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**Article**

## The economics of digitization

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# NBER Reporter

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No. 2, June 2020

## The Economics of Digitization

Shane Greenstein\*

The NBER Economics of Digitization Project, established in 2010 with support from the Alfred P. Sloan Foundation, provides a forum for disseminating research and fostering collaboration among economists exploring the enormous changes that digitization has brought to transaction costs, media functions, product personalization, and many other facets of modern life. These activities have helped to define a community of scholars.

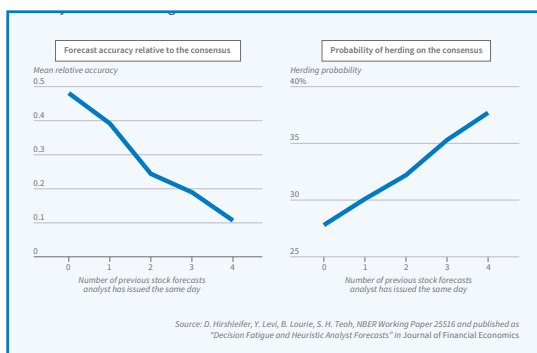
This report summarizes studies presented at project meetings over the last several years. It focuses on the role of digitization in new goods, digital platforms and algorithms, and online privacy. This research represents only a small subset of the work that has been presented and discussed.

### New Goods

Digitization has led to drastic declines in transaction costs — search costs, replication costs, communications costs, tracking costs, and verification costs. Though such declines often go unrecorded, Avi Goldfarb and Catherine Tucker offer a taxonomy of studies of digitization organized around declines in such costs.<sup>1</sup> Many new goods take advantage of these dramatically lower transaction costs.

Digitization has restructured the supply of digital goods and services in creative industries, such as movies, music, and television. Yet, it has not eliminated the unpredictable appeal of these new goods. Luis Aguiar and Joel Waldfogel explore the consequence of unpredictability for measuring the welfare benefit of new products, using recent developments in recorded music as an illustration.<sup>2</sup> New products have surprising appeal, and as firms explore the unpredictable outcomes, their exploration creates a long tail of realized appeal in the market. The researchers quantify the effects of new music on welfare, and show that a tripling of the number of new products between 2000 and 2008 added substantially to consumer surplus and over-

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all welfare. Importantly, this analysis differs from one with retrospective biases that presumes firms anticipate the long tail.

Some digital services have taken advantage of trivial replication and personalization costs to scale up to supply enormous numbers of customers. Many of these digital services are “free” goods, and it seems likely that standard procedures for GDP accounting do not measure the output accurately. Erik Brynjolfsson, Avinash Collis, and Felix Eggers propose a new approach to measuring consumer benefits from digital goods such as Facebook, Wikipedia, and online search.<sup>3</sup> Their study uses massive online

years, particularly since online advertising increased after 2005. However, this explosion is partially offset by a decrease in advertising in newspapers, which also served as a major source of content and advertising until recently. Including these adjustments for growth and decline, real GDP growth would have grown at 1.53 percent a year from 2005 to 2015 rather than the official growth rate of 1.42 percent; 0.11 percentage points faster. From 1995 to 2005, real GDP growth would have grown 0.07 percentage point faster, and in the earlier

