AI and the Modern Productivity Paradox:
A Clash of Expectations and Statistics

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based on work with
Erik Brynjolfsson and Daniel Rock

Technological Optimism

“The speed of innovation has never been faster.”

- Paul Polman, CEO Unilever

“Innovation is moving at a scarily fast pace.“

- Bill Gates, Founder, Microsoft

“the beginnings of...[a] rapid acceleration in the next 10, 15, 20 years”

- Vinod Khosla, Founder, Khosla Ventures

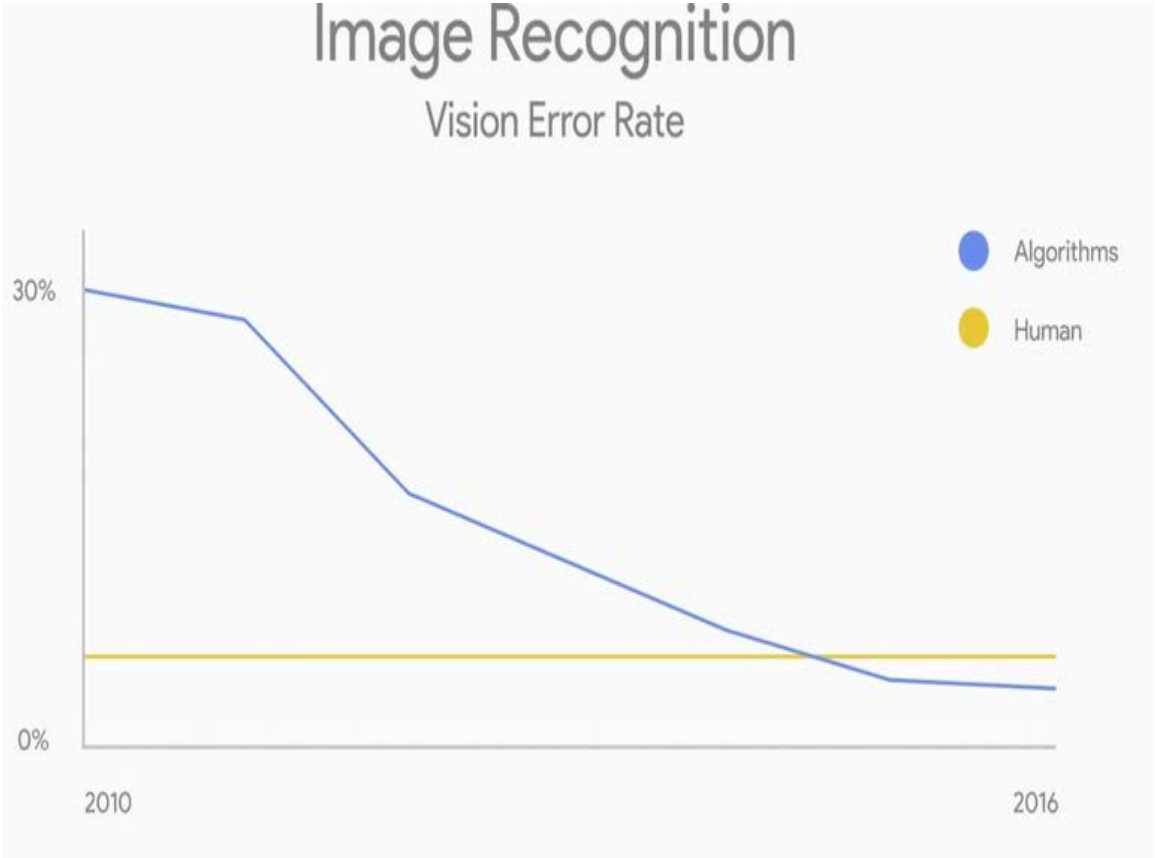
“We’re entering…the age of abundance [and] during the age of abundance, we’re going to see a new age…the age of intelligence”

- Eric Schmidt, Former Chairman, Alphabet

“The Singularity is near”

