

# Measuring the Value of Free Digital Goods

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# Why do we care?

## Welfare

Production → *Consumption* → *Utility*

- ▶ We gain utility from the consumption of services that do not have market prices.
- ▶ Substitution between market and non-market goods.

## Productivity Puzzle

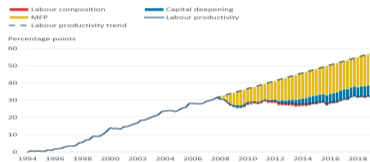


Figure: UK Labour Productivity Index

- ▶ Rapid innovation on the back of a productivity slowdown.
- ▶ Maybe we are not accounting for all the “output”?

# Paper Summary

## Research Goal

- ▶ Measure the value derived by households from the consumption of free digital goods.
- ▶ Quantify the impact of free digital goods to economic growth.
- ▶ **Coverage:** Videoconferencing, personal email, online news.

## Measurement Strategy

- ▶ Price of substitutes
  - ▶ Applied for ownership of dwellings, extraction of ground water, agricultural products for own consumption
  - ▶ Household satellite accounts
- ▶ What is the substitute? **Paid versions of free digital goods.**
- ▶ Hedonic regression to extract the value of the free component

# Spoilers: Results Preview

## Without accounting for multiple provider usage

- ▶ The gross value in 2020: GBP 3.3 billion and GBP 11.4 billion
- ▶ Impact to real **household consumption growth**: 0.06 to 0.18 ppts
- ▶ Impact to real **GDP growth**: 0.03 to 0.11 ppts

## Accounting for multiple provider usage

- ▶ The gross value in 2020: GBP 6.1 billion and GBP 22.7 billion
- ▶ Impact to real **household consumption growth**: 0.07 to 0.20 ppts
- ▶ Impact to real **GDP growth**: 0.04 to 0.12 ppts

# Empirical Literature

## Contingent Valuation

- ▶ Consumer Surplus Approach
- ▶ Experiments or surveys
- ▶ Individual's valuation
- ▶ Corrigan et al. (2018), Brynjolfsson, Collis, and Eggers (2019), Brynjolfsson, Collis, Diewert, et al. (2019), Nguyen and Coyle (2020), and Jamison and Wang (2021)

## Total Cost

- ▶ Barter Approach, SNA Approach
- ▶ 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)

# Empirical Literature

## Contingent Valuation

- ▶ Reflects the value of additional user
- ▶  $WTP < WTA$
- ▶ May introduce inconsistency with core accounting principles of the SNA SNA valuation
- ▶ Even satellite accounts seek to be consistent with the accounting principles of the SNA to preserve comparability ecosystem accounting

## Total Cost

- ▶ Consistent with SNA accounting principles
- ▶ Limited ability to capture welfare if the marginal cost of producing free goods is (close to) zero.

# Measurement Strategy

- ▶ 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: videoconferencing
- ▶ Premium component: recording, breakout rooms, custom domain, etc.



# Hedonic Regression

$$p_i = f(z_{i1}, \dots, z_{in}, \varepsilon_i) \quad (1)$$

- ▶ The hedonic regression approach assumes that the price  $p_i$  of a good  $i$  can be expressed as a function of its characteristics  $z_{in}$  and a random error term  $\varepsilon_i$ .

$$\log(p_{i,j}) = a_0 + \sum_{k=1}^K \beta_k z_{i,j} + \varepsilon_{i,j} \quad (2)$$

# Hedonic Regression

$$\log(P_{i,j}^t) = \sum_{j=1}^J \sum_{t=1}^T (\delta_j \times \tau^t) + \sum_{k=1}^K \beta_k Z_{i,j}^t + \varepsilon_{i,j} \quad (3)$$

$i$  = plan type (Standard, Pro, Business, etc),

$j$  = service provider (Zoom, Cisco Webex, Microsoft Teams, etc)

$\log(p_{ij})$  = log of the prices

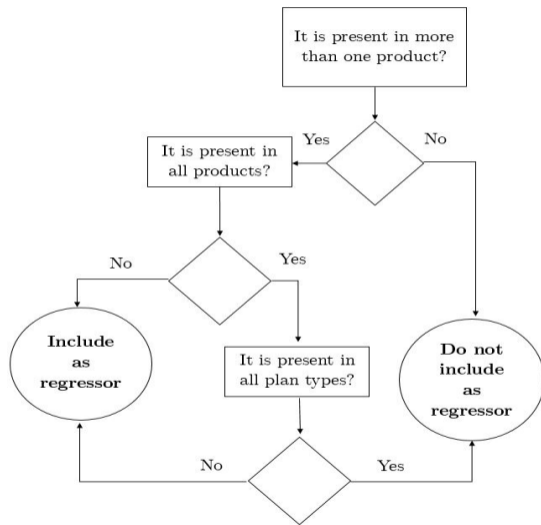
$Z_{i,j}$  = Matrix of other characteristics

$\delta_j$  = service provider fixed effects

$\tau^t$  = year fixed effects

$\varepsilon_{i,j}$  = random error term

# How do we choose the characteristics?



# Hedonic Regression

$$\hat{P}^t = \left[ \frac{1}{J} \sum_{j=1}^J \exp(\delta_j \times \tau^t) \times \exp(\beta_1 \log(z_1^t)) \right] \times \exp(0.5 \text{Var}(\varepsilon_{ij}^t)) \quad (4)$$

- ▶ Requires us to assume a value for the continuous 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

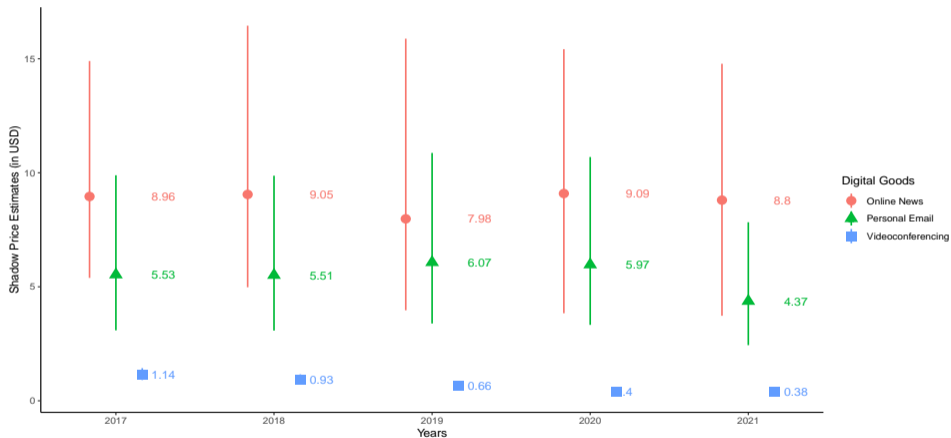
- ▶ Panel data from 2017 to 2021
- ▶ Internet Archive Wayback Machine ([web.archive.org](http://web.archive.org)) for past year data
- ▶ Acquired data of **Prices** and **Characteristics**
- ▶ Data was collected using the Rvest package of Rstudio
- ▶ Data collection was limited to characteristics posted on the website
- ▶ Aailed of *free trials* to validate
- ▶ 22 service providers for videoconferencing, 13 for email, and 10 for online news.
- ▶ 16 characteristics for videoconferencing, 10 for email, and 7 for online news.
- ▶ We collect data for 5 years.

