Valuation for the accounting of free digital services

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National Bureau of Economic Research Summer Institute 2023
Conference on Research in Income and Wealth
17 to 18 July 2023

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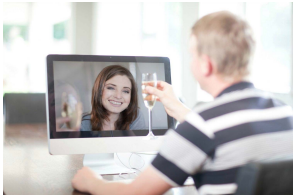
Why do we care?



- If Google or Microsoft decides to stop offering free email...
- If there is a cyber-attack that prevents us from accessing WhatsApp...
- **By how much would these events affect consumers?**
- These questions cannot be answered by official statistics.

Paper Summary

Research Goal

- Provide a road map for the compilation of a set of aggregates that incorporates the value of free digital service

What we do...

- We propose an **accounting framework** for the compilation of the value of free digital services.
- Using a common method from the National Accounts compilation, **we measure the value of three forms of free digital products for the UK**: videoconferencing, personal email, and online news.
- We **propose possible next steps** for the measurement of free digital services.

Previous efforts

Contingent Valuation

- Experiments or surveys
- Corrigan et al. (2018), Brynjolfsson et al. (2019), Nguyen and Coyle (2020), and Jamison and Wang (2021)
- Theoretical underpinnings by Schreyer (2021): **own-account production for own use.**

Total Cost

- Barter transaction between households and advertisers
- Cost of provision to impute for the value received by households
- R. Soloveichik (2015), L. I. Nakamura and R. H. Soloveichik (2015), L. Nakamura, Samuels, and R. H. Soloveichik (2017), Van Elp and Mushkudiani (2019), and Van Elp, Kuijpers, and Mushkudiani (2022)

Conceptual Framework

Firms producing market products

- Produce market goods and services purchased by households
- Spends on advertising in exchange for viewership

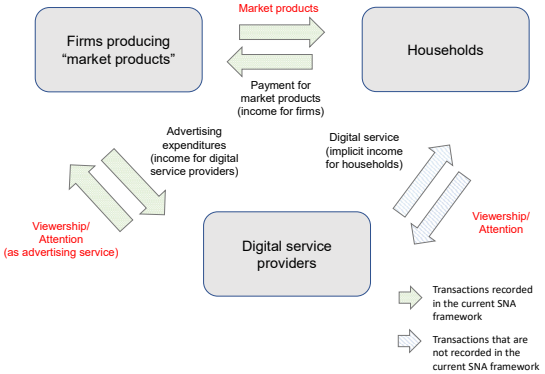
Digital service providers

- Acquire viewership from households and compensates them with digital services
- Transfer viewership to market firms in exchange for advertising expenditures

Households

- Sells viewership in exchange for digital services

Conceptual Framework



Accounting Framework

Figure: Use Table: Current SNA Application

	Oil Industry	Advertising Industry	Soap Industry	Intermediate Demand	Final Demand	Total Use		
Oil			10	10		**10**		
Advertising			10	10		**10**		
Soap				0	50	**50**		
Intermediate Consumption	0	0	20				**GDP**	**Total Use**
Value Added	**10**	**10**	**30**				50	70
Total Output	**10**	**10**	**50**					
				GDE	50		-	-
				Total Output	70			

Accounting Framework

- Advertising intermediate consumption $\Rightarrow$ final demand

Figure: Use Table: Barter Approach

	Oil Industry	Advertising Industry	Soap Industry	Household Viewership	Intermediate Demand	Final Demand	Total Use		
Oil			10		10		10		
Advertising			10		10		10		
Soap					0	50	50		
Household Viewership/Digital Service					0	10	10		
Intermediate Consumption	0	0	20	0	20			GDP	Total Use
Value Added	10	10	30	10				60	80
Total Output	10	10	50	10					
					GDE	60		-	-
					Total Output	80			

Accounting Framework

- Household produces viewership which it uses the produce digital services
- Value added of digital service = GO - viewership

Figure: Use Table: Proposed Approach

	Oil Industry	Advertising Industry	Soap Industry	Household Digital Service	Household Viewership	Intermediate Demand	Final Demand	Total Use
Oil			10			10		10
Advertising			10			10		10
Soap						0	50	50
Household Digital Service							25	25
Household Viewership				10		10		10
Intermediate Consumption	0	0	20	10	0	30		
Value Added	10	10	30	15	10			
Total Output	10	10	50	25	10			
						GDE	75	
						Total Output	105	

	Total Use
GDP	75
	105
	-

Empirical Requirements

How do we measure...

- Measure of Gross Output
- Measure of Intermediate Input

- Final Demand

Non-market valuation in the National Accounts

- Valuation of non-market goods is not new to the National Accounts
- Government services, services owner-occupied dwellings, groundwater, agricultural products for own use, barter transactions
- Satellite Accounts
  - Household satellite accounts
  - Ecosystem services (Environmental Satellite Accounts)
  - System of Health Accounts

Valuation of Ecosystem Services

- Environmental-Economic Accounting (SEEA) recommends various strategies for valuation
- If a market exist, what would be the price?

Examples

The use of prices from similar markets, residual value approach, productivity change method, hedonic regression, replacement cost method, travel cost method, avoided damage cost method, and simulated exchange value method and others.

Guiding principles

The use of *exchange value* to maintain consistency with the core SNA.

Valuation of Ecosystem Services

How do we choose the valuation strategy?

Atkinson and Obst (2017) recommended categories:

- ES#1 As inputs to production
- ES#2: As a substitute or a complement for the market goods
- ES#3: As a direct contributor to household utility

Measuring the value of digital services

Channels	Examples	Possible valuation methods
ES#1: As inputs to production.	Googles maps as an input to transportation services like Taxis, Google Scholar for researchers, Google Docs, Google Sheets for many industries.	Production function; change in productivity
ES#2: As a substitute or a complement for the market goods.	Amazon as a trading platform, ride-hailing apps such as Uber, food delivery apps, and online banking, free versions of goods with premium services.	Market substitutes, hedonic regression
ES#3: As a direct contributor to household utility.	Online maps, social media, and streaming sites.	Stated preferences and simulated exchange value method

Measurement the value of digital services

- Gross Value (Final Demand) of three digital services
  - videoconferencing, email, online news
- The price of substitutes as a proxy
  - But what's the substitute for free digital goods?
  - Paid versions (i.e. Zoom Premium, Skype Business, etc.).

