26 June

Output ← inputs: Labor

- L growth: current
  - Currently baby boomer retirement
  - Offset until 2009 by immigration
- Long-run L growth: from desired family size.
  - 2.1 children per family = LR stability
  - Target now 2 per family in US → very little future growth
  - In Japan target was 2 per family by 1966 → realized < 2
  - → population now falling!
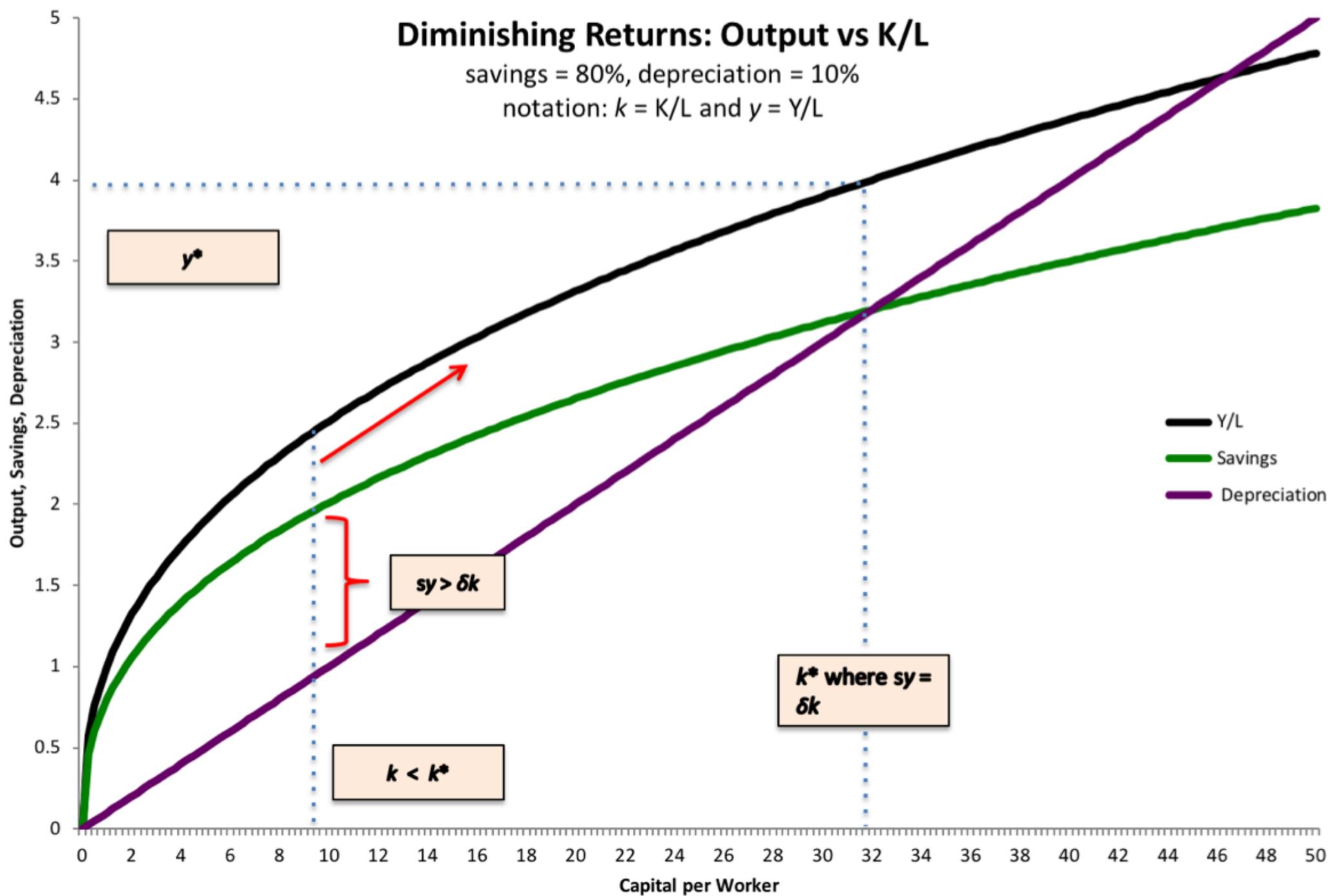
Output ← inputs: Capital

- K capital from investment
  - Investment ≈ 1/6 GDP in US
- BUT
  - Depreciation
- AND
  - Diminishing returns