# Data

**Table:** Table shows the descriptive statistics of prices over time

	2017	2018	2019	2020	2021
Videoconferencing					
Ave Price (in USD)	25.5	38.7	34.6	48.5	46.6
Ave Participants	72.5	228.4	237.6	173.3	183.2
Ave Price per Participant	0.8	0.6	0.4	0.4	0.4
Obs	33	37	45	59	69
Email					
Ave Price (in USD)	7.8	22.3	22.9	10.0	7.7
Ave Mail Storage (in GB)	58.8	40.0	25.6	23.0	23.2
Ave price per GB	0.5	0.9	0.9	0.7	0.5
Obs	26	30	32	37	37
Online News					
Ave Price (in USD)	13.4	13.0	12.1	18.7	19.2
Obs	14	13	13	14	14

# Results: Shadow Price of Free Digital Goods



regression results

breakdown

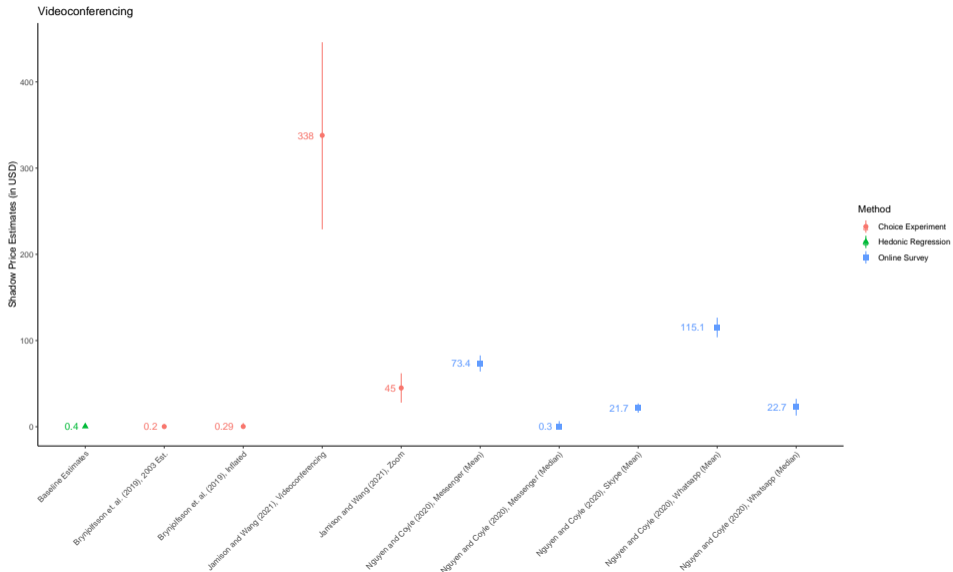
comparison with observed

# Robustness Check

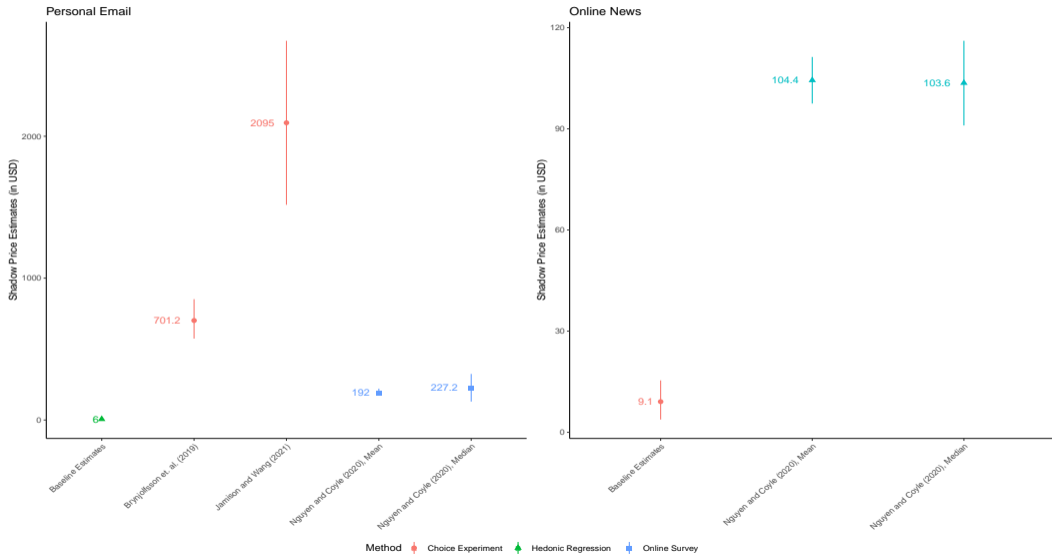
- ▶ Price estimates from hedonic regressions can be sensitive to characteristics included in the specification.
- ▶ Possibility of overfitting
- ▶ Forward, backward, and stepwise regression robustness check
- ▶ Test against a balanced panel (drop service providers that do not appear for all years)



# Comparison with other studies



# Comparison with other studies



# The Gross Value of Free Digital Goods

$$V^t = \sum_{f=1}^F \hat{P}_f^t Q_f^t \quad (5)$$

- ▶ To estimate the aggregate willingness to pay for free digital services, we multiply its imputed price from equation 4 to a volume measure.
- ▶ We use the Internet Access Survey of the ONS to estimate the number of people engaged in each activity. [ONS survey](#)
- ▶ *Caveat: Internet Access Survey was conducted January to February (before the March lockdown)*

# The Value of Free Digital Goods during the Pandemic

- ▶ Internet Access Survey was conducted January to February
- ▶ “2021 Online Nation” report of the UK’s Office of Communications (Ofcom) as an alternative volume indicator for 2020

