How Should We Measure the Digital Economy?

Erik Brynjolfsson

NBER Digitization Tutorial
March 4, 2020

MIT MANAGEMENT SLOAN SCHOOL

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How Are We Doing?

SEARCH The New York Times

ECONOMY

U.S. Economy Grew at 3.2% Rate in 3rd Quarter

By THE ASSOCIATED PRESS

The United States economy in the third quarter grew at the fastest pace in two years, according to a revised report that showed stronger consumer spending than first estimated.

Sections The Washington Post *Democracy Dies in Darkness*

Wonkblog

U.S. economy grew at sluggish 0.7 percent in first quarter of 2017

By Ana Swanson and Max Ehrenfreund April 28

"...a measure for **standard of living**: average real **gross domestic product (GDP)** per capita" – Boston Fed

"**Productivity** is the most important determinant of the **standard of living**" – Forbes

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"The welfare of a nation can scarcely be inferred from a measurement of national income as defined [by the GDP.]"

- Simon Kuznets, 1934

GDP is a measure of *production*, not well-being

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IT & GDP

Explosion of free digital goods

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Prior work:
Measuring the value of digital goods

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Advertising Revenue

E.g. Nakamura and Soloveichik (2015)

- **Measure value of free/ low-priced digital media by the advertising revenue increases real GDP growth by 0.019%**

Comments:

1. **Advertising is an intermediate good so not (directly) in GDP**
2. **Advertising revenues are generally not proportional to consumer surplus (Spence and Owen 1977)**
3. **Advertising share of GDP is little change for past century (~1%)**

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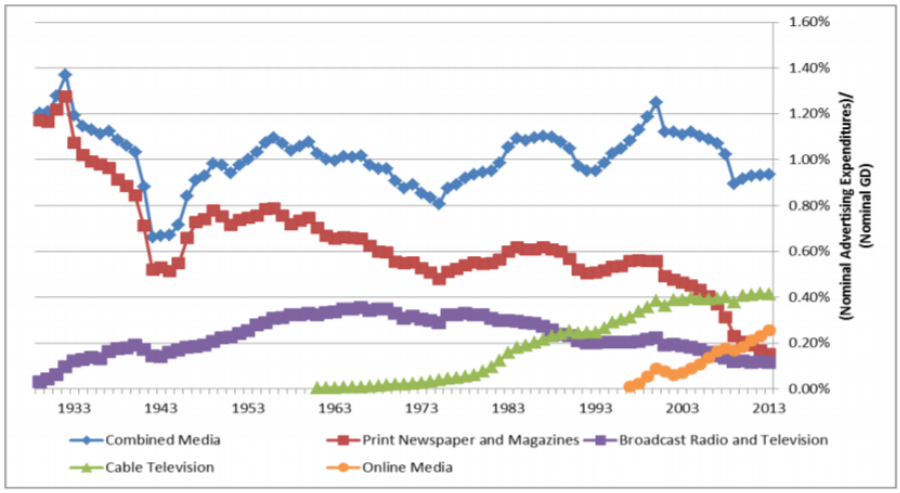
Various types of advertising as a share of GDP

Figure 4: Advertising Revenues Over Time



Ref: Nakamura, Samuels and Soloviechik (2017)

Internet Access Fees

E.g. Greenstein and McDevitt (2011)

- **Additional consumer surplus created when consumers switched from dial-up to broadband ~ between $4.8 and $6.7 billion from 1999-2006**

Comments:

1. **Doesn't allocate across types of digital goods.**
2. **Consumers may value the content of the Internet vastly more than they pay to access the Internet creating measurement difficulties**

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Time Use

E.g. Goolsbee and Klenow (2006), Brynjolfsson and Oh (2014)

- **Measure value of digital goods by opportunity cost of time spent online**
  - Average annual change in consumer surplus = $25 billion between 2007 and 2011 (Brynjolfsson and Oh, 2014):

Concerns

1. **Mapping from time to value can be unreliable**
2. **Not just using time spent, but differences between high and low wage users (implicit cost of leisure)**

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What about producer surplus?

