Valuation of Digital Goods During the Coronavirus Outbreak in the United States

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We examine how the Coronavirus pandemic affected consumer valuation of digital services. Governments responded to the pandemic with various forms of lockdowns and social distancing, leading to increased dependence on digital services for work, social engagement, and leisure activities. We identify consumer valuations through surveys where respondents express their reservation prices for digital services such as email, search, and social media. We compare our results to surveys done in 2016 and 2017 and find an about five-fold increase in valuations.

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The outbreak of the Coronavirus (COVID-19) has provided significant disruptions to the economy and people's everyday lives. The virus emerged in China in late 2019 and China first let the rest of the world know about the virus in early January 2020. Within four months one-third of the world's population was in lockdown, including roughly 80% of Americans. (Kaplan, Frias and McFall-Johnsen 2020; Page, Fan, and Khan 2020; Secon, Woodward, and Mosher 2020)

These lockdowns restrict people's abilities to work, spend, and conduct business, which slows economies: In March, the United Nations Conference on Trade and Development estimated the slowdown would cost $1 trillion to $2 trillion worldwide. (UNCTAD 2020) At about the same time Goldman Sachs estimated that US gross domestic product could drop 34% in the second quarter of 2020, followed by a rapid recovery if the restrictions are removed quickly. (Cox 2020)

People in lockdowns look for substitutes for physically congregating and for moving from place to place. For many people, this means increased reliance on the internet and related services. In the United States, NCTA (2020) reported that on a nationwide basis, downstream internet use (data flowing into people's homes) increased 20.1% in March and upstream internet use (data flowing from people's homes) increased 27.7%. In New York, the state most severely affected as of April 1, 2020, the increases were at or slightly above the national average: 20.1% downstream and 34% upstream.

People outside the US responded in similar fashion and service providers responded to the changes. Facebook (2020) reported at one point that messaging was up about 50% in countries hardest hit by the virus. Network usage was also up in Europe, so much so that networks struggled to keep up, prompting the European Commission to ask video content providers to decrease the amount of bandwidth their services required. (Alexander 2020)

Government-imposed lockdown and voluntary social distancing – a term adopted to describe how people keep their physical distance from each other to decrease the

chances of the virus moving from one person to another – affect also how people use mobile communications. On April 2, 2020, Verizon reported decreases in mobile handoffs, the instances where a person's communications session moves from one cell site to another as the person moves around. These were "significantly down in the New York Metro area (-53%) and Upstate New York (-49%) vs. a typical day. Other metro regions like the Mid-Atlantic/greater Washington, D.C. metro area and New England follow with declines of -39% and -37%, respectively, with Southern California declining -35% and Northern California down -27%. Nationally, mobile handoffs have dropped -29% versus a typical day." (Verizon 2020) People were moving around significantly less during lockdowns than before.

Verizon also witnessed a ten-fold increase in its customers' use of collaboration tools, applications that enable customers to see and speak with colleagues, friends and family. Use of other services also increased: at one point, gaming more than doubled, use of virtual private networks was up 40%, video was up 33%, and web use was up 24% relative to normal times. (Verizon 2020)

These increases in usage imply that such services became more valuable to people during the pandemic. How much people increased their valuation is an important question for at least two reasons. One is that it indicates how central to people's lives and work these services are during the pandemic. This informs policymakers as it helps put dollar values to developing information infrastructure. A second reason is that valuation enables more accurate estimates of the economic impacts of the pandemic. As Brynjolfsson, Collis, and Eggers (2019) (hereafter, BCE) explain, the value of many digital services is missing from estimates of national income, so this increased value of digital services could be missing from calculations of the magnitude of the economic downturn.

We estimate the increased value of digital services with surveys comparable to those done in 2016 and 2017 by BCE. We find that people's valuations were about five-fold higher on average in March 2020 than three years earlier. More

specifically, we find that the median U.S. consumer consuming all nominally free digital services we study was unwilling to part ways with them even if compensated $12,907.43 to do so. We also find that the valuations rose during our survey period, providing support for the notion that the pandemic was responsible for much of the increased value.

In addition to adding to the literature on valuing services that have zero monetary prices, our study adds to the literature on the digital divide. Pew Research reports that 58% of eighth-grade students in the United States use the internet for doing homework, but 17% teens ages 13 to 17 are often or sometimes unable to complete homework assignments because of a lack of reliable access to a computer or internet. This is particularly acute in low-income and racially black households. (Auxier and Anderson 2020) Gonzales (2015) adds that internet services used by the poor in the United States is unstable and characterized by frequent periods of disconnection. The U.S. Census Bureau found that 18% of U.S. households lacked internet access in 2016 and Friemel (2014) observes that lack of internet access hinders households' economic activity because many public and private services are designed for online access. Little has been done by way of cost-benefit analysis of closing the digital divide, and what has been done has not benefited from a quantification of the value of internet services during times of emergency.