# The Gross Value of Free Digital Goods

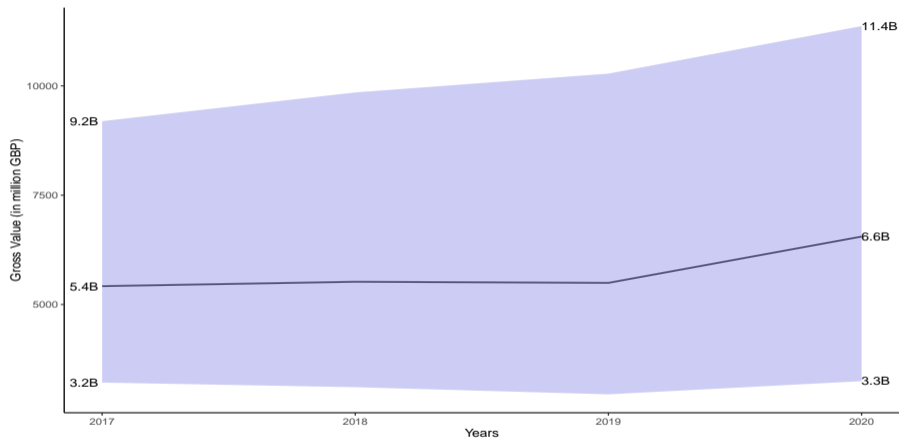


Figure: Gross Value of Free Digital Goods, at current prices

## Constant prices

We construct a standard Laspeyres Price Index for digital good  $f$ :

$$Index_f^{2019} = 100^{2018} \times (P_f^{2019} / P_f^{2018}) \quad (6)$$

We deflate the nominal gross value using the price index

$$V_{f,R}^{2019} = \frac{V_{f,N}^{2019}}{(Index_f^{2019} / 100)} \quad (7)$$

# The Gross Value of Free Digital Goods

**Table:** Growth rates of digital goods and household consumption using Ofcom volume indicators

	2017-2018	2018-2019	2019-2020
HFCE	1.03	1.14	-10.01
GDP	1.25	1.45	-9.83
Digital goods			
Point	2.33	2.83	13.53
Lower	2.26	2.98	13.54
Upper	2.37	2.72	13.51
HFCE + digital goods			
Point	1.03	1.14	-9.91
Lower	1.03	1.14	-9.95
Upper	1.04	1.15	-9.83
GDP + digital goods			
Point	1.25	1.45	-9.77
Lower	1.25	1.45	-9.80
Upper	1.25	1.45	-9.72

# Multiple Service Use

- ▶ Often, people use multiple service providers for the same purpose.
- ▶ People would often use Messenger and Telegram on top of Whatsapp.
- ▶ Read news from different sources (hopefully).



# Multiple Service Use

## Videoconferencing

- ▶ Use number of active users in the UK for Whatsapp and Messenger
- ▶ Source: Statista
- ▶ Imputed no. of Telegram users based on the proportion of downloads vs Whatsapp

## Online News

- ▶ Estimated online news readers using 2020 News Consumption in the UK Report by Ofcom
- ▶ BBC, Sky News, The Guardian, Daily Mail, Google News, Youtube, Local Newspaper, Huffington Post, ITV, BuzzFeed, MSN, LADbible, Yahoo, The Sun, The Metro
- ▶ 2018 to 2020 data only
- ▶ Imputed 2017 data using growth rates of recent years

# The Gross Value of Free Digital Goods

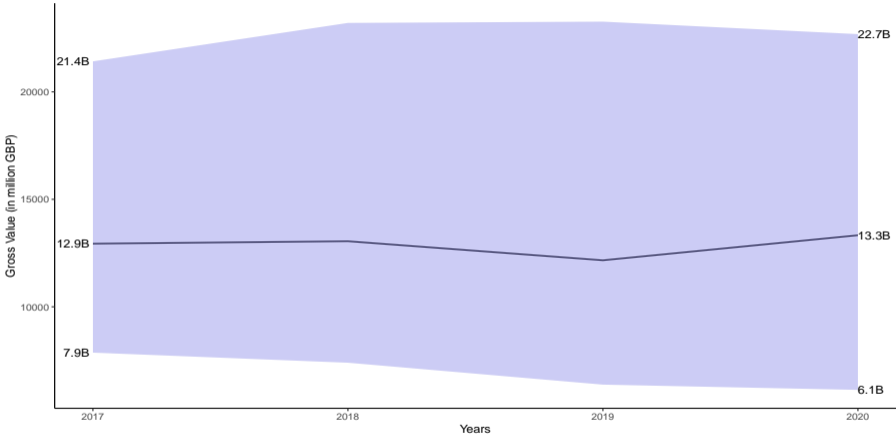
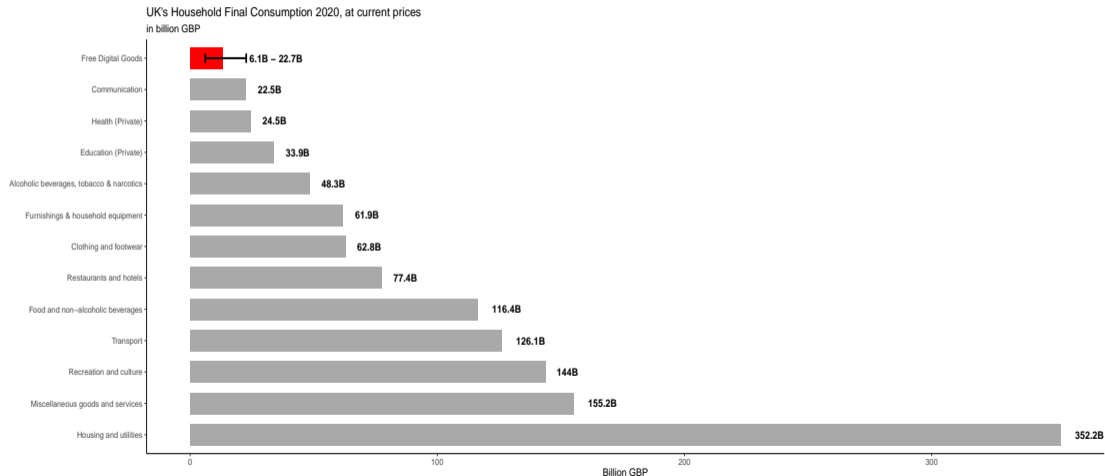