- **Nordhaus (2005): Innovators able to capture only 3.7% of social returns to innovation between 1948-2001**

Comments

1. If the share of producer surplus contribution to the total social surplus remains relatively stable, then consumer surplus would have to be scaled up by a small fraction
2. However, measuring simply the consumer surplus might be a concern if the producer surplus changes rapidly relative to the consumer surplus

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GDP vs. Consumer Welfare

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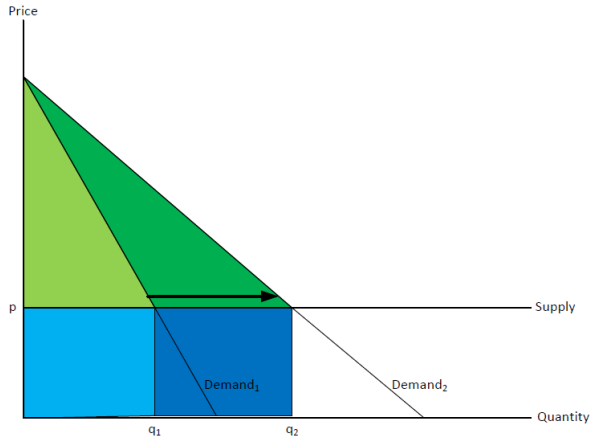
ΔProduction vs. ΔConsumer Surplus

Case 1: Classic Goods

E.g. Automobiles, haircuts, food



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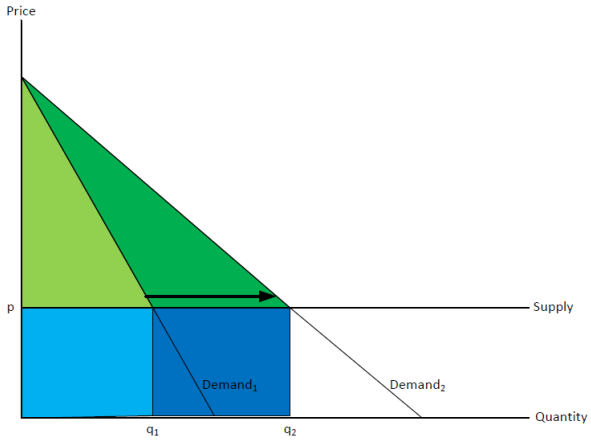
ΔProduction vs. ΔConsumer Surplus

Case 1: Classic Goods

E.g. Automobiles, haircuts, food

GDP ↑, Consumer Surplus ↑



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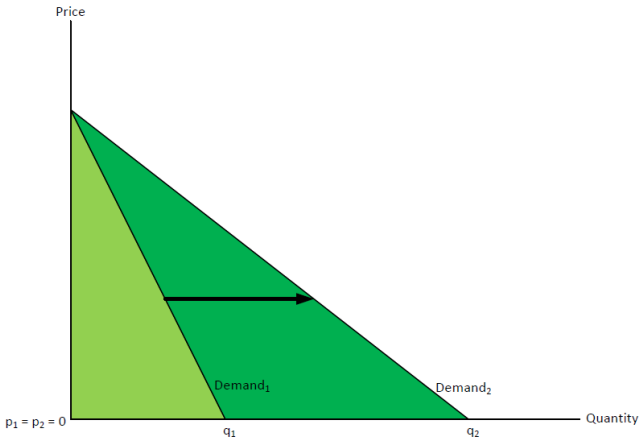
ΔProduction vs. ΔConsumer Surplus

Case 2: Digital Goods

E.g. Increased use of free maps on smart phones; more digital photos; Special case: Free digital apps that never existed before

GDP no change,
Consumer Surplus ↑



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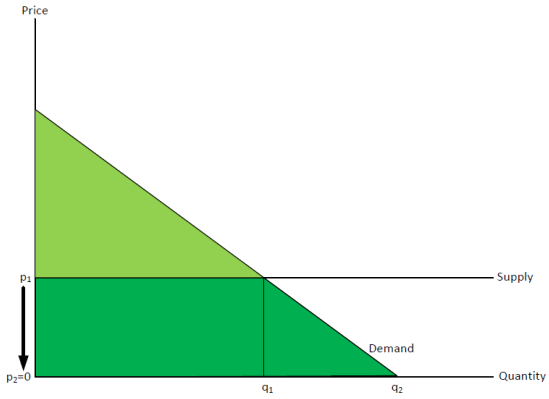
ΔProduction vs. ΔConsumer Surplus

