



FEDERAL RESERVE BANK OF SAN FRANCISCO

The Future of U.S. Economic Growth

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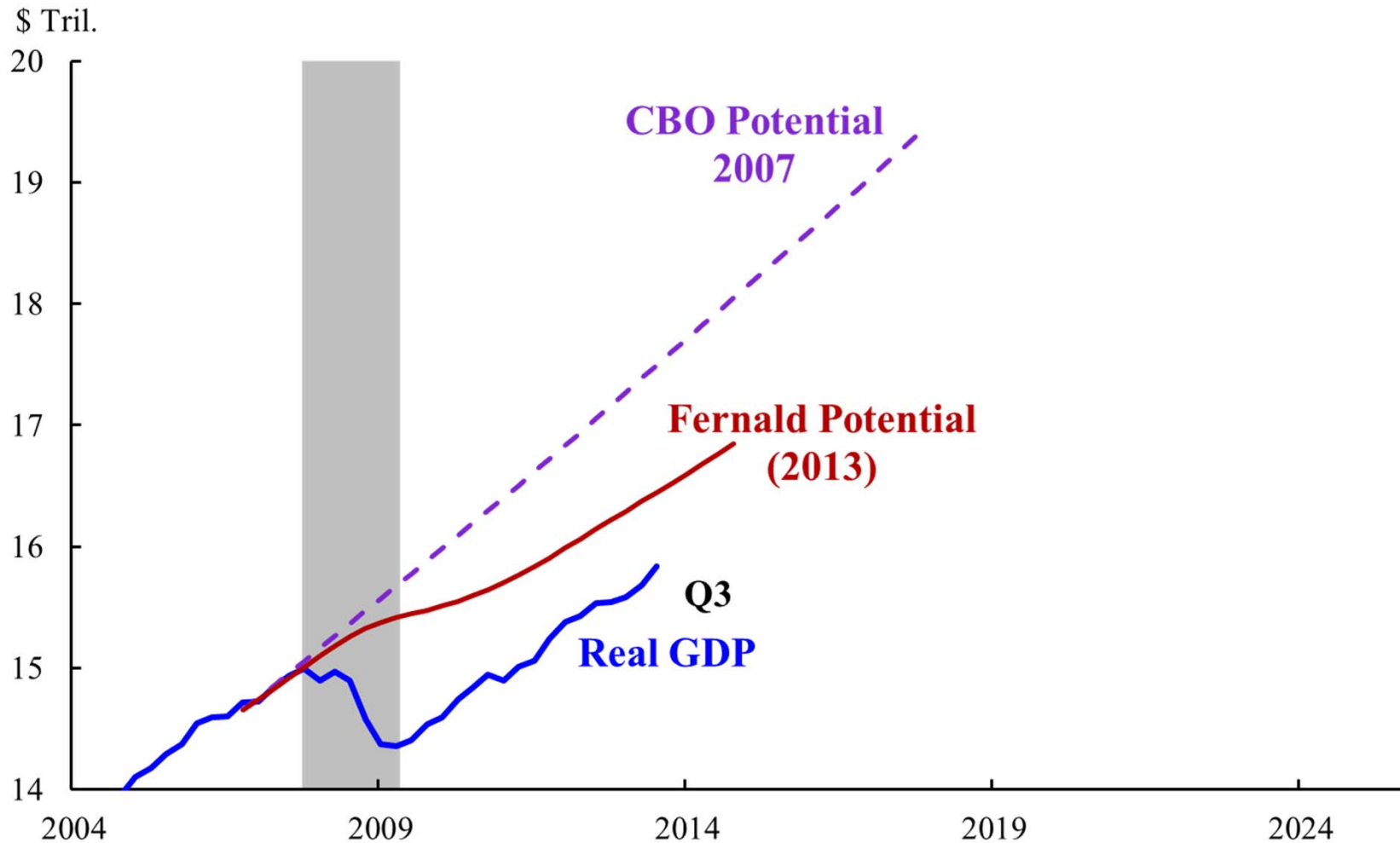
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U.S. GDP is well below pre-recession projections