Figure: Gross Value of Free Digital Goods, at current prices

# The Gross Value of Free Digital Goods

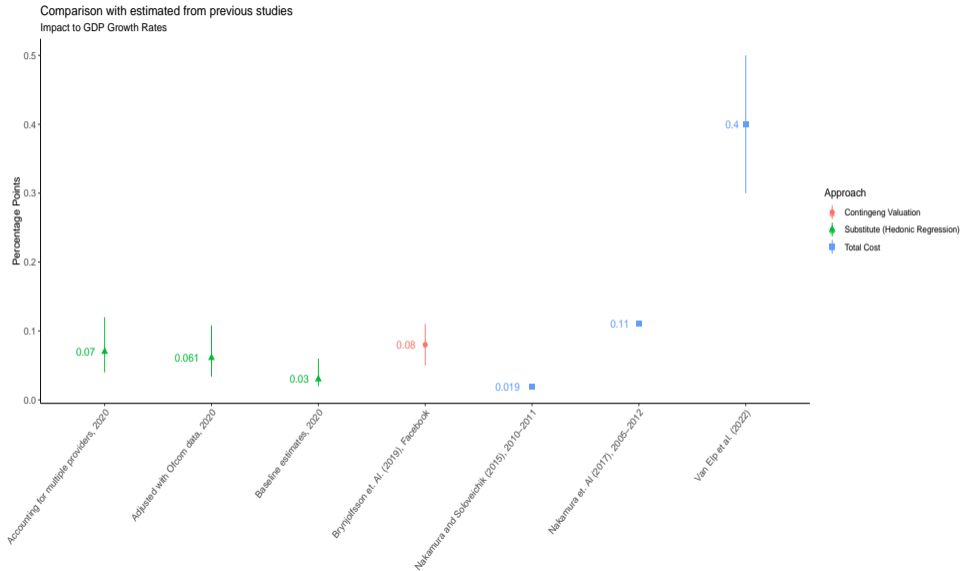


# The Gross Value of Free Digital Goods

**Table:** Growth rates of digital goods and household consumption for multiple service provider usage, at constant prices

	2017-2018	2018-2019	2019-2020
HFCE	1.03	1.14	-10.01
GDP	1.25	1.45	-9.83
Digital goods			
Point Estimate	1.51	2.25	1.90
Lower	1.62	2.14	2.24
Upper	1.43	2.32	1.66
HFCE + digital goods			
Point Estimate	1.03	1.15	-9.89
Lower	1.03	1.14	-9.94
Upper	1.03	1.16	-9.80
GDP + digital goods			
Point Estimate	1.25	1.45	-9.76
Lower	1.25	1.45	-9.79
Upper	1.25	1.45	-9.71

# Comparison with other studies



# Key Takeaways

- ▶ The inclusion of even just three forms of digital goods impacts national economic aggregates.
- ▶ Free internet services helped alleviate welfare declines during the lockdown.
- ▶ However, it is not enough to offset total welfare loss.

# Ways Forward

- ▶ Accounting framework (for a Satellite Account)
  - ▶ How do we derive gross value added?
  - ▶ Free digital goods as intermediate input and intermediate inputs to free digital goods
  - ▶ Factor income?
- ▶ Better measures of volume
- ▶ Incorporating network effects
- ▶ Productivity statistics
- ▶ Cross-country comparison [Whatsapp](#)

# Ways Forward

## Extensions

- ▶ Games
- ▶ Software (Assets or Goods?)
- ▶ Video and music streaming
- ▶ Dating Apps
- ▶ Digital Piracy (working on a separate paper) prelim results



# 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

## MEETING

/host/month billed annually

£2

10 Participants

£4

25 Participants

£6

50 Participants

£8

100 Participants

- ✓ Storage for 10 recordings ⓘ
- ✓ Video conferencing (up to 25 video feeds)
- ✓ Embed meeting widget
- ✓ International dial-in numbers
- ✓ Record meetings
- ✓ Multiple email reminders
- ✓ Lock and host private meetings
- ✓ Give keyboard and mouse control
- ✓ Advanced moderator controls

## WEBINAR

/host/month billed annually

£12

25 Attendees

£18.34

50 Attendees

£24.84

100 Attendees

£50

250 Attendees

- ✓ Storage for 25 recordings ⓘ
- ✓ Embed registration widget
- ✓ Registration moderation
- ✓ International dial-in numbers
- ✓ Record webinar
- ✓ Automated emails
- ✓ Email customization
- ✓ Change presenters during webinar
- ✓ Add co-organizers

We're Online!  
How may I help you today?



# Data

Table: Sample data set

Provider	Plan Type	Year	Price (in USD)	z1 Participants	z2 Encryption	z3 HD	...	zk Calendar
Provider 1	Plan 1.1	2017	15	50	0	0	...	0
Provider 1	Plan 1.2	2017	20	60	1	0	...	0
Provider 1	Plan 1.3	2017	30	100	1	0	...	1
Provider 2	Plan 2.1	2017	10	100	0	0	...	1
Provider 2	Plan 2.2	2017	20	150	0	0	...	1
...	...	...	...	...	...	...	...	...
Provider J	Plan J.1	2017	8	5	0	0	...	0
Provider J	Plan J.2	2017	15	60	0	1	...	0
Provider J	Plan J.3	2017	30	150	0	1	...	0
Provider J	Plan J.4	2017	50	200	1	1	...	0
Provider 1	Plan 1.1	2018	15	60	0	0	...	0
Provider 1	Plan 1.2	2018	20	70	1	0	...	0
...	...	...	...	...	...	...	...	...
Provider J	Plan J.4	2020	80	800	1	1	...	0

# 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

$$U = u(x, y, z_1, z_2, \dots, z_n; \alpha^j). \quad (8)$$

- ▶ Representative household,  $j$  with demographic traits,  $\alpha$  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  $z_1, z_2, \dots, z_n = \bar{z}$ .
  - ▶ 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

$$P(y) + P^p(x, \bar{z}) \leq w + P^f(x). \quad (9)$$

- ▶ Household pays  $P(y)$  for the purchase of  $y$
- ▶ If the household 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

$$\frac{P_x^f}{P_{z_i}} = \frac{P_x^p}{P_{z_i}} - \frac{u_x}{u_z} \quad (10)$$

- ▶  $P_x^p$ ,  $P_{z_i}$ : marginal expenditure from the extra unit of consumption of  $x$  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

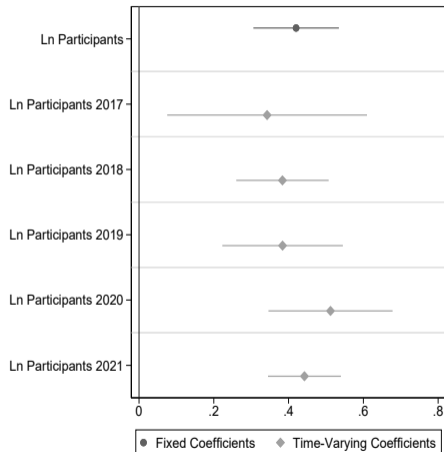
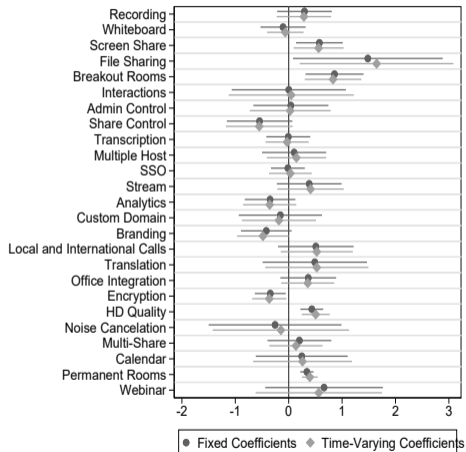
# The Model

$$P_x^f = P_x^p \quad (11)$$

- ▶ 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?

