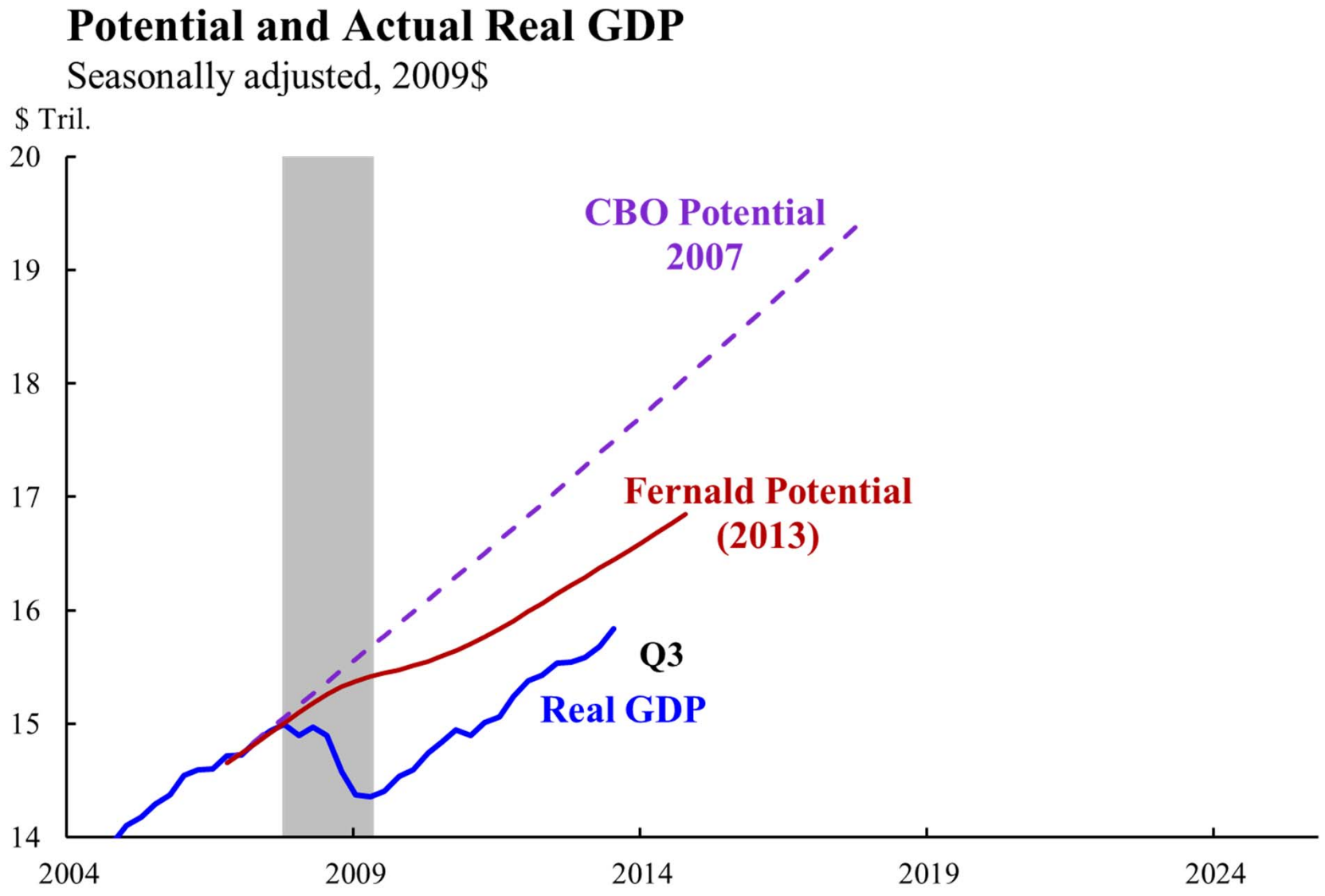
The Future of U.S. Economic Growth

John Fernald
Federal Reserve Bank of San Francisco

Chad Jones
Stanford University

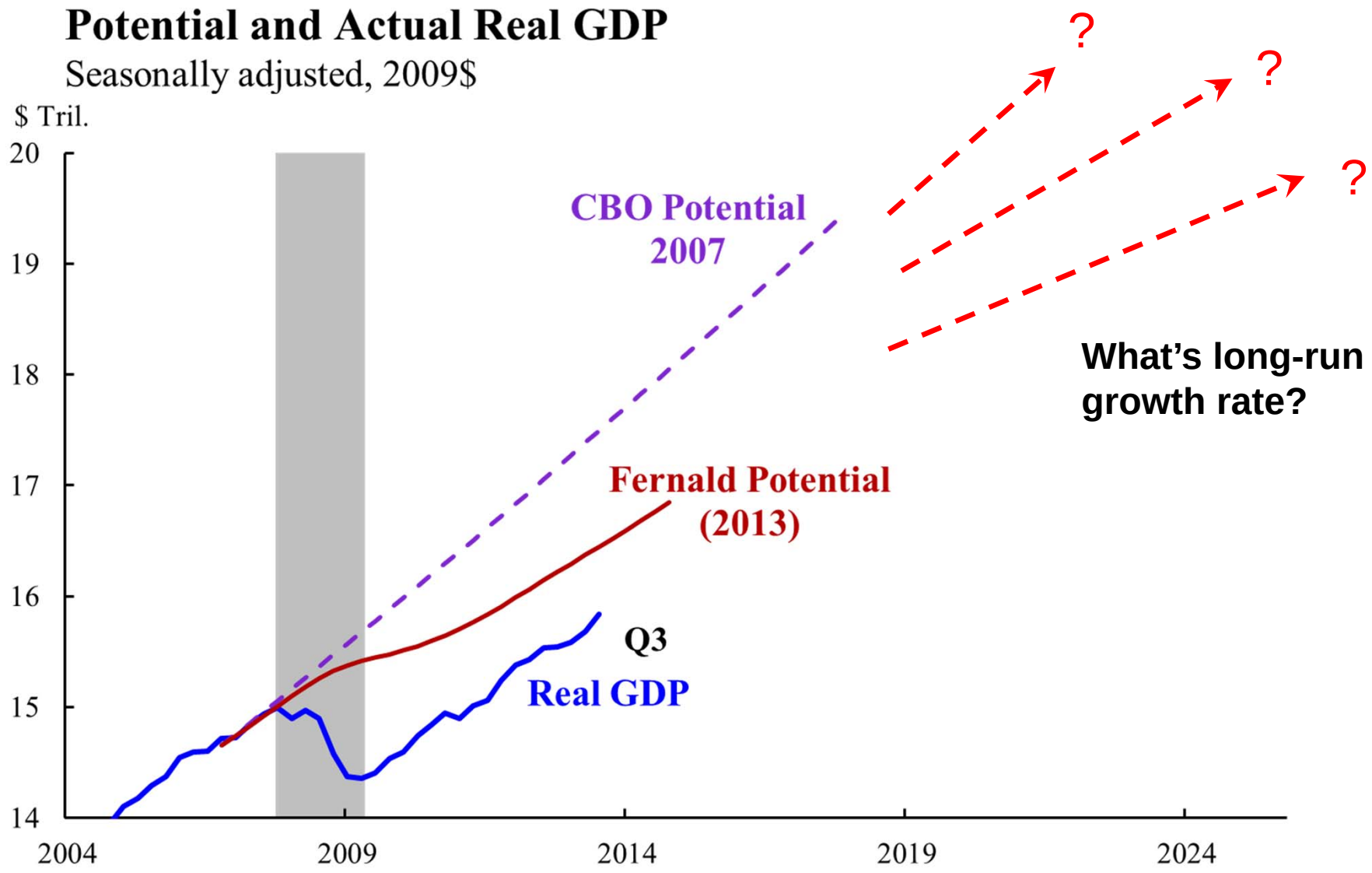
The views expressed here are our own and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or others associated with the Federal Reserve System.