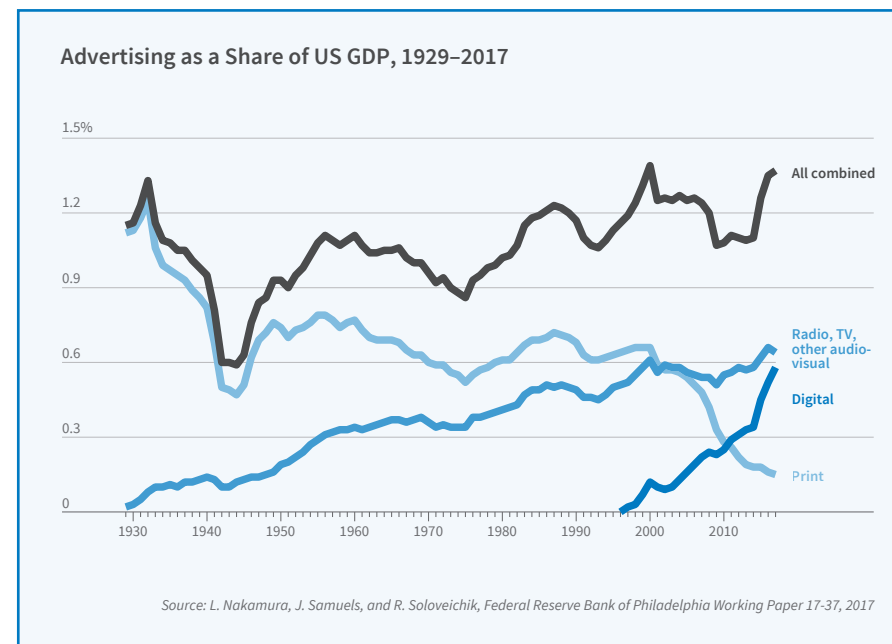


Figure 1

choice experiments to measure consumers’ willingness to accept compensation for losing access to these digital goods. The results indicate that digital goods have created large gains in well-being. Their demonstration suggests that querying a large, representative sample of users could provide cost-effective supplements to existing national income and product accounts.

While unpriced services contribute little directly to GDP by traditional methods, many are supported by advertising. Figure 1 shows advertising as a percentage of GDP, heightening the importance of accounting for its reallocation across media. Leonard Nakamura, Jon Samuels, and Rachel Soloveichik develop an experimental methodology that values “free” digital content through the lens of production accounting, the framework of the national accounts.<sup>4</sup> They estimate that the contribution of “free” digital content to US GDP has accelerated in recent

period, from 1929 to 1995, 0.01 percentage point faster.

Of the many new goods enabled by digitization, those related to social media have been among the most controversial because of their capacity to facilitate the spread of misinformation, polarize political debate, and potentially to foster depression. Hunt Allcott, Luca Braghieri, Sarah Eichmeyer, and Matthew Gentzkow conduct a randomized experiment of

Facebook users.<sup>5</sup> They ask users to deactivate Facebook for the four weeks before the 2018 US midterm election, resulting in reduced online activity along with increased offline activities such as watching TV alone and socializing with family and friends; reduced factual news knowledge and political polarization; increased subjective well-being; and a large, persistent reduction in post-experiment Facebook use. Deactivation also reduced post-experiment valuations of Facebook, which, the researchers argue, suggests that traditional metrics may overstate consumer surplus.

Another controversial experiment in new goods is Google Books, a Google-organized searchable digital repository of all pre-existing books and periodicals.

Critics argued it violated copyright and decreased book sales. Defenders stressed that it made knowledge available, and proposed it would increase book sales by lowering the cost of sampling. What impact did Google Books have before copyright lawsuits hampered the project? Abhishek Nagaraj and Imke Reimers track the timing of the digitization of individual books from Harvard University’s libraries.<sup>6</sup> They find that Google books hurt loans within Harvard but increased sales of physical editions by about 35 percent, especially for less-popular works. They conclude that, rather than harming all copyright holders, mass digitization could have significantly increased the diffusion of historical works.

## Platforms and Algorithms

Digital platforms have been deployed widely in the economy, transforming many markets. One common operating model provides one service at a price of zero, while raising revenue through related services, such as automated auctions for advertising. Another common operating model facilitates the match of supply and demand from different participants using algorithms. A number of studies examine the impact of these arrangements.

Digital platforms have emerged to manage “gig work” for rideshare driving. This involves workers supplying flexibility to the platform, providing service when demand is high, which can be attractive to workers who value flexibility. M. Keith Chen, Judith A. Chevalier, Peter E. Rossi, and Emily Oehlsen use data on hourly earnings for Uber drivers and document ways in which drivers utilize real-time flexibility.<sup>7</sup> Drivers’ reservation wages vary, as illustrated by their start and stop times in Figure 2. Their results indicate that, while the Uber relationship may have other drawbacks, Uber drivers benefit significantly from real-time flexibility, earning more than twice the surplus they would earn in less-flexible arrangements. If required to supply labor inflexibly at prevailing wages, they also would reduce the hours they supply by more than two-thirds.

