ESCoE Research Seminar

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

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12 March 2019

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

Economic Statistics Centre of Excellence
March 12, 2019
London UK

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Overview

- I will discuss research done with Chuck Hulten

- We argue that a welfare-oriented measure of income may be growing significantly faster than real GDP as now measured.

  – But uncertainties are very large

- To go further, we need two kinds of GDP

  – One closely related to inputs, another measuring welfare

Output-saving

- We live in an age of rapidly increasing knowledge
- A key form in which progress occurs is the diffusion of knowledge
  - To Consumers
  - To Producers
- This diffusion of knowledge is output-saving
  - With better information, we produce more utility with less inputs required
- This flow of information is largely omitted from GDP

How large our uncertainties?

- Trillions of dollars of stock market valuation for firms whose output largely does not appear in GDP
- Rapid changes in consumer behavior as measured in time use
  - Two hours a day are spent on the Internet, up from 1 just a decade ago
  - But no impact on GDP or PCE
- Consumers face zero marginal prices for many Internet products
  - Because their marginal cost of reproduction has fallen to zero
- With two-way mass communication, boundary between paid work and household work has become porous
  - As much as one-third of Internet time is uploading
- Widely viewed disconnect between welfare and GDP
- Could real growth be 1 or 2 % higher than we think?

If in US GDP we were off by 1-2 %

- We missed some $2-4 trillion over the past decade
  - $6000 to $12000 per capita
- Brynjolfsson et al:
  - Internet, maybe $3-5000 per capita?
    - Vs. $350 in input costs NSS
- Cutler and co-authors:
  - Health care, maybe $3-5000 per capita?
- Self-driving cars, education, entertainment?

Can GDP do what we want it to do in the modern era?

- Recently, economists have begun to ask very basic questions about GDP

- What are we trying to capture with GDP?
  - We want GDP to answer short run questions about real demand for inputs (Keynes/Okun) and long run questions about welfare gains (Solow)

- Is it possible we are asking too much of GDP?
  - Perhaps GDP cannot answer both questions at the same time

Inputs and outputs

- The Okun/Keynes question for GDP is:
  - Is demand adequate for full employment?
    - Connect expenditure to resource use
  - We want Okun's Law to hold: a relatively tight relationship between real GDP growth and unemployment
  - This tight relationship is a product of mass production: output predictable with given inputs
    - This tight relationship doesn't hold for Internet firms
      - Also didn't hold in agricultural economy before industrialzation

Outputs and inputs

- The Solow growth model connects inputs to welfare

- If productivity rises 2 % a year
  - We want to understand what the sources of that growth are
  - The answer was: mainly technological progress

- To answer this question we are very much concerned with outputs measured in terms of welfare

Defining inflation

- The standard definition of inflation is based on the expenditure function:
  - How much money does it cost to purchase the same utility in two different periods
- With a fixed set of goods, changing prices, and fixed utility map
  - Laspeyres and Paasche indexes provide bounds for expenditure function and Fisher Ideal Index provides a good approximation (Diewert)
- This is revealed preference
- But: with new goods and information, revealed preference may not be enough
- If new goods provide substantial consumer surplus, then standard methods won't work
  - The methods that do work require assumptions and are hard to implement in real time

Defining real income/output

- The standard definition of real income growth is:
  - How much more nominal income do we *have* relative to the nominal income we need to purchase the same utility in two different periods
    - Income relative to expenditure function
  - This provides Samuelson's "money metric utility"
  - But if we deflate with a fixed bundle consumer price measure, we won't get welfare, but we are likely to get a good measure to track inputs

What we want for some purposes are welfare measures

- Welfare is important for measures of inflation when we want to calculate real rates of return
  - If I save and invest a dollar today, how much utility will the proceeds buy tomorrow?
- Welfare is important for measures of output when we want to evaluate long-run economic policy
  - Are our policies making us better off over time?

But are welfare gains and input costs commensurate?