When market prices for transactions are not observable, valuation according to market-price equivalents provides an approximation to market prices. In such cases, **market prices of the same or similar items when such prices exist will provide a good basis for applying the principle of market prices.** *Generally, market prices should be taken from the markets where the same or similar items are traded currently in sufficient numbers and in similar circumstances. If there is no appropriate market in which a particular good or service is currently traded, the valuation of a transaction involving that good or service may be derived from the market prices of similar goods and services by making adjustments for quality and other differences. (2008 SNA, par 3.123)*

Estimation Strategy

$$\underbrace{p_i}_{\text{price of premium service}} = \underbrace{p_f}_{\text{free component}} + \underbrace{p_p}_{\text{premium component}}$$

- Free component: vidoeconferencing
- Premium component: recording, breakout rooms, custom domain, etc.

Hedonic Regression

$$p_i = f(z_{i1}, ..., z_{i,n}, \varepsilon_i)$$

$$log(p_i) = a_0 + \sum_{k=1}^{K} \beta_k Z_i + \varepsilon_i$$

Hedonic Regression: Digital Services

$$log(P^t_{i,j}) = \sum_{j=1}^{J}\sum_{t=1}^{T}(\delta_j \times \tau^t) + \sum_{k=1}^{K}\beta_k Z^t_{i,j} + \varepsilon_{i,j} \quad (1)$$

i = plan type (Standard, Pro, Business, etc),
j = service provider (Zoom, Cisco Webex, Microsoft Teams, etc)
$log(p_{ij})$ = log of the prices
$Z_{i,j}$ = Matrix of other characteristics
δ_j = service provider fixed effects
τ^t = year fixed effects
$\varepsilon_{i,j}$ = random error term

We tried to make variable selection as systematic as possible variable selection

Hedonic Regression: Predicting Prices

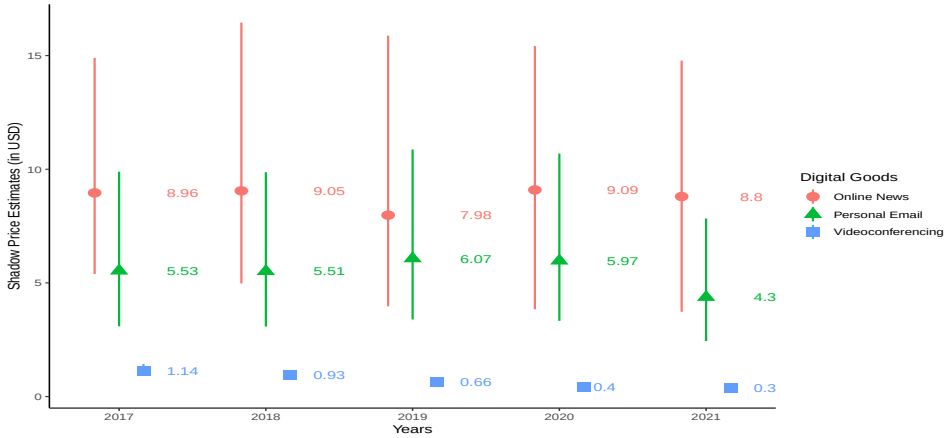
$$\hat{P}^t = \left[\frac{1}{J} \sum_{j=1}^{J} exp(\delta_j \times \tau^t) \times exp(\beta_1 log(z_1^t)) \right] \times exp(0.5 Var(\varepsilon_{ij}^t)) \quad (2)$$

- Requires us to assume a value for the continues variable
  - Participants: 7 (Maximum for Whatsapp and Messenger)
  - Mail storage: 15GB (Free Gmail and Hotmail)
- The expectation of the error term $E(log(\varepsilon_{ij}))$ should be taken into consideration in the estimation of the price, otherwise, the estimates would be biased. We employ the standard correction suggested by the literature (Pakes, 2003; Aizcorbe, 2014; Erickson, 2016).

Data

- Panel data from 2017 to 2021
- Internet Archive Wayback Machine (web.archive.org) for past year data
- Data collection was limited to characteristics posted on the website
- Availed of *free trials* to validate
- 22 service providers for videoconferencing, 13 for email, and 10 for online news.
- Observations: 243 for videoconferencing, 162 for email, and 68 for online news
- 16 characteristics for videoconferencing, 10 for email, and 7 for online news.

Results: Shadow Price of Free Digital Goods



regression results | breakdown | comparison with observed

Robustness Check

- Price estimates from hedonic regressions can be sensitive to characteristics included in the specification.
- Possibility of overfitting
- Forward, backward, and stepwise regression robustness check
- Test against a balanced panel (drop service providers that do not appear for all years)

The Gross Value of Free Digital Goods

$$V^t = \sum_{f=1}^{F} \hat{P}_f^t Q_f^t \tag{3}$$

- To estimate the aggregate value of free digital services, we multiply its imputed price, $\hat{P}_f^t$, from equation 2 to a *volume measure*, Q_f^t.