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



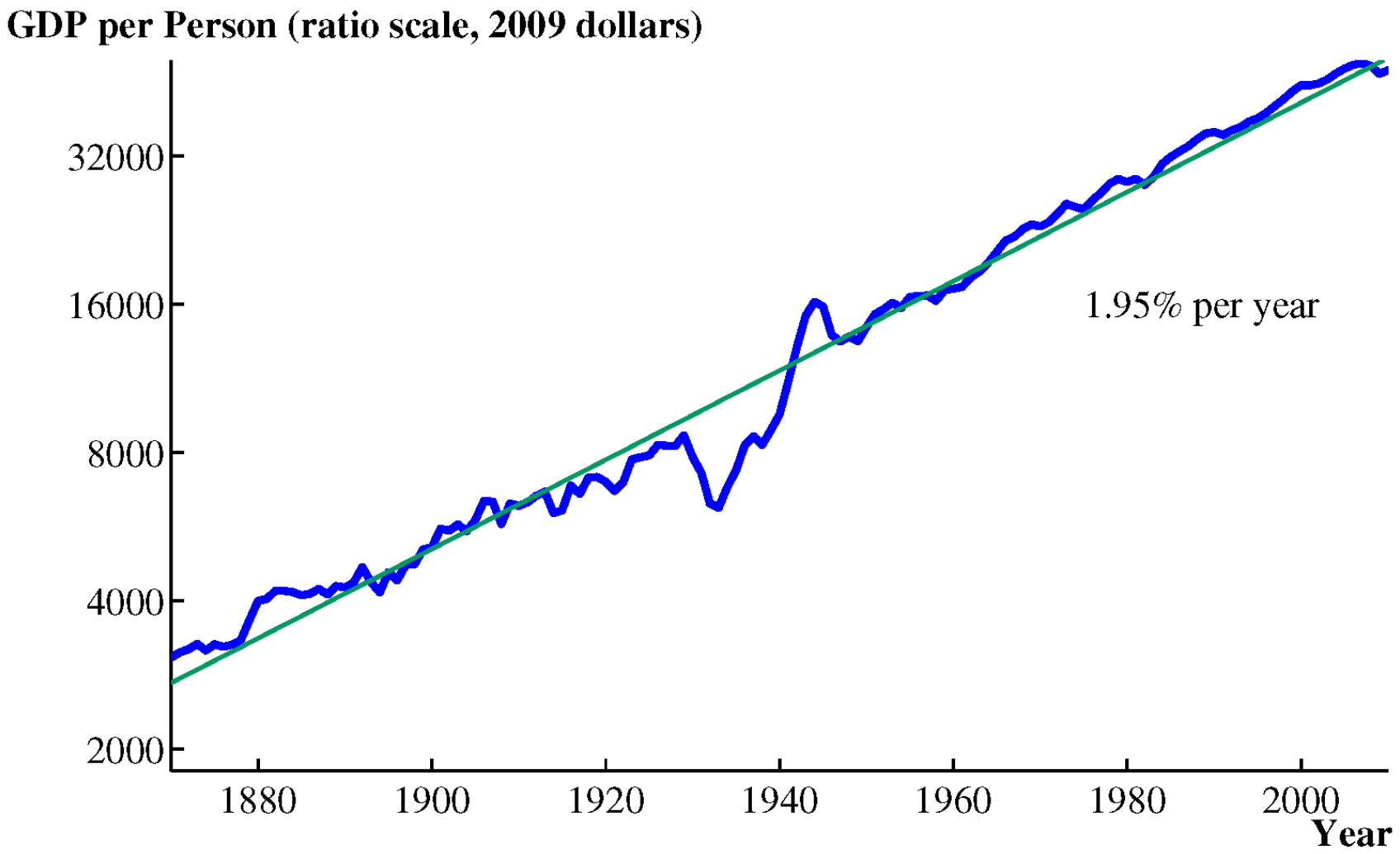
Source: Haver and Fernald (2013). CBO 2007 has been adjusted from 2000$ to 2009$

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



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