The remainder of this paper proceeds as follows. Section I describes our approach. Section II provides our results and Section III is our discussion. Section IV is the conclusion.

I. Methods

We use a stated preference approach, which is a method often used in environmental economics to uncover how much people value goods and services,

called their reserve prices[1]. The values represent people's willingness to accept (WTA) a payment in exchange for giving up a service. Hanemann (1991) shows that WTA gives similar results as willingness to pay (WTP) except when there are no close substitutes for the services in question. We find price elasticities of demand expressed as WTA are quite inelastic for the services we study, indicating that there are few substitutes at least in the short run. Therefore, our WTA estimates should be different from what would be found in WTP studies.

We conducted our surveys using Google Surveys by asking people how much they would need to be compensated to forgo various digital goods for one month. A person's answer implies that the good in question is at least worth this much to the consumer, all other things being equal. To improve validity, we used multiple Google online surveys in which various price points were presented to randomly selected consumers in simple take-it-or-leave-it offers. Previous research found Google Surveys results to be very comparable to those obtained by other professional public survey organizations, such as when comparing Google Surveys results to Pew research. (Stephens-Davidowitz and Varian, 2015).

We began our surveys on March 20, 2020 and ended on April 1st. Google Surveys allowed us to choose our audience and ask up to ten questions at a time in a variety of formats. Google provides incentives for people to participate and protects the respondents' privacy. To be timely and to provide results that could be compared to those of BCE, we chose to survey persons in the United States. Each person was asked a single question: "Would you give up *y* for one month with a compensation of $*x*?" where "*y*" is the service (e.g., email) and "$*x*" is a price randomly selected within ranges that we chose. At each price point, 250 samples

[1] This refers to individual reserve prices, rather than the "price" at which no individual elects to keep the good in question.

were chosen. We obtained 14 to 20 price points per category, equating to a sample size of 3,500 to 5,000 per category of digital goods.[2]

Since the dependent variable in our study is a binary outcome of whether the consumer will report keeping the digital good or giving up the digital good in exchange for the amount hypothetically offered, We analyzed our data with a binary logit regression model, where we assumed the log-odds of the event that the consumer reports keeping the digital goods is linearly related to the log[3] of the "price" offered, or the WTA. In other words:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 \ln(Res.\ Price) \tag{1}$$

To categorize consumers' stated valuation of a particular digital good category, we are interested in the reservation price that makes exactly half of the consumers keep the good and half of the consumers "willing to accept" the offer and give up the digital good. i.e., the median price that is equivalent to $p = 0.5$. With some algebra, one can see that the median price thus occurs at:

$$\text{Res. Price} = \exp(-\frac{\beta_0}{\beta_1}) \tag{2}$$

We first use the logistic regression model to estimate β_0 and β_1. We then compute the median reservation price, and obtain standard errors using bootstrap methods. Note that in calculating this median price we are using a bivariate model of offer price on offer acceptance. We later examine a multivariate regression by adding available demographic variables of age, gender, and regions to the right-hand side of equation (1) to examine what matters for people's stated valuations.

[2] Inevitably, these types of surveys suffer a hypothetical bias because people do not face real choices. However, if we were to believe that people's hypothetical bias remained relatively constant during this time from 2017 to today, we can reasonably conclude that digital goods and services provided significantly greater value during the pandemic. Degree of hypothetical bias cannot be assessed unless with incentive compatible experiments, however it would seem inappropriate to conduct real-world experiments during a pandemic.

[3] Log of prices provides a better fit. Also, this transformation is used in BCE (2019) for a closer comparison between 2017 figures.

II. Results

Table 1 shows our results and compares them with BCE's findings. Column (1) lists the categories of digital goods as ranked by the 2017 valuations[4]. Search was the most valuable and instant messaging was the least. Column (2) shows the 2017 median value found by BCE. Column (3) shows the median values from our surveys, with standard errors in brackets, and column (4) shows the change in value from 2017 to March 2020. Column (5) shows the percentage change of the value during the pandemic from the 2017 value. The last two columns show the ranks of the goods categories for 2017 and for March 2020.

Following BCE, table 1's reserve prices represent the estimated median WTA payment to forgo these digital goods and services for one month, i.e., the reservation prices for which exactly 50% the population would accept the amount and forgo the service and 50% would refuse. We calculate the March 2020 reserve prices using equation (2) where we use 50% as the quantity. For completeness, table 2 records the logistic regression results.