- Ray Kurzweil, National Medal of Technology Laureate

ML Has Crossed an Important Threshold



The Disappointing Recent Reality

- Productivity growth has slowed 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
  - 2005-2017: 1.3% per year
- OECD: 29 of 30 countries saw similar-sized slowdowns after 2004
- Emerging markets experienced slowdown around Great Recession (U.S. and OECD slowdowns began earlier)

Slow Productivity Growth Matters—a Lot

- Productivity is the “speed limit” on economic growth
- Even small changes in growth rates add up
- Had productivity growth not slowed after 2004:
  - GDP would now be (conservatively) $3 trillion higher per year
    - $9200 per capita
    - $24,000 per household
- If this slowdown continues another 10 years, we will be “missing” over one-third of GDP

A Paradox: Potential Explanations

1. False hopes
   - Technological optimism unwarranted; future productivity acceleration won't happen
2. Mismeasurement
   - Reality better than measured; no current slowdown
3. Distribution and dissipation
   - Technological benefits are real but concentrated; large dissipative efforts to grab or guard benefits
4. Implementation and restructuring lags
   - Technology is real, but benefits take time to emerge

Explanations for the Paradox

1. False hopes: Certainly some past technologies have disappointed
   - But not hard to estimate large productivity gains from existing technologies
2. Mismeasurement: Reasonable prima facie case
   - But lots of recent work indicating this isn't the story
3. Distribution and dissipation: Consistent with more skewed/concentrated company and worker outcomes
   - But hardly dispositive, and implies huge amounts of dissipative activity

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4. Implementation and restructuring lags
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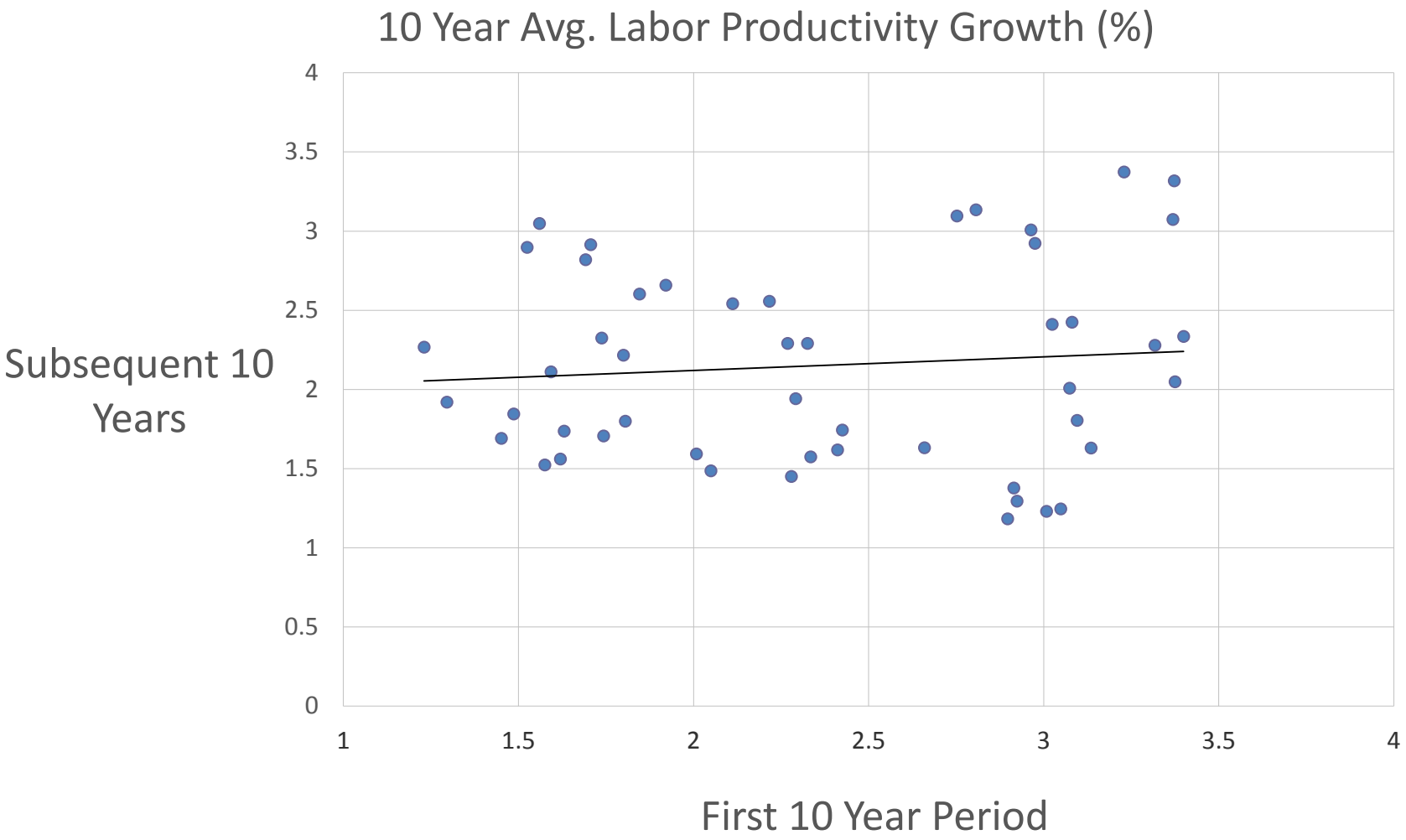
- The AI Paradox is not a contradiction:
  1. Optimists are looking to future impacts of current technologies, but GDP and productivity data reflect past and present
  2. General purpose technologies (GPTs) take time to have an impact
  3. GPTs may *reduce* measured productivity initially
     - Current slowdown tells us little about future