Big picture: Steady growth for 140 years



(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

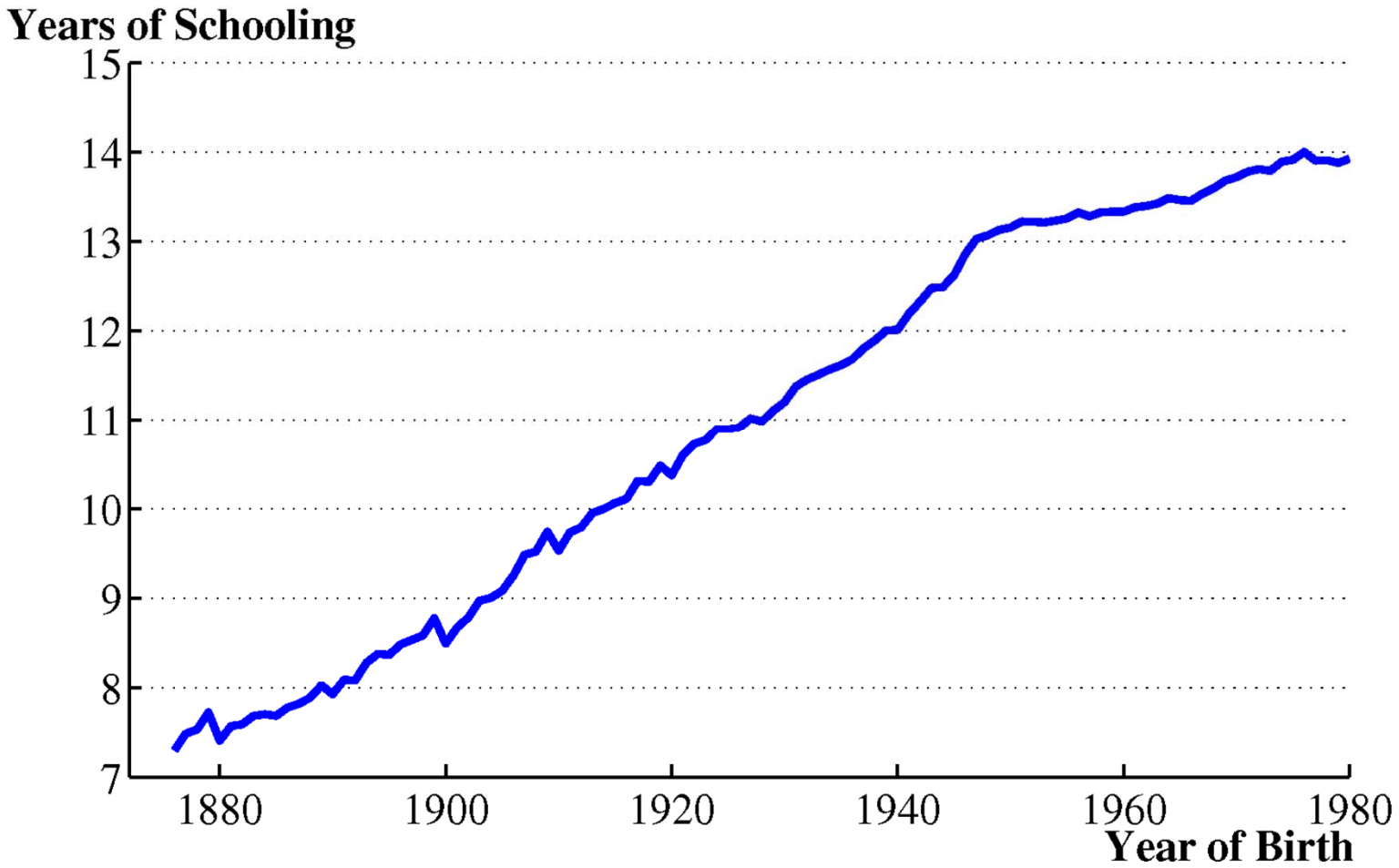
$$\rightarrow A = \text{const} \cdot R^{\gamma} = (R \,\&\, D \text{ Intensity})^{\gamma} L^{\gamma}$$