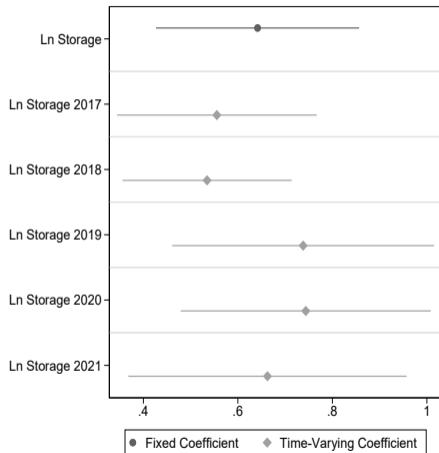
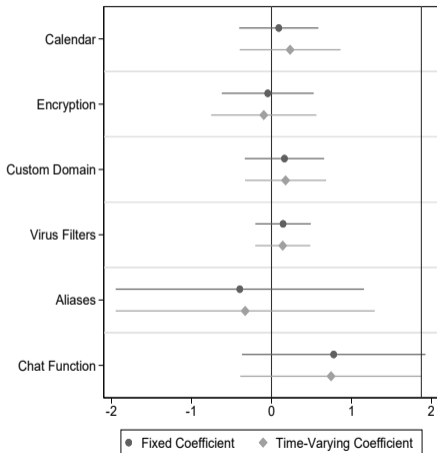
# Hedonic Regression Results: Videoconferencing

## Videoconferencing

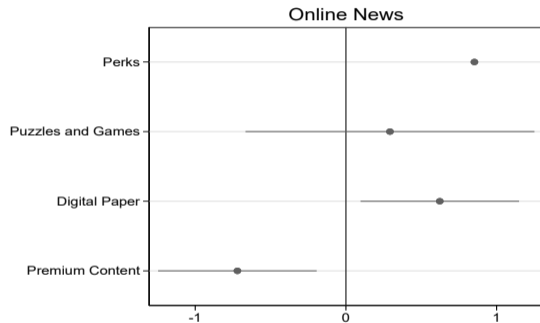


# Hedonic Regression Results: Email

## Email



# Hedonic Regression Results: Online News



back

# 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.

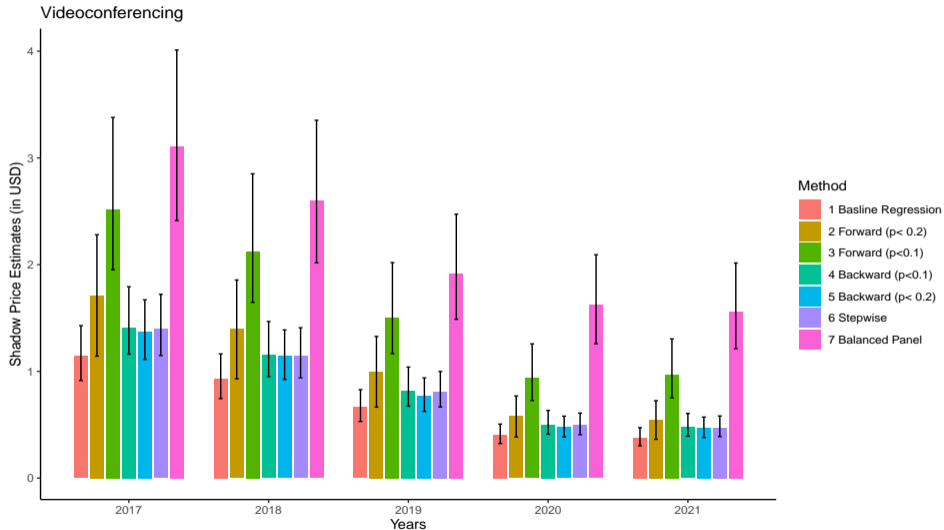
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Source: Office for National Statistics

