

# Productivity Growth, Market Power, and Monetary Policy

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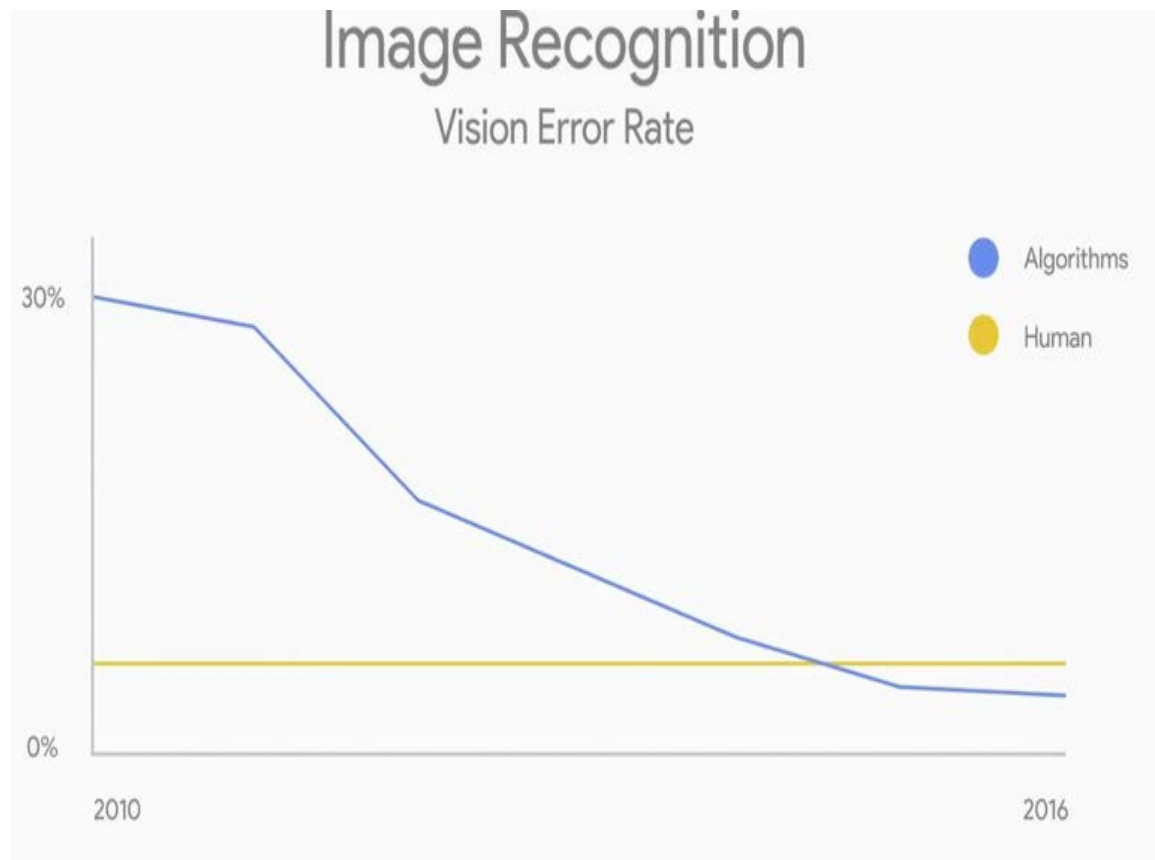
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# The Modern Productivity Paradox

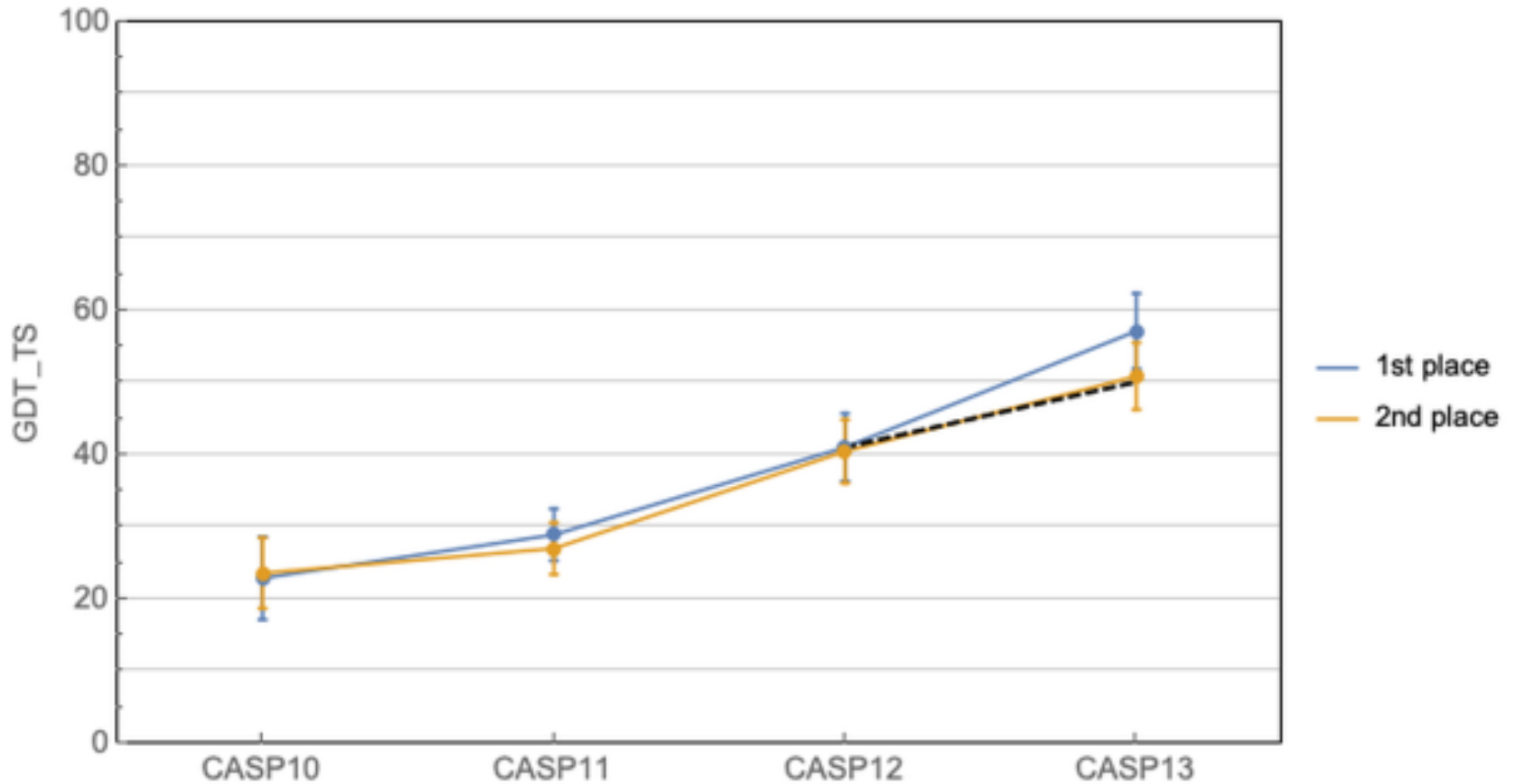
In recent work with Erik Brynjolfsson and Daniel Rock, I have explored a paradox:

- Broad optimism about potential of AI and associated technologies
- vs.
- Poor measured productivity performance in the data

# Technological Progress: ML and Image Recognition



# Technological Progress: ML and Protein Folding



# The Disappointing Recent Reality

Juxtaposed with technological progress is slow productivity growth, everywhere

- We are more than one decade into a slowdown in the U.S. and OECD countries
  - United States:
    - 1995-2004: 2.9% per year
    - 2005-2018: 1.3% per year
  - OECD: 29 of 30 countries saw similar-sized slowdowns after 2004
- Major emerging markets slowdown later, around 2010

# A Paradox: Potential Explanations

1. False hopes
  - But not hard to estimate large productivity gains from existing technologies
2. Mismeasurement
  - But lots of recent work indicating this isn't the story
3. Distribution and dissipation
  - But implies huge amounts of dissipative activity
4. Implementation and restructuring lags

# Explanations for the Paradox

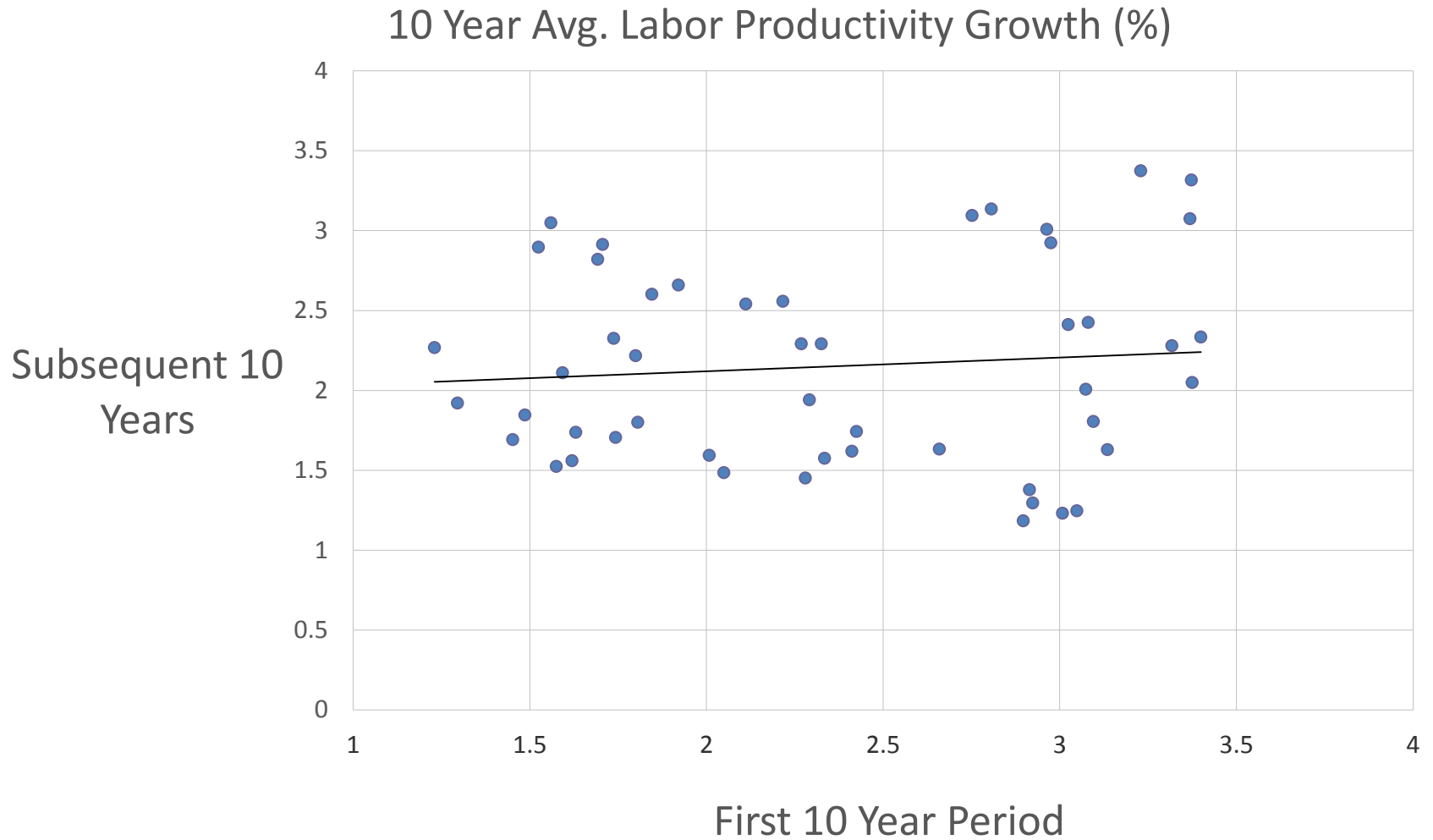
- 4. Implementation and restructuring lags
  - Technology is real, but benefits take time to emerge
- If lag story is right, AI Paradox is not a contradiction
  - Current slowdown and future potential are two sides of the same coin
  - Transformative technologies can actually cause a slowdown initially

# Case for Implementation Lag Story

- Current productivity growth does not predict future productivity growth
- Back-of-the-envelope examples of achievable productivity growth
- AI as a GPT