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 reports 3.5 million “motor vehicle operators”
  - Suppose autonomous vehicles reduced that to 1.5 million
  - Private employment is 122 million

    => ~ 1.7% increase in productivity

    Over 10 years, perhaps an additional 0.17%/yr

Examples of Potential AI-Driven Productivity Growth

- Call Centers
  - 2.2 million employed in large call centers
  - If reduced by 60%:

    => ~ 1% increase in productivity

    Over 10 years, perhaps an additional 0.1%/yr

Examples of Potential AI-Driven Productivity Growth

- Note: these calculations are for potential productivity gains due to direct replacement of existing technologies
- They don’t include potentially large gains from complementary innovations tied to core technology

AI as a General Purpose Technology

- Defining properties of GPTs
  1. Pervasive
  2. Able to be improved upon over time
  3. Able to spawn complementary innovations

AI as a General Purpose Technology

- Defining properties of GPTs
  1. Pervasive
     - **Prediction**, including diagnosis, classification, and labeling, is core to broad range of tasks, occupations and industries
  2. Able to be improved upon over time
     - Essence of machine **learning** is (self-)improvement
  3. Able to spawn complementary innovations
     - **Perception** (esp. vision, voice recognition) and **cognition** (problem solving) are building blocks enabling massive combinatorial innovation
     - Cloud robotics amplifies this impact

If AI Is So Great, Why a Slowdown?