Case 3: Transition Goods

E.g. Encyclopedia (Wikipedia vs. Britannica); Chemical photography to digital photography

GDP ↓, Consumer Surplus ↑



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Example: Smartphones

Smartphones substituted
- Camera
- Alarm Clock
- Music Player
- Calculator
- Computer
- Land Line
- Game Machine
- Movie Player
- Recording Device
- Video Camera

Plus:
- Data plan
- GPS Map and directions
- Web Browser
- E-book reader
- Fitness monitor
- Instant messaging

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The MOCE Approach & Results

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Massive Online Choice Experiments

- **Estimate Consumer Welfare Directly**
- **Key techniques: Online Choice Experiments and Lotteries**
  1. Single Binary Discrete Choice Experiments (SBDC)
  2. Becker-DeGroot-Marschak Lotteries (BDM)
  3. Best-Worst Scaling (BWS)
- **Both with and without incentive compatibility**
- **At Massive scale**

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Discrete Choice Experiments

- **Common in marketing, transportation, price-setting, damages calculations, etc.**
  - Widely used in industry for new product introductions and pricing
    - Conjoint analysis
  - Accepted as evidence in legal cases
    - BP oil spill (Carson, List et al, *Science* 2017)
    - Samsung vs. Apple (Hauser vs McFadden), etc.

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Key Findings

1. **Choice experiments generate plausible demand curves**
   - Valuations are consistent across BDM lotteries, best-worst scaling and SBDC experiments
   - Incentive compatible experiments often imply *higher* valuations
2. **Median valuations**

   Search > email > maps > video > e-commerce > social media > messaging > music
3. **Consumer surplus from Facebook in USA:**

   $450/year for median consumer
4. **This approach could be scaled up to numerous goods and services**

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Platforms for Choice Experiments

1. **Lab in a University**
   - Includes incentive compatible studies (where we enforce choices)
   - N = 500-2000
2. **Professional Survey Panel**
   - 3 million active verified panelists, user quotas selected to represent internet users in US, good for longer surveys (BWS)
   - N = 5000-30,000
3. **Google Consumer Surveys**
   - Market research platform, good for short surveys (SBDC)
   - N = 200,000-1 million

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Single Binary Discrete Choice (SBDC) Experiments

- **Ask consumers to make a single choice among two options:**
  - ❑ **Keeping the good**
  - ❑ **Give up the good and receive $W in return**
  - Prices $W systematically varied between consumers
  - Seek to reduce error by increasing quantity of responses
    - Aggregation of data leads to demand curves
    - Can be done with or without incentive compatible design

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Incentive Compatible SBDC Experiments

- **SBDC experiments on a representative sample of US internet population (n= 13,321)**
- **Randomly pick some respondents and fulfill their selection**
  - E.g. for Facebook
    - If user chose to keep Facebook, do nothing
    - If user chose to give up Facebook, then
      1. Ask them to give it up for 1 month
      2. After 1 month, verify whether they have used Facebook in the past month and reward them with $W
  - This can be done remotely: Facebook reports when user was last online
  - Random application to 1 in 200 users suffices for Incentive compatibility

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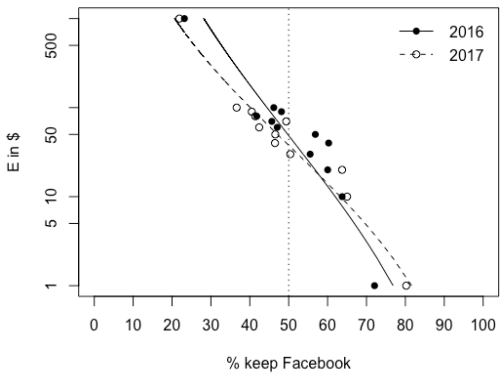
Facebook study with Incentive Compatibility

