Accounting for Growth in the Age of the Internet
The Importance of Output-Saving Technical Change

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ISSUES ADDRESSED

- **The growth in real GDP has slowed despite a period of vibrant innovation. This is the Solow Paradox Redux.**

- **Much research, many explanations:**
  - **It's real; it's the legacy of the Great Recession; it's measurement error**

- **We suggest that a shift in the growth accounting paradigm is needed**

FACTOIDS

- **Many of the Internet Age benefits go directly to consumers, bypassing market GDP**

  - *"the internet has made information free, copious, and ubiquitous"*, Schmidt and Rosenberg (2014)

- **Rapid uptake of the tech revolution**

LANCASTER 1966 CONSUMPTION TECHNOLOGY MODEL

- **Utility is based on the blending of the characteristics of the goods produced, not the goods themselves, via a consumption technology**

- **Distinction between resource cost of goods produced and the utility benefits of consumption of their characteristics**

- **The consumption technology can shift over time, allowing consumers to *use each dollar of income more efficiently***

GROWTH ACCOUNTS WITH AND WITHOUT THE CONSUMPTION TECHNOLOGY

- **Production function**: $Q_t = e^{\lambda t} (L_t)^{\alpha}(K_t)^{1-\alpha}$
  - **Growth equation**: $q_t = \lambda + \alpha\eta_t + (1-\alpha)\kappa_t$

- **Standard utility function**: $U(C_t) = m(C_t)^{\mu}$
  - **Consumption Function**: $C_t = (1-\sigma)Q_t$
  - **Growth equation**: $u_t = \mu c_t = \mu q_t$

- **New utility function**: $U(C_t) = e^{\omega t}(e^{\beta t}(1-\sigma)Q_t)^{\mu}$
  - **Growth equation**: $u_t = \omega + \mu\beta + \mu q_t$

COMBINED UTILITY AND PRODUCTION FUNCTIONS ($\mu=1$)

- Combined: $U(C_t) = (1-\sigma) \, e^{\omega t} \, e^{\beta t} \, e^{\lambda t} \, (L_t)^\alpha (K_t)^{1-\alpha}$

- Growth Equation: $u_t = \omega + \beta + \lambda + \alpha\eta_t + (1-\alpha)\kappa_t$

  – Output-Saving Innovation: $\omega + \beta$

  – Resource-Saving Innovation: λ

  – Resource-Using Growth: $\alpha\eta_t + (1-\alpha)\kappa_t$

MEASURING OUTPUT-SAVING INNOVATION

- **Can express the utility formulation in its price-dual form**

- **Compensating and equivalent variations**

- **Helps locate consumer surplus in expanded accounts**

Implications

- **Conventional GDP not a sufficient statistic for the "Internet Age"**

- **Resource-based GDP can go down while welfare increases**

- **Resource-based GDP should not be adjusted for *costless* part of quality change**

