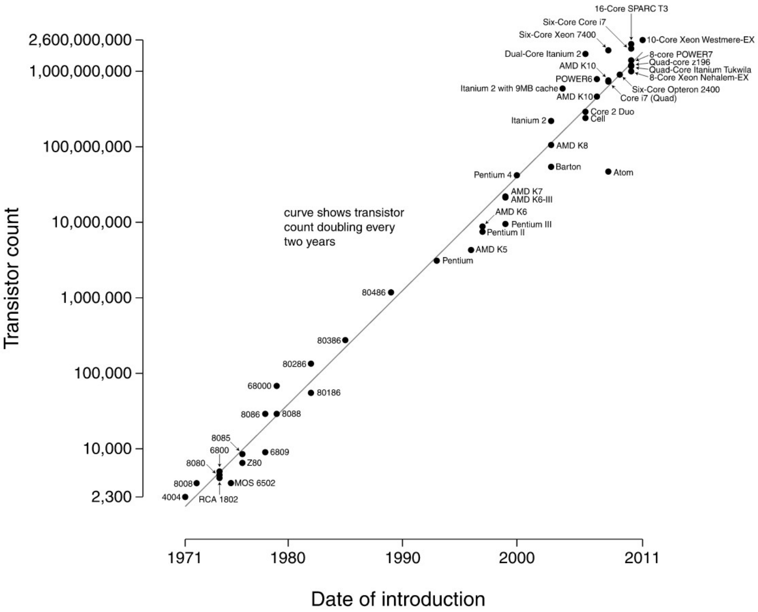
- γ, θ determine scale of returns to idea production.

- Are Ideas Getting Harder to Find?

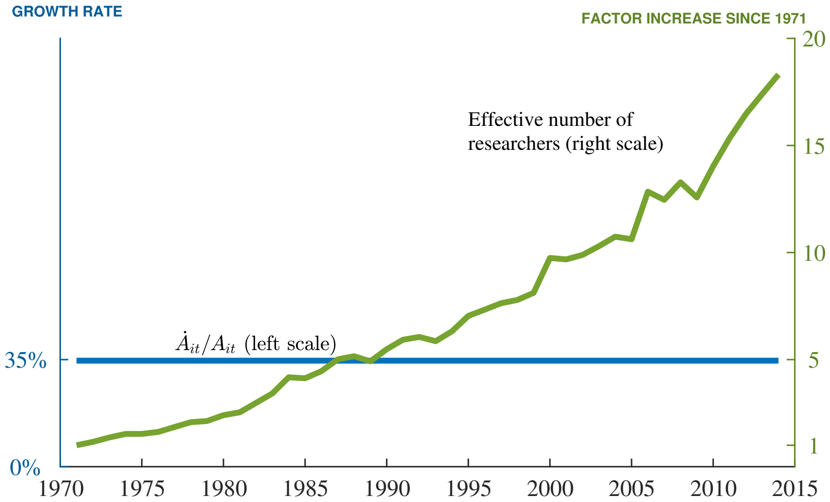
Aggregate Evidence



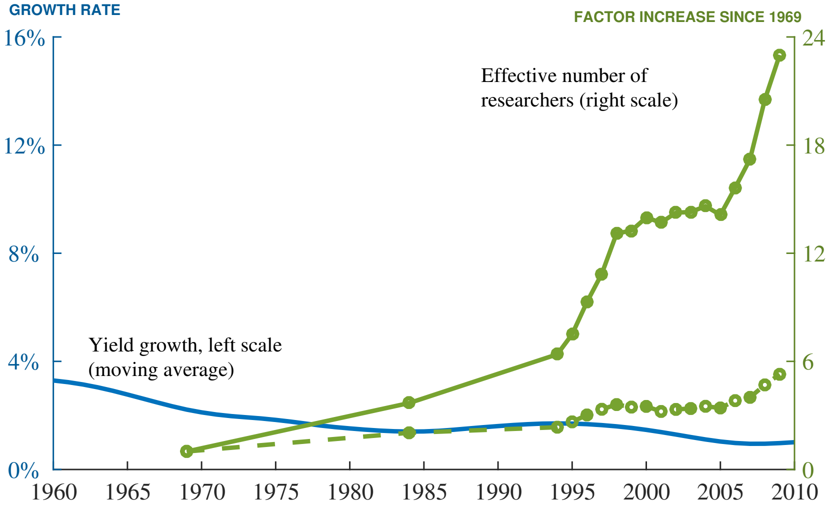
The Steady Exponential Growth of Moore's Law