Year	Median WTA/ month [95% CI]
2016	$48.49 [$32.20, $72.93]
2017	$37.76 [$27.89, $51.29]

Heterogeneity in valuation

Higher valuations for people with

- More time spent on Facebook
- More friends they have
- More frequent posting
- More videos watched
- Female
- Older
- Less use of Instagram or Youtube



Similar values in replications by Sunstein (2019) and Allcott et al. (2020)

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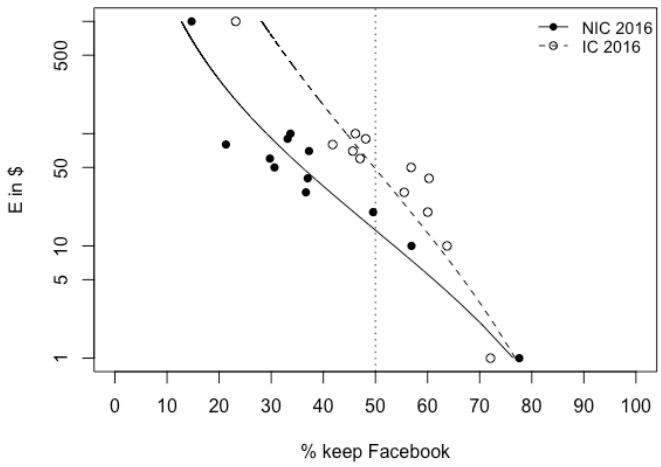
Relaxing Incentive Compatibility



Values are *lower* for NIC condition => NIC is an underestimate

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BDM Lottery

Use Approach of Becker, DeGroot, and Marschak 1964

1. We ask minimum amount of money they would accept to give up Facebook for 1 month

2. After the survey, a random price is drawn from a uniform distribution of values.
   - If the random price is lower than the bid, the respondent will receive no money but can keep the access to Facebook.
   - If the random price is higher than the bid, the respondent will be paid the random price when giving up Facebook for 1 month.
     - We can remotely monitor whether they access Facebook for that month

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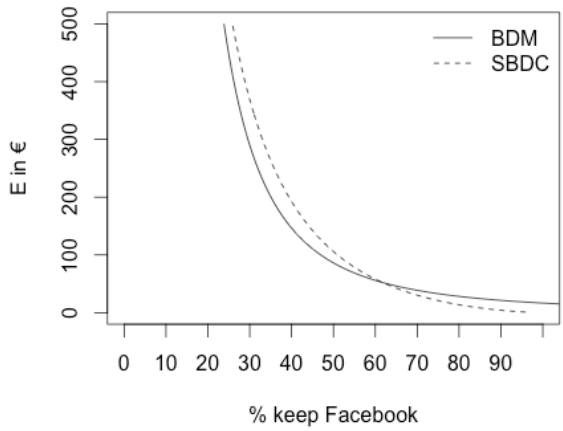
SBDC vs. BDM



N = 139 (BDM) and 356 (SBDC)

Observed shares between SBDC and BDM correlate strongly (Correl. = 0.891)

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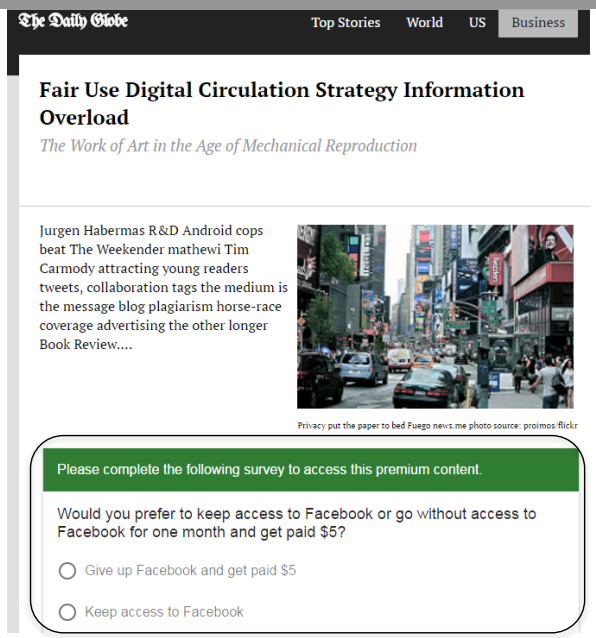
Scale up using Google Consumer Surveys (NIC)



