# *Accounting for Growth in the Age of the Internet*

## Charles Hulten* and Leonard Nakamura**

Presentation at

THE 6th IMF STATISTICAL FORUM

*"Measuring Economic Welfare in the Digital Age: What and How?"*

November 19, 2018

*University of Maryland and NBER

**Federal Reserve Bank of Philadelphia

The material presented in the following slides is derived from our 2018 NBER Working Paper 23315. Please see that paper for technical details and references to other research.

# GDP: THE WORKHORSE OF OUR STATISTICAL SYSTEM

- **Paul Samuelson and William Nordhaus have called GDP *"One of the Great Inventions of the 20th Century"***

- **The GDP movement started during the Great Depression of the 1930s, in order to create the data necessary for economic policy. GDP continues to be critically important for policy, and provides a snapshot of the economy in each year.**

- **As the economy changes, the relationship of measured GDP to what we want it to measure changes. *GDP is a continuous work in progress.***

# The Current Challenge Comes from the Digital Revolution

- In their 2014 book *How Google Works*, Schmidt and Rosenberg argue that *"the internet has made information free, copious, and ubiquitous"* to the consumer.

- The digital revolution has brought forth many new or improved consumer goods: the personal computer, the smart phone, the Internet and social media. It also enabled important break-throughs elsewhere (e.g., health care, the driverless car).

- The rapidity of the uptake of digital goods has added to the challenge.

# WHERE IS THE DIGITAL REVOLUTION IN GDP?

- **Part of it appears as:**
  - spending on digital equipment and devices
  - access fees and subscriptions
  - marketing and advertising revenues
- **The volume and value of the *"free, copious, and ubiquitous"* information is NOT included in GDP. Thus, just how copious it is cannot be answered by a look at the GDP accounts.**
- **A zero price does not mean a zero value.**

# THE INFORMATION AND "FREE" GOODS PROBLEM

- **The units of measurement of information are hard to define in an economic context - value depends on the way that it's organized, its relevance, its accessibility, timeliness, and credibility.**

- **Its "zero price" feature reflects its public good nature: non-rival in consumption with hard-to-protect property rights.**

- **Increasing returns in production, low marginal cost.**

- ***Consumer willingness to pay (WTP) is not "revealed" by the market. It must therefore be discovered by other means.***

# CONSUMER WILLINGNESS TO PAY

- **We believe that part of the value of information by-passes GDP and goes directly to the consumer by enhancing the *welfare content* of GDP.**

- **The "*free, copious, and ubiquitous*" information allows consumers to make BETTER CHOICES that leverage their incomes, giving them more BANG FOR THE BUCK. The consumer is willing to pay for this "BANG".**

- **We propose a conceptual framework that allows for this to happen.**
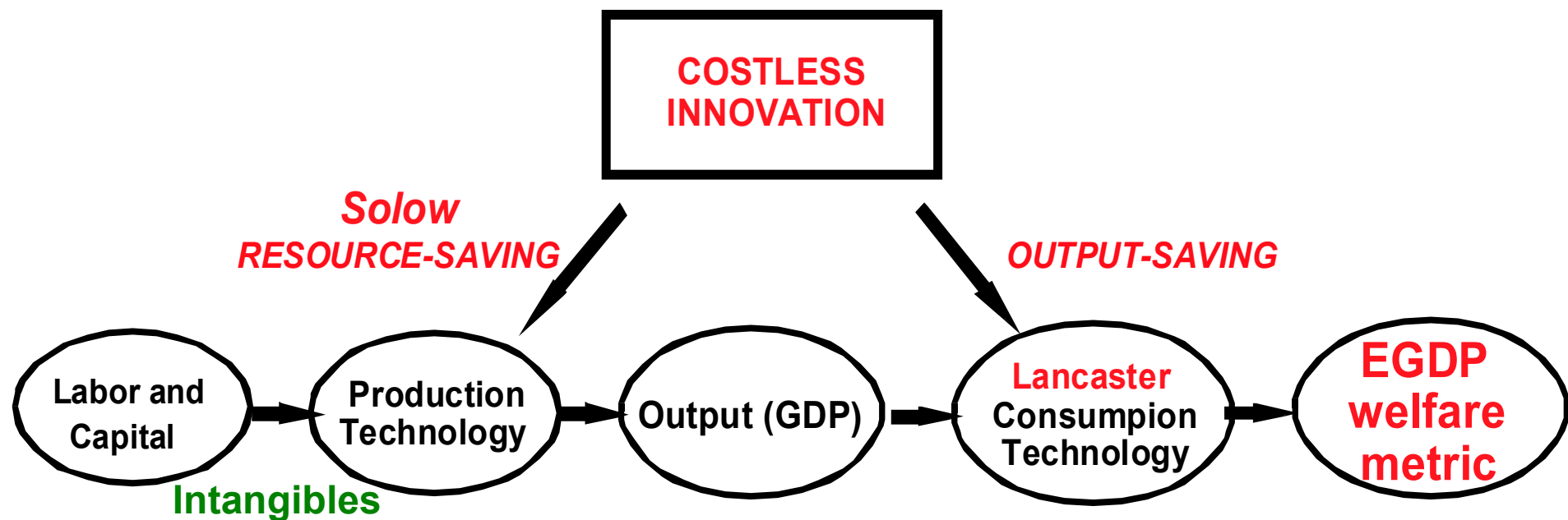
# OUR CONCEPTUAL FRAMEWORK