# Past Performance Does Not Predict Future Results



# Examples of Potential AI-Driven Productivity Growth

- Autonomous Vehicles
  - BLS: 3.5 million “motor vehicle operators” in U.S.
  - Plausible: autonomous vehicles reduces this to 1.5 million
  - Private employment is 125 million
    - => ~ 1.7% increase in productivity
    - Over 10 years, an additional 0.17%/yr growth
- Call Centers
  - 2.2 million employed in large call centers in U.S.
  - Plausible: reduced by 60%:
    - => ~ 1% increase in productivity
    - Over 10 years, perhaps an additional 0.1%/yr

# What Is a GPT?

Bresnahan and Trajtenberg's Criteria:

1. Pervasive
2. Able to be improved upon over time
3. Able to spawn complementary innovations

# If AI Is So Great, Why a Slowdown?

1. Enough new capital stock must be accumulated to affect aggregates
2. GPTs require complementary assets to be invented, built, and installed

*These processes can take years or decades*

3. Investment in intangible complements can create “J-curve” measurement dynamics

# Slowdowns and GPTs in History

“Engels’ pause” during early industrial revolution

- Wage growth stagnant even as output rose quickly

Only half of U.S. mfg establishments electrified in 1919

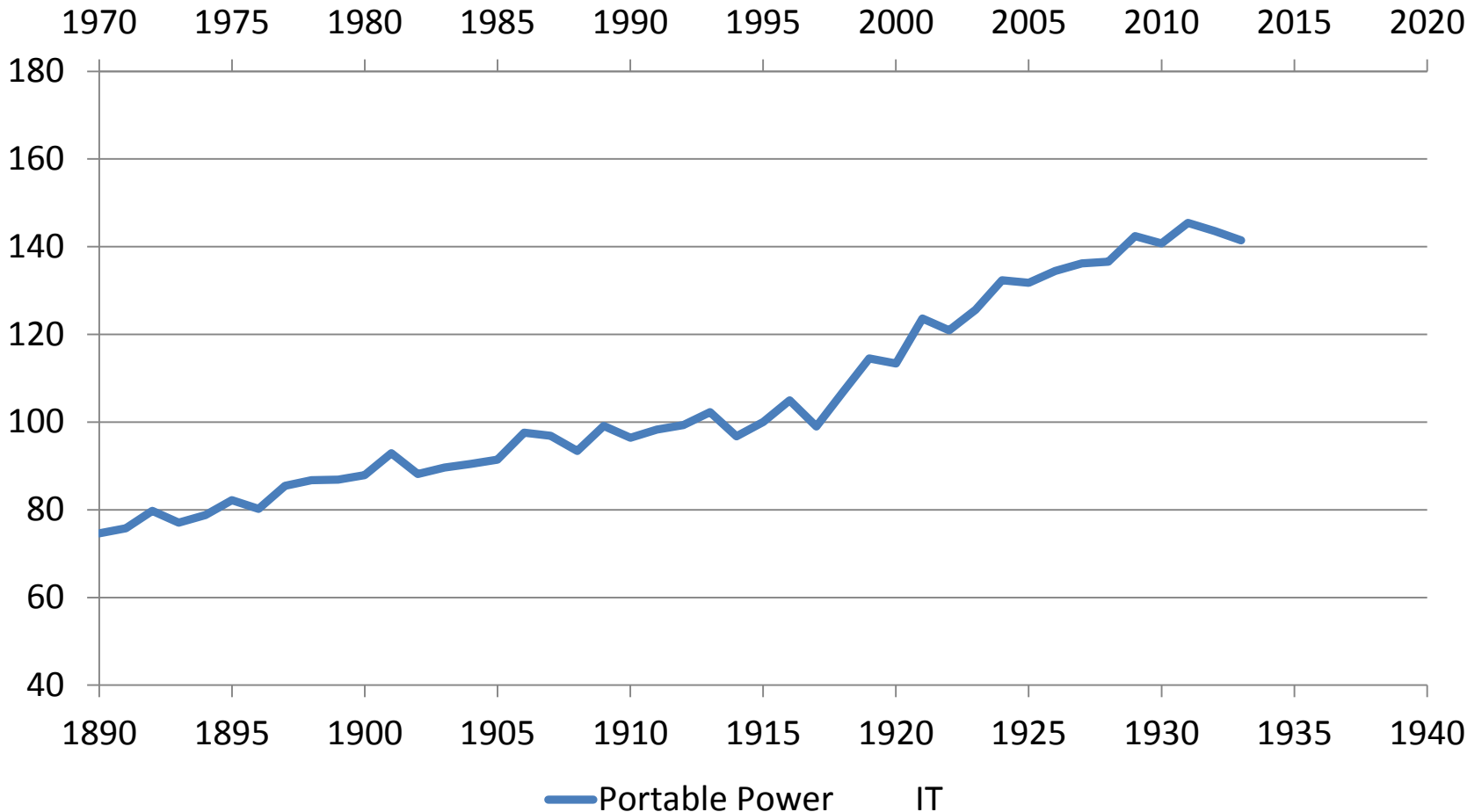
- 30 years after AC systems standardized

Computer capital in U.S. didn’t reach long-run level until late 1980s

- 25+ years after invention of integrated circuit
- Only half that level 10 years earlier