- Perhaps not
  - Internet welfare gains (Brynjolfsson et al) may be an order of magnitude greater than input costs (NSS)
  - The value of car sensors and software (backup cameras, driverless cars) may be an order of magnitude greater than costs
  - Baby aspirin and heart attack/stroke survival
    - A few orders of magnitude!
  - Human genome costs fell 100 thousand fold in two decades
    - Now over 1 million whole human genomes sequenced
    - Genetic manipulation (Crispr) technology really cheap
    - Gene therapy being practiced

- But these can't be known in real time!
  - In real time, we only have expectations of trend welfare gains

Internet issues

- Main costs of Internet:
  - Internet and telecom service subscriptions
    - Real increase per person about $300 in past decade
    - These are small relative to Brynjolfsson welfare impacts
  - Measured telecom real growth during the smartphone revolution has been slow (2 % annually in US)!
    - How fast should deflator be falling?
    - 60 percent a year based on bytes?
  - Many types of real output are made obsolete by Internet and smartphones – output-saving technology
   - We get photos, music, video, banking, mail, maps, news, books

Internet giants

- The rewards for innovation are increasingly concentrated in Internet giants

- Microsoft, Apple, Amazon, Google, Facebook:
  - Collectively worth more than $3 trillion up from $0.9 trillion in 2007

- Much of their output not reflected in GDP
  - Google and Facebook produce advertiser-supported free goods
  - Amazon is a new outlet and cloud
  - Apple is an importer
  - Microsoft now has numerous free Internet products and cloud

Health issues

- Chernew et al (2016) show that over the 16 years from 1992 to 2008, disability free life expectancy grew by 1.8 years for those age 65+
  - 10 months of disability free life per decade: what is that worth? $100 thousand?
- Human genome sequencing fell in cost from $100 M in 2001 to $10 M in 2007 to $10 K 2010 to $1000 in 2015
  - One million + human genomes sequenced today worldwide
  - Cost to fall to $100 within next few years!

Genome sequencing costs drop far faster than Moore's Law

Others
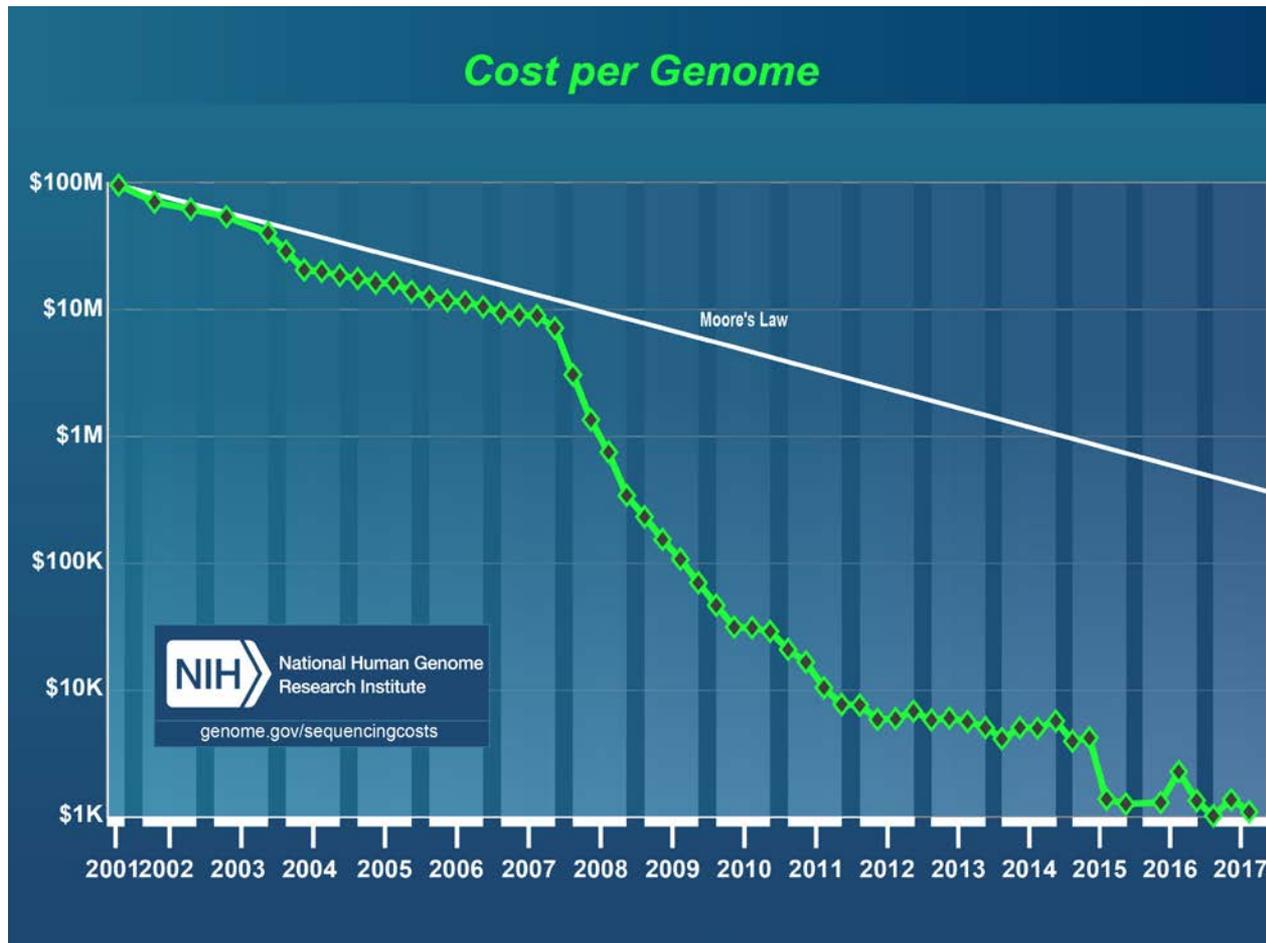
- Marginal costs of sensors and software in cars is small relative to benefits of
  - Back-up camera
  - Accident prevention
  - Self-driving
- US: drivers in cars 1000 hours per year