Potential and Actual Real GDP

Seasonally adjusted, 2009\$

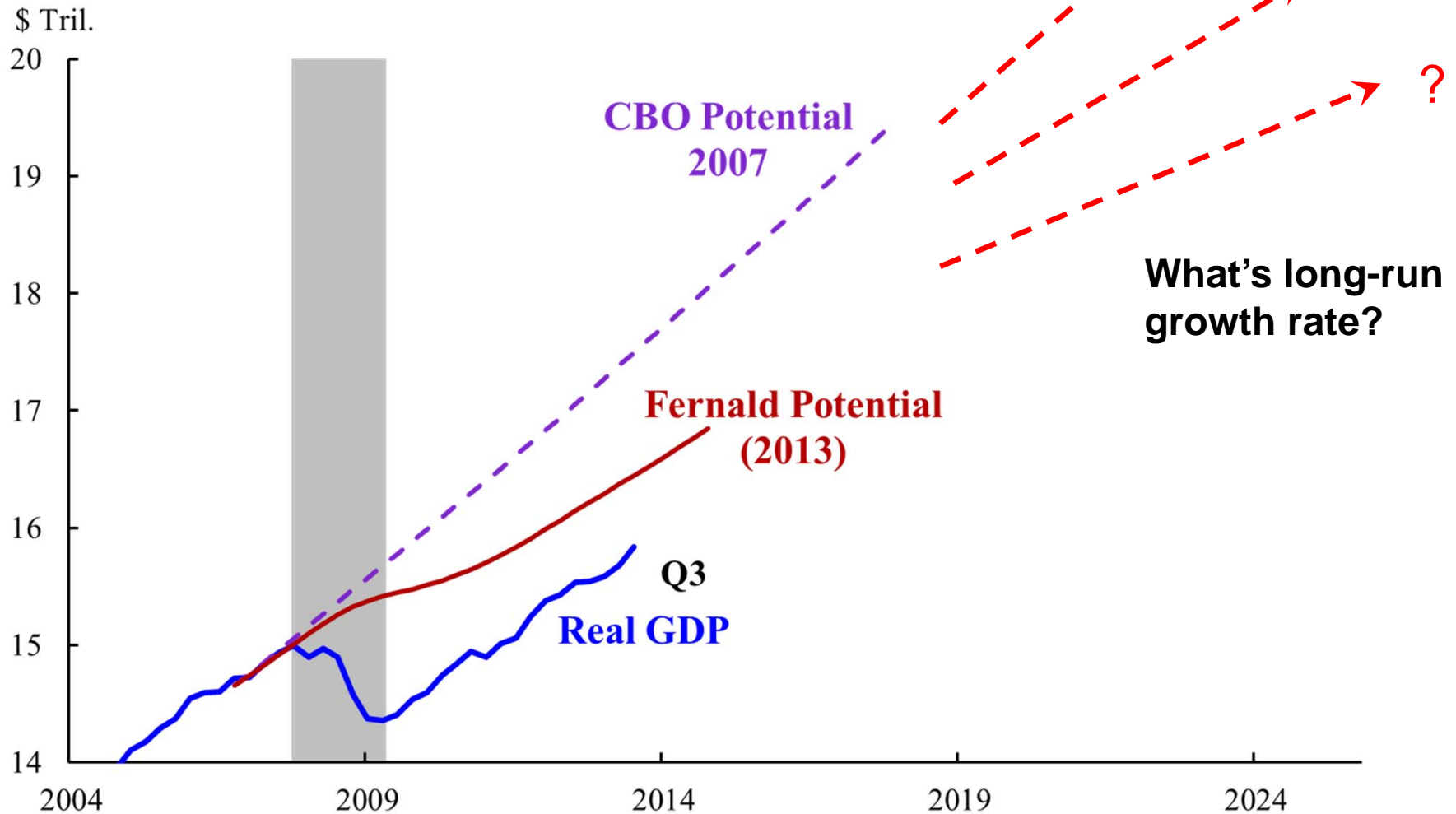


Source: Haver and Fernald (2013). CBO 2007 has been adjusted from 2000\$ to 2009\$