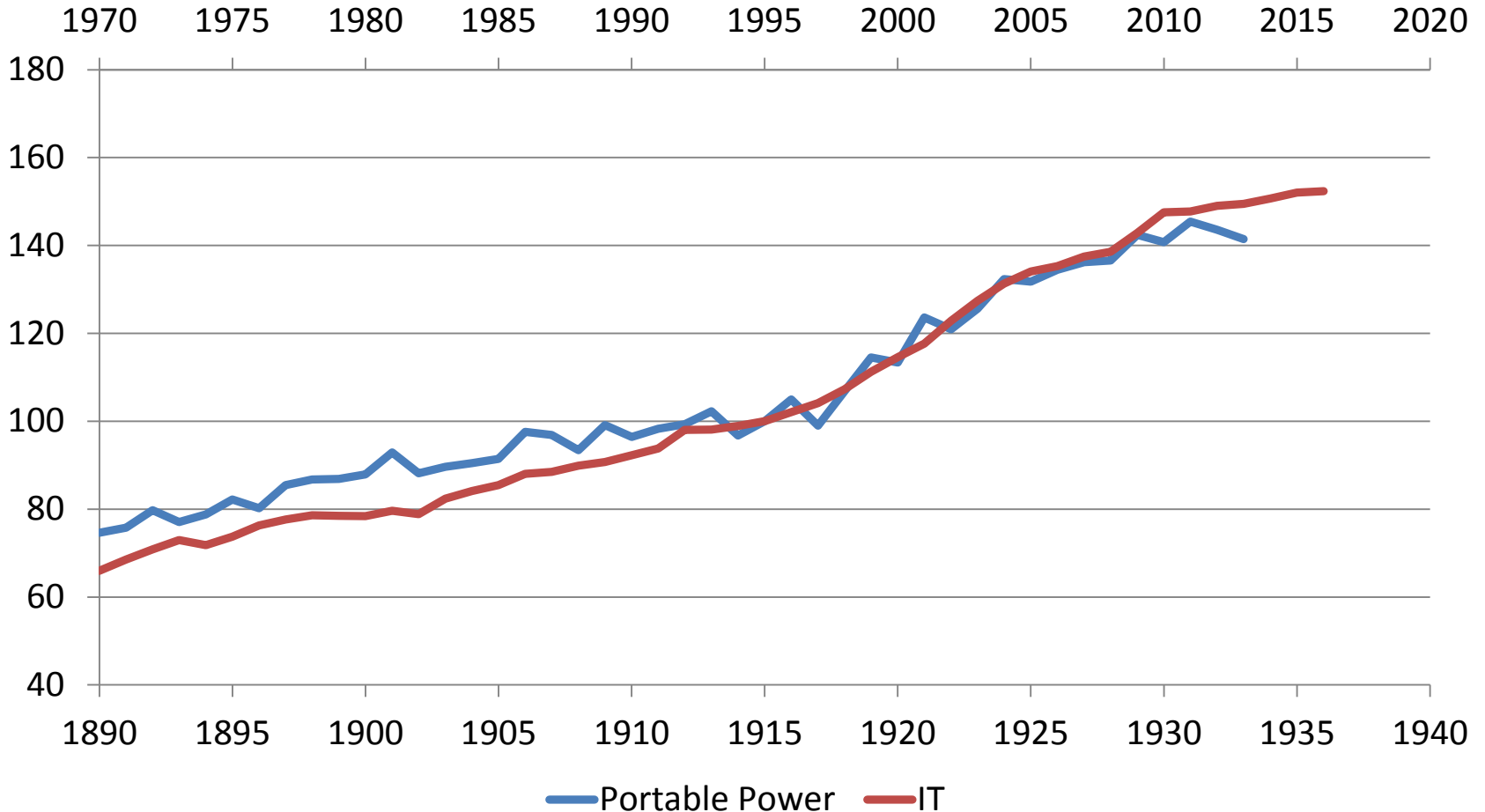
# History's Lens on Today's Paradox

## Labor Productivity in the Portable Power and IT Eras



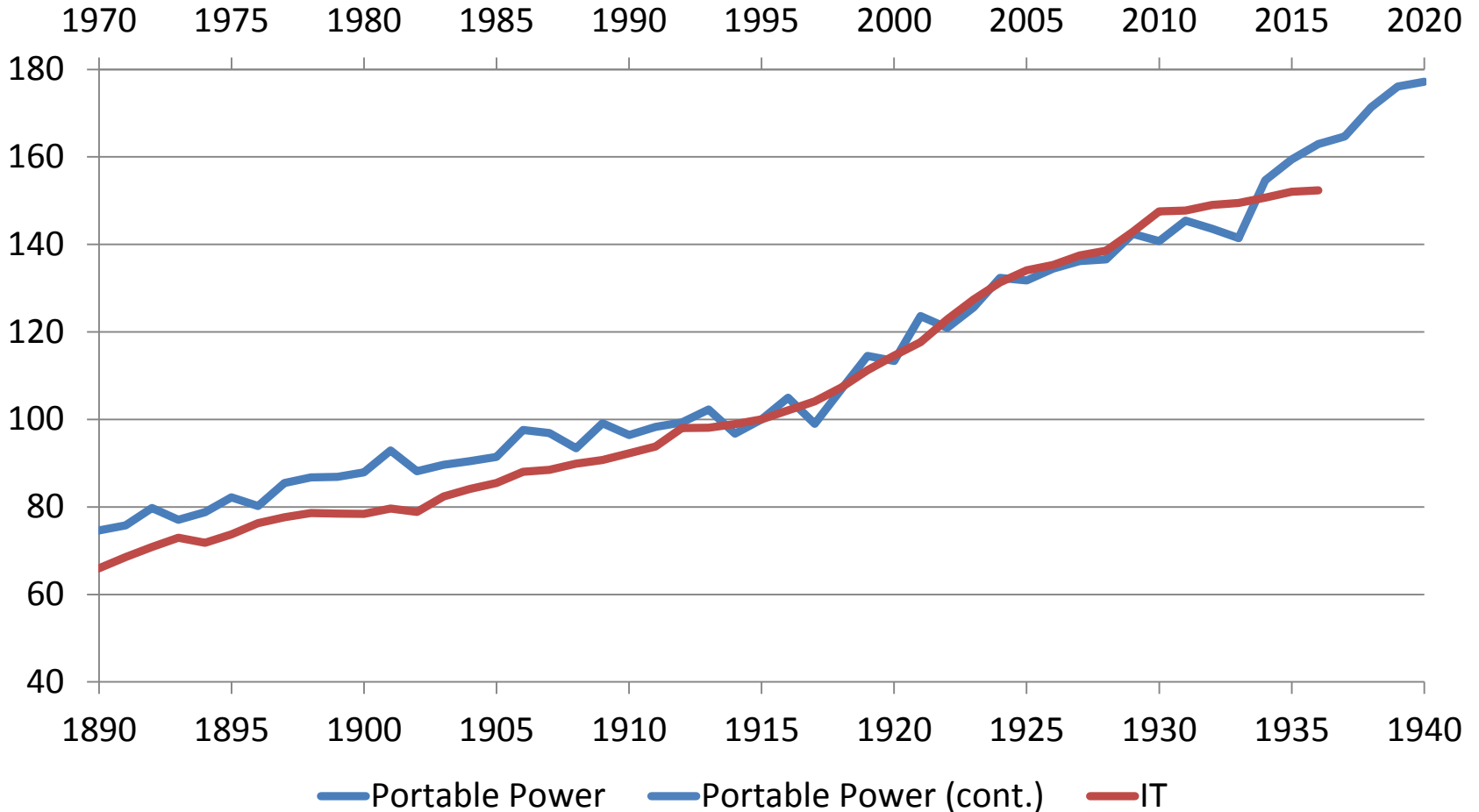
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# Intangibles and Productivity Measurement: The J-Curve