Our results are consistent with those of BCE, except that the valuations we find are several orders of magnitude higher, presumably reflecting the increased importance of digital goods during the pandemic. Each digital good's rank in importance is the same in 2020 as in 2017, with two exceptions: E-Commerce rose from fifth to Fourth and instant messaging rose from eighth to sixth.

The first thing to notice in table 1 is the magnitudes of individual value changes. Only two goods – maps and email – have percentage changes less than 400%. That their percentage changes are the lowest makes sense as they are both highly valued products in both years, which biases their percentage changes downward even

[4] These are annual BCE values divided into monthly values. A caveat is that BCE has found a non-linear effect of time on the percentage keep, with people more likely to keep the digital good the longer the timeframe and in an increasing fashion. In Appendix II we present a method to take the timeframe effect into account for a more conservative estimate.

though they have high dollar changes: $1,394.58 for email and $853.61 for maps. The highest dollar amount change in value is Search at $7,242.50 dollars, with a percentage jump of 496%. These large value changes also make sense because people working from home are more reliant on search to find work-related information that might normally be obtained by informally asking a colleague, and more reliant on email to asynchronously engage with co-workers, customers, and vendors. This is also true for home-bound students and teachers.

People in lockdown also value search to find vital information on healthcare, government actions, and changes to essential services. Edelman (2020) describes in its special report on trust and the coronavirus that Americans place low trust in the media and politicians for accurate coronavirus information. So rather than accept the word of traditional media and government officials, Americans search the internet for what health professionals are saying. As for maps, in the first month of the ongoing pandemic, there were rampant news reports and rumors of various commodity shortages, such as face masks, hand sanitizers and toilet papers, for which map applications were useful to locate the stores with these items in stock. We suspect that the valuation of maps would subside somewhat, had similar binary choice survey been conducted in late April or May, although the rise of food and grocery delivery services might make segments of the population value these services highly. There is a large increase in the consumer valuation of E-commerce, even early in the pandemic, which we suspect only have maintained, even increased in value since then.

Table 1. Comparisons of consumers' median valuations of digital goods, 2017 versus March 2020

(1)	Reserve Price for One Month of Service			(5)	(6)	(7)
Digital Goods Categories	(2) 2017	(3) March 2020	(4) Change	Percent change	Rank 2017	Rank 2020
Search	$1,460.80	$8,703.30 [1205.80]	$7,242.50	496%	1	1
Email	$701.10	$2,095.68 [294.74]	$1,394.58	199%	2	2
Maps	$304.00	$1,157.61 [194.35]	$853.61	281%	3	3
Video	$97.75	$499.79 [60.39]	$402.04	411%	4	5
E-Commerce	$70.16	$689.70 [131.69]	$619.54	883%	5	4
Social Media	$26.80	$140.32 [14.83]	$113.52	424%	6	7
Music	$14.00	$95.89 [13.05]	$81.89	585%	7	8
Instant Messaging	$12.90	$310.73 [44.88]	$297.83	2309%	8	6
Video Conferencing	*_*	$337.54 [55.42]	*_*	*_*	*_*	*_*
Zoom	*_*	$44.93 [8.66]	*_*	*_*	*_*	*_*

Sources: Authors' calculations and BCE (2019). "Video" means streaming video, such as YouTube and Netflix. For each Mar. 2020 estimate, bootstrap standard errors are provided in brackets. See text for estimation method.

Video streaming also rose in value for both work and personal reasons. People working from home and engaging in education from home can use video streaming, such as YouTube, as an information source. Video and Music streaming for entertainment, such as Netflix and Spotify, has also increased in value since entertainment is less available from sporting events, movies, eating out, etc. Social media's value increased 424%, but it had the second lowest dollar increase. This

might reflect social media's relative unimportance for working remotely and for online education. And while it has its usefulness for staying in touch with others on a social basis, social media conversations are perhaps too public to make up for in-person conversations. It also appears that consumers view social media's information on healthcare and the like as less reliable than what is found with traditional search. (Edelman 2020)

Regarding the changes in rankings, instant messaging's rise in the ranking is understandable. Messaging apps, such as WhatsApp, are popular outside the United States and so are convenient, low-cost ways for persons in the United States to stay in touch with relatives in other countries and include multiple family members in private conversations. Instant messaging also allows people working from home to utilize a silent communication channel while on video or audio conferences and webinars. Instant messaging had the highest percentage increase, 2,309%, but that is largely because of its low 2017 value. It had the third lowest increase in dollar value, $297.83. The rise in rankings of E-Commerce was also reasonable. It has a median valuation of $619.54, with a percentage increase from 2017 of 883%. When people are largely restricted to their homes from the middle of March on, shopping and ordering things online became a much more prominent activity. Indeed, some life essentials were rumored to go out of stock in early weeks of the COVID-19 pandemic and caused people to go out of their homes to "hunt" these items down. But as the craze died down, the purchase of these life essentials and other groceries through online stores became common place.

