

Introducing Consumer Durable Digital Services into the BEA Digital Economy Satellite Account

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Abstract	Measuring the digital economy is a high priority for analysts of economic growth. We augment the Bureau of Economic Analysis's Digital Economy Satellite Account to include digital services provided by high-tech consumer durables. We find that including the service flow from these goods raises the growth rate of the digital economy between 2005 and 2021 from 6.4 percent per year to 6.9 percent per year. Consumer durable services accounted for about 10 percent of digital economy GDP within augmented digital economy GDP. While most household services are not digital, the household owns a significant part of the digital infrastructure.
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¹ This essay was written in memory of Dale W. Jorgenson, who inspired many of the ideas and methods used in this paper.

1. Introduction

Capturing the digital economy in economic statistics is one of the highest priorities for economic statisticians, statistical agencies, and scholars of economic growth. The motivation for the focus on the digital economy is twofold: First, the digital economy has impacted almost every facet of daily life for individuals, and almost all production decisions for businesses. Second, the digital economy is hard to measure. Components of the digital economy such as high-tech computing hardware and software often have characteristics that change over time (like computing power or software functionality) and this requires price indexes that reflect these underlying changes in quality. Digital services are often provided without a price (such as internet search) or are provided on own account, for example when a company produces and uses its own software or information technology (IT) hardware.

To help track advances in the digital economy, the U.S. Bureau of Economic Analysis (BEA) produces a Digital Economy Satellite Account that measures the role of the digital economy's contribution to U.S. GDP growth.² The satellite account currently highlights production and spending for the digital economy that is already present in BEA's supply-use tables, which are the foundation of BEA's industry economic accounts. Digital economy production includes information and communication technologies (ICT) hardware, software, e-commerce margins, digital services performed for a fee, and federal nondefense government agencies whose services are directly related to supporting the digital economy. The latest data show that the share of the U.S. digital economy in nominal GDP grew from 7.8 percent in 2005 to 10.3 percent in 2021. In real terms, the digital economy grew by 6.4 percent per year on average over that period, significantly faster than the overall U.S. growth rate of 1.7 percent per year (Highfill and Surfield [2022]).

In this paper, we augment the measures in BEA's Digital Economy Satellite Account to include digital services provided by high-tech consumer durables. Our approach to measuring this is to introduce a new sector into the digital economy account that is analogous to the treatment of owner-occupied housing in the official GDP accounts. In the official BEA GDP accounts, the provision of owner-occupied housing is grouped within the real estate sector in the industry accounts and in personal consumption of housing services in the national income and product account. To measure owner-occupied housing, an imputation is made (using market rents) to account for the rent that would have been paid for owner-occupied homes so that measured GDP is isomorphic to how housing is financed. We introduce a similar imputation for the digital services provided by high-tech devices purchased by consumers. For example, if a \$1,000 cell phone is sold by a manufacturer to a rental company and the rental company rents the phone to a household for \$500 a year for 3 years, the \$1,000 is counted as business investment

² BEA produces economic statistics through its system of satellite accounts that highlight specialized areas of the economy that are not directly apparent in BEA's official economic statistics published under the North American Industry Classification System (NAICS), such as outdoor recreation and arts and culture. For more information about these and other BEA satellite accounts, see the special topics section on BEA's website: <https://www.bea.gov/data/special-topics>.

and the \$500 each year is measured as digital services.³ But, if the manufacturer sells the \$1,000 phone directly to a household, only the \$1,000 is measured even though the phone is providing digital services over the same three years. Basically, we treat consumer durables as a capital asset that yields a service flow over time.

The issue of capitalizing consumer durables is not new to scholars of economic growth and national accountants. [Christensen and Jorgenson \[1973\]](#) introduces consumer durable capital services into their measures of the private economy, and updated work in [Jorgenson and Landefeld \[2007\]](#) adds consumer durables to an integrated aggregate production account. [Fraumeni et al. \[2001\]](#) has raised the issue of measuring consumer durable services with BEA's advisory committee. In his Nobel Prize lecture, [Prescott \[2006\]](#) argues that including consumer durable capital services is important in building model-consistent data and understanding macroeconomic fluctuations. There is focus on IT consumer durables as well: [Byrne and Corrado \[2020\]](#) argues that the service flow from IT consumer durables is important in understanding changes in consumer surplus and GDP growth. Our paper's focus is most similar to their analysis. We differ in our attention on measuring the digital economy and how including the services from digital products owned by consumers impacts the value and growth of the digital economy estimates.