U.S. GDP is well below pre-recession projections

Potential and Actual Real GDP

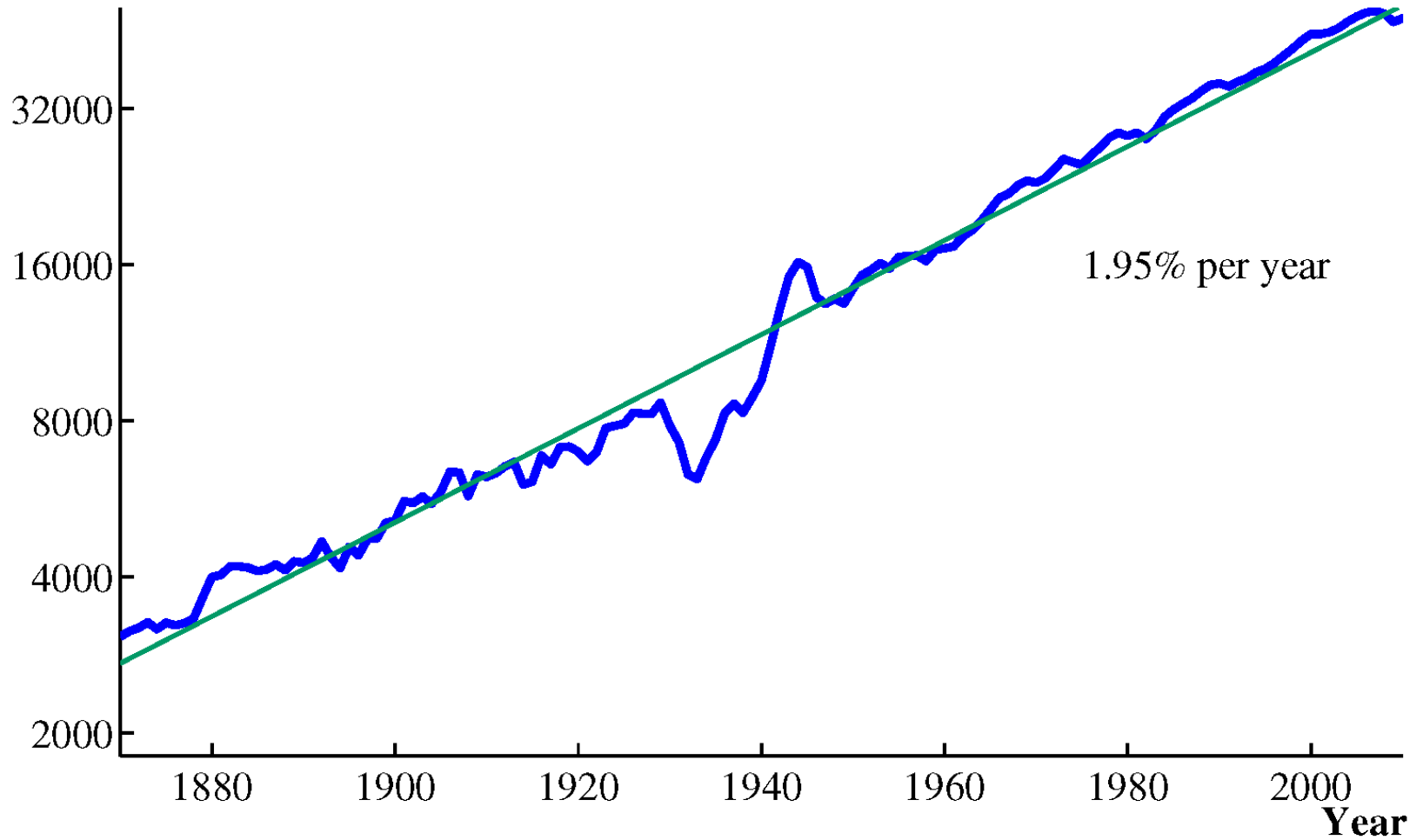
Seasonally adjusted, 2009\$



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Big picture: Steady growth for 140 years

GDP per Person (ratio scale, 2009 dollars)



(Simplified) growth accounting from Jones (2002)