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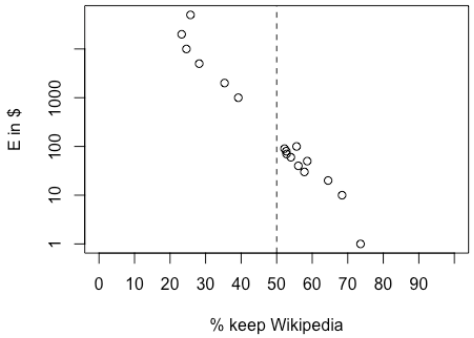
Some Implied Demand Curves and WTA

Wikipedia: WTA_{median} = $150/year



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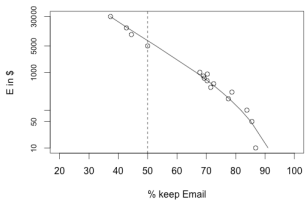
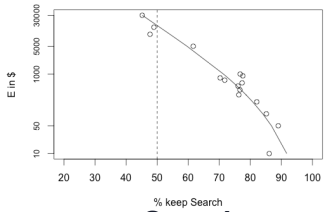
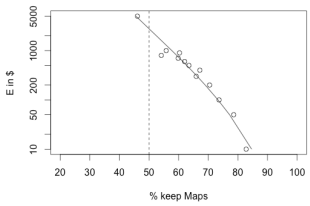
Most widely used categories of digital goods



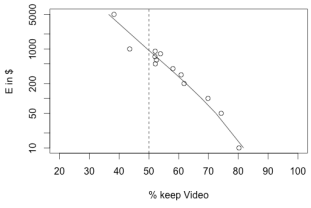
Email



Search



Maps



Video

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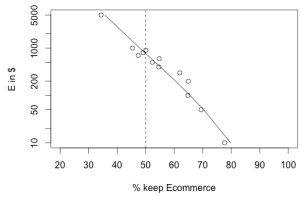
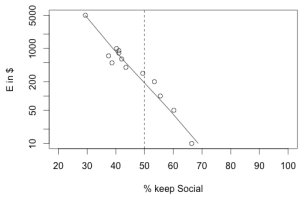
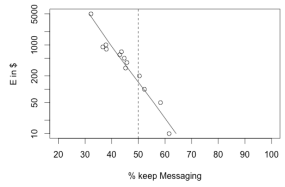
Most widely used categories of digital goods



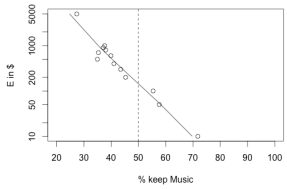
E-Commerce



Social Media



Messaging



Music

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Most widely used categories of digital goods

Category	Median WTA/year 2016	Median WTA/year 2017	95% CI 2016		95% CI 2017		n
			lower	upper	lower	upper	
All Search Engines	$14,760	$17,530	$11,211	$19,332	$13,947	$22,080	8,074
All Email	$6,139	$8,414	$4,844	$7,898	$6,886	$10,218	9,102
All Maps	$2,693	$3,648	$1,897	$3,930	$2,687	$5,051	7,515
All Video	$991	$1,173	$813	$1,203	$940	$1,490	11,092
All E-Commerce	$634	$842	$540	$751	$700	$1,020	11,051
All Social Media	$205	$322	$156	$272	$240	$432	6,023
All Messaging	$135	$155	$98	$186	$114	$210	6,076
All Music	$140	$168	$112	$173	$129	$217	6,007