Our results also show how price insensitive customers are for these digital products. While conducting the surveys, we noticed that expressing reservation prices in $50 or even $100 dollar increments barely affected the number of consumers rejecting the offers. As an illustration, figure 1 shows the relationships between reserve prices and the percent of respondents choosing to keep their digital goods for search and emails. Figure A1 in the appendix shows the rest of the figures

for all other digital goods and services categories. The solid lines represent the probability of reportedly keeping the digital good at the given offer price. Relative to consumer valuations in 2017, the coronavirus outbreak appears to have caused consumer valuation of these digital goods to shift upward and become more insensitive to price changes. For each category, 10% to 25% of the population is readily willing to give up these services for even $1. But the remaining consumers are largely insensitive to price, to the point that for any category, there is always some portion – generally 20% to 40% – that appears unwilling to give up the service even at very high prices.

This suggests that demand of these digital services has become more inelastic. For example, at the median price of search ($1,460.80), the price elasticity of demand[5] for search is 0.137 in absolute value[6], and at the median price of emails ($701.10), the price elasticity of demand for emails is 0.152 in absolute value.[7] This level of inelastic demand indicates that these digital goods and services are viewed as necessities in times of pandemic, possibly because users would not find alternatives in a compressed amount of time.

Although not examined by BCE, we examine video conferencing because of its importance to people working from home and to distance education. We find all video conferencing had a median monthly estimated value of $337.54, which is between the e-commerce and social media values. This is surprising given its use for work and distance education. It might be that our sample is dominated by people that are not working from home or do not have students at home. They might also

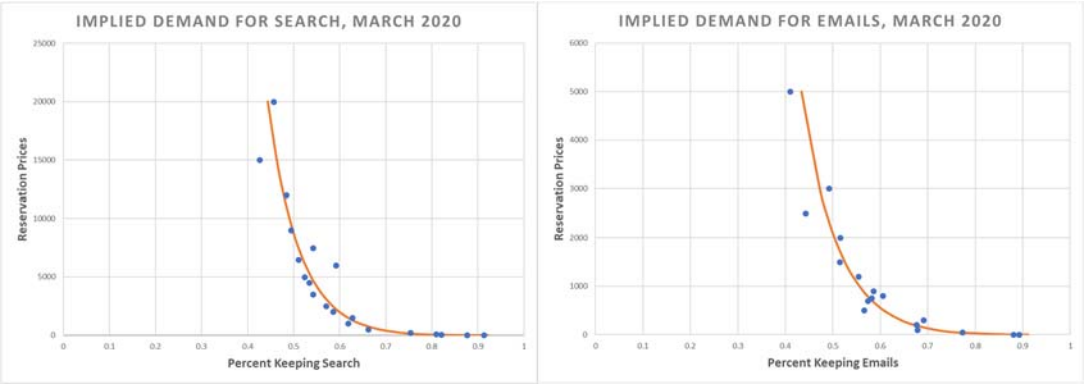
[5] Our data represent valuations of digital goods from the perspective of Hicksian or compensated demand, i.e., consumers are given additional income to make up for the value they lose in giving up the products. As a result, it cannot be said that consumers would pay these amounts for these services since that would mean lowering the amount of income they would have available for other purchases.

[6] With some derivations, one can see that the price elasticity of demand anywhere on a logistic curve is $\beta_1(1-p)$, following our notation and with logged prices.

[7] Although not directly comparable because our data represent compensated demand, Franz et al. (2008) estimated the price elasticity of demand for cigarettes is about 0.37.

view video conferencing as something they could give up personally because it is provided by their employer or school. Table A2 provides the logistic regression results. We also examined how a specific service, Zoom, which has escalated in use and prominence among all video conferencing applications compared to the entire category. Zoom has a median WTA of $44.93, which is significantly lower than video conferencing as a whole category, illustrating the fact that there tends to be a high degree of substitutability between digital goods and services within the same category.

Figure 1. Valuations and Percent Keeps by Digital Product



Source: Authors' calculations.

In table A1 we report the results when we add all available demographic variables to equation (1). These multivariate models help us answer questions about how demographics influence consumer valuation of digital goods and services. For example, it is commonly believed that the older population will be less attached to digital goods and services and should be more willing to give up on them. Surprisingly, age categories do not seem to matter for many of the digital goods. In fact, consumers aged 45 and above tend to value search more, and people above the age of 65 tend to value email more than other age groups. It seems that during the pandemic, email is particularly important to people above the age of 65 for

communicating with friends and family, while people age 45 and above rely a lot on search, likely for access of news. On the topic of age, one might believe millennials to be constantly plugged into social media and therefore have a high evaluation of them, but in fact people between the ages of 25 to 34 tend to have the lowest valuation of social media relative to all other age groups, suggesting either an income effect, or a higher opportunity cost of time for this age group. Interestingly, females tend to value search, maps, social media, and instant messaging more than their male counterparts, while regionality does not seem to play a significant role in people's variation in WTAs.