- Production function for output

$$Y = A^{1-\alpha} K^\alpha (hN)^{1-\alpha}$$

- (World) production function for ideas

$$\dot{A} = Rf(A) = \delta R A^\phi$$

- If $\dot{A}/A = g_A$ is constant, $\gamma = 1/(1-\phi)$,

L = pop. of idea-producing countries

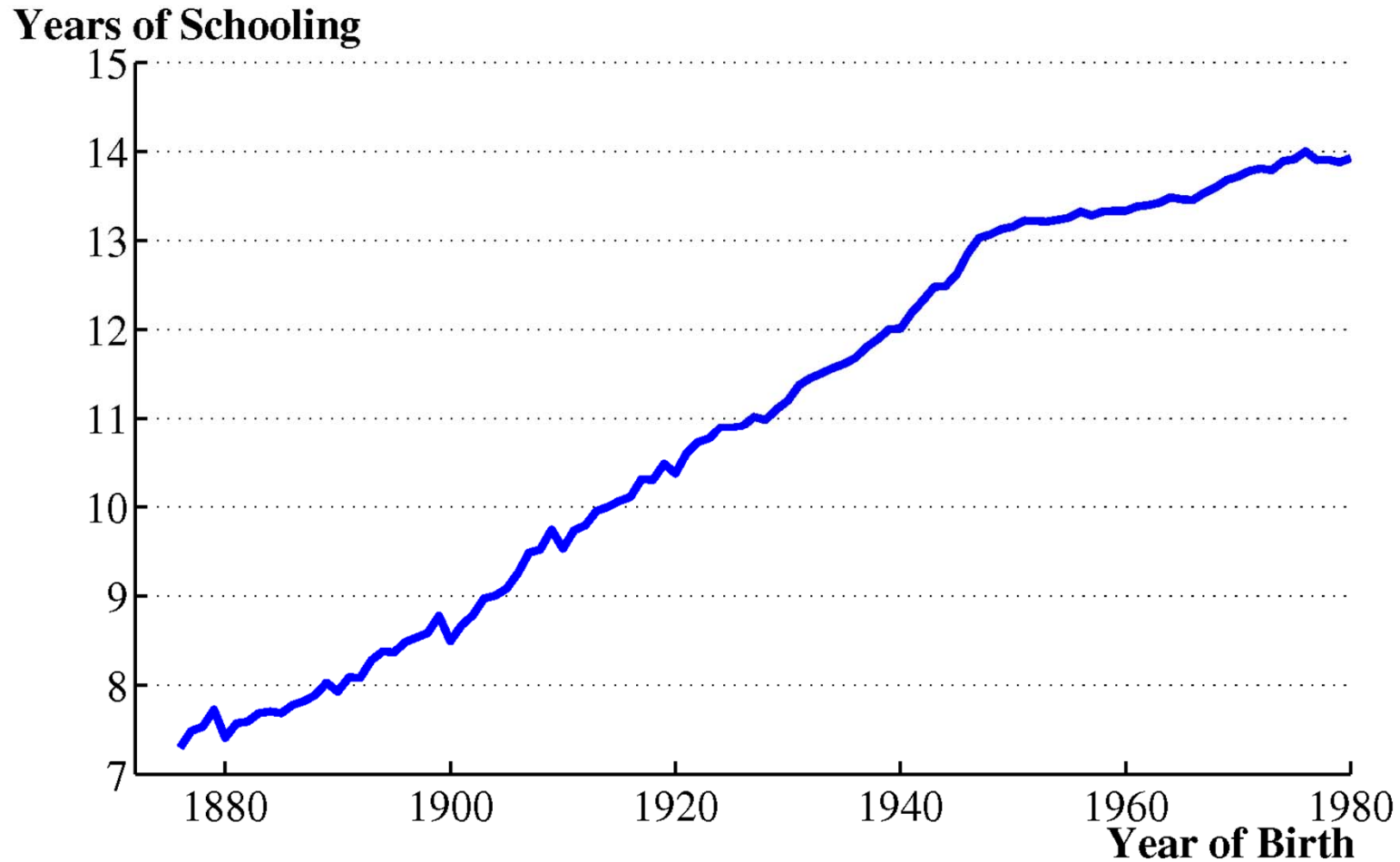
$$\rightarrow A = \text{const} \cdot R^\gamma = (R \& D \text{ Intensity})^\gamma L^\gamma$$

Most growth 1950-2007 is transition dynamics

$$y^* \approx \left(\frac{K}{Y} \right)^\beta \cdot h \cdot (\text{R\&D intensity})^\gamma \cdot L^\gamma$$

	Solow	Lucas	Romer/AH/GH	J/K/S
	2.0	0.3	1.2	0.5
	(100%)	(16%)	(61%)	(23%)