Monthly inflation measurement

- If we just measure prices of existing goods, then we miss quality improvements due to advances in knowledge

- So our welfare measures are off

- But we are able to maintain a close relationship between measured real output and unemployment

Knowledge and output saving

- Better information improves welfare for fixed consumption
  - Information about restaurants and hotels makes travel more enjoyable because tourists can better match their tastes
  - Very generally, improved information – on the part of consumers and producers – makes us better off even without changes in inputs or visible outputs
  - This creates a further disconnect between inputs and welfare

Two kinds of GDP?

- Hulten and Nakamura propose an Expanded GDP (EGDP) that tries to measure welfare and includes improvements in consumption technology due to information gains a

  – There would still be a regular GDP that is more closely aligned with inputs

 – EGDP could not be measured very accurately in real time

- Lancaster
  - Utility depends on consumption goods (C) plus other factors (X)
  - In particular, information can shift consumption function: more information improves utility with the same consumption goods
  - We call this output-saving technological progress because information implies you can have the same utility with less output

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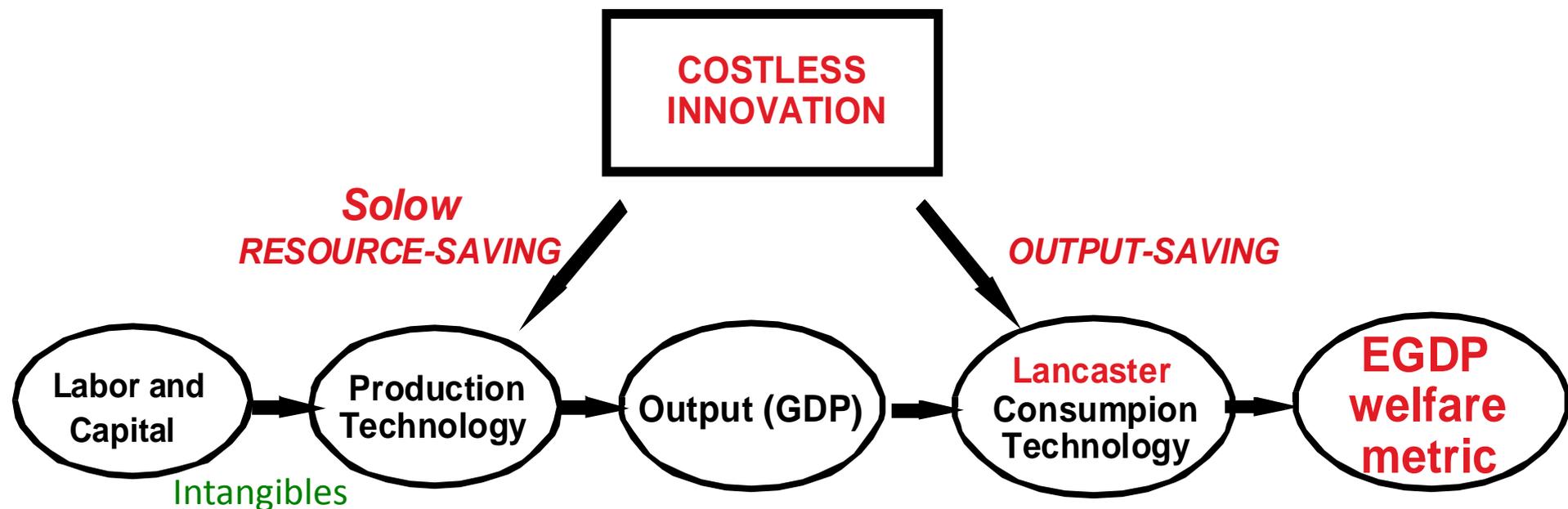
The conventional approach essentially stops with the middle link, assuming utility is proportional to real GDP. We add the last two links, *allowing welfare (EGDP) to grow faster than real GDP.*