1. Enough new capital stock must be accumulated to affect aggregates

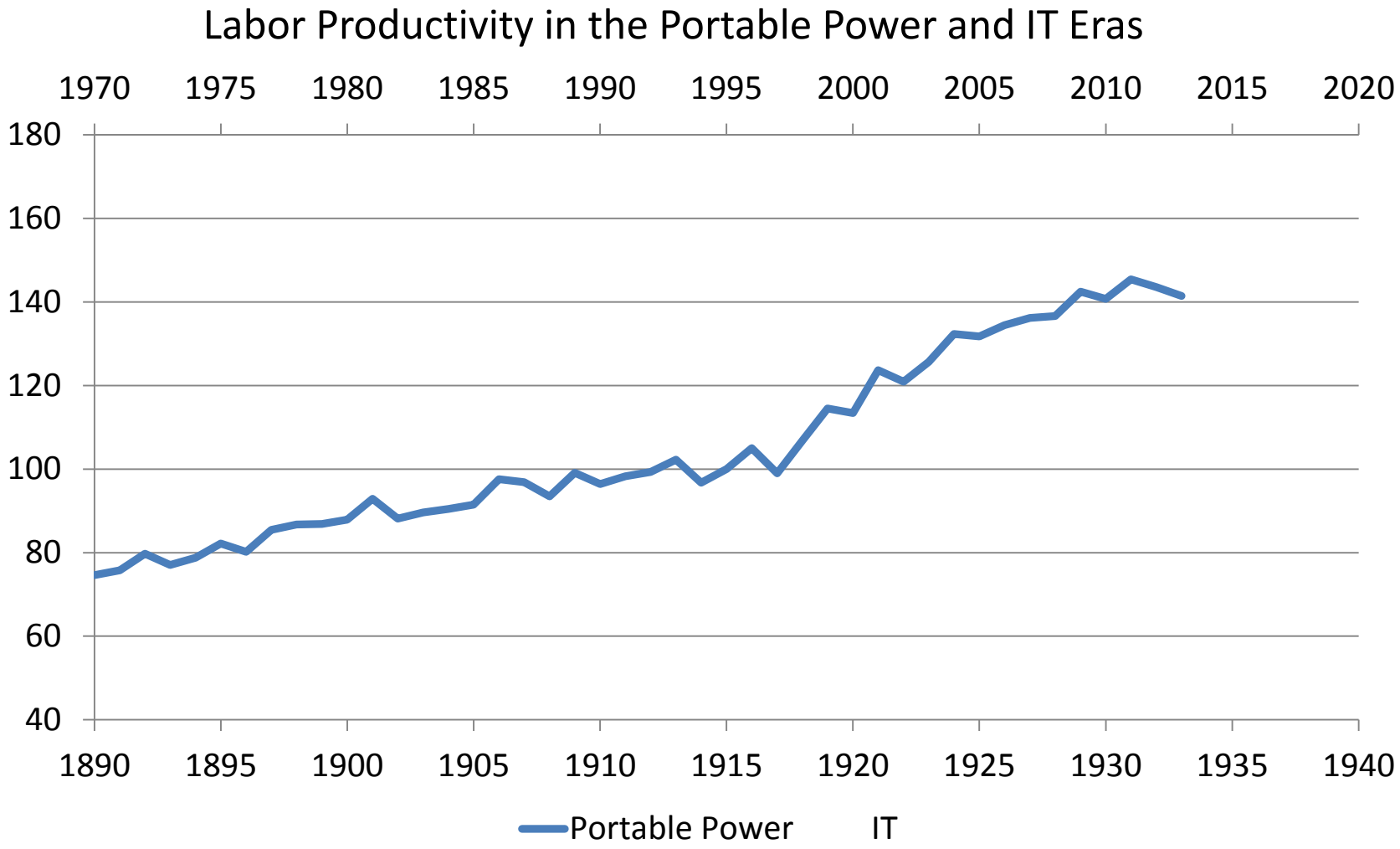
2. Complementary assets need to be invented, built, and installed

These processes can take years or decades

If AI Is So Great, Why a Slowdown?

- It can take a long time for enough GPT stock to be accumulated to show up in aggregates
  - Computer capital in U.S. topped off at about 5% of total nonresidential equipment capital by late 1980s
    - 25+ years after invention of integrated circuit
    - Only half that level 10 years earlier
  - Over half of U.S. manufacturing establishments unelectrified in 1919
    - 30 years after AC systems standardized