Volume measure

Combination of the UK's Internet Access Survey of the ONS (for email) and the number of users for the top three videoconferencing apps and news websites (based on Ofcom data)

The Gross Value of Free Digital Goods

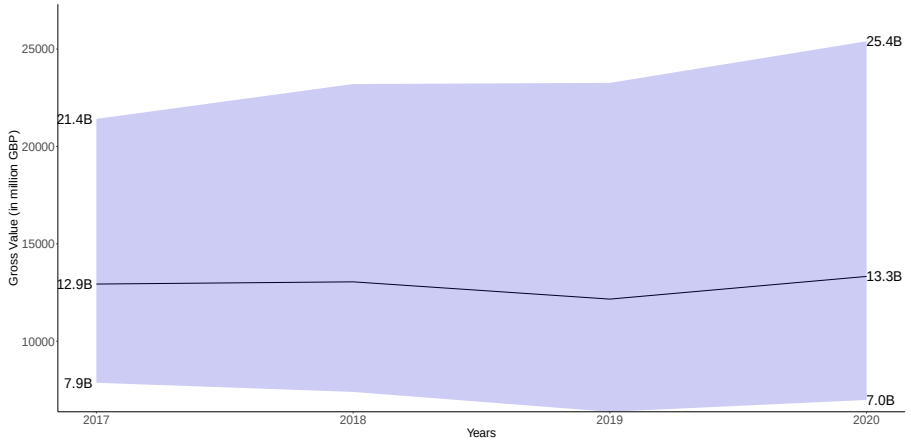
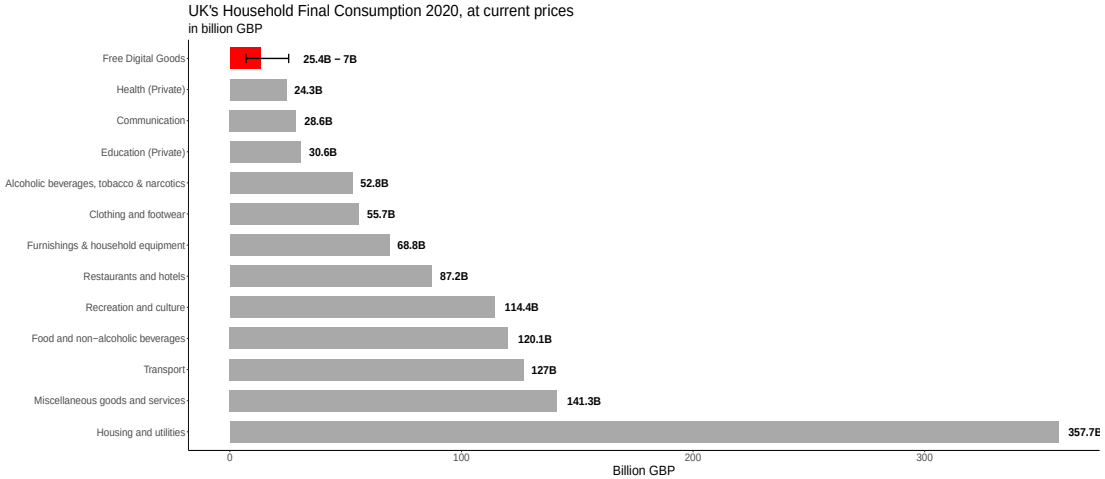


Figure: Gross Value of Free Digital Goods, at current prices

The Gross Value of Free Digital Goods



The Gross Value of Free Digital Goods

- The gross value in 2020: between GBP 7.0 billion and GBP 25.4 billion
- Makes up **0.3%** to **1.1%** of UK's **GDP**
- Makes up **0.6%** to **2.0%** of UK's **Household Consumption**
- Impact to real **GDP growth**: 0.04 to 0.12 ppts

Ways Forward

- **Household inputs**
- **Measure the value of digital services consumed by households**

Household inputs

Advertising and Marketing-Financed Digital Services

- Using advertising and marketing expenditures (similar to total cost approach)
- Reflects the willingness-to-pay of advertisers to acquire viewership

Network Inclusion as Inputs

- By joining the network, the households increase the value of the ecosystem.
- Can be exploited by service providers by selling the paid versions to other users.
- How much does an additional user contribute to the value of the network?

- Most digital services is probably a combination of both.

Value of other Digital Services used by HHs

Other digital services with paid counterparts

- Storage (Dropbox, OneDrive, Google One), office tools (Google Docs, LaTeX), dating apps, and online games.
- Digital piracy piracy

Digital services with no paid counterparts

- Social media, streaming, search engines, etc
- *Use of contingent valuation studies / stated preferences*
- Willingness to Pay versus Willingness to Accept WTP version
- Simulated exchange value example

Thank you

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Valuation in the SNA

Market prices for transactions are defined as amounts of money that willing buyers pay to acquire something from willing sellers; the exchanges are made between independent parties and on the basis of commercial considerations only, sometimes called "at arm's length." Thus, according to this strict definition, a market price refers only to the price for one specific exchange under the stated conditions. A second exchange of an identical unit, even under circumstances that are almost exactly the same, could result in a different market price. (2008 SNA, par 3.119)

back

Ecosystem Accounting

In ecosystem accounting, the primary motivation for monetary valuation using a common monetary unit or numeraire is to be able to make comparisons of different ecosystem services and ecosystem assets that are consistent with standard measures of products and assets as recorded in the national accounts. This requires the use of exchange values. In turn, this facilitates the description of an integrated system of prices and quantities for the economy and the environment that is a core motivation of the SEEA EA. (SEEA Ecosystem Accounting, par 8.2)

back

List of Regressors: Videoconferencing

- Log Participants
- Recording
- Whiteboard
- Screen Share
- File Sharing
- Breakout Rooms
- Interaction (Hand Raising, Poll, etc.)
- Virtual Background
- Admin Control
- Share Control
- Transcription
- Multiple Host
- Single Sign On

- Streaming
- Analytics
- Custom Domain
- Branding
- Local and International Calls
- Translation
- Office Integration
- Encryption
- HD Quality
- Noise Cancellation
- Multi-Share
- Calendar
- Permanent Rooms