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	0.0	0.3	1.2	0.5
(100%)	(0%)	(16%)	(61%)	(23%)

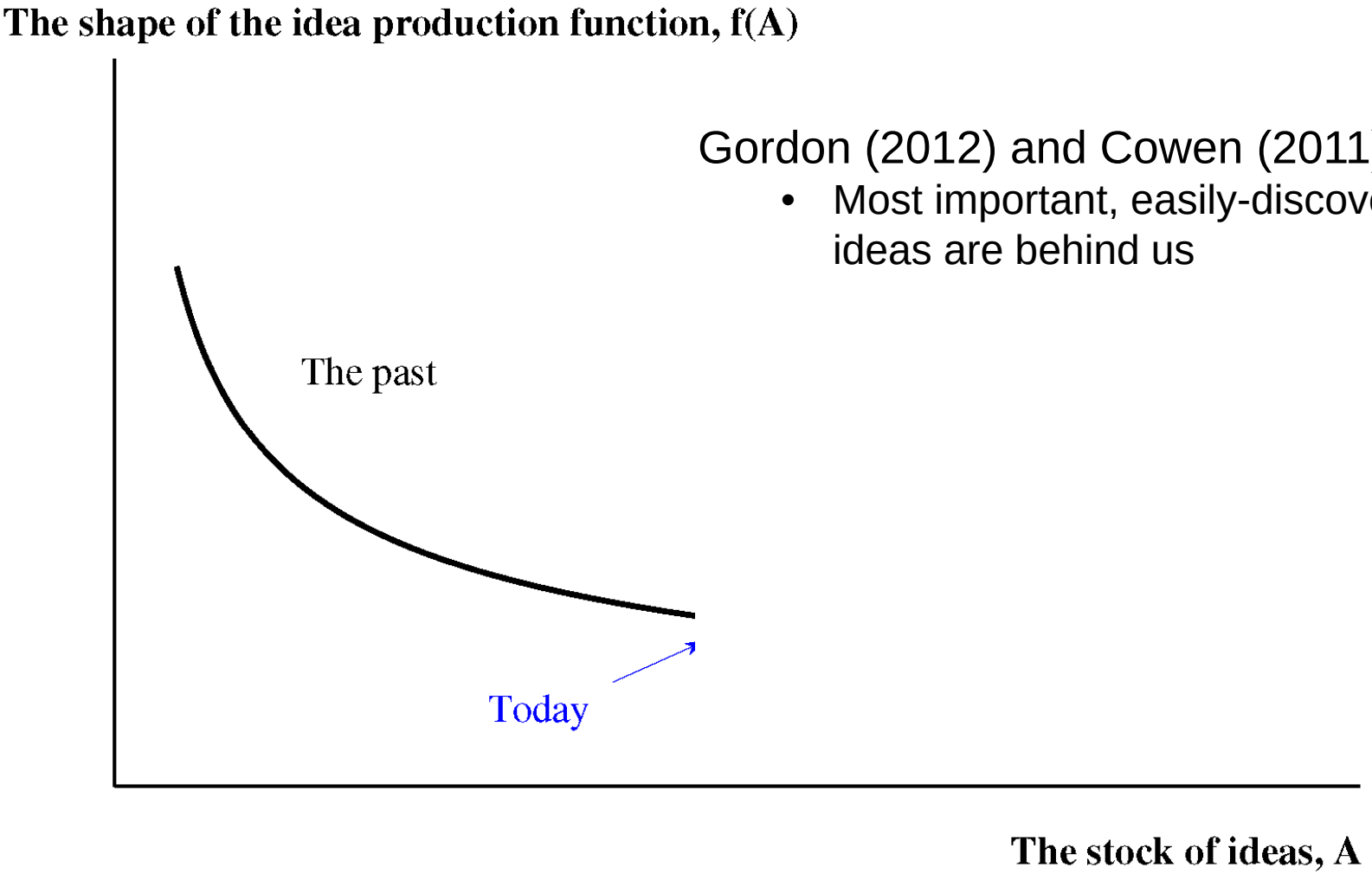
Educational attainment already plateauing