History's Lens on Today's Paradox



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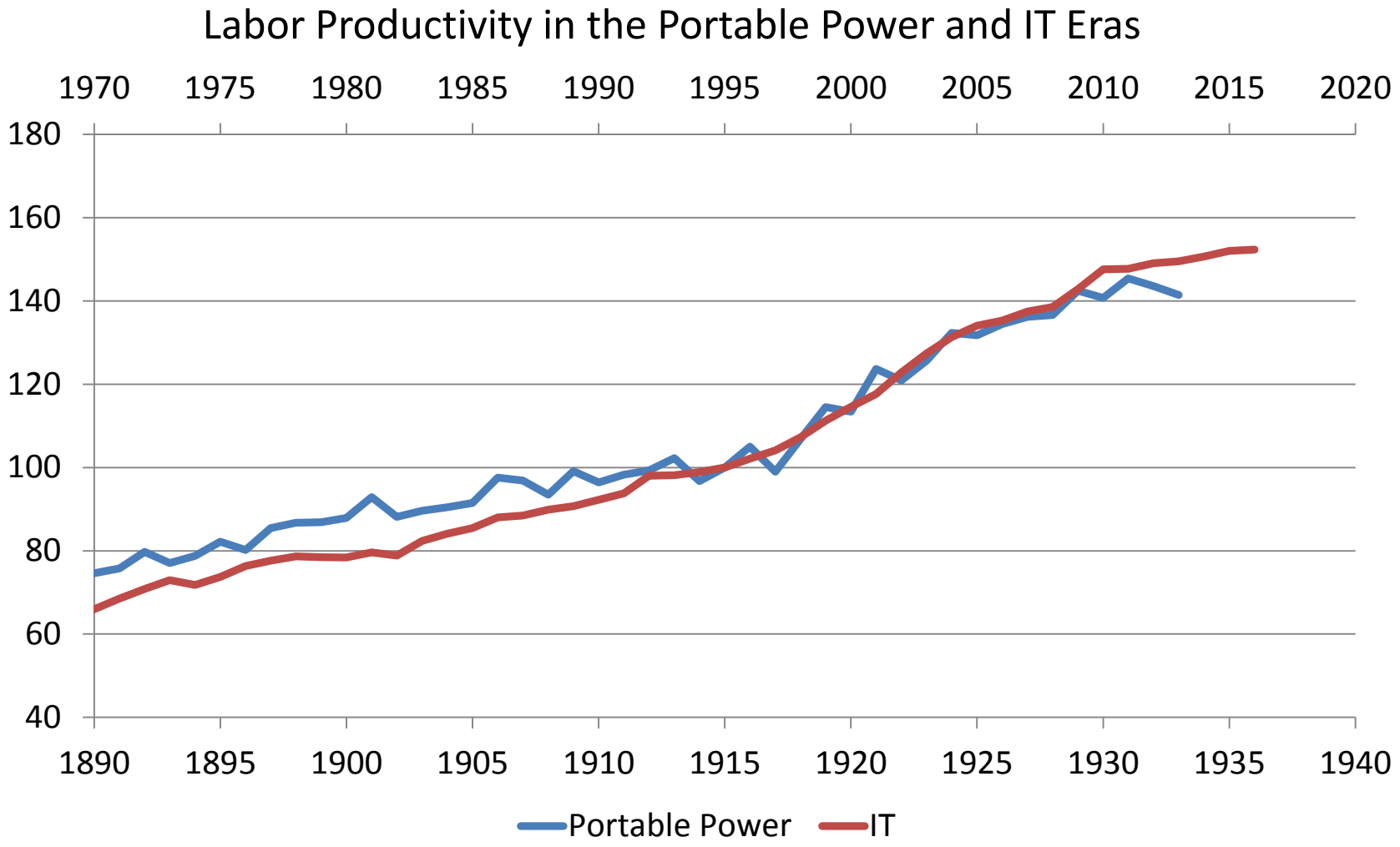