List of Regressors: Email

- Log Storage
- Calendar
- Mobile App
- Encryption
- Custom Domain
- Virus Filter
- Aliases
- Email Template
- VPN
- Chat Function

back

List of Regressors: Online News

- Puzzles and Games
- Breaking News
- Multimedia Content
- Newsletters
- Share Subscription
- Digital Paper Version
- Premium Content
- Business/Finance Focus

back

The Model

$$U = u(x, y, z_1, z_2, ..., z_n, ; \alpha^j). \tag{4}$$

- Representative household, j with demographic traits, α household derives utility from the consumption of three types of goods:
  - Digital good, x, which can either be acquired for free or consumed as a bundle with $z_1, z_2, ..., z_n = \bar{z}$.
  - Premium-exclusive goods, $\bar{z}$.
  - Other goods y
- We assume that $u_x > 0$, $u_y > 0$, $u_{z_i} > 0$, $u_{xx} < 0$, $u_{yy} < 0$, and $u_{z_i z_i} < 0$

back

The Model

$$P(y) + P^p(x, \bar{z}) \leq w + P^f(x). \tag{5}$$

- Household pays $P(y)$ for the purchase of y
- If the households consumes x as a bundle with $\bar{z}$, he pays $P^p(x, \bar{z})$
- Exogenous income w
- Gains implicit income $P^f(x)$ when consuming x for free

back

The Model

$$\frac{P_x^f}{P_{z_i}} = \frac{P_x^p}{P_{z_i}} - \frac{u_x}{u_z} \tag{6}$$

- P_x^p, P_{z_i}: marginal expenditure from the extra unit of consumption of z and paid x, respectively.
- P_x^f: additional income from the unit consumption of x for free
- u_x, u_z: marginal utilities from the consumption of x and z, respectively.
- When consumed as bundle, x and z are complements.

back

The Model

$$P_x^f = P_x^p \tag{7}$$

- The price of premium version is equal to the shadow price of the free version
- One can argue that paid and free versions are (imperfect) substitutes.
- The use of substitute goods as a source of valuation for non-market goods is a common practice in the compilation of National Accounts
  - Imputed rentals, extraction of groundwater, and agricultural products for own consumption
  - Household satellite accounts (i.e. childcare)
- How do we untangle the shadow price of free digital from the price of premium-exclusive service?

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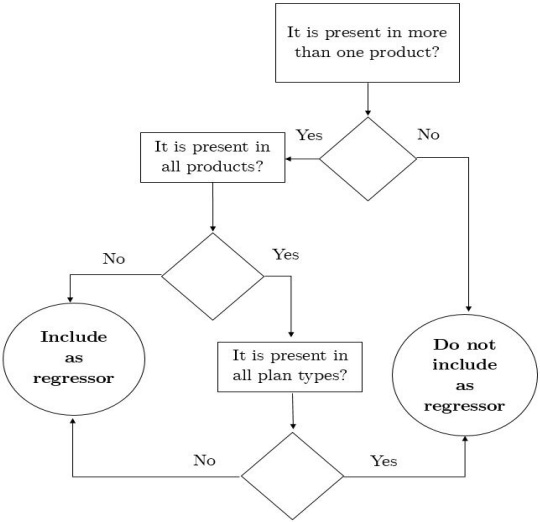
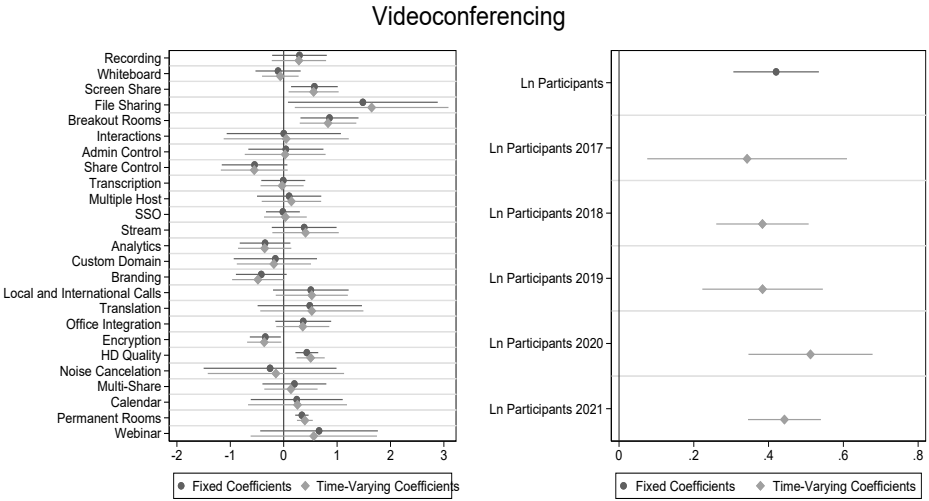
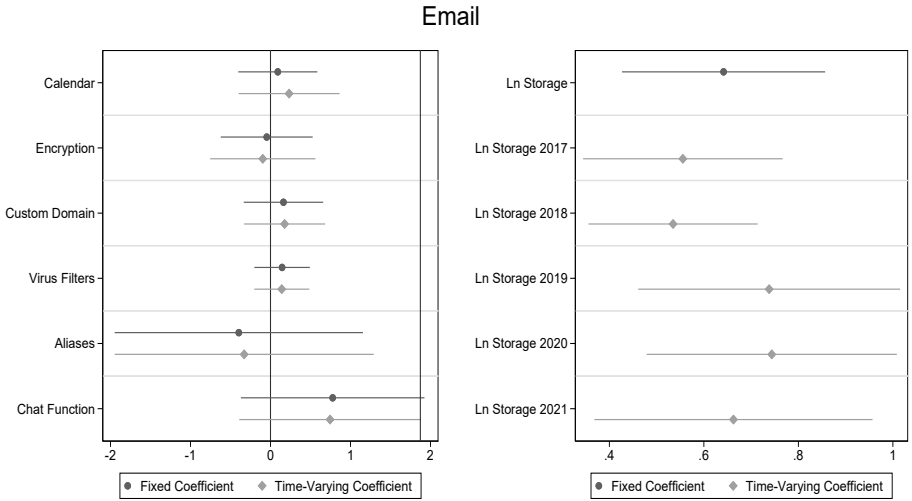
How do we choose the characteristics?