How can a platform build enough trust to facilitate transactions between strangers thousands of miles apart? Moshe A. Barach, John Horton, and Joseph Golden examine money-back guarantees, which create a direct financial stake for the platform in seller performance.<sup>8</sup> They consider whether these might be effective at steering, even as they align buyer and platform interests in creating a good match. They conduct an experiment in which an online labor market guaranteed

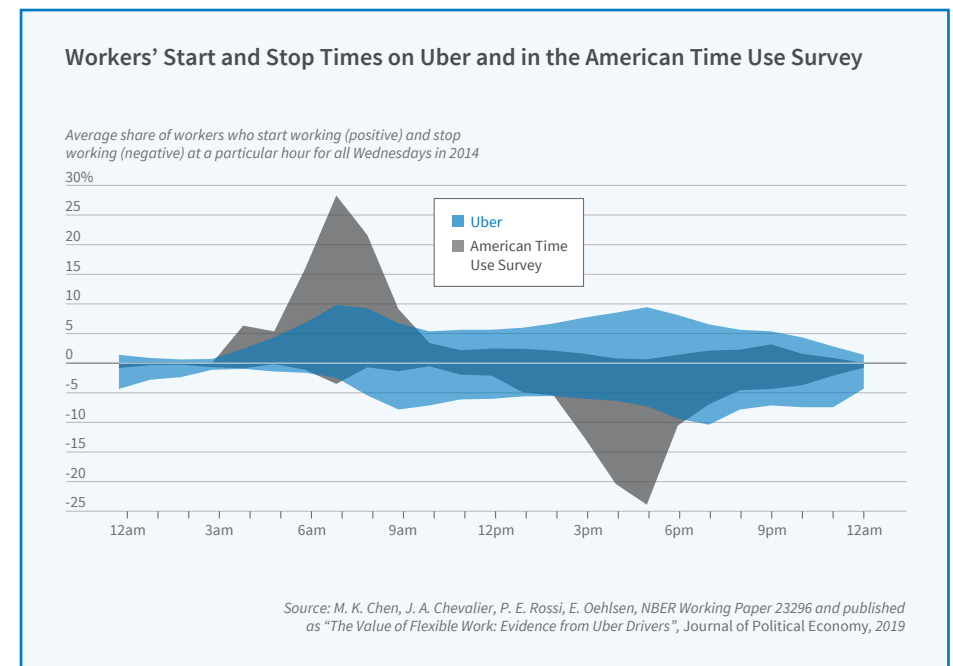


Figure 2



some sellers for some buyers. The presence of a guarantee steered buyers to these sellers, but offering guarantees did not increase sales overall, suggesting financial risk was not determinative for the marginal buyer. The researchers conclude that buyers viewed the platform's decision to guarantee as informative about relative seller quality.

Negotiation receives attention in the study by Matthew Backus, Thomas Blake, Bradley Larsen, and Steven Tadelis.<sup>9</sup> Their study examines patterns of behavior in bilateral bargaining situations using a rich and detailed dataset that describes back-and-

forth bargaining occurring in over 25 million listings from eBay's Best Offer platform. They demonstrate that several patterns in the data can be explained by existing theoretical models. These include interactions ending quickly, interactions ending in agreement after some delay, and stronger bargaining power or better outside options improving a player's outcome. Other robust patterns, however, remain unexplained by existing theories. These include negotiations resulting in delayed disagreement, gradually changing offers that are reciprocal, and "splitting the difference" between the two most recent offers. These robust patterns call for new explorations in the theory of bargaining. The researchers have made the data available for additional experiments.<sup>10</sup>