While there is a body of work recognizing that consumer durable capital services is worthy of attention, these service flows remain outside of the official BEA national income and product accounts. BEA does track these services in its household production account. [Bridgman et al. \[2022\]](#) presents BEA's latest estimates of household production and these estimates include the service flow from consumer durables. Another way to summarize the exercise we undertake in this paper is that we move the digital consumer capital services that are included in BEA's household production account into BEA's digital economy satellite account. For reasons discussed above and below, this presents a more comprehensive picture of the evolution of the digital economy.

We find that including the service flow from digital consumer durables raises the growth rate of the digital economy between 2005 and 2021 from 6.4 percent per year to 6.9 percent per year. In nominal terms, within the augmented digital economy GDP, consumer durable services accounted for about 10 percent of digital economy GDP, and the provision of consumer durable services becomes one of the largest sectors tracked in the Digital Economy Satellite Account. While most household services are not digital, the household owns a significant part of the digital infrastructure. Many market digital services require the household to hold digital equipment. Our results show that the household's share of this infrastructure is quantitatively significant.

³ In most cases the cell phone would be bundled with data services, so the consumer would pay for this on top of the rental rate for the hardware.

2. Measuring the Digital Economy

BEA's Digital Economy Satellite Account measures the contribution of the digital economy to U.S. GDP (current-dollar and constant-dollar), plus gross output, compensation, and employment related to digital economy production.⁴ Following international standards, specifically guidance from the Organisation for Economic Co-operation and Development (OECD),⁵ BEA includes in its definition of the digital economy four major types of goods and services:

1. Infrastructure, or the basic physical materials and organizational arrangements that support the existence and use of computer networks and the digital economy, primarily information and communications technology (ICT) goods and services.
2. E-commerce, or the remote sale of goods and services over computer networks.
3. Priced digital services, or services related to computing and communication that are performed for a fee charged to the consumer.
4. Government digital services, or the annual budget for four government agencies whose services are directly related to supporting the digital economy: the Federal Communications Commission (FCC), National Telecommunications and Information Administration (NTIA), Department of Education's Office of Education Technology, and U.S. Digital Service.

Most goods and services that constitute the digital economy can be taken directly from BEA's supply-use tables, such as ICT hardware and software. In cases where the good or service includes both digital and non-digital production, we use external source data to isolate the digital activity. For example, to isolate e-commerce margins for retail and wholesale trade, data from the U.S. Census Bureau's Annual Retail Trade Survey and Annual Wholesale Trade Survey are used.

The statistics are presented by standard industry classifications under the NAICS and by activities that align with the four major types of goods and services. Activities are further broken down into eight subcategories: software and hardware (infrastructure); business-to-business and business-to-consumer e-commerce margins; and cloud services, telecommunications services, internet and data services, and all other priced digital services (priced digital services).

⁴ The gross output of an industry is the market value of the goods and services produced by an industry. The primary component of gross output is revenue or receipts, but it also includes commodity taxes, other operating income, and inventory change. The value added for an industry represents the market value it adds in production, or the difference between an industry's gross output and the cost of its intermediate inputs. Real or constant-dollar estimates hold prices constant such that growth rates for real estimates reflect changes in quantities produced, removing the impact of inflation. Chained-dollar estimates are calculated by taking the current-dollar level of a series in the reference period and multiplying it by the change in a chained-type quantity index number for the series since the reference period.

⁵ For information on the OECD's digital economy measurement work, see <http://www.oecd.org/sti/ieconomy/>.