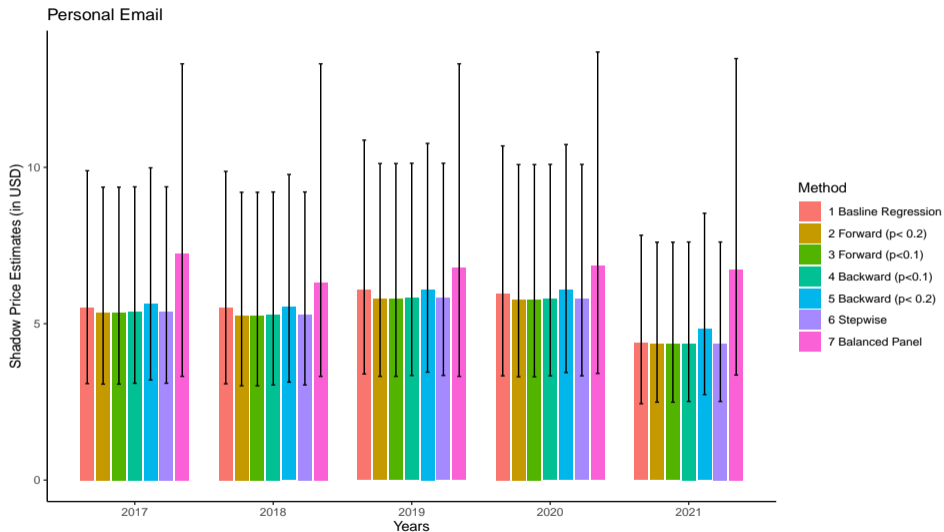




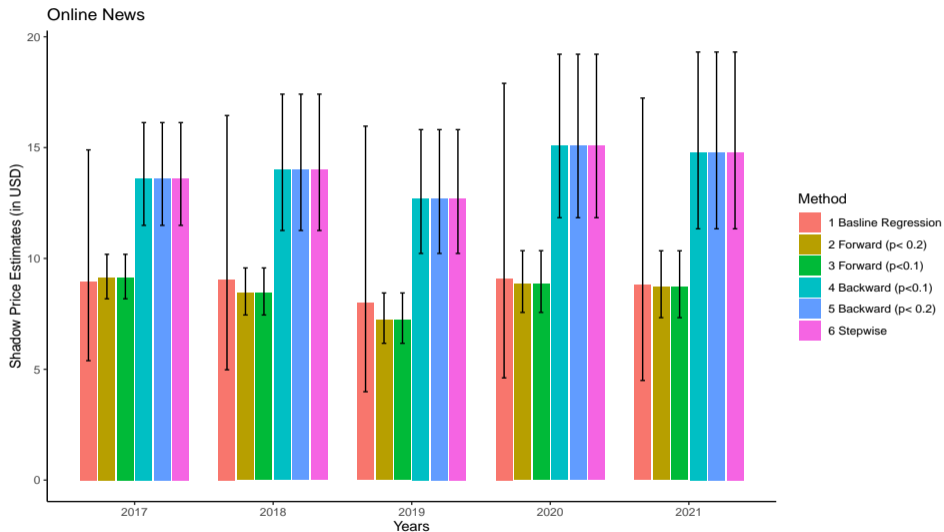
# Robustness Check: Videoconferencing



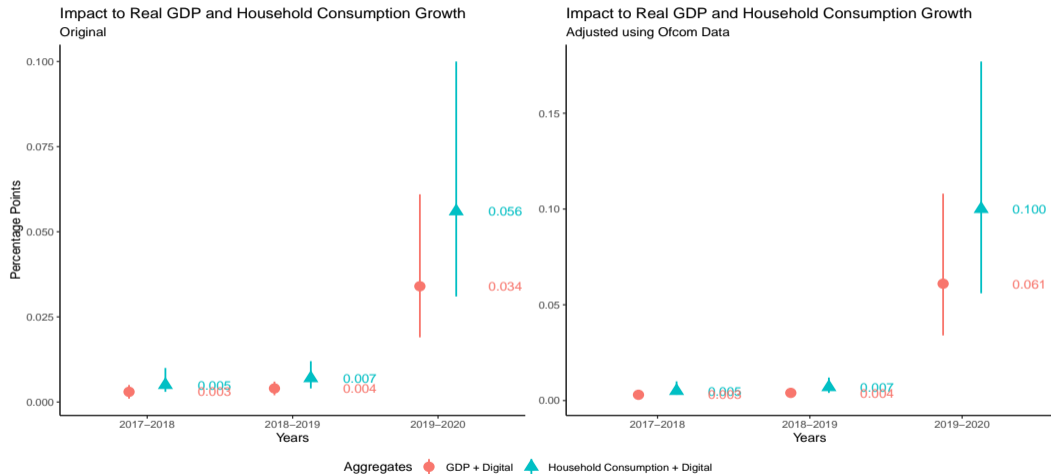
# Robustness Check: Personal Email



# Robustness Check: Online News

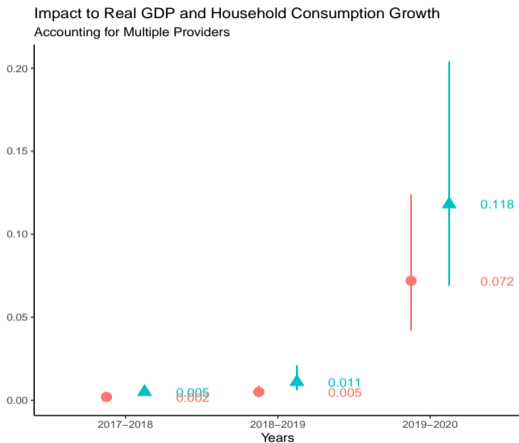
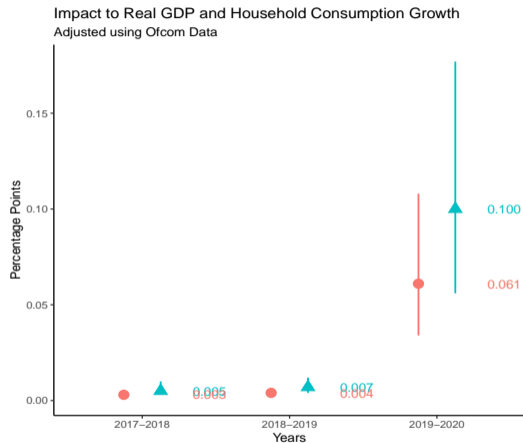


# Impact to Growth Rates



back

# Impact to Growth Rates



Aggregates ● GDP + Digital ▲ Household Consumption + Digital

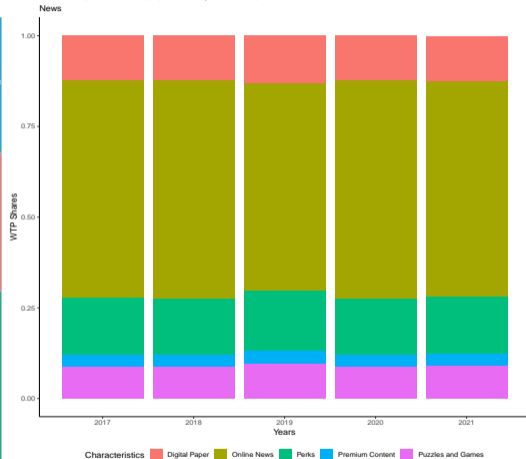
back

# Contribution of Components

Share of Characteristics (in percent), 2019



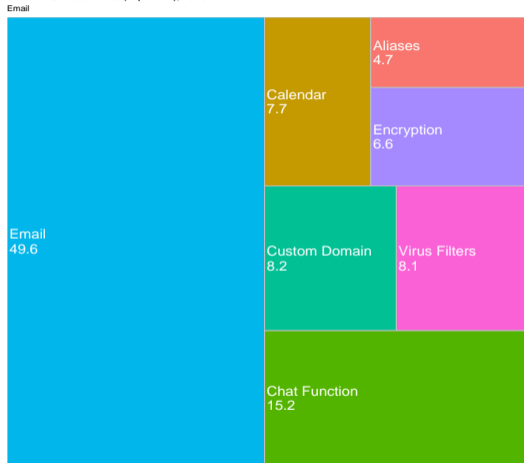
Share of Characteristics Over Time, 2017 to 2021



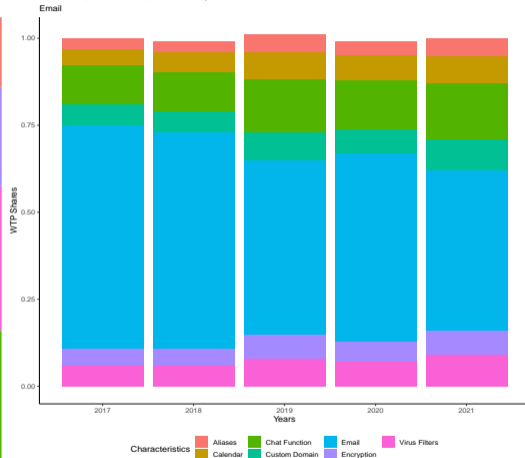
back

# Contribution of Components

Share of Characteristics (in percent), 2019



Share of Characteristics Over Time, 2017 to 2021



back

# Contribution of Components

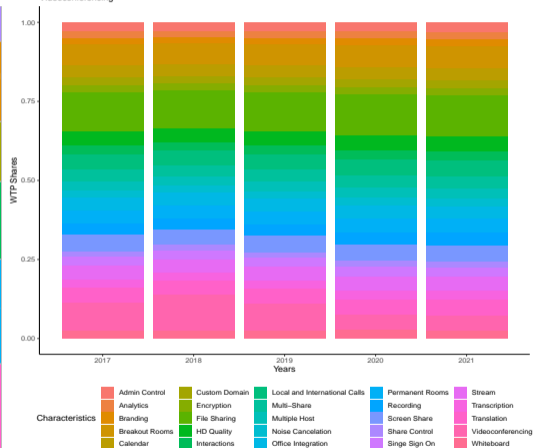
Share of Characteristics (in percent), 2019