How do intangibles affect productivity measurement?

$$Productivity = \frac{Output}{Input}$$

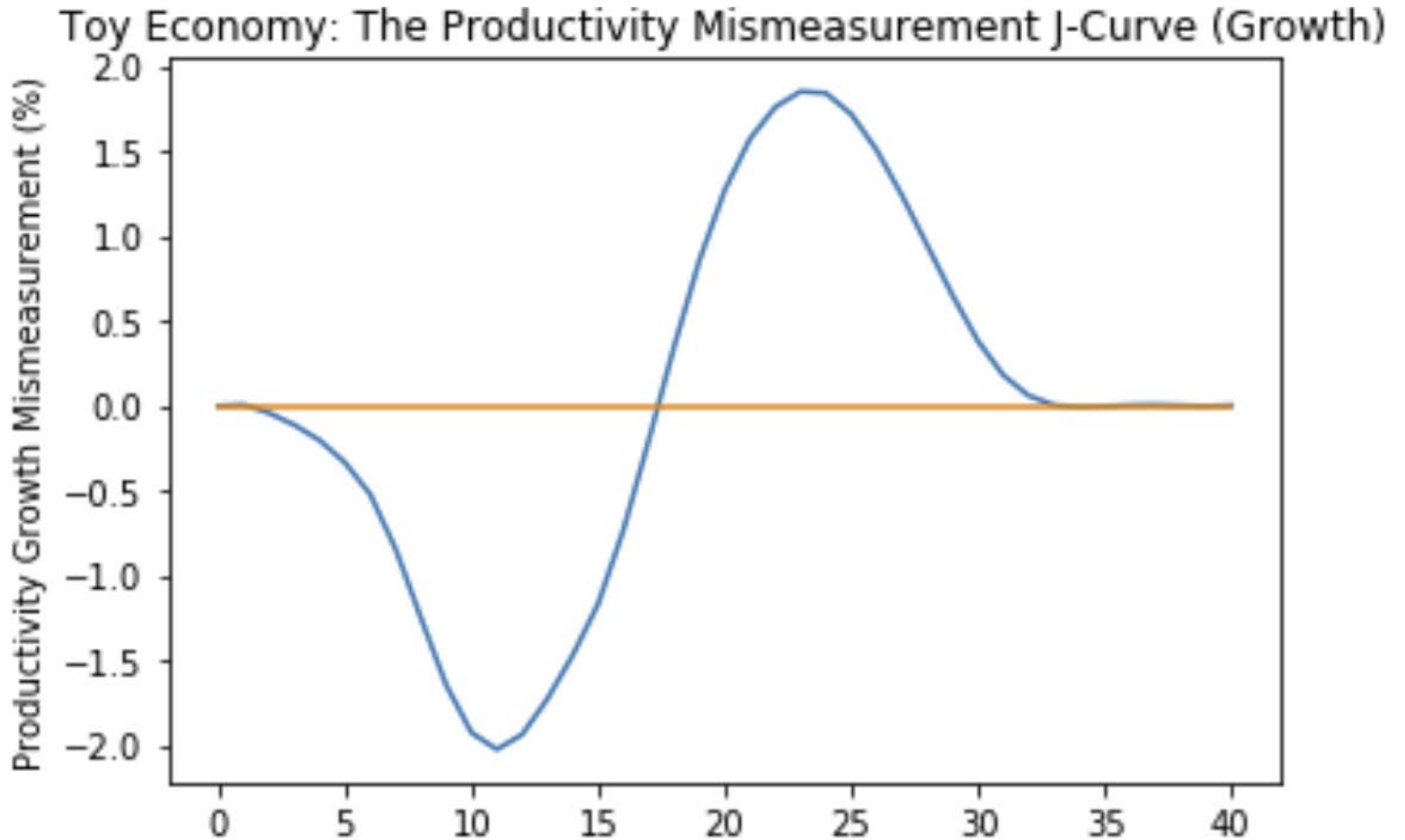
- Intangible capital would be an unmeasured input
  - This will cause productivity to be overstated
- But intangible capital investment also an output
  - This will cause productivity to be understated
- Net effect on productivity measurement depends on relative timing of input vs. output mismeasurement

# Intangibles and Productivity Measurement: The J-Curve

How might we expect mismeasurement to evolve?

- Early in a GPT diffusion process, undercounted intangibles outputs are likely larger than undercounted inputs
  - So true productivity growth higher than measured early
- Later, intangible outputs growth falls relative to intangible inputs
  - So true productivity growth lower than measured
- Eventually, in steady state, intangible outputs and inputs are growing at the same rate
  - Two types of mismeasurement cancel, even as intangible investment continues

# The J-Curve



# Empirical Strategy

How to measure intangibles?