Platforms have changed many aspects of the travel markets, permitting more informed matches of supply and demand prior to travel. Chiara Farronato and Andrey Fradkin study the effects on the accommodation industry of enabling peer supply through Airbnb.<sup>11</sup> They analyze the impact by estimating a model of competition between flexible and dedicated sellers — peer hosts and hotels. They estimate the model using data from major US cities and quantify the welfare effects of Airbnb on

travelers, hosts, and hotels. They show that the welfare gains from this activity are concentrated in locations (e.g., New York) and times (e.g., New Year's Eve) when capacity constraints bind availability of hotel rooms. This occurs because peer hosts are responsive to market conditions, expand supply as hotels fill up, and keep hotel prices down as a result. Figure 3 shows the researchers' estimates for the varying costs of Airbnb rentals at different times, illustrating the importance of accommodating variability in demand.

Online platforms also can serve as new sources of information for economic anal-

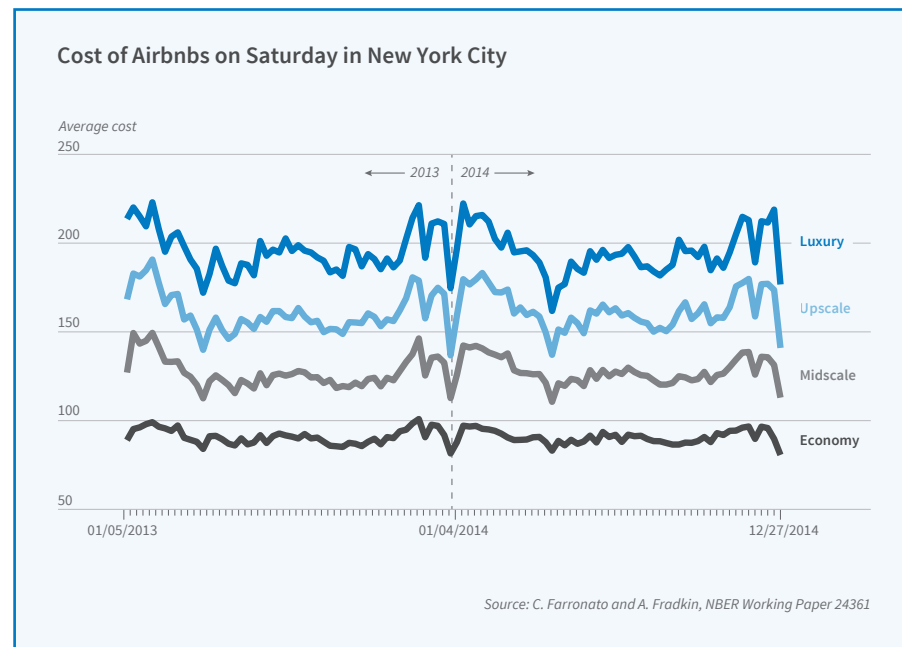


Figure 3

ysis. Edward Glaeser, Hyunjin Kim, and Michael Luca investigate whether data from Yelp can improve measurement of changes to a neighborhood and the local economy.<sup>12</sup> Combining Yelp and census data, they find that gentrification, as measured by changes in the education, age, and racial composition within a ZIP code, is strongly associated with increases in the numbers of grocery stores, cafés, restaurants, and bars in the area, with little evidence of crowd-out of other categories of businesses. A leading indicator of housing price changes is change in the local business landscape, particularly the entry of Starbucks, and coffee shops more generally. Each additional Starbucks that enters a ZIP code is associated with a 0.5 percent increase in housing prices.

Do the advertising algorithms reflect common notions of fairness and appropriate business decision-making? Can automated processes in advertising lead to gender biases? Anja Lambrecht and Catherine Tucker conduct a field test of how an algorithm delivered ads promoting job opportunities in the science, technology, engineering, and math (STEM) fields.<sup>13</sup> The researchers created an ad that was explicitly intended to be gender-neutral in its delivery. Empirically, however, fewer women saw the ad than men. This happened because younger women are a prized demographic and are more expensive to show ads to. An algorithm that simply optimizes cost-effectiveness in ad delivery will deliver ads that were intended to be gender-neutral in an apparently discriminatory way. The researchers show that this empirical regularity extends to other major digital platforms.