Quality improvements in output due to producer information

- More controversially, we argue that we can include in EGDP quality improvements that are due to information flowing to producers

- Information flows to doctors and professors are largely invisible in GDP, as they do not arise from standard intermediate transactions

- The improvements in the value of an office visit or a year in university due to these information flows are invisible

Three forms of knowledge hard to capture in GDP

- Embedded in new products
  - Tricky form: software upgrades
- Embedded in human experts
  - Doctors, educators, barbers, chefs, etc.
  - Hard to measures service outputs
- Embedded in consumers
  - More consumer knowledge from Internet results in better consumer decisions
- All of these require consumer welfare evaluation

How should welfare measurement proceed?

- We argue that expenditure functions – willingness to pay – are the theoretical measures of value when information flows are hard to measure
    - Can provide us with a money-metric utility
- But how do we go about finding convincing measures of willingness to pay?

Incorporating time use

- Coyle and Nakamura propose aggregate analysis of time use as a means toward fulfilling the Hulten-Nakamura proposal

- Use household economics, well-being studies, cost-benefit analyses, behavioral economics

- Household-based satellite accounts are one way to go

- A burgeoning literature!

Summary

- Without a credible measure of aggregate welfare, economists' ability to make macro policy recommendations will be increasingly attenuated.

- To recapture welfare in the age of digitalization, we need shadow prices, particularly of time.

- We are a long ways from a complete new picture, but a tremendous amount of research has been launched.

- Coordinating this research, and maintaining it statistically over time so that we can make time series, is the big task ahead.

Thanks!

- This is very much work in progress
- Email us with comments
  - Leonard.nakamura@phil.frb.org

Lots of recent studies on time use and/or broader wellbeing measures

- Diewert & Fox 2018
- Alpman et al 2018
- Cassar & Meier, and Kaplan & Schulhofer-Wohl, JEcPerspectives 2018
- Hulten & Nakamura 2018
- Jones & Klenow, AER 2016
- Dotsey et al, Int Economic Review 2014
- Gershuny & Fisher 2014
- Benjamin et al, AER, 2012, 2014
- Deaton, 2018
- Bridgman, 2016
- Maestas et al, 2018
- Aguiar and Hurst, Handbook of Macro, 2016
+
- Goolsbee & Klenow, AER 2009
- Krueger et al, 2009
- Brynjolfsson et al 2018a, b
- Coyle, Economica 2018
- Coyle & Rogers in progress

Time use

- To understand household choices and welfare today, need to measure time use
  - Gary Becker's full income used in household economics
- A major cost of consuming products
  - Is the time spend producing and enjoying them
  - Medical, education, transportation, food prep and dining
- The main (only?) cost of consuming products with zero price
  - Internet use: entertainment
- What is our perceived shadow value of time?

Shadow value of time

- First approximation: wage rate
- But work may be pleasant or unpleasant
  - Enjoyment means there is a consumption value to work, which raises the shadow value of time relative to the wage
- And work may involve learning
  - Learning by doing further raises the shadow value of time
- And work may be meaningful
  - Studies show that people will accept lower wages to do work they consider meaningful
- Can we find the shadow value of time by asking people?
  - E.g., what wage would you have to be paid to shelve books at a library?
  - Or, what would you pay to have a shorter commute?
  - Driverless car?

Three ways to estimate shadow value of time

- "Revealed" preference: how much will someone spend to save time?
  - Trade-off between commute and rent may be captured in measured rent gradients
- "Stated" preference: how much would you pay to have a shorter commute?
- "Stated Feelings" : how do you feel as you commute (direct report on welfare)
  - Miserable commute raises the shadow cost of commute relative to value of time

Many, many questions

- Can we reconcile the answers we get from these different approaches?
  - Can econometric encompassing techniques help us out?
- How will these money-metric utility measures align with real consumption measures?
- We need time use data with stated feelings (discontinued in US)
- We need more surveys—both private and official.