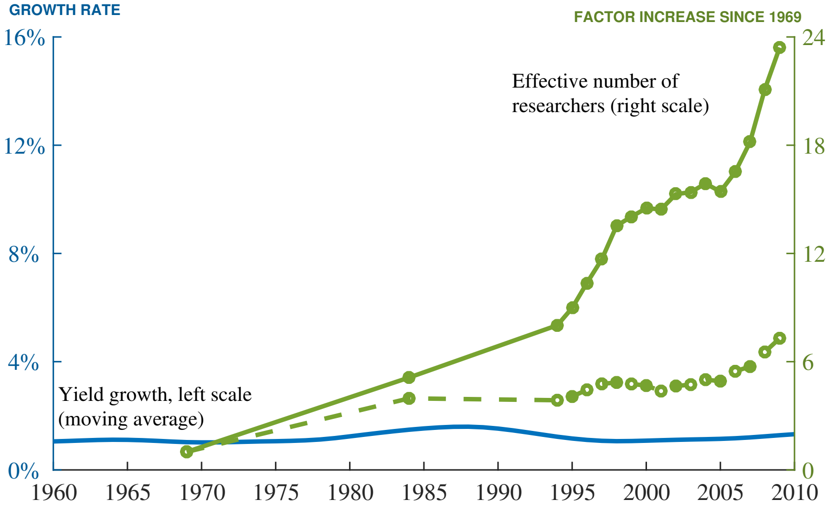
Evidence on Moore's Law



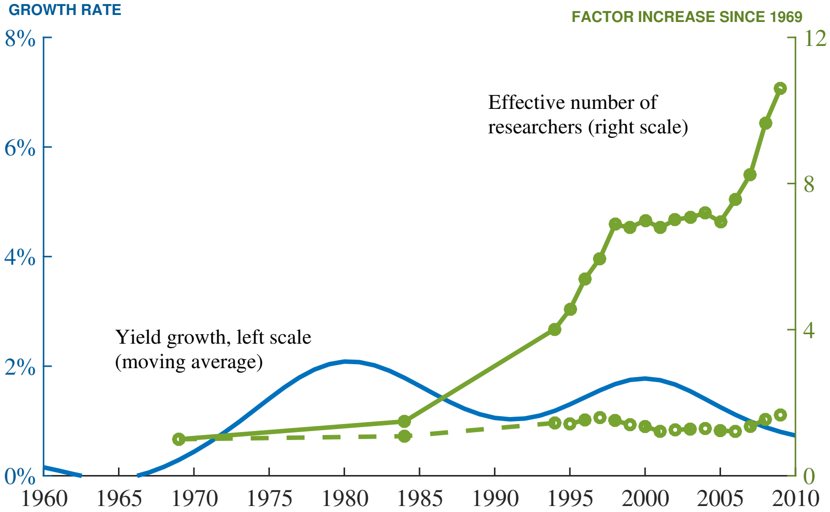
Yield Growth and Research: Corn



Yield Growth and Research: Soybeans



Yield Growth and Research: Cotton



The end of growth?

- Gordon's main thesis is that these transformative inventions can happen only once.
- The growth optimists think he is not imaginative enough:
  - DNA revolution and personalized medicine.
  - Artificial intelligence.
  - Advanced robots.
  - Things we haven't conceived of yet...
- Gordon's reply: play spot the robot.
- And so far no evidence of these innovations raising productivity in the data, despite research effort increasing.