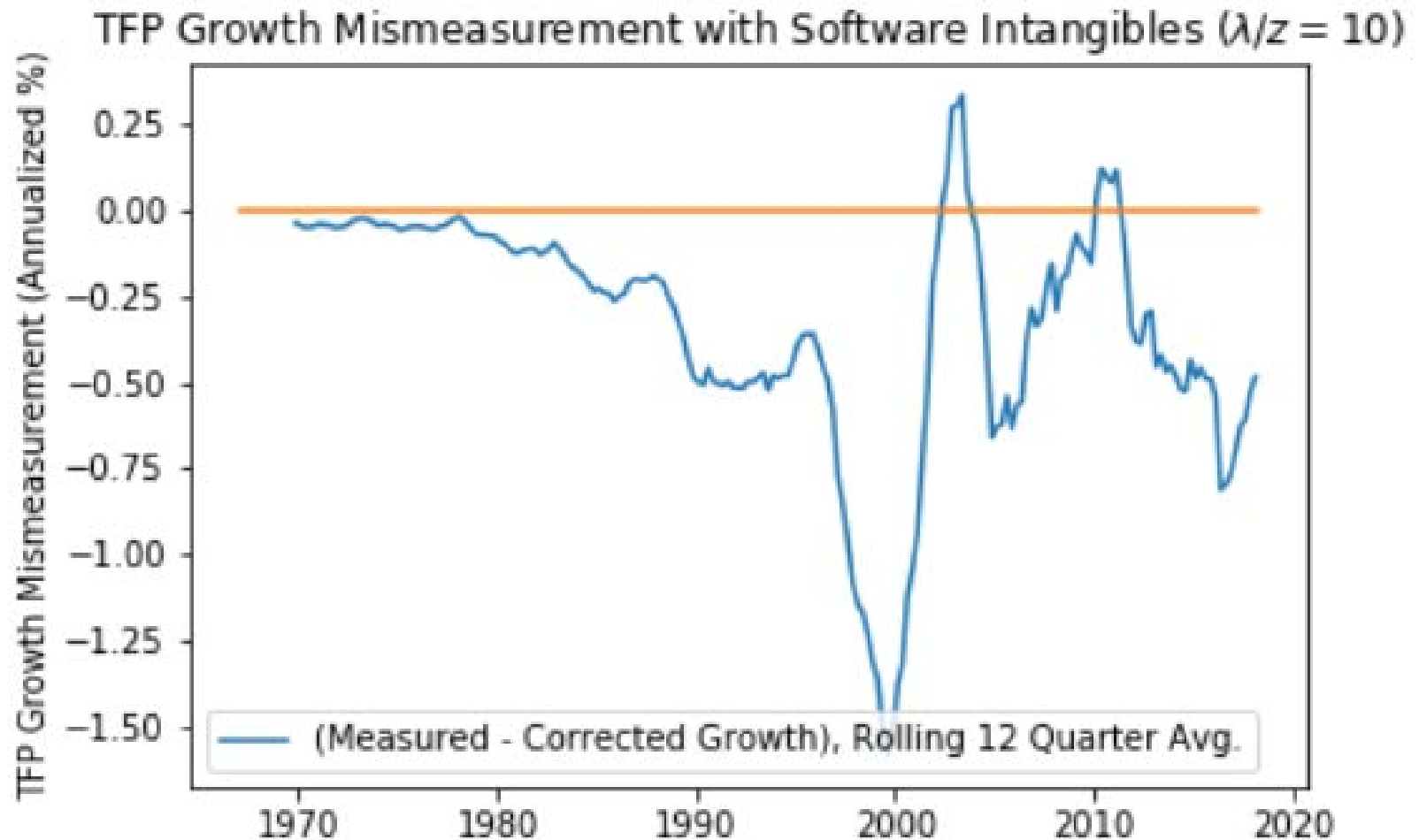
- Suppose two types of K, tangible ( $j = 1$ ) and intangible ( $j = 2$ )
- Firm makes intangible investments that accompany tangible investments, so that  $K_2(t) = \mu K_1(t)$

- Firm's market value is then

$$V = \lambda_1 K_1 + \lambda_2 K_2 = \lambda_1 K_1 + \lambda_2 \mu K_1 = (\lambda_1 + \lambda_2 \mu) K_1$$

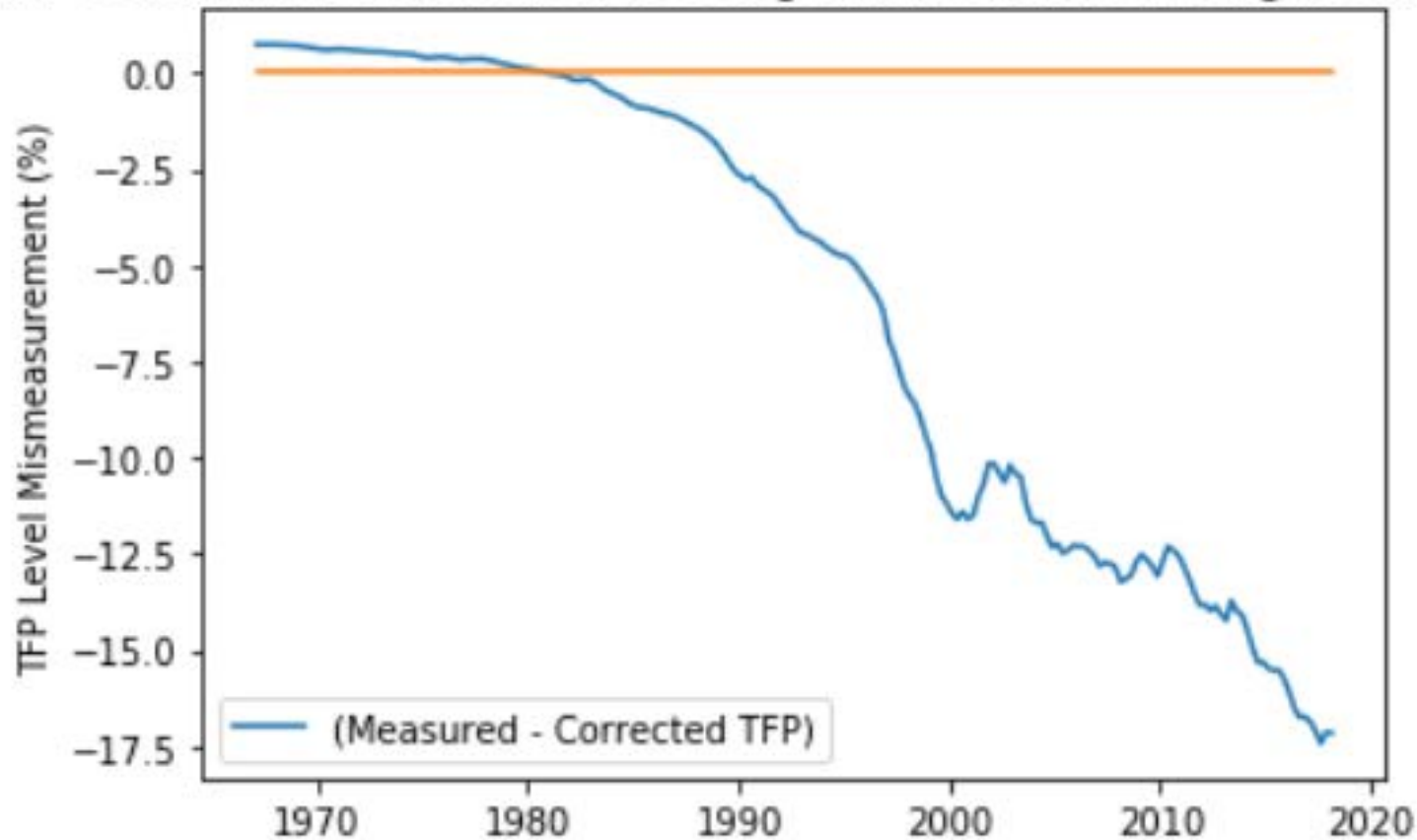
- Thus regression of firm market value on tangible capital gives insight into stock and shadow value of intangible capital