Formal model: graphing

- $Y = f(K, L, TFP)$

- $I = S = sY$ but we have depreciation δ

- So net is $I - \delta K$

Diminishing Returns: Output vs K/L
savings = 80%, depreciation = 10%
notation: k = K/L and y = Y/L

y^*

$sy > \delta k$

$k^* \text{ where } sy = \delta k$

$k < k^*$

Y/L

Savings

Depreciation

Output, Savings, Depreciation

Capital per Worker

Implications

- **In Long Run**
  - Capital Accumulation Can't Produce Growth
- **In Long Run**
  - Hit ceiling for labor quality
  - Education & training & experience can't produce growth
- **Total Factor Productivity**
  - Is **ALL THAT MATTERS**

Formal Model: For empirics

- $Y = A K^{\alpha} L^{1-\alpha}$ where $0 < \alpha < 1$ which gives diminishing returns
  - Cobb-Douglas function, typical US value $\alpha = 0.3$

- $\mathbf{g_Y = g_A + \alpha\, g_K + (1-\alpha)\, g_L}$ where $\mathbf{g}$ is growth rate

- definition of TFP $= g_A$ $(= g_Y - \alpha\, g_K - (1-\alpha)\, g_L)$

Data in Fred

- LF: https://fred.stlouisfed.org/graph/fredgraph.png?g=hOVa

- Capital Intensity, Mfg: https://fred.stlouisfed.org/series/MPU9900082

- I, ∂ and I-∂
  - Nominal: https://fred.stlouisfed.org/graph/fredgraph.png?g=hOVd
  - Log: https://fred.stlouisfed.org/graph/fredgraph.png?g=hOVf

- Share GDP: https://fred.stlouisfed.org/graph/fredgraph.png?g=hOVh

- Productivity (Non-Farm): https://fred.stlouisfed.org/series/MPU4910013

- LProd: https://fred.stlouisfed.org/graph/?g=hOYF

3 snapshots of TFP data

- An EU – US comparison

- Business Labor Productivity
  - which includes any boost from more capital per worker

- Dale Jorgenson study (he's the doyen of productivity studies)

Productivity at 1% pa as an approximation. This ignores capital accumulation so total growth will be greater. The paper analyzes ICT (info & computer tech). What is clear is that TFP is **not** in the 2+% range needed for strong growth. **But** these data don't pick up the earlier time period so are they really a good comparison with the 1950s and 1960s? In general, limited data mean TFP studies focus on narrow questions, here it's an EU-EU comparison rather than TFP itself.

Table 7, Contributions to total factor productivity growth in ICT producing, ICT using and Non-ICT industries, EU-4 and U.S.
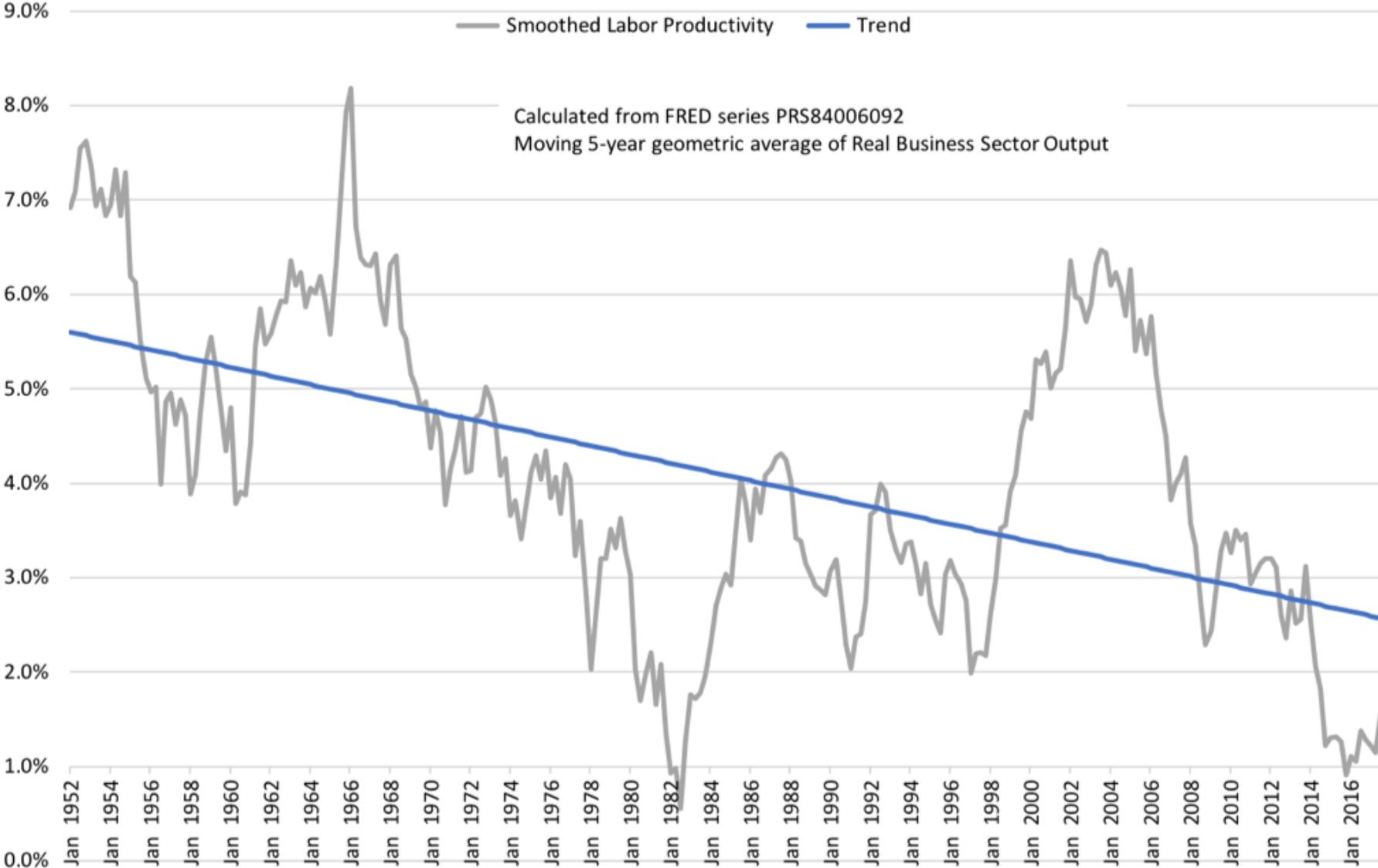
	1979-1995			1995-2000			Change 1995-2000 over 1979-1995		
	EU-4	U.S.	US-EU	EU-4	U.S.	US-EU	EU-4	U.S.	US-EU
Total economy	0.94	0.26	-0.67	1.07	1.05	-0.02	0.13	0.79	0.66
ICT producing	0.30	0.35	0.06	0.53	0.71	0.18	0.24	0.36	0.12
ICT using	0.17	-0.15	-0.31	0.19	0.68	0.50	0.02	0.83	0.81
Non-ICT	0.48	0.06	-0.42	0.35	-0.34	-0.69	-0.13	-0.40	-0.27