Source: Goldin and Katz (2008).

Future: shape of idea production function key

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



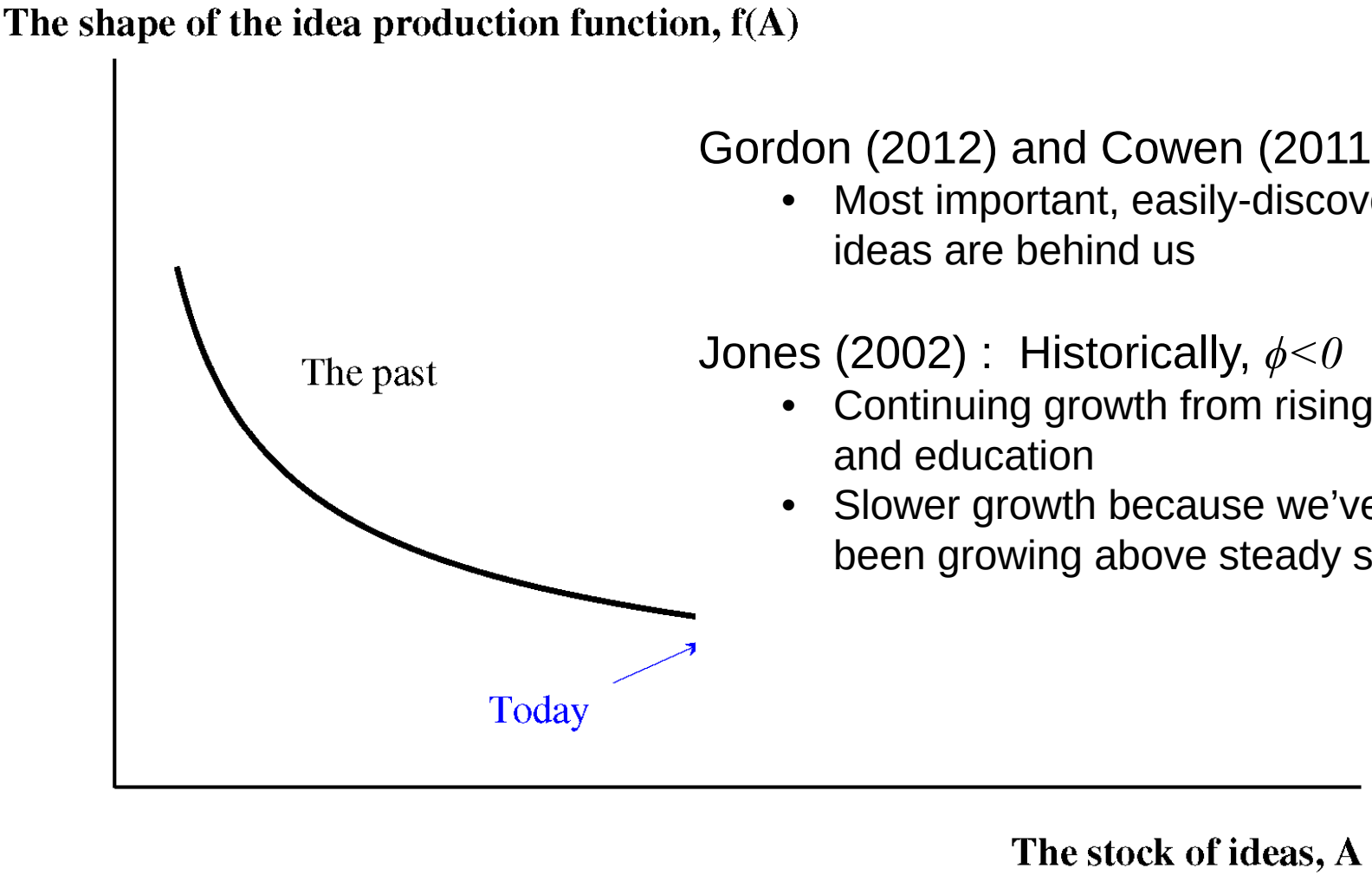
Gordon (2012) and Cowen (2011)