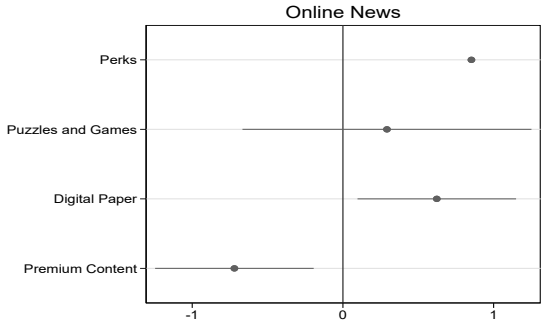
Hedonic Regression Results: Videoconferencing



Hedonic Regression Results: Email



Hedonic Regression Results: Online News



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Internet Access Survey

TABLE 5: INTERNET ACTIVITIES, 2007 TO 2020

Within the last 3 months %

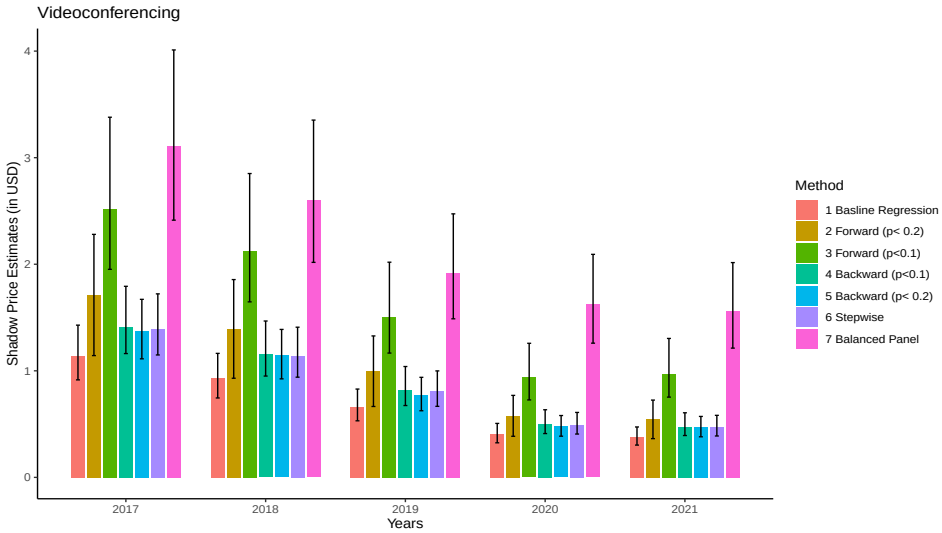
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Sending/receiving emails	57	62	68	69	:	73	75	75	75	79	82	84	86	85
Finding information about goods or services	58	59	59	58	62	67	66	73	70	76	71	77	78	81
Internet banking	30	35	41	42	44	47	50	53	55	60	63	69	73	76
Using instant messaging services (eg Skype or WhatsApp)	:	:	:	:	:	:	:	: :		:	:	:	72	71
Social networking (eg Facebook or Twitter)	:	:	:	:	45	48	53	54	57	63	66	65	68	70
Reading online news, newspapers or magazines	20	34	39	39	42	47	55	55	61	60	64	:	66	70
Watching video content from sharing services such as YouTube	:	:	:	:	:	:	:	: :		47	:	62	:	66
Listening to or downloading music	:	:	:	:	:	:	:	: :		:	:	:	:	62
Looking for health-related information (eg injury, disease, nutrition, improving health e	18	24	32	30	34	:	43	:	48	51	53	54	63	60
Watching internet streamed live or catch-up TV	:	:	:	:	:	:	:	: :		43	:	56	:	59
Watching Video on Demand from commercial services	:	:	:	:	:	:	:	: :		29	:	46	:	56
Making video or voice calls over the internet (eg via Skype or Facetime)	8	:	16	18	17	32	25	:	36	43	46	45	50	49
Playing or downloading games	:	:	:	:	:	:	:	: :		32	:	31	:	41
Selling goods or services over the internet	12	13	14	16	25	22	28	23	21	18	19	25	29	21
Making an appointment with a medical practitioner via a website or app	:	:	:	:	:	10	:	10 :		15	:	13	:	21
Using other online health services via a website or app instead of having to go to the hospital or visit a doctor, for example getting a prescription or a consultation online	:	:	:	:	:	:	:	:	:	:	:	:	:	15
Accessing personal health records online	:	:	:	:	:	:	:	:	:	:	:	:	:	8
Listening to music	:	:	:	:	:	:	:	:	:	49	:	58	65	:

Base: Adults (aged 16+) in Great Britain.

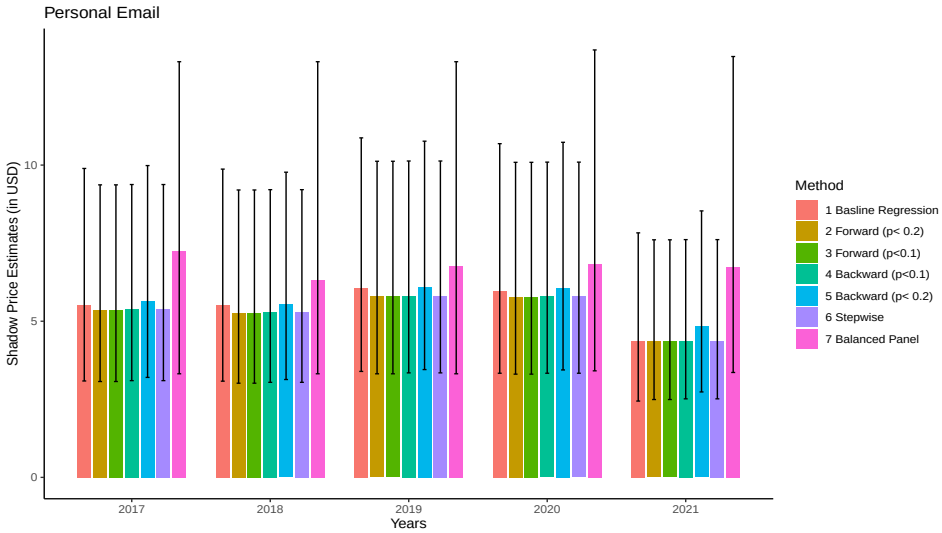
: Data not available.