Table 2: Binary Logit Model of Digital Goods Categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Search	Email	Maps	Video	E-Comm.	Social Media	Music	Instant Messaging
ln(Res. Price)	-0.273***	-0.304***	-0.266***	-0.305***	-0.208***	-0.306***	-0.262***	-0.234***
	(0.0148)	(0.0188)	(0.0203)	(0.0202)	(0.0177)	(0.0183)	(0.0194)	(0.0169)
Constant	2.481***	2.328***	1.875***	1.897***	1.357***	1.514***	1.197***	1.344***
	(0.117)	(0.124)	(0.125)	(0.121)	(0.105)	(0.102)	(0.0984)	(0.0967)
Observations	5,027	4,270	3,514	3,516	3,766	4,270	3,532	4,266

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

III. Discussion

The digital goods we study come mostly to users at zero monetary prices, asking only that users have internet service, provide their time and attention, and allow service providers to gather data. The exceptions in our categories are e-commerce, video conferencing, and music. If WTA payments to forgo is indeed a good measure of flow of benefits to the consumers from the zero-price services, in total,

the median consumer using all the nominally free services enjoys a monthly benefit of $12,907.43 during the pandemic, compared to a 2017 benefit of $2,603.35.[8]

We develop a conservative estimate of the aggregate value of the nominally free services in March 2020 of $3.09 trillion. This is an over 498% increase over the 2017 value. Table 3 shows these results. Column (1) lists the services for which there was zero nominal charge for users. Column (5) shows the number of users that we use for our calculations. They are conservative in that they underestimate the number of actual users. For search, we used the number of Google search users for the United States for 2019. This omits people that used only non-Google search. Google's share of general search in the United States was 62.5%. (Statista 2020) For email, we used the total number of U.S. adults using email in 2019. For maps, we used the number of Google Maps users for 2018, omitting the users of Waze, Mapquest, and the like. For streaming video, we used the number of YouTube users in the United States for 2019. This includes users that pay for YouTube, but omits users of other free streaming services, such as some AMC Networks and HBO offerings made free during the lockdowns, Crackle, Hoopla, and IMDb. For social media we only count Facebook users for the United States for 2019. For instant messaging, we count only users of Facebook instant messaging in 2018. Columns (2) and (3) show the monthly values in 2017[9] and March 2020 respectively, which we derive by multiplying the number of users by the respective monthly values in table 1 and annualize the products. Column (4) is the change.

While the high valuations of these digital products certainly represent a change in demand, they also reflect how well the service providers responded to market demand by adding capacity for established services and adapting services. Amazon hired thousands more workers and prioritized household staples and medical

[8] The sum of the 2017 reservation prices in table 1 for search, email, maps, video streaming, social media, and instant messaging is $4,165.36, and for 2020 is $12,907.43.

deliveries. (Amazon 2020a; Amazon 2020b) Internet service providers adapted their networks to education and work-at-home needs. AT&T provided free service to healthcare workers on FirstNet. (AT&T 2020) Zoom expanded to accommodate a 378% increase in video-conferencing. When uninvited guests began "Zoombombing," Zoom adapted with new security measures. (Bary 2020; Hodge 2020)

Table 3. Total Value Estimate

(1)	Value in Trillions of US Dollars			(5)
Digital Goods Categories	**(2) Month in 2017**	**(3) March 2020**	**(4) Change**	**Users in Millions**
Search	$0.3784	$2.2542	$1.8758	259.0
Email	$0.1766	$0.5277	$0.3511	251.8
Maps	$0.0469	$0.1787	$0.1318	154.4
Video	$0.0123	$0.0630	$0.0507	126.0
Social Media	$0.0059	$0.0310	$0.0251	221.0
Instant Messaging	$0.0016	$0.0392	$0.0375	126.0
Total	$0.62	$3.09	$2.47	

Sources: Authors' calculations and BCE (2019); Statista (2019a, 2019b, 2019c, 2020); 99 Firms (2020); and Review 42 (2020).

Our valuations also provide input to a hole in public policy in the United States, namely a meaningful cost-benefit analysis of government efforts to expand broadband access. Our valuations of digital services provide a useful datapoint that can be used to assess the economic loss of not having broadband available in some areas during the pandemic.