- Most important, easily-discovered ideas are behind us

19th c Inventions were, indeed, valuable

Future: shape of idea production function key

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



Gordon (2012) and Cowen (2011)

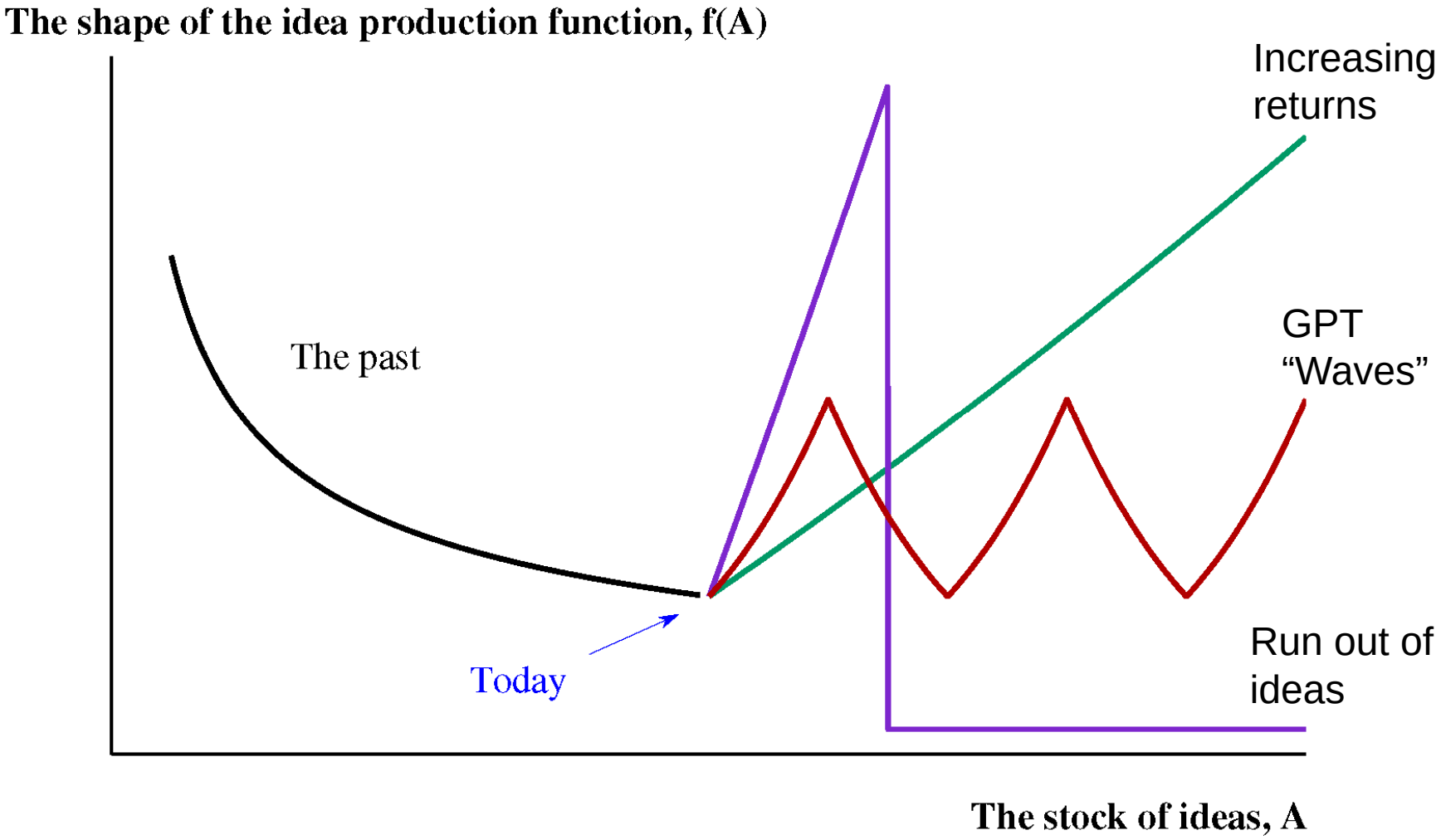
- Most important, easily-discovered ideas are behind us