Educational attainment already plateauing

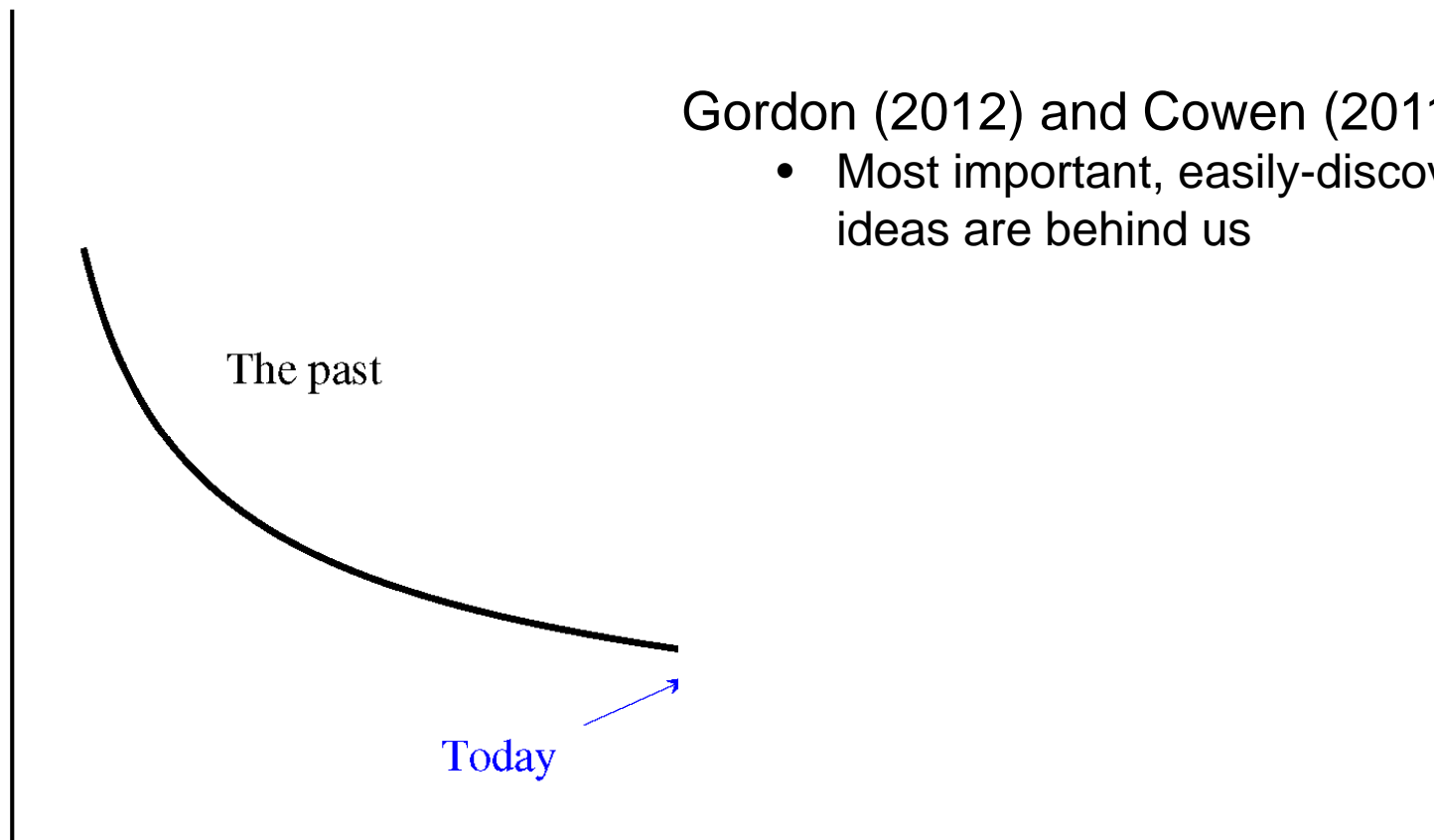


Source: Goldin and Katz (2008).

Future: shape of idea production function key

$$\dot{A} = Rf(A) = \delta RA^\phi$$

The shape of the idea production function, $f(A)$



Gordon (2012) and Cowen (2011)

- Most important, easily-discovered ideas are behind us

The stock of ideas, A

19th c Inventions were, indeed, valuable



The Economist

JANUARY 12TH-18TH 2013 economist.com

Obama's controversial new men
Pressure for change builds in China
Men close the longevity gap
The ghastly gurus of personal finance
Microchipping your children