IV. Conclusion

We examine how the coronavirus crisis in the United States affected people's valuations of digital services. How quickly these digital products adapted to the changed circumstances and how quantities consumed responded so quickly to changed demand tells us something about the importance of responding to market forces. Some regulators have wisely stayed out of the way of consumer choice. The Federal Communications Commission's deregulatory policies encouraged internet service providers to build networks that are handling the traffic surge.

These are extraordinary times. In these times when people are experiencing the tightening of their budget and forgoing of some luxuries, our research shows that their WTA payment to forgo digital goods and services spiked. The significance of the value from digital goods during the coronavirus outbreak can be illustrated by imagining how the society would have operated without these goods: It is likely that more jobs would have been lost, productivity would have declined more, and people might have been less inclined to follow stay-at-home guidelines.

More research is needed. We have not focused on minority and rural populations. Doing so would inform us about distributional effects. We have also omitted analyses of impacts by type of employment, geographic area, lockdown provisions, and the like. Nor have we focused on the implications for entrepreneurs and small businesses.

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Appendix I

Table A1. Logit Regression with Available Demographic Variables

VARIABLES	(1) Search	(2) Email	(3) Maps	(4) Video	(5) E-Comm	(6) Social Media	(7) Music	(8) Instant Messaging
ln(Res. Price)	-0.278***	-0.305***	-0.269***	-0.306***	-0.209***	-0.314***	-0.261***	-0.236***
	(0.0149)	(0.0189)	(0.0205)	(0.0203)	(0.0178)	(0.0185)	(0.0195)	(0.0170)
Constant	1.995***	2.204***	1.516***	1.752***	1.125***	1.582***	1.336***	1.243***
	(0.161)	(0.173)	(0.180)	(0.175)	(0.155)	(0.155)	(0.160)	(0.153)
Age: 25-34	0.186	-0.0657	0.236	0.0573	0.153	-0.353***	-0.101	-0.185
	(0.129)	(0.138)	(0.150)	(0.147)	(0.135)	(0.137)	(0.143)	(0.133)
Age: 35-44	0.0344	-0.133	0.123	0.0557	0.309**	-0.187	-0.162	-0.00227
	(0.127)	(0.135)	(0.149)	(0.146)	(0.136)	(0.134)	(0.145)	(0.133)
Age: 45-54	0.480***	0.0111	0.221	0.188	0.275**	-0.109	0.0700	0.0136
	(0.132)	(0.138)	(0.149)	(0.149)	(0.139)	(0.138)	(0.146)	(0.133)
Age: 55-64	0.389***	0.273*	0.290*	0.00823	0.252*	0.0941	-0.234	0.115
	(0.130)	(0.141)	(0.153)	(0.150)	(0.139)	(0.136)	(0.144)	(0.135)
Age: 65+	0.331**	0.390***	0.129	0.149	0.0894	-0.000539	-0.667***	0.153
	(0.132)	(0.141)	(0.155)	(0.153)	(0.142)	(0.137)	(0.150)	(0.136)
Age Unknown	0.536**	-0.000325	0.379*	0.0942	0.00643	-0.00466	0.0991	0.358*
	(0.215)	(0.221)	(0.229)	(0.210)	(0.210)	(0.214)	(0.233)	(0.213)
Sex: Female	0.361***	0.0584	0.367***	0.135*	-0.0115	0.268***	-0.0457	0.155**
	(0.0688)	(0.0739)	(0.0801)	(0.0803)	(0.0750)	(0.0725)	(0.0782)	(0.0712)
Sex Unknown	-0.306	0.0265	-0.00534	-0.140	0.242	-0.128	-0.502**	-0.547***
	(0.206)	(0.209)	(0.217)	(0.199)	(0.203)	(0.204)	(0.226)	(0.202)
North East	0.159	-0.0656	-0.155	-0.136	0.000845	-0.0849	0.300**	0.102
	(0.0977)	(0.108)	(0.120)	(0.118)	(0.110)	(0.109)	(0.117)	(0.105)
South	0.129	0.0688	0.0752	0.105	0.0614	0.0169	0.0432	0.126
	(0.0788)	(0.0836)	(0.0906)	(0.0903)	(0.0868)	(0.0819)	(0.0904)	(0.0818)
West	0.189**	0.110	-0.0631	0.0727	0.128	-0.169**	0.157*	0.0528
	(0.0835)	(0.0879)	(0.0952)	(0.0954)	(0.0917)	(0.0862)	(0.0935)	(0.0841)
Reg. Unknown	-0.679	-1.350	0.133	-1.373	-1.048	0.240	-0.351	-0.537
	(0.768)	(1.123)	(0.768)	(1.170)	(0.846)	(0.550)	(0.586)	(0.696)
Observations	5,027	4,270	3,514	3,516	3,766	4,270	3,532	4,266