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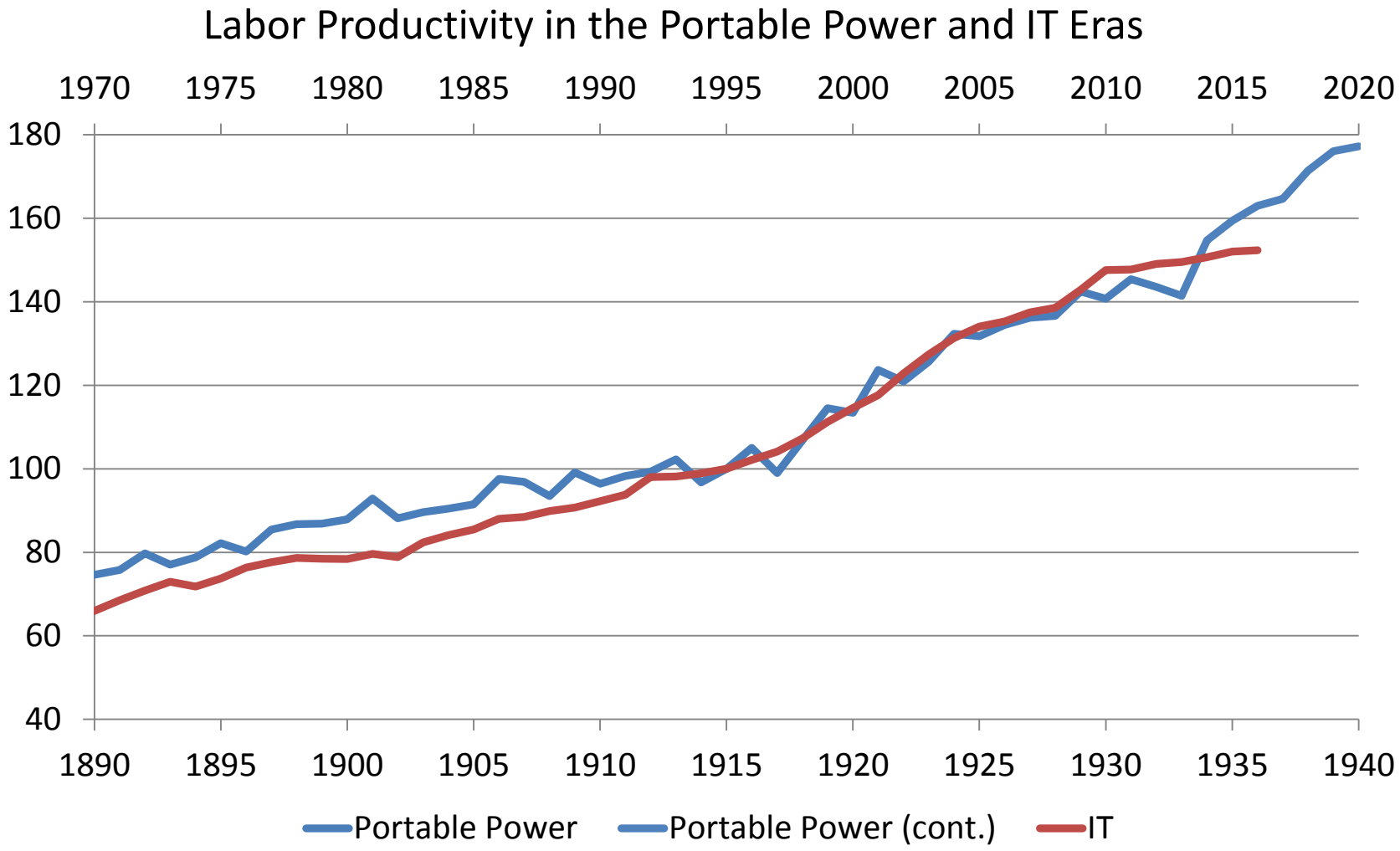
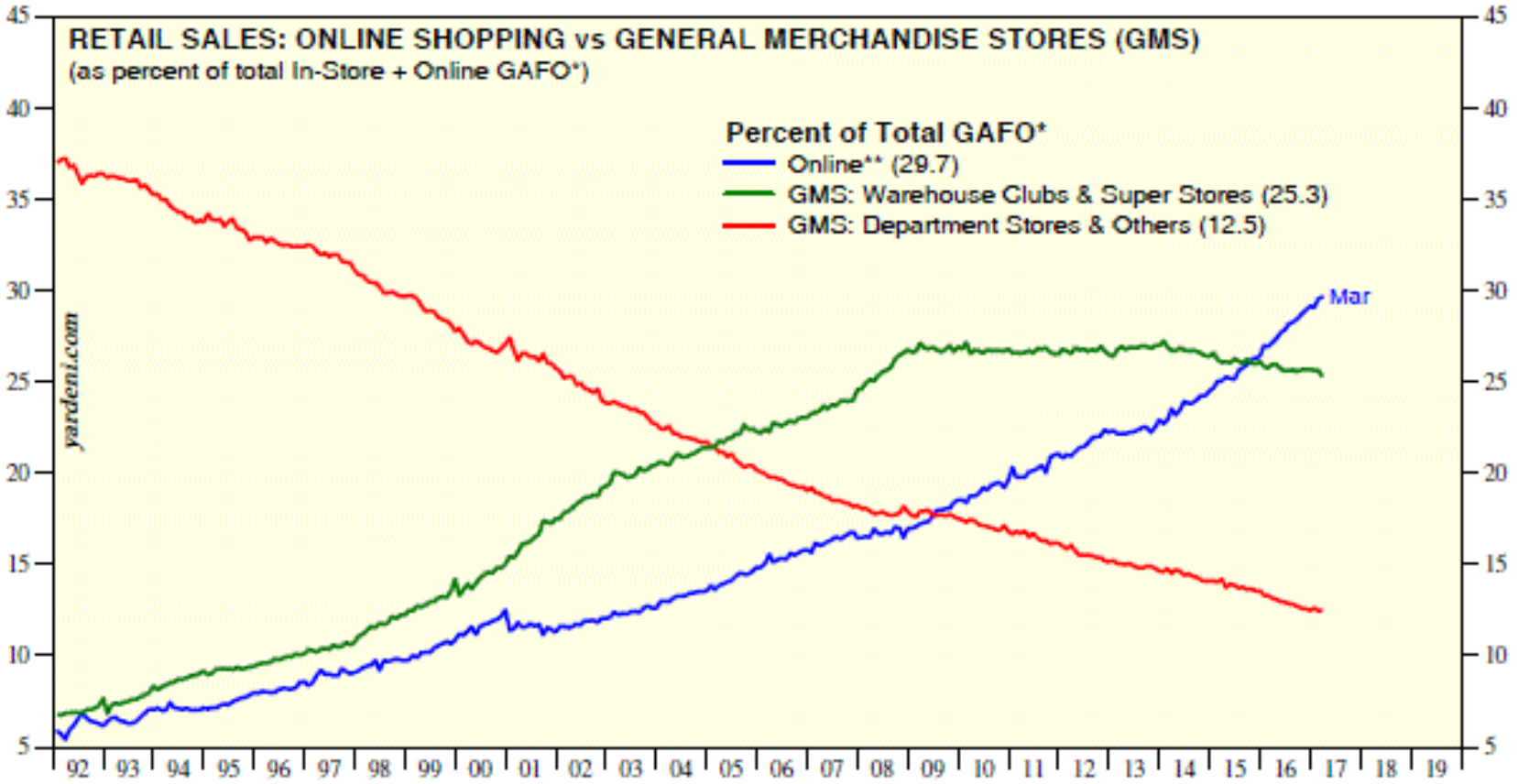