**Will we ever
invent anything this
useful again?**

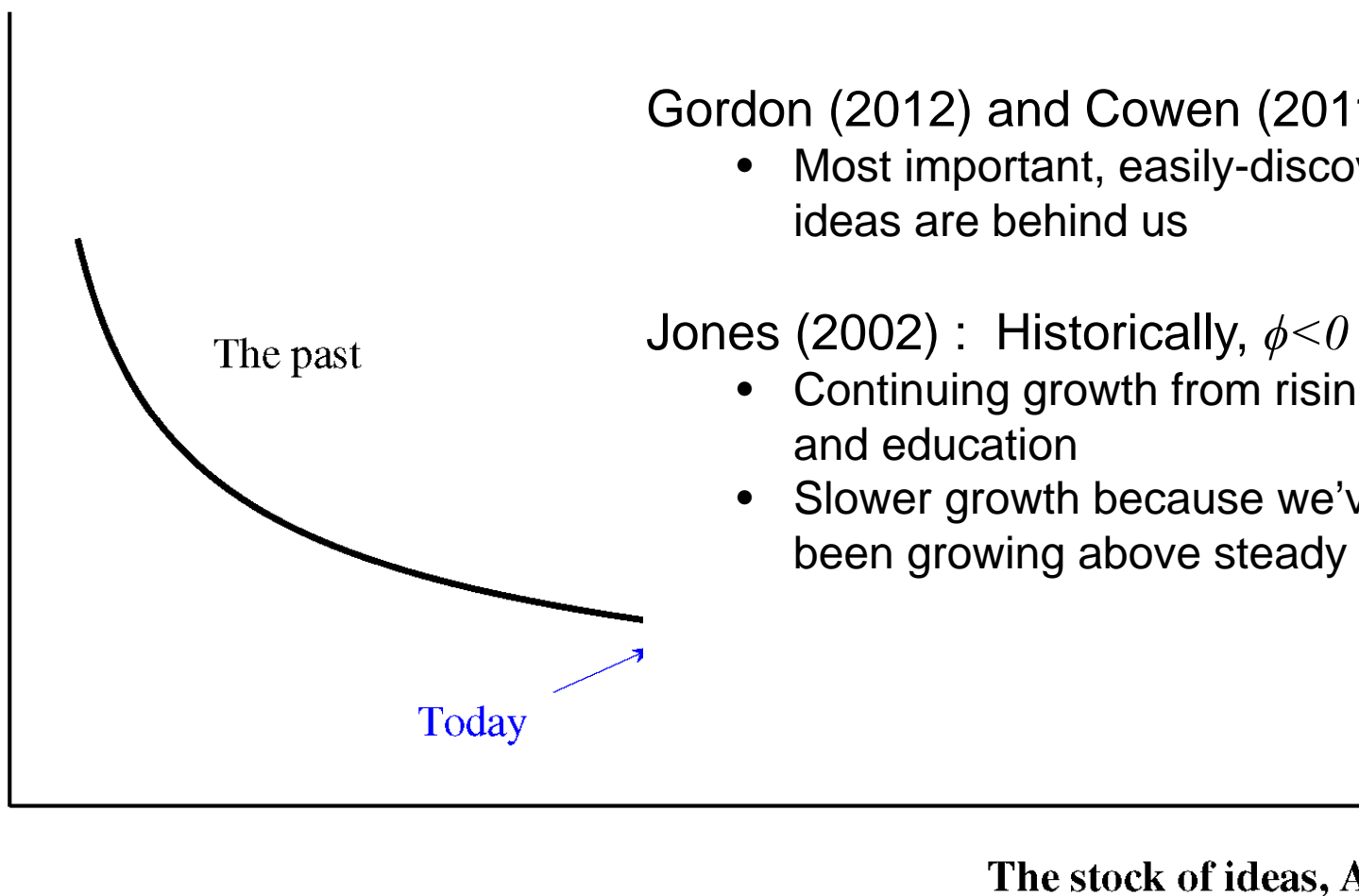
The growing debate about
dwindling innovation

The image shows a bronze statue of a man in a thinking pose sitting on a white toilet. A thought bubble above him contains the text 'Will we ever invent anything this useful again?'. The background is white with a red header for 'The Economist' and a light blue sidebar with article teasers. At the bottom left, there is a blue caption: 'The growing debate about dwindling innovation'.

Future: shape of idea production function key

$$\dot{A} = Rf(A) = \delta RA^\phi$$

The shape of the idea production function, $f(A)$



Gordon (2012) and Cowen (2011)