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

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

But the future need not look like the past

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



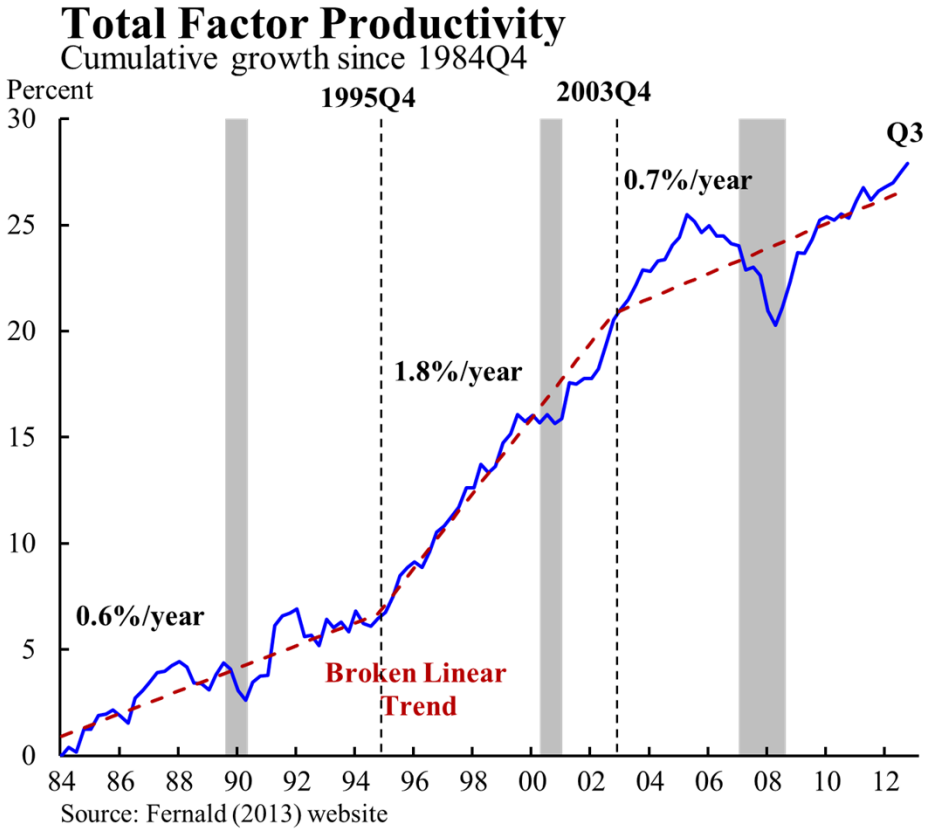
Robots and Machine Learning?

- 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).

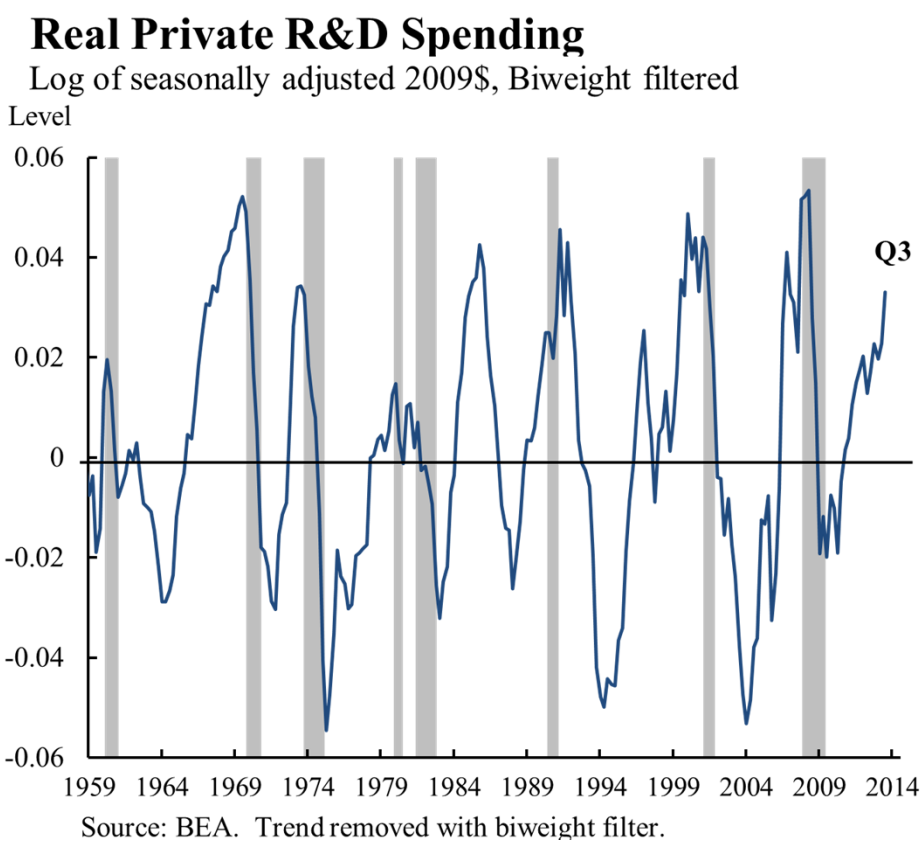
$$Y = AK^{\alpha}(L_1^{\beta_1} L_2^{\beta_2} \ldots L_n^{\beta_n})^{1-\alpha}$$

What about Great Recession?