Ecommerce Wasn't Finished in 1999



* GAFO (general merchandise, apparel and accessories, furniture, and other sales) includes retailers that specialize in department-store types of merchandise such as furniture & home furnishings, electronics & appliances, clothing & accessories, sporting goods, hobby, book, and music, general merchandise, office supply, stationery, and gift stores.

** Electronic shopping and mail order houses.

Source: Census Bureau and Haver Analytics.

Growth Accounting: The J-Curve

- Productivity mismeasurement involves both hidden input and hidden output:

$$\hat{S} - S^* = \left(\frac{r_2 K_2}{Y}\right) g_{K_2} - \left(\frac{z I_2}{Y}\right) g_{I_2}$$

- When intangible investment growth times its output share is large (small) relative to stock of intangibles times its output share, productivity will be underestimated (overestimated)
- I_2 likely to be relatively large compared to K_2 early, so underestimated productivity growth early
- g_{I_2} will tend to decline over time, so overestimated productivity growth later

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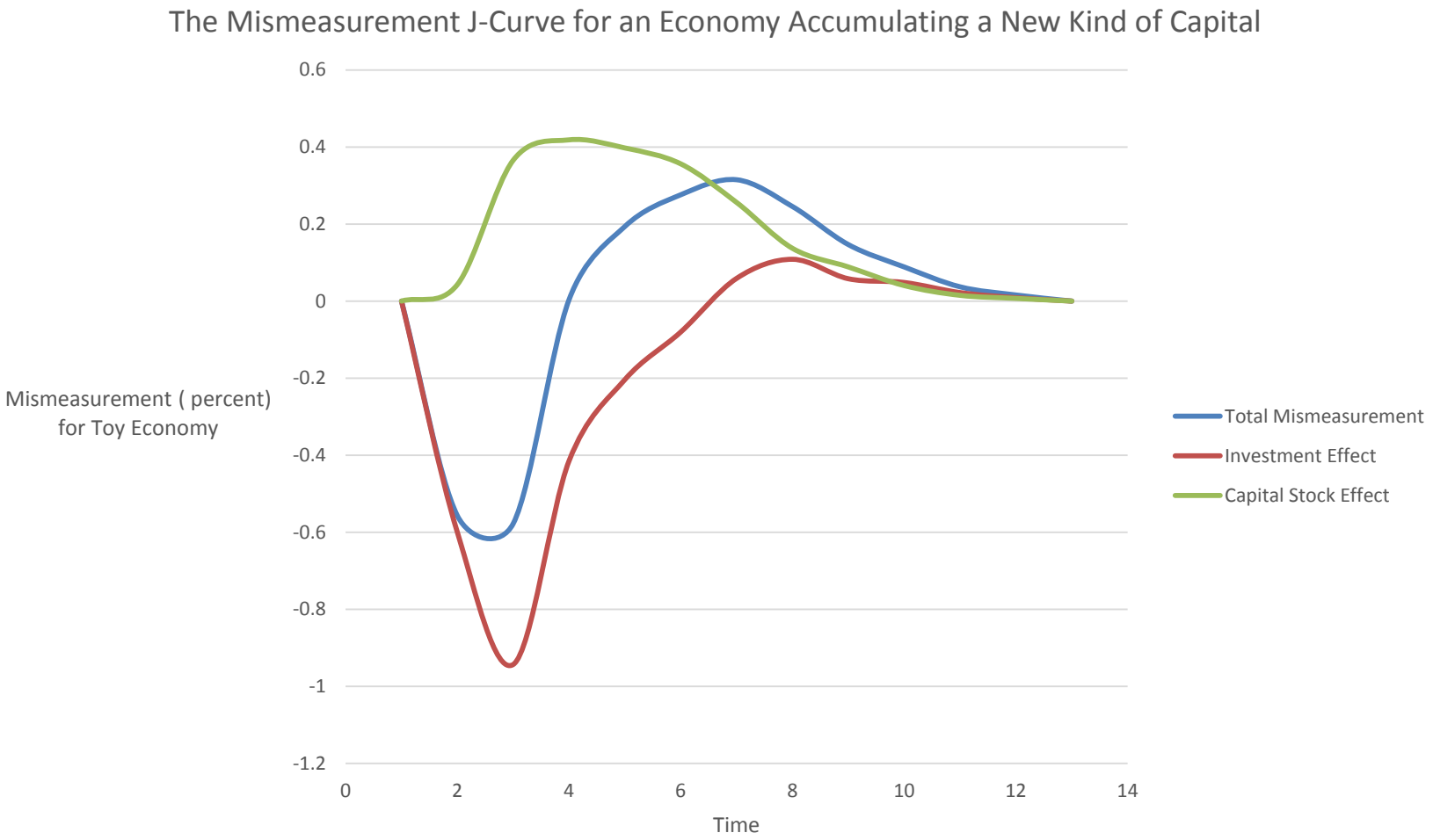

Conclusion

- Implementation and restructuring lags story a plausible resolution to the current paradox of technological optimism and disappointing current empirical reality
- The story says these two things not in conflict
- Indeed, it implies they are an internally consistent and necessary result of GPT invention and diffusion
- But realizing benefits of AI will not be automatic
  - Workers, organizations, and industry institutions do not change quickly
  - Dynamism is important, yet there has been a long-term downward trend