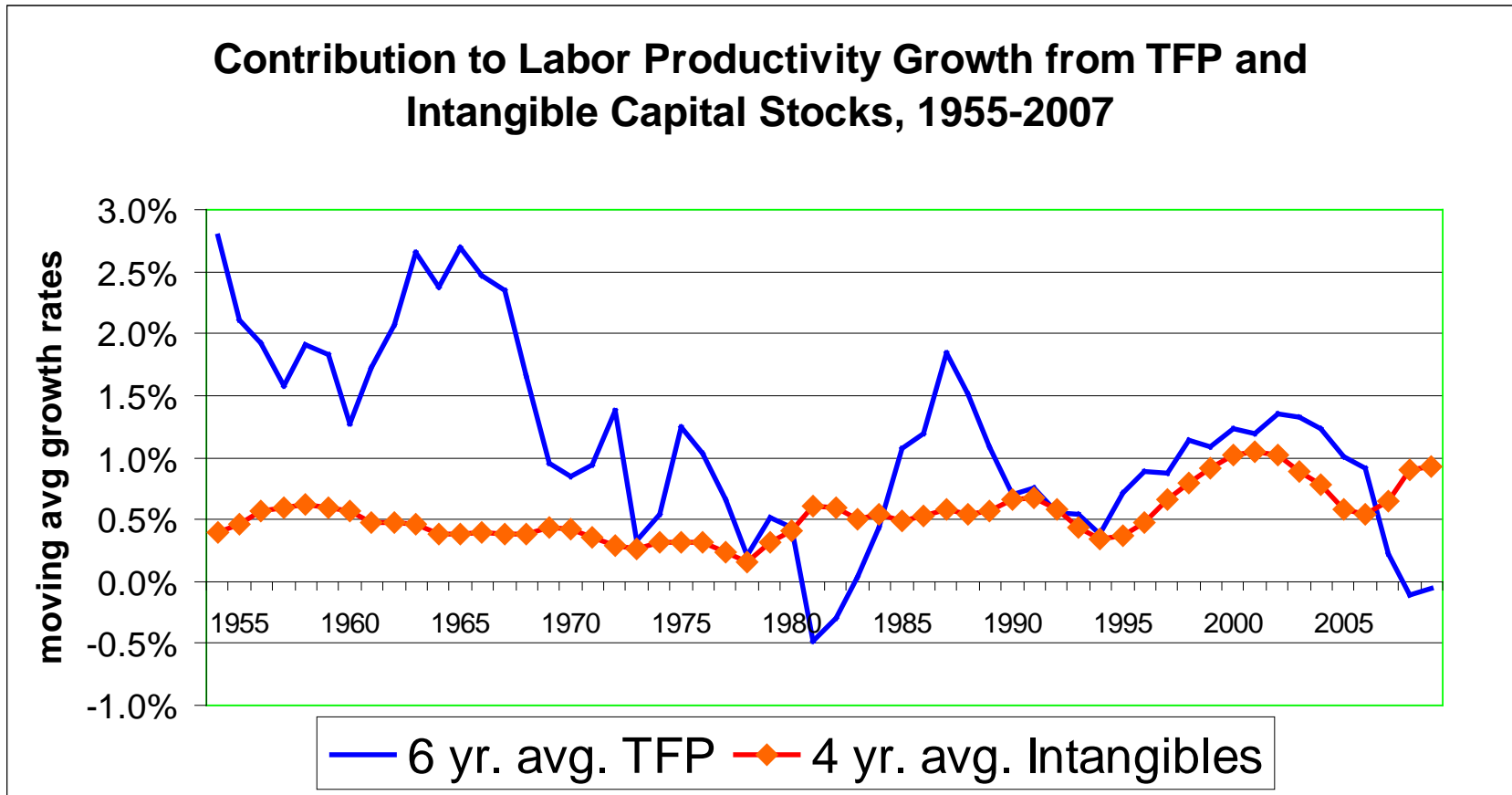- **Resource-based GDP is still an indispensable tool for policy.**

CONVENTIONAL GROWTH ACCOUNTING WITH PRODUCT QUALITY CHANGE (HYBRID GDP)

- **Production w/o:** $Q_t = e^{\lambda t} (L_t)^{\alpha}(K_t)^{1-\alpha}$

  – **Growth equation:** $q_t = \lambda + \alpha\eta_t + (1-\alpha)\kappa_t$

- **Production with:** $Q^e_t = e^{\beta t} Q_t = e^{\beta t} e^{\lambda t} L_t)^{\alpha}(K_t)^{1-\alpha}$

  – **Growth equation:** $q^e_t = [\beta + \lambda] + \alpha\eta_t + (1-\alpha)\kappa_t$

CONVENTIONAL GROWTH ACCOUNTING WITH *COSTLY* INNOVATION IN INTANGIBLES

- **Production func w/o:** $\quad Q_t = e^{\lambda t} (L_t)^\alpha (K_t)^{1-\alpha}$

  - **Growth equation:** $\quad q_t = \lambda + \alpha\eta_t + (1-\alpha)\kappa_t$

- **Production func:** $\quad Q^{*e}_t = e^{\lambda t} (L_t)^\alpha (K_t)^\theta (R_t)^{1-\alpha-\theta}$

  - **Growth equation:** $\quad q^{*e}_t = \lambda + \alpha\eta_t + \theta\kappa_t + (1-\alpha-\theta)r_t$

Costly vs Costless Innovation

Contribution to Labor Productivity Growth from TFP and
Intangible Capital Stocks, 1955-2007

Legend: 6 yr. avg. TFP — 4 yr. avg. Intangibles

THE SERVICE SECTORS

- **Hard to measure, rapid growth.**
- **The utility of many services is contingent on an initial state (health, knowledge, education, finance).**
  - **Outcomes are different from purchased services**
- **Lancaster characteristics model natural way to think about this**
  - **Implied utility function is** $U(C_t, \Theta_{t-1})$

LAST THOUGHTS

THIS ANALYSIS POINTS TO THE DESIRABILITY OF AN EXPERIMENTAL INNOVATION ACCOUNT IN WHICH REAL "GDP" IS MEASURED AT RESOURCE COST AND CONSUMER WELFARE TREATED SEPARATELY.

- THE CURRENT "HYBRID" GDP APPROACH WILL MISS MANY OF THE BENEFITS OF MEDICAL INNOVATION AND THE DIGITAL REVOLUTION. A SMALL GDP SHARE DOES NOT NECESSARILY IMPLY LOW BENEFITS.