Source: Office for National Statistics

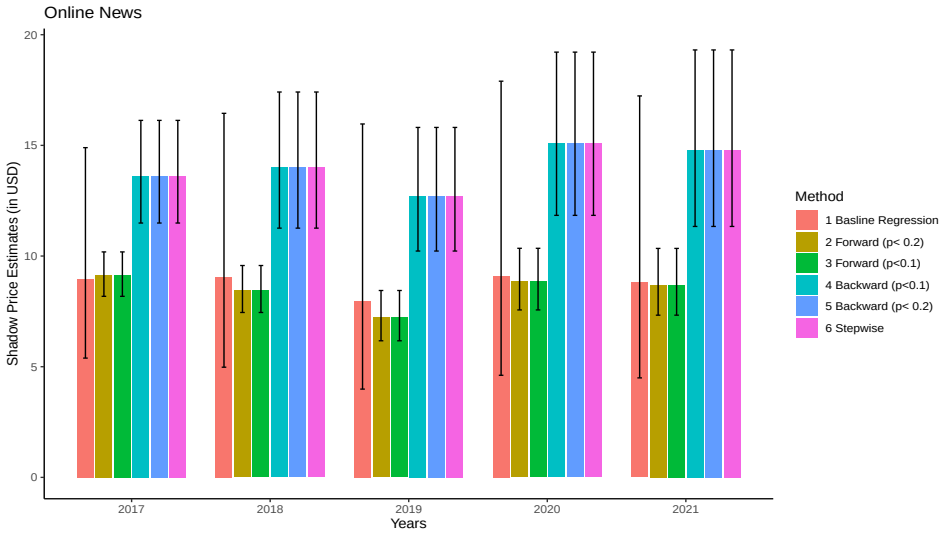
Robustness Check: Videoconferencing



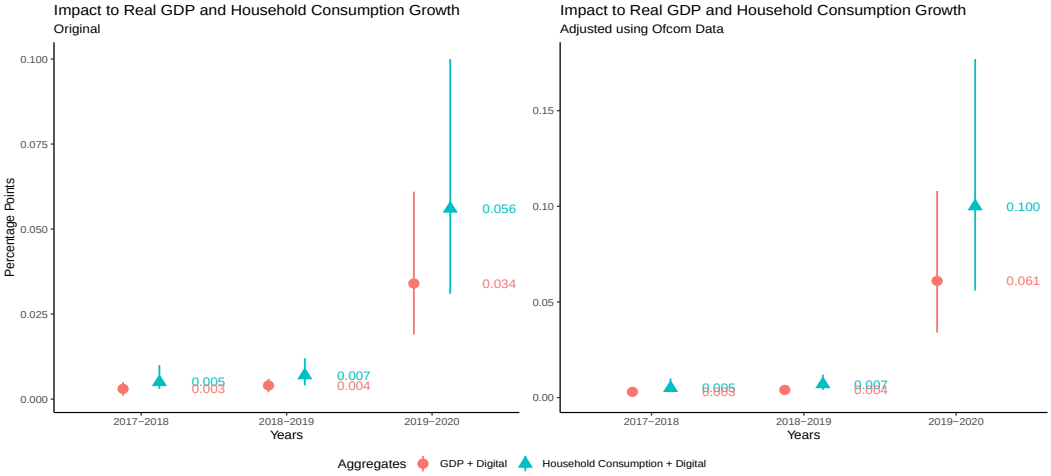
Robustness Check: Personal Email



Robustness Check: Online News



Impact to Growth Rates



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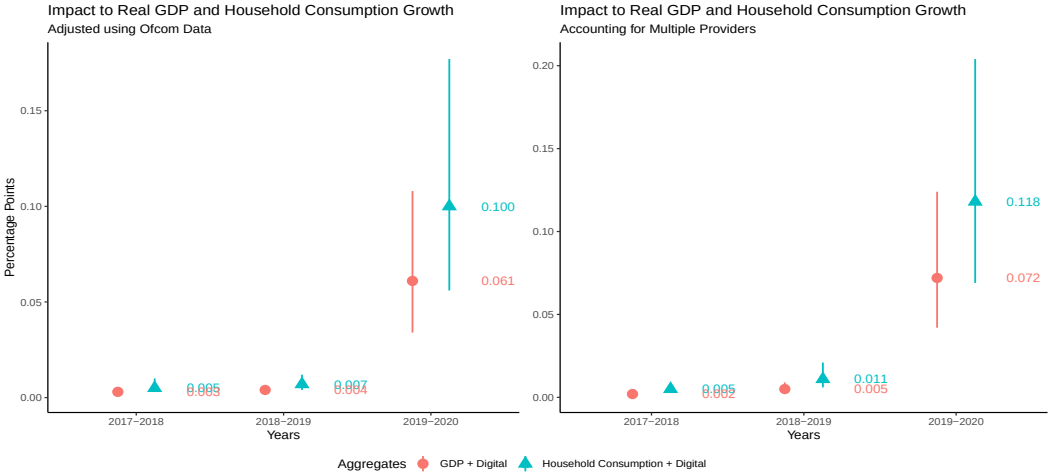
Impact to Growth Rates