Notes: An industry's contribution is calculated as industry total factor productivity growth weighted by the industry's value added share.
Source: see Appendix A

Inklaar, Robert, Mahony O', and Marcel Timmer. 2003. "ICT and Europe's Productivity Performance Industry-Level Growth Account Comparisons with the United States." GGDC Research Memorandum 200368. Groningen Growth and Development Centre. p 22

Smoothed US Labor Productivity

Calculated from FRED series PRS84006092
Moving 5-year geometric average of Real Business Sector Output

Education, Participation, and the Revival of U.S. Economic Growth (2016)

Dale Jorgenson, *Mun Ho* and *Jon D. Samuels*, NBER Working Paper No. 22453

Abstract: Labor quality growth captures the upgrading of the labor force through higher educational attainment and greater experience. We find that **average levels of educational attainment** of new entrants remain high, but **will no longer continue to rise**. Growing educational attainment will gradually disappear as a source of U.S. economic growth. We find that the investment boom of 1995-2000 drew many younger and less-educated workers into employment. Employment rates for these workers declined during the recovery of 2000-2007 and dropped further during the Great Recession of 2007-2009. **Based on estimates of labor quality growth, growth in total factor productivity, and growth in capital quality, we project labor productivity to grow at 1.3% per year. This implies a GDP growth rate of 1.8%.**

Varying methods and data, consistent picture

- TFP Growth in the US has slowed down
  - Data suggest about 1% level
- **THE question**: will it increase in your future?

China

	1981-1991	1991-2001	2001-2007	2007-2011	1981-2011
			Factor contributions to value-added growth (ppts)		
Value-added growth (%)	8.81	8.85	11.37	9.37	9.41
- Capital input:	5.83	7.01	9.45	10.83	7.61
- Stock	5.83	7.08	9.54	10.82	7.65
- Capital quality (composition)	-0.00	-0.07	-0.08	0.01	-0.04
- Labor input:	1.12	1.12	0.59	0.77	0.97
- Number (homogenous)	1.07	0.69	0.54	-0.60	0.61
- Labor quality (composition)	0.06	0.43	0.05	1.37	0.36
- Aggregate TFP	1.86	0.72	1.32	-2.22	0.83

So ... How do we increase TFP?

- R&D
  - Do "apps" raise TFP?
    - Evidence very weak
    - Displacing previous forms of advertising, small net gain
- Urbanization
- Education
- International Trade