- **STANDARD Economic Optimization Model:**
  - **Max U(Q) s.t. technology and resources $Q = e^{\lambda t}F(X)$**
  - **GDP/GDI identity  $P \cdot Q = w \cdot X$**
- **Lancaster New Theory adds consumption technology**
  - **$C = \Phi(Q,t) = e^{\mu t}e^{\beta t}\Phi(Q)$**
- **EXPANDED Economic Optimization Model:**
  - **Max U(C) s.t. $Q = e^{\lambda t}F(X)$ and $C = e^{\mu t}e^{\beta t}\Phi(Q)$**
  - **Same GDI/GDI identity**
  - **Greater consumer utility over time**

# TAXONOMY OF INNOVATION

- **Innovation on the *production* (resources) side of economy**
  - **Costless input-saving technical change (TFP) $\lambda$**
  - **Innovation from intangible capital investment**
- **Output-saving technical change on the *consumption* (uses) side of economy**
  - **Costless disembodied innovation $\mu$**
    - **Information**
    - **Wedge between outcomes and expenditure**
  - **Costless product-embodied innovation $\beta$**

# INTUITIVE REPRESENTATION
## Stages of the Optimization Process



**COSTLESS INNOVATION**

*Solow*
*RESOURCE-SAVING*

*OUTPUT-SAVING*

Labor and Capital → Production Technology → Output (GDP) → Lancaster Consumpion Technology → EGDP welfare metric

**Intangibles**

**The conventional approach essentially stops with the middle link, assuming utility is proportional to real GDP. We add the last two links, *allowing welfare metric (EGDP) to grow faster than real GDP.***

# What is EGDP?  How is it estimated?

- **Expanded GDP (EGDP) is the sum of GDP and a monetary *willingness–to-pay* metric of output-saving innovation.**
- **This theoretical metric is the *compensating variation* of economic theory.**
- **This metric can be used to estimate the output-saving parameters of EGDP (the β and μ), and thus, indirectly, the growth in welfare.**
- **In practice, a variety of techniques, surveys, and *welfare-correlates* can be used to estimate the willingness–to-pay.**