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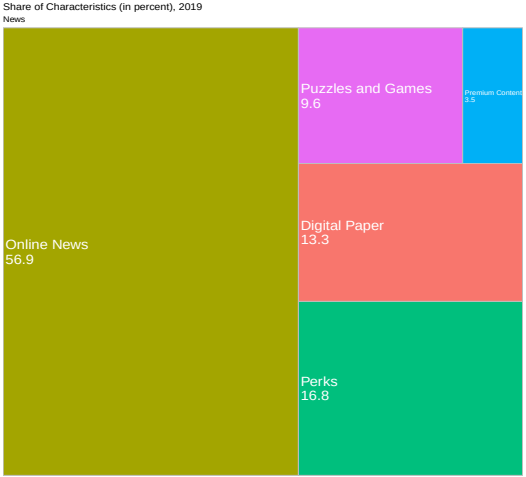
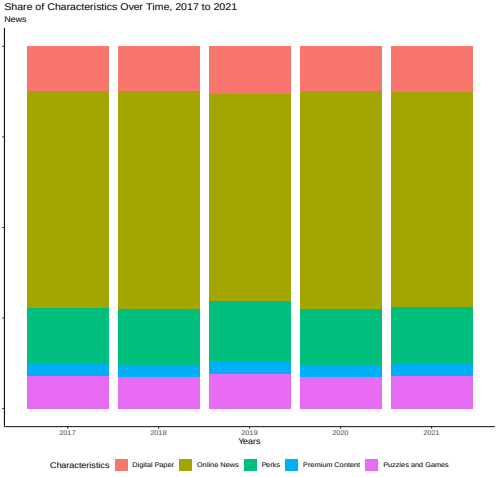
Contribution of Components





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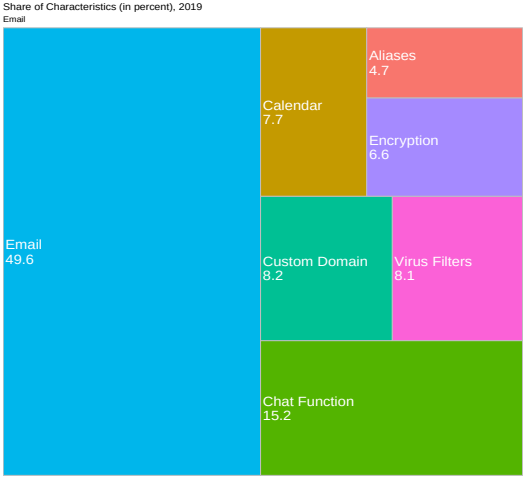

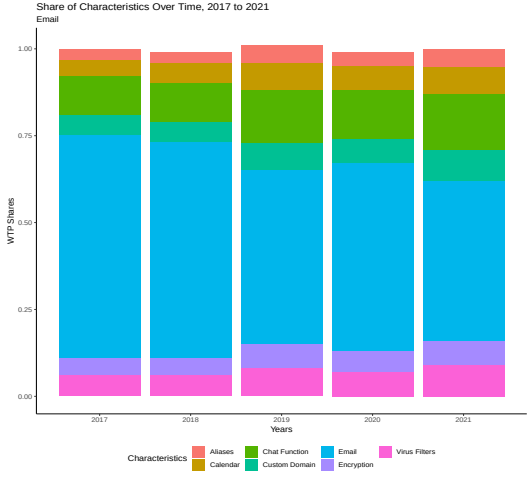

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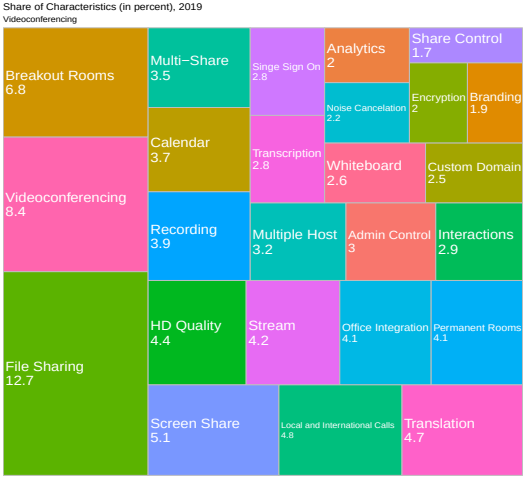

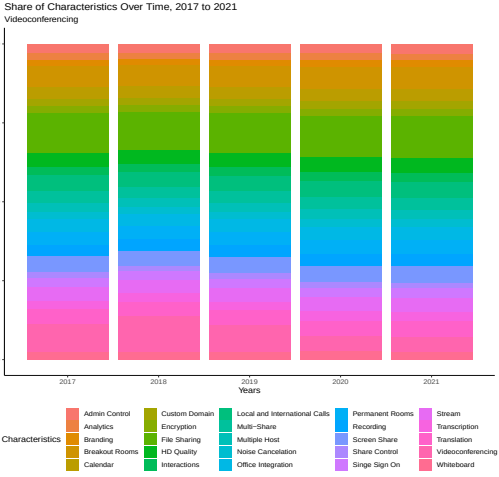

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Estimates versus observed

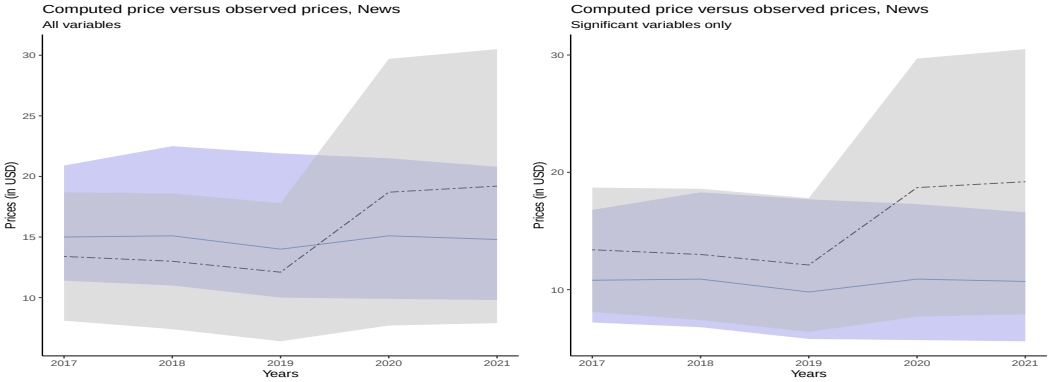

Figure: Comparison between observed (grey) and estimated price (blue) for online news