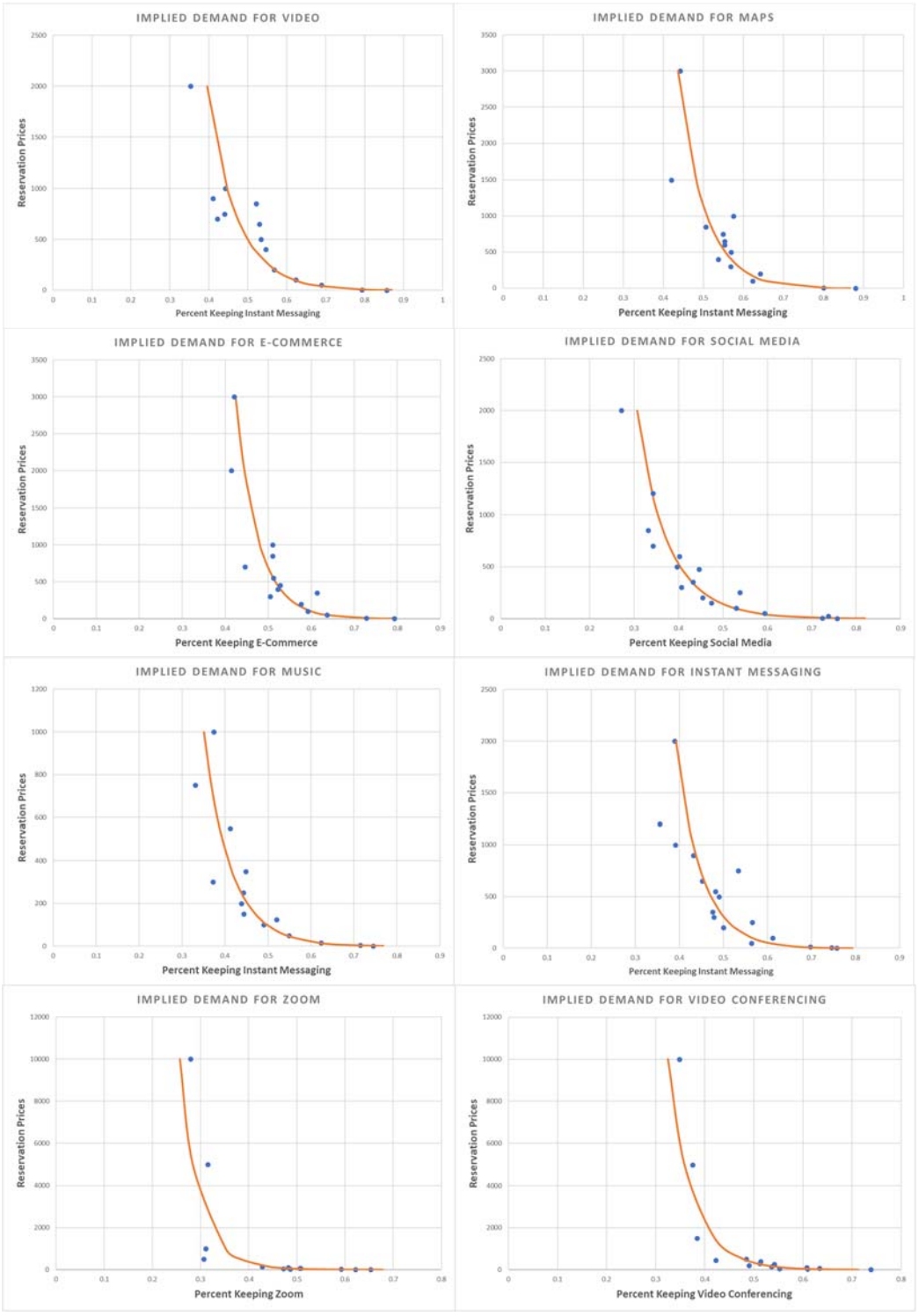
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 The base is a male, between the ages of 18 and 24, living in the Midwest.