Videoconferencing



Share of Characteristics Over Time, 2017 to 2021

Videoconferencing





# Estimates versus observed

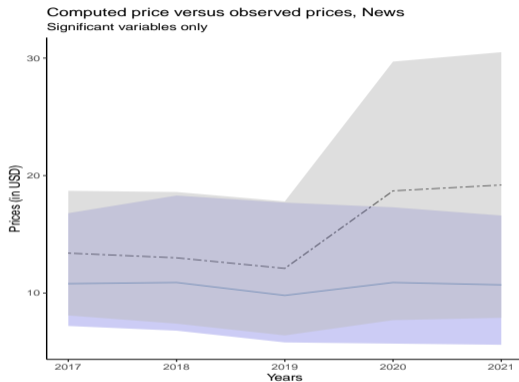
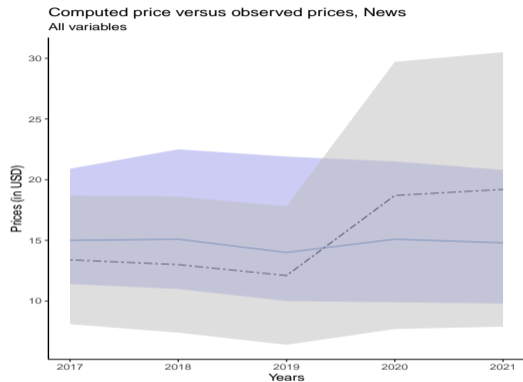


Figure: Comparison between observed (grey) and estimated price (blue) for online news

# Estimates versus observed

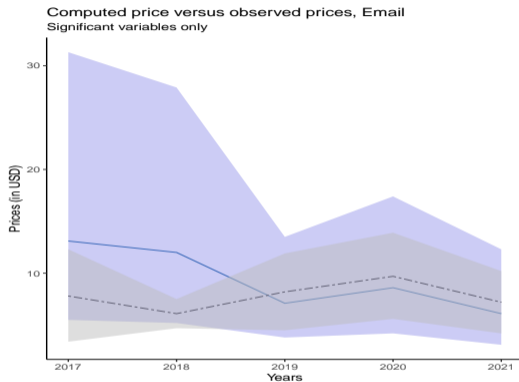
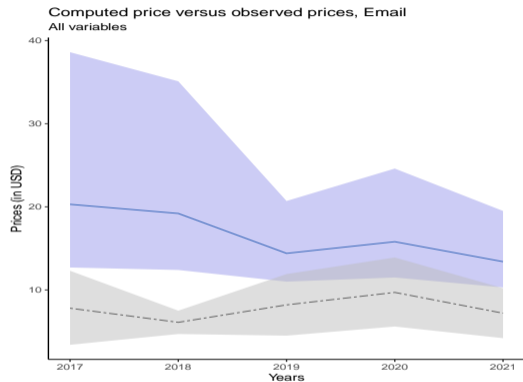


Figure: Comparison between observed (grey) and estimated price (blue) for email

# Estimates versus observed

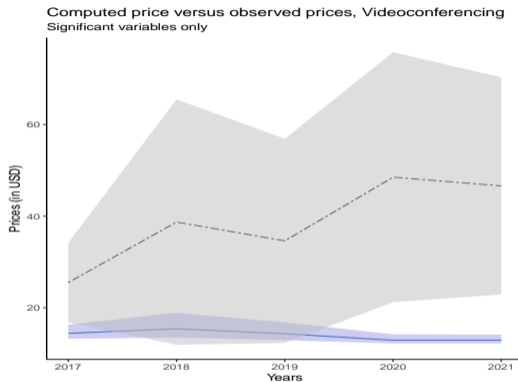
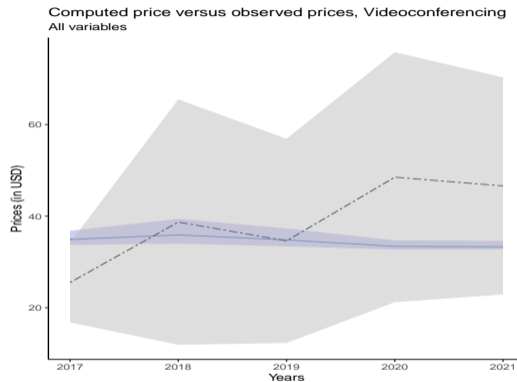
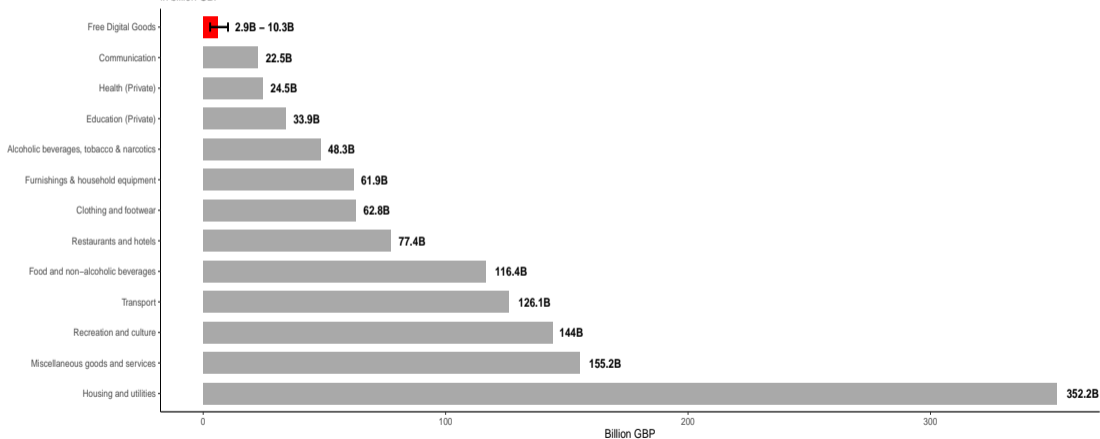