- Most important, easily-discovered ideas are behind us

Jones (2002) : Historically, $\phi < 0$

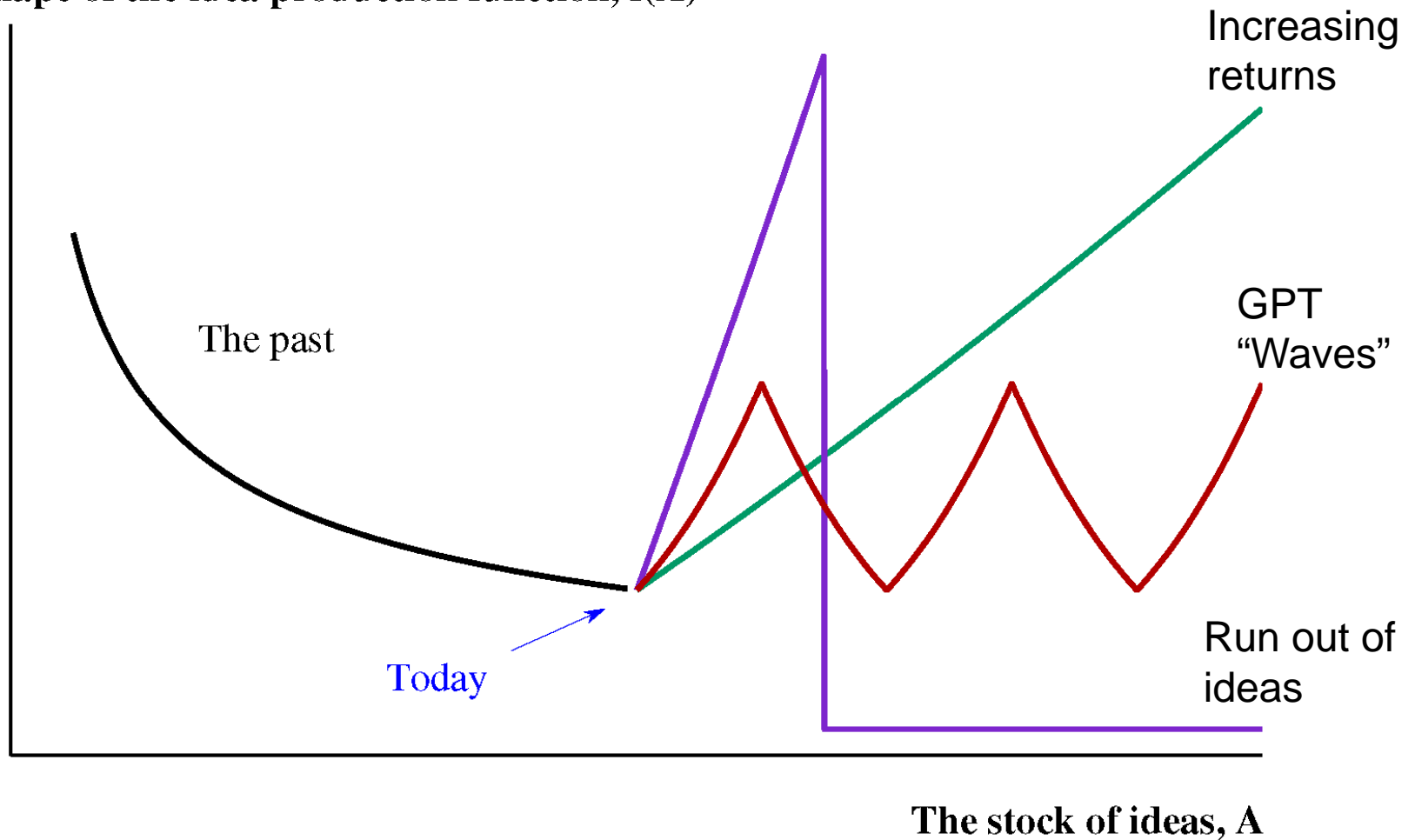
- Continuing growth from rising R and education
- Slower growth because we've been growing above steady state

The stock of ideas, A

But the future need not look like the past

$$\dot{A} = Rf(A)$$

The shape of the idea production function, $f(A)$



Robots and Machine Learning?