Productivity slowed prior to G.R



Decline in real R&D modest



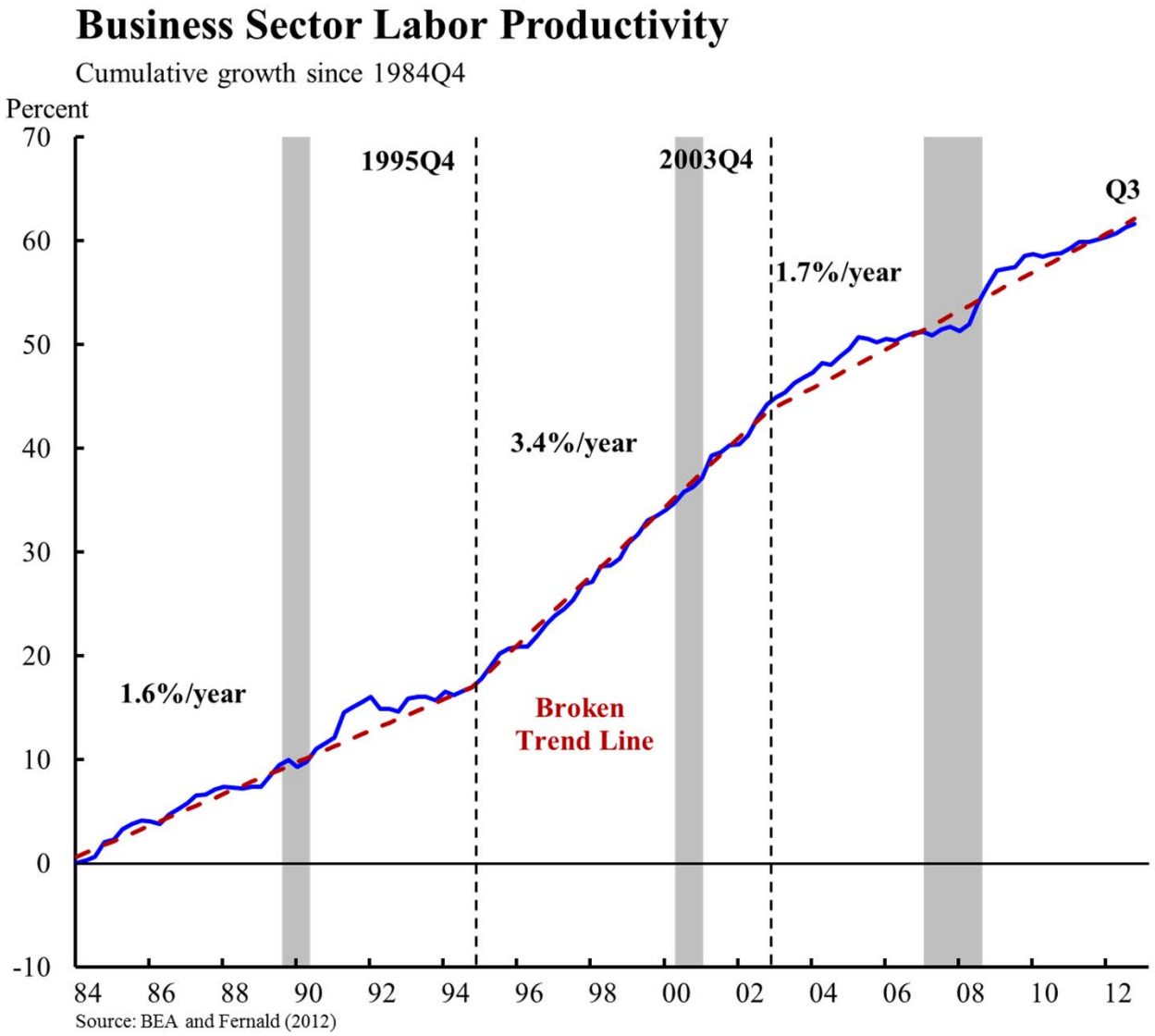
What is a reasonable 10-20 year forecast?

- 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