Figure: Comparison between observed (grey) and estimated price (blue) for videocalls

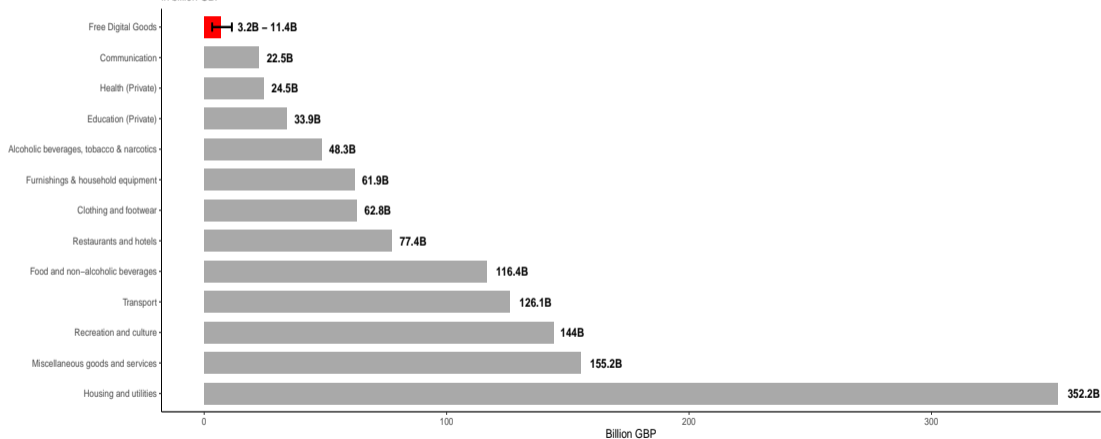
# Comparison with other Expenditure Items

UK's Household Final Consumption 2020, at current prices  
in billion GBP

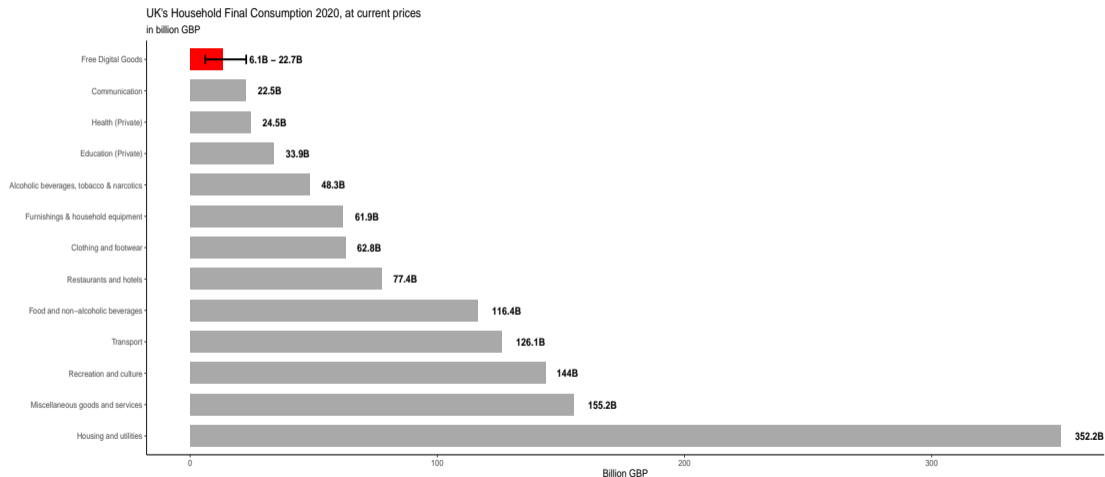


# Comparison with other Expenditure Items

UK's Household Final Consumption 2020, at current prices  
in billion GBP



# Comparison with other Expenditure Items



# Cross-Country Comparison

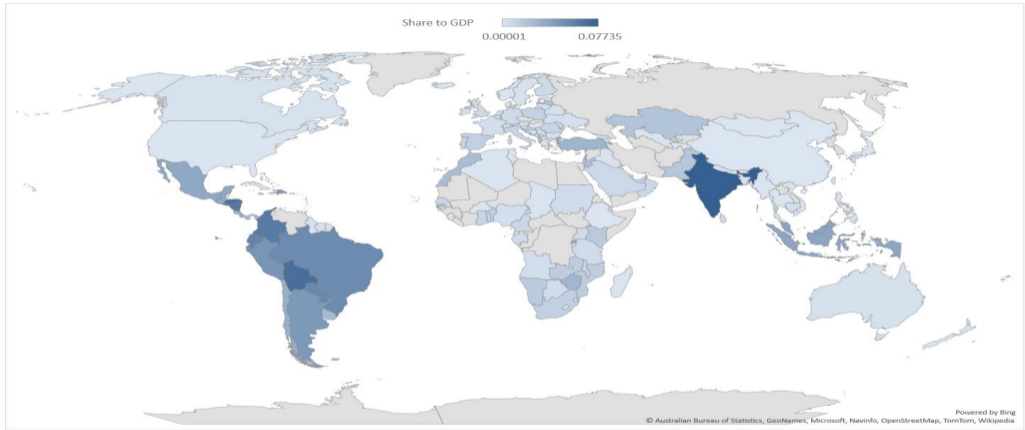


Figure: Share of Videoconferencing to GDP using Whatsapp as volume indicator

# Gross Value of Digital Piracy

**Table:** Gross value of digital piracy and final consumption of recreation and culture, at current prices

	2016	2017	2018	2019	2020
Music	1,294	1,171	1,242	1,315	1,190
TV and Film ver 1	998	982	1,035	1,093	997
TV and Film ver 2	1,546	1,422	1,254	1,074	931
TV and Film ver 3	1,272	1,202	1,145	1,083	964
Digital Piracy 1	2,292	2,152	2,277	2,408	2,187
Digital Piracy 2	2,840	2,593	2,496	2,389	2,121
Digital Piracy 3	2,566	2,373	2,387	2,398	2,154
Recreational and culture	131,754	140,067	145,233	151,097	144,023

back



# Gross Value of Digital Piracy

Table: Growth rates of digital piracy GV and final consumption of recreation and culture

	2016-2017	2017-2018	2018-2019	2019-2020
Digital Piracy 1	-5.95	2.55	-0.48	-9.20
Digital Piracy 2	-5.57	2.19	-1.15	-9.17
Digital Piracy 3	-5.75	2.36	-0.83	-9.18
Recreation and culture	4.00	1.59	2.85	-5.8
Recreation and culture + Piracy 1	3.83	1.61	2.8	-5.85
Recreation and culture + Piracy 2	3.66	1.62	2.74	-5.91
Recreation and culture + Piracy 3	3.50	1.63	2.68	-5.96

back