Table A2. Binary Logit Model of Video Conferencing and Zoom

VARIABLES	(1) V-Conf.	(2) V-Conf.	(3) Zoom	(4) Zoom
ln(Res. Price)	-0.216***	-0.215***	-0.196***	-0.198***
	(0.0184)	(0.0185)	(0.0154)	(0.0155)
Constant	1.255***	1.318***	0.746***	0.870***
	(0.107)	(0.164)	(0.0795)	(0.151)
Age: 25-34		-0.00477		-0.173
		(0.139)		(0.144)
Age: 35-44		-0.0746		-0.246*
		(0.138)		(0.146)
Age: 45-54		0.0782		-0.249*
		(0.139)		(0.149)
Age: 55-64		-0.151		-0.180
		(0.140)		(0.147)
Age: 65+		-0.266*		-0.129
		(0.143)		(0.154)
Age: Unknown		-0.134		-0.0837
		(0.197)		(0.228)
Sex: Female		0.0620		0.162**
		(0.0759)		(0.0817)
Sex Unknown		-0.0133		-0.237
		(0.188)		(0.221)
North East		-0.100		0.00422
		(0.109)		(0.118)
South		-0.00148		0.0191
		(0.0864)		(0.0953)
West		0.0464		0.00953
		(0.0955)		(0.106)
Reg. Unknown		0.0534		-0.247
		(0.700)		(0.588)
Observations	3,765	3,765	3,266	3,266

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure A1. Additional Valuations by Digital Product



Appendix II

For the consumer choice surveys, we used a duration of one month for the hypothetical scenario of forgoing the digital good for a compensation of $x. Indeed, the one-month duration was intended to reflect what we thought would be the height of coronavirus activity. Since BCE (2019) used annual values (duration of one year), for comparison we looked at the monthly values of their figures. This raised the concern of whether the effect of time-duration is linear with respect to valuations, and indeed BCE (2019) presented evidence of such non-linearity.

We therefore present a low estimate of the difference in valuations between 2017 and 2020, using a "back of the envelop" method as follows. According to BCE (2019) table A.2 results for the binary logit model with percentage keep of Facebook for $50 on the left-hand side, log of timeframe (one month, two months, three months, six months, one year) and log of timeframe squared and a constant on the right-hand side, the implied probability of keeping Facebook when presented with $50 to forgo it for one year is 0.507[10]. This means, at a monthly compensation of $4.17, only 0.507 of the surveyed elects to keep Facebook[11]. We can also look at the prediction of percentage keeping Facebook when presented with the choice of $4.17 or forgoing Facebook for one month as calculated with BCE (2019) table 1, which is a proportion of 0.747 electing to keep Facebook. In other words, looking at annual figures divided into months understates the valuation, by a ratio of 1.47[12]. Though rather crude, we apply this ratio to all BCE monthly values presented in table 1 & 3 as an adjustment to get a conservative estimate of the percentage change from 2017 to 2020.

[10] Coefficient on log(T) is 0.137, $\log(T)^2$ is 0.025, and an intercept term of -1.65.

[11] Coefficient on log(E) is -0.019, with an intercept term of 1.109, for the year 2017.

[12] If we instead use their 2016 coefficients in table 1, the proportion keep would be 0.68, with a ratio of 1.34.

Table A1. Low Estimates of Table 1 with Timeframe Adjustment

(1) Digital Goods Categories	Reserve Price for One Month of Service			(5)	(6)	(7)
	(2) 2017	(3) March 2020	(4) Change	Percent change	Rank 2017	Rank 2020
Search	$2,147.38	$8,703.30 [1205.80]	$6,555.92	305%	1	1
Email	$1,030.62	$2,095.68 [294.74]	$1,065.06	103%	2	2
Maps	$446.88	$1,157.61 [194.35]	$710.73	159%	3	3
Video	$143.69	$499.79 [60.39]	$356.10	248%	4	5
E-Commerce	$103.14	$689.70 [131.69]	$586.56	569%	5	4
Social Media	$39.40	$140.32 [14.83]	$100.92	256%	6	7
Music	$20.58	$95.89 [13.05]	$75.31	366%	7	8
Instant Messaging	$18.96	$310.73 [44.88]	$291.77	1539%	8	6

Table A2. Total Value Estimate Table 3 with Timeframe Adjustment

(1) Digital Goods Categories	Value in Trillions of US Dollars			(5) Users in Millions
	(2) Month in 2017	(3) March 2020	(4) Change	
Search	$0.5562	$2.2542	$1.6980	259.0
Email	$0.2596	$0.5277	$0.2681	251.8
Maps	$0.0689	$0.1787	$0.1098	154.4
Video	$0.0181	$0.0630	$0.0449	126.0
Social Media	$0.0087	$0.0310	$0.0223	221.0
Instant Messaging	$0.0024	$0.0392	$0.0368	126.0
Total	$0.91	$3.09	$2.18	

The percentage change of median valuations now ranges from 103% to 1539%, comparted to the previous figures of 199% to 2309%. Using our total value estimates of nominally free goods, the increase in total value is by a factor of 3.40 as opposed to a multiple of 4.98 as in the main text table 3. The main result of our paper cannot be overlooked, that of how much more people value digital goods and services, even during the early stages of the present pandemic, COVID-19.