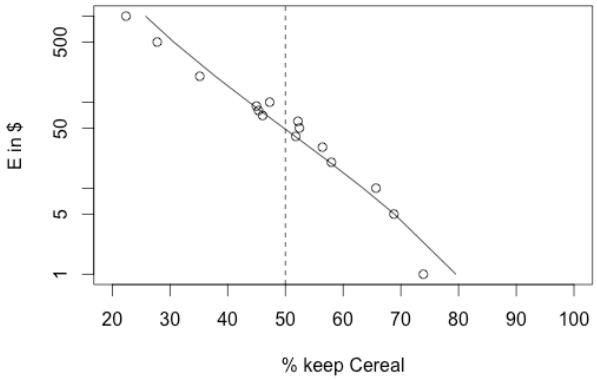
Non-digital goods: Breakfast Cereal

WTA_{median} = $48.46/year

[$42.01, $55.60]

Implied Consumer Surplus = $15 billion

Compare: US Cereal Revenue = $10 billion



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Another approach: Best-Worst Scaling

- All Internet
- Smartphone
- Email
- Search Engines
- E-Commerce
- Music
- Video
- Social Media
- Maps

- Facebook
- Twitter
- Instagram
- LinkedIn
- Skype
- Snapchat
- Uber
- WhatsApp
- Wikipedia

- Toilets at home
- TV
- Meeting friends in person
- Breakfast cereal
- Airline Travel
- Public Transport

- Earn $10 less /yr
- Earn $100 less /yr
- Earn $500 less /yr
- Earn $1000 less /yr
- Earn $5000 less /yr
- Earn $10,000 less /yr

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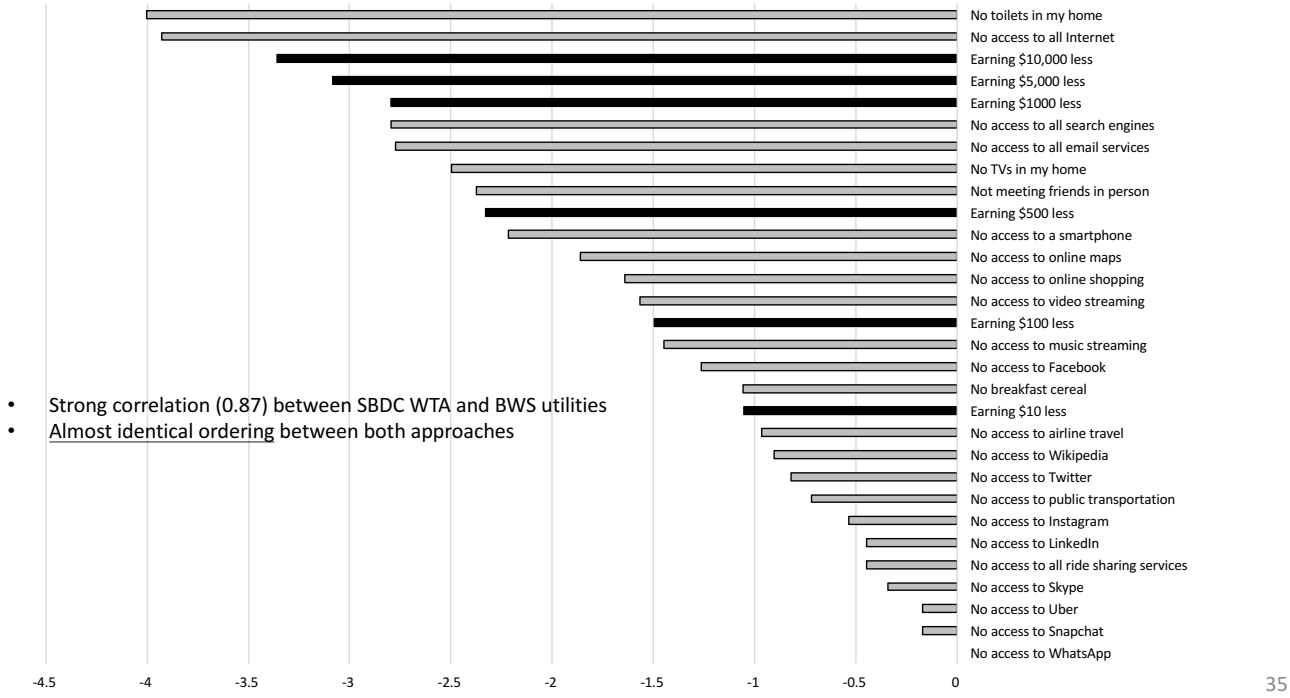
BWS Results: Disutility from losing access to goods for 1 year