# WHAT CAUSES THE CONSUMPTION TECHNOLOGY TO SHIFT?

- **THE INTERNET.   More *information* enables more efficient consumption decisions.**
- **Better OUTCOMES from given interventions. *Minimally invasive surgeries*.  Better diagnostics and monitoring. Anyone remember dentistry in the 1960s?**
- **Costless increases in PRODUCT QUALITY, like software upgrades; new features (road-side assistance);  *new goods* (driverless car).**
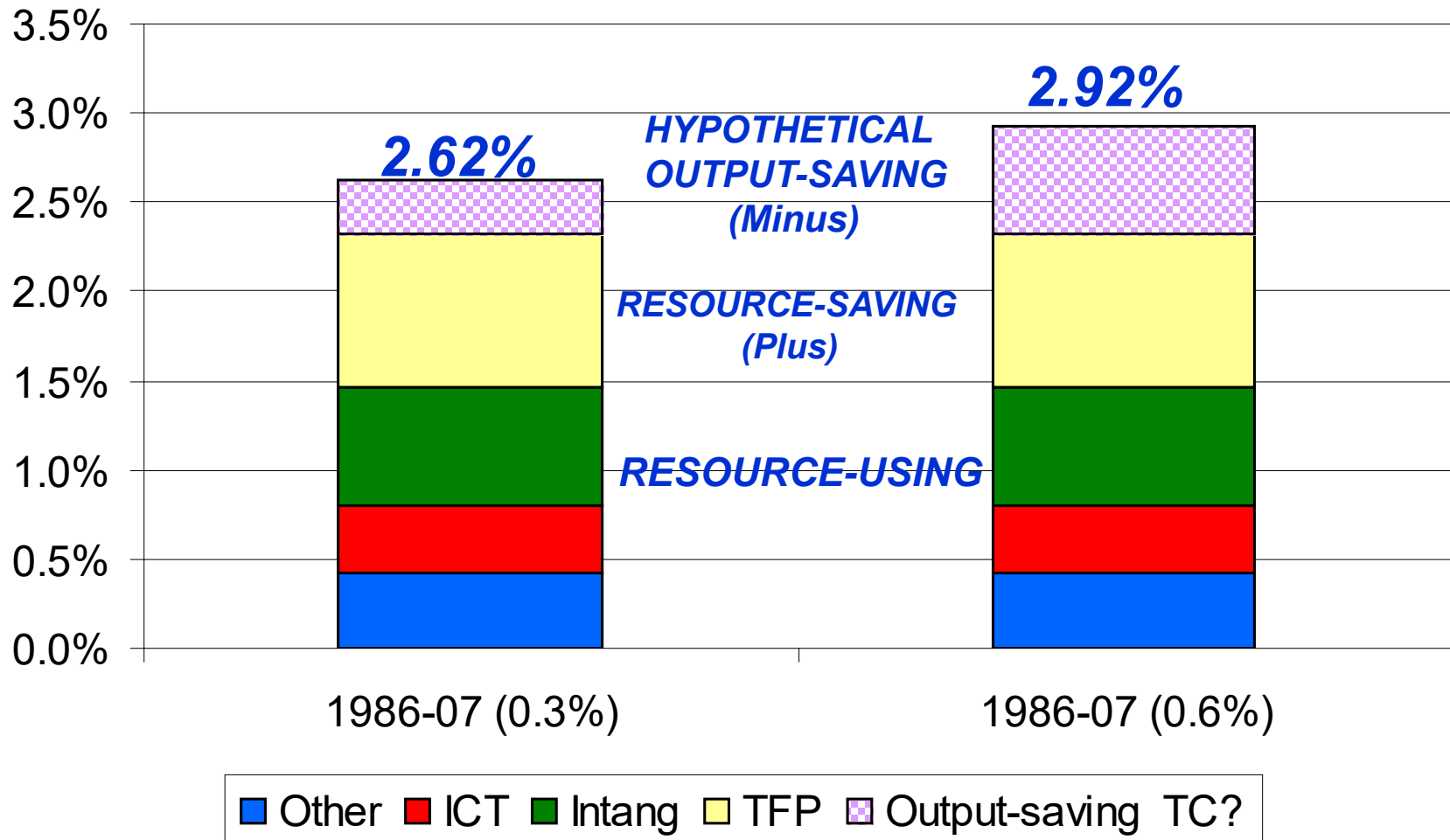
# SOME SPECIFIC RESULTS

- **INTERNET/INFORMATION:  There is a broad range of estimates from tens of billions to over a trillion dollars.**

- **OUTCOMES: A 2016 study found that disability-adjusted life years attributable to improved health treatment increased over the period 1992 to 2008 by a full year at age 65.  A 2018 paper found that outcomes in three treatment areas have improved over the period 2001 to 2014 with much less increase in spending,**

- **PRODUCT QUALITY:  Survey of the bias in price indexes by Groshen, Moyer, Aizcorbe, Bradley, and Friedman (*JEP*, 2017) put the downward bias in the growth of real GDP at -26 bp in 2015 due to consumer goods, and -15 bp due to private investment.**

# Digital Revolution too Small to Matter?

- **A central theme in the recent literature is that digital goods are subject to measurement bias, but their GDP share *is too small for this to matter*.**

- **In our model, effect of output saving innovation ($\beta$ and $\mu$) multiplies *the value* of GDP rather than adding to GDP, so the GDP share is not dispositive.**

- **There are estimates of the bias in product quality ($\beta$), but *NOT the size of $\beta$ itself*.**

- **The *thought experiment* in the next slide illustrates these issues, and shows that the *impact of output-saving innovation can be non-trivial.***