# TFP Growth Mismeasurement by Year: IT Software



# TFP Accumulated Level Mismeasurement: IT Software

TFP Level Mismeasurement Percentage with Software Intangibles ( $\lambda/z = 10$ )



# Adjusted TFP: IT Software

Implied mismeasurement due to software-related intangibles is much larger than for intangibles related to R&D or hardware

Adjusted TFP level is 17% higher in 2016 than measured

First half of growth J-curve might be played out

- But less clear than for hardware
- R&D J-curve played out; R&D at steady state

# Does This Explain the Post-2004 Productivity Slowdown?

No; implied slowdown actually larger

A mismeasurement explanation for the slowdown doesn't require just mismeasurement; it requires a *change* in mismeasurement (in a particular direction and around 2004)

Period	Measured Annual TFP Growth (%)	Implied Annual TFP Growth (%)	Implied – Measured
1995-2004	1.63	2.53	0.90
2005-2017	0.40	0.85	0.45
Slowdown	1.23	1.68	0.45



# Are AI-Related Intangibles Causing Mismeasurement?

Still very early in AI adoption, but fast investment growth

Generous estimate of U.S. AI investments in 2018 is \$65-100B

If, as some estimates suggest, \$10 of intangibles for every observed \$1 of AI investment, that's \$650B to \$1T in missing output (about 3-5% of GDP)

Likely an upper bound, plus doesn't account for (still likely small) countervailing input effect of AI-related intangibles

- Note pre-2016 AI investments probably too small to matter

# Market Power and Monetary Policy

There has been a wave of recent work looking at the potential macroeconomic implications of increasing market power

My contribution to this work includes comments at the 2018 Jackson Hole Symposium on the relationships between market power and the efficacy of monetary policy

# Market Power and Monetary Policy

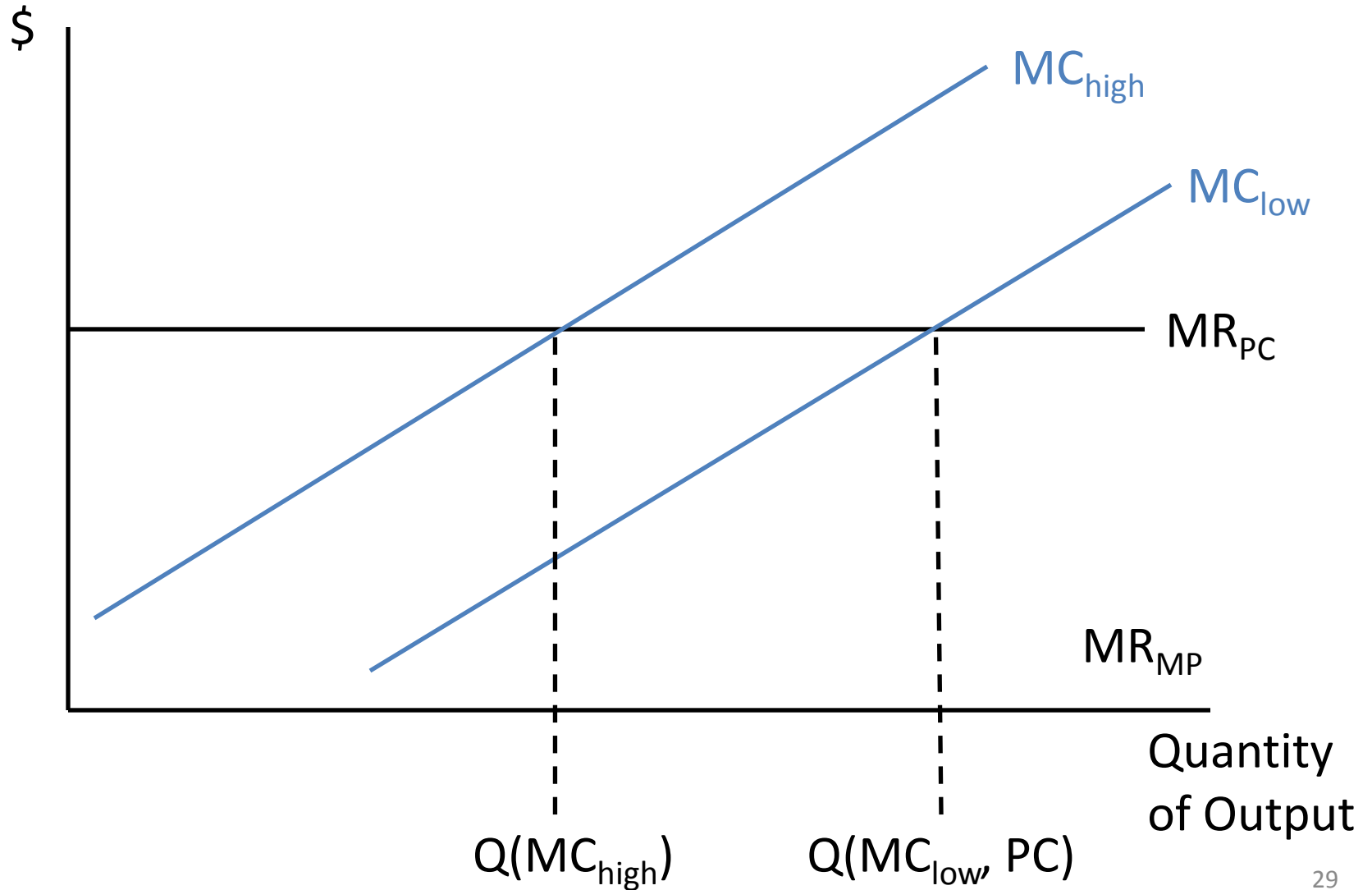
I consider here two classes of effects of market power on monetary policy efficacy

1. The market power of *firms* affects the magnitude of the response to a given change in interest rates (JH remarks)
2. The market power of *banks* affects pass through of interest rates (subject of ongoing work by Eliot Abrams and others)