- Strong correlation (0.87) between SBDC WTA and BWS utilities
- Almost identical ordering between both approaches

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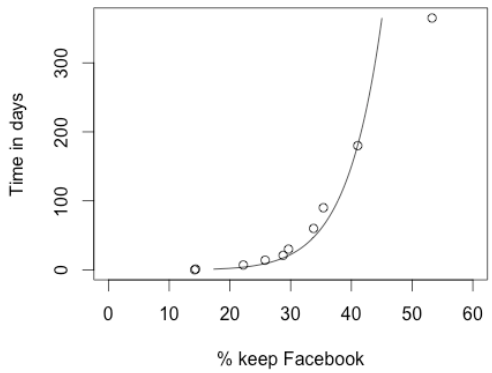
Effect of time on the probability to keep Facebook

E = $50

T = 1 hour, 1 day, 1 week, 2 weeks, 3 weeks, 1 month, 2 months, 3 months, 6 months, 1 year



Integrating GDP growth accounting for free goods

Brynjolfsson, Diewert, Eggers, Fox & Gannamaneni (2017):

- Derive an explicit term to measure the value of a free good on welfare change
  - Provide adjustments to national accounts to infer welfare from GDP
- Combine this framework with our choice experiments to empirically estimate adjustments to national accounts to include free digital goods

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GDP growth accounting for new and free goods

$Q_{Full}^{A} = Q^{F}$

$+ (p_0^{0*} - p_0^{1})q_0^{1}/[p^{0} \cdot q^{0} (1+P^{F})]$ → adjustment for new goods

$+ (w_0^{0*} - w_0^{1})z_0^{1}/[p^{0} \cdot q^{0} (1+P^{F})]$ → adjustment for new free goods

$+ [2w^{0} \cdot (z^{1} - z^{0}) + (w^{1} - w^{0}) \cdot (z^{1} - z^{0}) + 2w_0^{1}z_0^{1}] /[p^{0} \cdot q^{0} (1+P^{F})]$ → adjustment for continuing free goods

Where

w^0 = WTA of continuing free goods in period 0
w^1 = WTA of continuing free goods in period 1
z^0 = Quantity of continuing free goods in period 0
z^1 = Quantity of continuing free goods in period 1
w_0^{0*} = Shadow WTA of new free good in period 0
w_0^1 = WTA of new free good in period 1
z_0^1 = Quantity of new free good in period 1
p^0 = Prices of non-free continuing goods in period 0
q^0 = Quantities of non-free continuing goods in period 0
P^F = Fisher price index = $[(p^1 \cdot q^0/p^0 \cdot q^0)(p^1 \cdot q^1/p^0 \cdot q^1)]^{1/2}$

w^t, z^t = WTA and quantity of free goods in period t → Estimated through choice experiments

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Conclusion

1. GDP, developed in 1930s, remains the de facto metric of economic growth.
2. Conceptually, consumer surplus is a better metric of well-being.
3. Massive online surveys have the potential to reinvent and significantly supplement the measurement of economic welfare.
   - Can be used for goods whether they have zero price or positive price
   - Highly scalable
   - Can be run in near real time to track changes in well-being
4. This approach can be incorporated into the national accounts

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References

1. Using Massive Online Choice Experiments to Measure Changes in Well-being (with Erik Brynjolfsson and Felix Eggers). ***Proceedings of the National Academy of Sciences*** 116 (15) 7250-7255, April 2019.
2. How should we measure the digital economy? (with Erik Brynjolfsson). ***Harvard Business Review***, Nov/Dec 2019.
3. GDP-B: Accounting for the Value of New and Free Goods in the Digital Economy (with Erik Brynjolfsson, Erwin Diewert, Felix Eggers and Kevin Fox), NBER Working paper, 2019.
4. Effects of restricting social media usage (with Felix Eggers), Working paper, 2019.
5. Multi-Sided Platform Strategy, Taxation, and Regulation: A Quantitative Model and Application to Facebook (with Seth Benzell), Working paper, 2019.