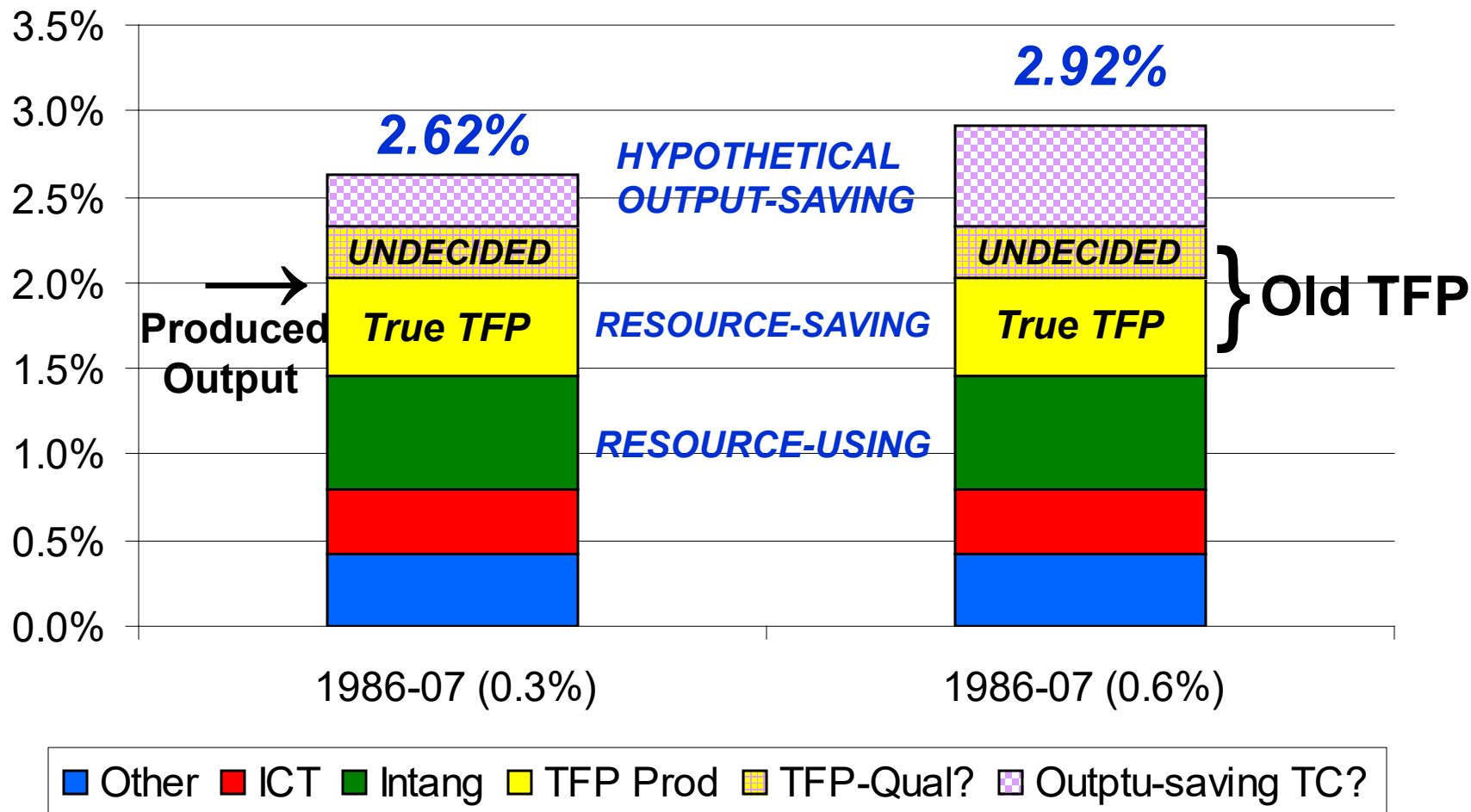# A Hypothetical Sources of Growth with Output-Saving Innovation: It MAY Matter for Growth! (A Thought Experiment)



*Corrado and Hulten (2014), and authors calculations; U.S. PB Sector*

# THIS FIGURE MAY UNDERSTATE THE TRUE BENEFITS OF OUTPUT-SAVING INNOVATION

- **Recall that current GDP practice (imperfectly) adjusts the components of resource-based GDP for improvements in embedded product quality ($\beta$).**

- **It is thus a *HYBRID GDP* index conflating the value of the market output produced by business with the use value of that output to consumers.**

- **As a result, the hybrid GDP does not indicate the individual magnitudes of $\beta$ (or, indeed, $\mu$). It indicates just the conflated total.**

- **Moreover, the calculated Solow Residual conflates productivity change (our $\lambda$) with the unknown $\beta$ and $\mu$.**

# Output-saving Innovation Matters Even More With a *Full* EGDP Growth Account



The *UNDECIDED* is the β buried in hybrid-GDP; the bias is in the purple area

# SUMMARY OVERVIEW

- **EGDP is a unifying framework that *pulls together* various aspects of the emerging economic system that have proved difficult to measure.**

- **EGDP establishes a clear boundary between the *sources* of output and its consumption *uses*.**

- **Current GDP is a hybrid of resource and welfare elements, thereby blurring this boundary.**

- **The elements of hybrid-GDP are NOT shown explicitly.**

- **EGDP does show the elements explicitly, which we need know for policy purposes and insight into the effects of innovation on growth.**

# THE PATH AHEAD

- **The changes wrought by the digital revolution require changes to official statistics. The statistical agencies are well-aware of this and are active in this process of accounting for the new economy.**

- **The path ahead is long (and expensive). GDP accounts were not built in a day. New surveys and data sources are needed. For example, tapping into the data and techniques pioneered by Google, Facebook, Amazon, etc.**

- **The framework described in this presentation provides an organizing framework for linking the digital economy into the existing GDP framework. Adds consumption side of the economy (welfare) in a way symmetric to the existing production-orientation framework.**