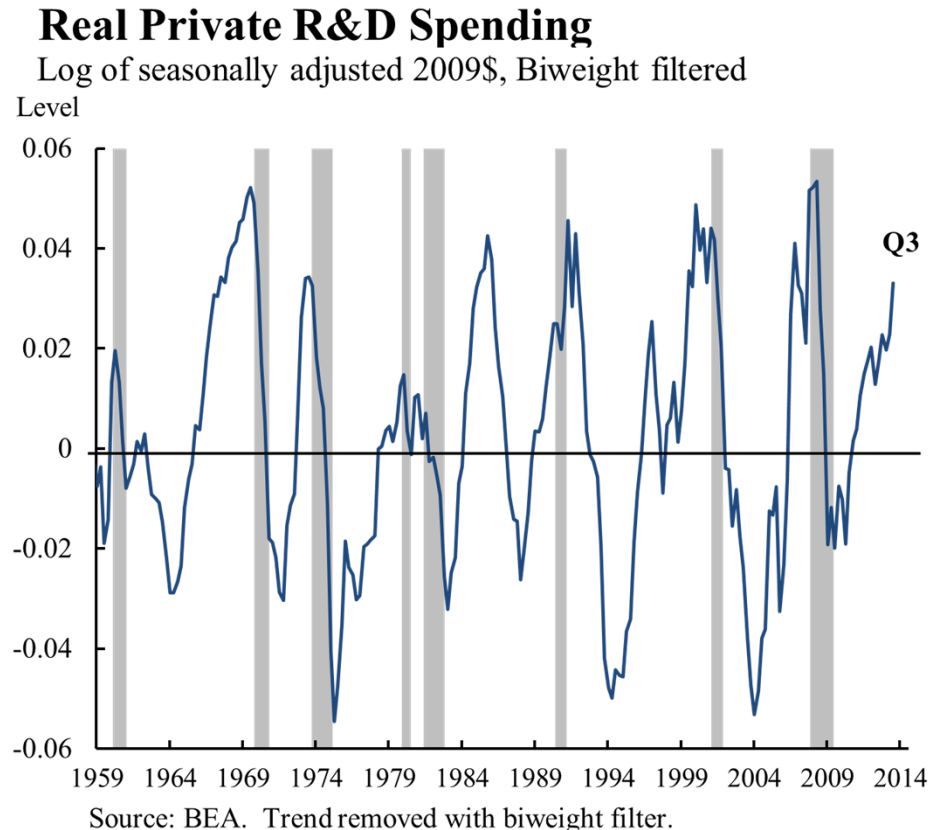
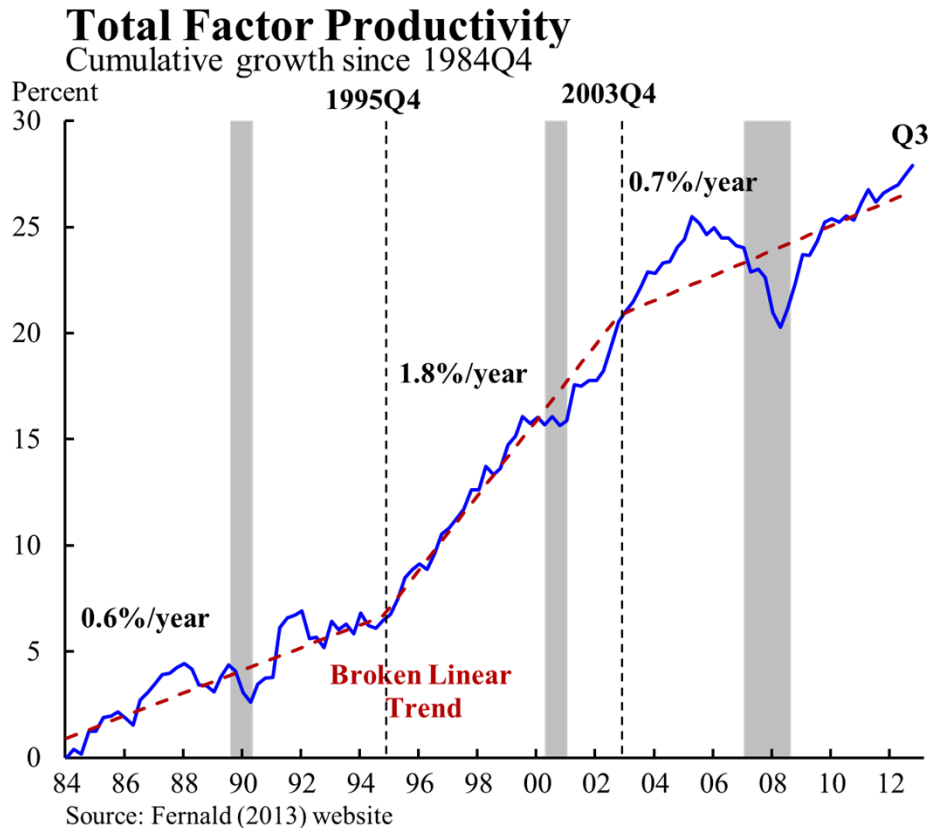
- Could affect shape of idea production function
 - Machines learn how to learn
- Could affect effective research effort
 - Labor not a constraint on researchers
- Could replace labor in production function for goods
 - Growth rates could explode. E.g., Zeira (1998).

$$Y = AK^\alpha (L_1^{\beta_1} L_2^{\beta_2} \dots L_n^{\beta_n})^{1-\alpha}$$

What about Great Recession?

Productivity slowed prior to G.R

Decline in real R&D modest



What is a reasonable 10-20 year forecast?

- Müller and Watson (2013) suggest an 80 percent prediction set for growth in GDP/capita (using post-WWII data)
 - 10 years 0.9-3.4
 - 25 years 1.2-2.8
- Projections for GDP per hour typically lower than historical average (sample periods may vary)

Fernald (2013)	1.6 %/yr
Byrne, Oliner, Sichel (2013)	1.6
Gordon (2014)	1.3
Jorgenson, Ho, Samuels (2013)	1.3

Conclusion: What's the “new normal”?

- Slower growth? Educational attainment, developed-country R&D intensity, population all slowing
- Faster growth? Rise of China, India, other emerging economies implies rapid growth in world research
- Uncertain? Shape of idea production function
- There may well be a new normal, but the Great Recession doesn't have much to do with it.
 - Rather, the 2-percent per capita benchmark might never have been steady state

Productivity growth slowed in early 2000s

Business Sector Labor Productivity

Cumulative growth since 1984Q4