### Online Privacy

A reduction in costs of verifying user identity has made it far easier to track identities of consumers across the internet. Though these shifts have enhanced productivity for sellers of advertising and electronic services, they have also increased privacy concerns. In May 2018, the European Union began enforcing the General Data Protection Regulation (GDPR), which endowed EU citizens with new personal data rights, imposed new responsibilities on firms, and enabled users to opt out of common tracking technologies altogether. The unprecedented scale and scope of the GDPR make it the most important regulatory effort since the commercialization of the internet.

Samuel Goldberg, Garrett Johnson, and Scott Shriver examine the short-run consequences for a firm's cost of collect-

ing consumer data.<sup>14</sup> They examine the impact of the GDPR on European web traffic and e-commerce sales using web analytics data from a diverse set of 1,508 firms that use the Adobe Analytics platform. Using a difference-in-differences approach, they show that recorded page-views and recorded revenues fall by about 10 percent for EU users after the GDPR's enforcement deadline. The extensive margin drives these changes as users' average time on sites and average page views per visit stay constant.

Do consumer privacy decisions have externalities for other consumers, and, therefore, the firms that supply them and advertise to them? Guy Aridor, Yeon-Koo Che, and Tobias Salz study the effects of the GDPR on the ability of firms to collect consumer data, focusing on the online travel industry.<sup>15</sup> They conclude that the GDPR enabled privacy-conscious consumers — approximately 12.5 percent of their sample — to substitute away from less-efficient privacy protection. The remaining consumers become more observable for a longer period of time, and the average value of the remaining consumers to advertisers increased. These two changes came close to offsetting each other.

Jian Jia, Ginger Zhe Jin, and Liad Wagman examine the short-run, unintended impact of the GDPR on investment in new and emerging technology firms.<sup>16</sup> Their findings indicate negative post-GDPR effects on ventures within the EU compared with their US counterparts. The negative effects manifest in the overall dollar amounts raised across funding deals, the number of deals, and the dollar amount raised per individual deal.

As many countries contemplate their own versions of data protection and privacy regulations, there is a growing need for additional analysis and measurement of the GDPR. Current empirical work focuses on the short-run impact on suppliers and users. As policymakers craft their approaches, there will be a need to research the longer-run implications.

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<sup>7</sup> "The Value of Flexible Work: Evidence from Uber Drivers," Chen MK, Chevalier JA, Rossi PE, Oehlsen E. NBER Working Paper 23296, March 2017, revised June 2019, and *Journal of Political Economy* 127(6), December 2019, pp. 2735–2794. [Return to Text](#)

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<sup>9</sup> "Sequential Bargaining in the Field: Evidence from Millions of Online Bargaining Interactions," Backus M, Blake T, Larsen B, Tadelis S. NBER Working Paper 24306, February 2018, and *The Quarterly Journal of Economics*, forthcoming. [Return to Text](#)

<sup>10</sup> See <http://data.nber.org/data/bargaining/>. [Return to Text](#)

<sup>11</sup> "The Welfare Effects of Peer Entry in the Accommodation Market: The Case of Airbnb," Farronato C, Fradkin A. NBER Working Paper 24361, February 2018, revised March 2018. [Return to Text](#)

<sup>12</sup> "Measuring Gentrification: Using Yelp Data to Quantify Neighborhood Change," Glaeser EL, Kim H, Luca M. NBER Working Paper 24952, August 2018. [Return to Text](#)

<sup>13</sup> "Algorithmic Bias? An Empirical Study of Apparent Gender-Based Discrimination in the Display of STEM Career Ads," Lambrecht A, Tucker C. *Management Science* 65(7), July 2019, pp. 2966–2981. [Return to Text](#)

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<sup>15</sup> "The Economic Consequences of Data Privacy Regulation: Empirical Evidence from GDPR," Aridor G, Che Y, Salz T. NBER Working Paper 26900, March 2020. [Return to Text](#)

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