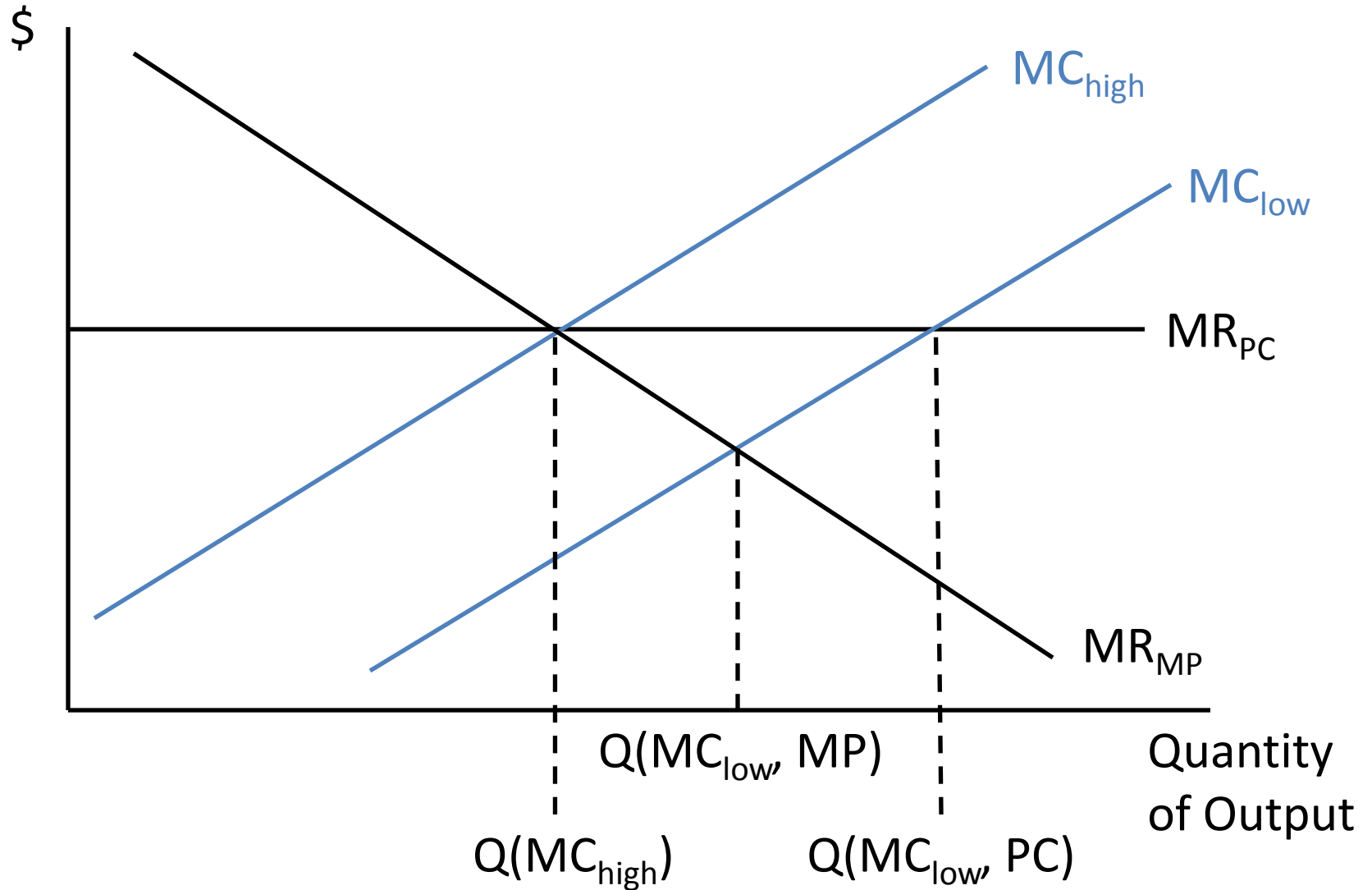
# Market Power, Pass-Through, and Monetary Policy: Firms

- Key mechanism of action for monetary policy: capital cost changes should move companies' activity levels
  - Investment, employment, output, etc.
- Strength of relationship depends on ties between companies' costs and desired activity levels
- Ties generally depend on companies' market power
- Relative to perfect competition, companies with market power expand less when costs decrease (and contract less when costs increase)

# Market Power, Pass-Through, and Monetary Policy: Firms



# Market Power, Pass-Through, and Monetary Policy: Firms



# Market Power, Pass-Through, and Monetary Policy: Firms

- What affects steepness of marginal revenue curve?
  - Shift from perfect competition to market power does steepen MR
  - BUT, shift from less market power to more market power does *not* necessarily steepen MR
  - Less competition means steeper *demand curve*, but not necessarily steeper MR curve
  - MR steepness depends on slope of demand *and* whether demand is flattening or steepening *and* size of quantity shift as competition changes

# Market Power, Pass-Through, and Monetary Policy: Firms

- Upshot:
  - Moving from perfect to imperfect competition reduces monetary policy's ability to shift producers' activity levels
  - However, no general comparatives between different levels of imperfect competition
  - Need to know what demand curves look like for general comparative statics



# Market Power, Pass-Through, and Monetary Policy: Banks

- Monetary policy affects banks' input prices
- Perfectly competitive banks pass through monetary policy changes in costs one-for-one
- Imperfectly competitive banks will not
  - Degree of pass through depends on shape of demand and nature of competition among banks

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# Market Power, Pass-Through, and Monetary Policy: Banks

- Optimal pass-through with constant marginal costs,  $c$ , and monopolistic competition:

$$p - c = \frac{-\frac{\partial q(p)}{\partial p}}{q(p)}$$

- Clearly, this depends on the shape of the residual demand curve  $q(p)$
- Change in pass-through rate as marginal costs change also depends on higher-order curvature of demand
- In strategic oligopoly, residual demand shaped by competitors' actions

# Market Power, Pass-Through, and Monetary Policy: Banks

- Pass-through effects complicated further by fact that a bank is a platform and prices on both sides (deposits and loans) affected by monetary policy
- Recent work by Eliot Abrams suggests deposit-side pass through in U.S. may have fallen after global financial crisis because of a reduction in competition among banks
- Again, size of effect is critically reliant on shape of demand system

# Conclusion

Potential resolution to productivity paradox is implementation lags associated with new GPT of AI and associated technologies

- Can cause upfront slowdown in both real terms and in measurement
- Timing going forward unclear; J-curve may have started

Market power influences monetary policy efficacy in two ways

- Firms' market power: influences ability of monetary policy to change firms' activity levels (i.e., how much a shift in MC changes activity)
- Banks' market power: influences pass-through of rate changes (i.e., how much MC shifts in the first place)