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Estimates versus observed

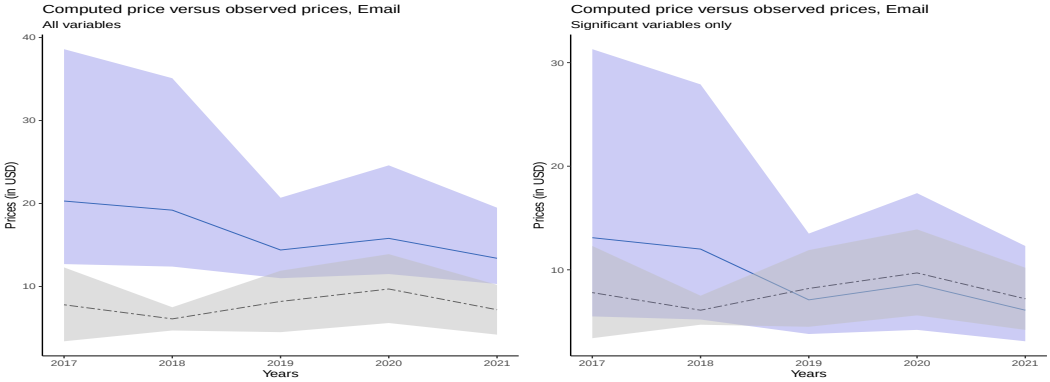


Figure: Comparison between observed (grey) and estimated price (blue) for email

back

Estimates versus observed

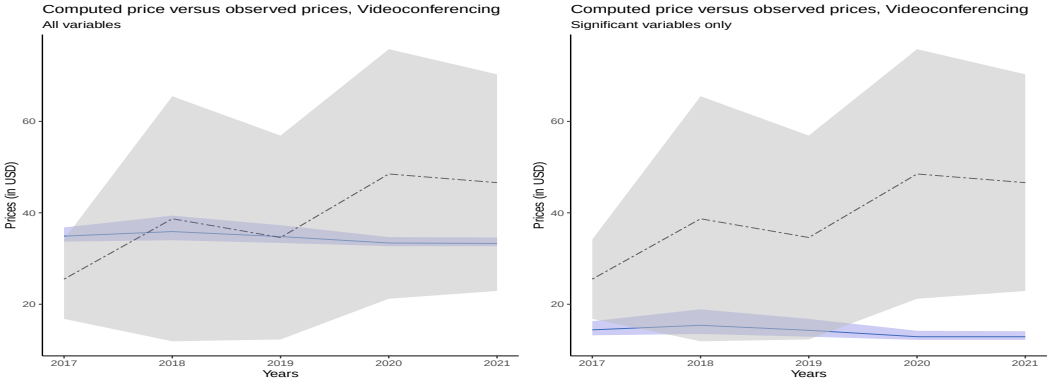
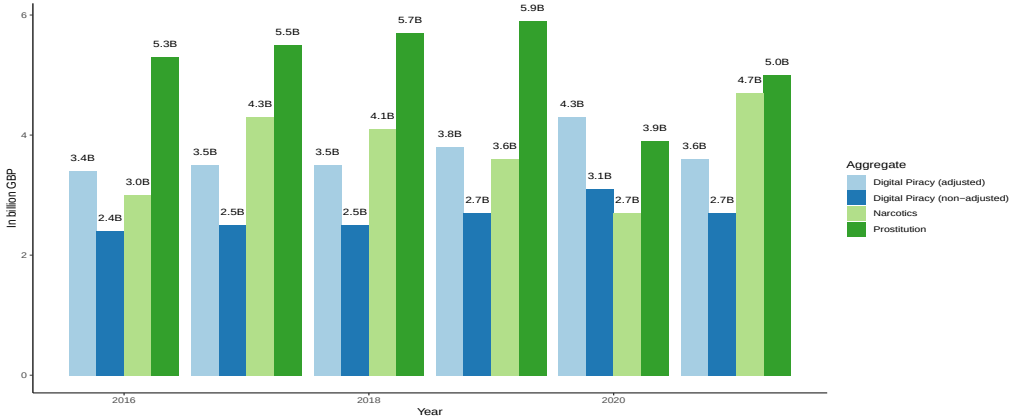


Figure: Comparison between observed (grey) and estimated price (blue) for videocalls

back

Gross Value of Digital Piracy



back

Value of other Digital Services used by HHs

Willingness to pay version

If Meta, the company that owns and operates Facebook, plans to discontinue offering the social networking site for free, what is the acceptable monthly subscription price that you are willing to pay in order to gain access to Facebook as it is now?

back

Simulated Exchange Value

back

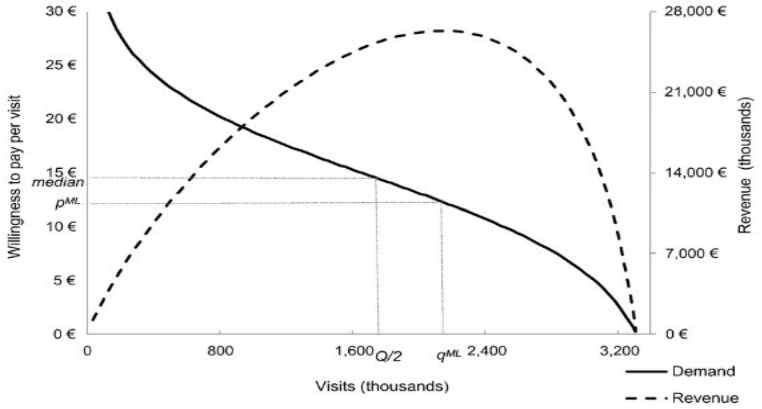


Figure: Simulated exchange value for recreational service by ecosystems in Cazorla

Value of other Digital Services used in Production

- Surprisingly, there is little work in this area!
- Critical in determining the exposure of industries to shocks in digital service provision
- How much trade would be affected if Instagram is down? What would happen to the research industry if Google Scholar is no longer available?

Possible measurement strategy

- Estimate production function.
- Time use surveys to determine how many labor hours are used accessing free digital services.