2.1. The Digital Economy's Contribution to GDP

The 2021 data show the U.S. digital economy accounted for \$2.41 trillion of value added (translating to 10.3 percent of GDP), \$3.70 trillion of gross output, \$1.24 trillion of compensation, and 8.0 million jobs ([Highfill and Surfield \[2022\]](#)). Priced digital services was the largest activity in the digital economy in 2021, contributing \$939 billion in current-dollar value added, followed closely by infrastructure (\$911 billion), then e-commerce (\$559 billion) and federal non-defense digital services (\$258 million). In terms of NAICS, nearly all value added generated by the digital economy in 2021 was accounted for by five industries: Information (40.9 percent), Professional and business services (19.5 percent), Wholesale trade (18.8 percent), Manufacturing (10.1 percent), and Retail trade (8.2 percent).

2.2. Towards a Comprehensive Measure of the Digital Economy

The Digital Economy Satellite Account statistics have evolved since the first report was released in 2018. Initially, only products considered primarily “digital” were included, and products that were only partially digital, like e-commerce and cloud services, were excluded because additional research and expertise were required to produce reasonable estimates ([Barefoot et al. \[2018\]](#)). By 2021, BEA’s digital economy estimates were expanded to include cloud services and e-commerce after suitable source data were identified and vetted ([BEA \[2021\]](#)). BEA intends to continue expanding the Digital Economy Satellite Account in the future to include areas that are currently excluded from the statistics. Notably, BEA’s digital economy statistics do not yet fully capture production of digital intermediary services earned from operating a digital platform that facilitates the direct interaction between multiple buyers and multiple sellers for a fee, such as peer-to-peer rideshare and homeshare. Additionally, research is underway to estimate production related to operating data centers, including construction of structures and own-account manufacturing of servers by cloud providers.

Including the capital service flow from consumer durable digital equipment, as we do in this paper, is part of ongoing work to better understand the impact of the digital economy by expanding the statistical coverage of activities. Household digital goods are part of the underlying infrastructure that delivers digital services. Without household-owned digital devices, much market activity would be difficult or impossible to deliver. For example, ridesharing apps require the user to have a smart phone to connect with a driver.

3. Measuring the Household Digital Economy

Previous measures of the digital economy have concentrated on the market economy. In this article, we extend our measure to non-market household production (HP). This section reports what portion of HP that we attribute to the digital economy and the methodology for estimating household production.

3.1. The Digital Economy in the Household

The first question is what parts of HP to include in the digital economy. In the market economy, digital industries are those that produce a digital output or those that are significant users of digital factors of production. We apply this same methodology to the household sector.

We identify the household digital economy as the capital services of the ICT categories of consumer durables. These services are part of the digital-enabling infrastructure that is included in the market digital economy. Specifically, we include “Video, audio, photographic, and information processing equipment and media” and “Telephone and related communication equipment.”

Like the market equivalent, we omit some digital activities due to source data constraints. The methodology codes partially digital items as non-digital. Therefore, we omit items like appliances that may have a digital component but are not fundamentally digital in their output. The methodology gives the example of an internet enabled refrigerator as a good that is *not* included, since its major function is to cool food (Barefoot et al. [2018]).

We also omit the value of online shopping time. While this function would be in-scope as e-commerce, the time use data do not distinguish shopping by mode. Online and in-person grocery shopping are coded the same. We return to the impact of this omission below.

3.2. Methodology

We use BEA's Household Production Satellite Accounts as the basis for the estimates. (The most recent release is [Bridgman et al. \[2022\]](#)). These estimates impute payments to factors of production to get value added.⁶

Our measure of the household digital economy consists of the capital services of digital goods. For each consumer durable asset a , the nominal value added $V_{a,t}$ is returns as measured by the user cost of capital:

$$V_{a,t} = (r_t + \delta_a - \pi_{a,t})P_{a,t}Q_{a,t}$$

where $Q_{a,t}$ is the real net stock of the asset, $P_{a,t}$ is the current investment price of the asset, r_t is the rate of return, δ_a is the depreciation rate, and $\pi_{a,t}$ is the asset-specific annual capital gain (or loss). The capital gain is the change in the investment price:

$$\pi_{a,t} = \frac{P_{a,t} - P_{a,t-1}}{P_{a,t-1}}$$

BEA's HP Satellite Accounts do not include capital gains. However, IT assets have a large expected capital *loss* in the period we examine. [Jorgenson et al. \[2005\]](#) argues that it is important to account for expected capital losses when measuring the service flow of IT, since they increase the holding period required rate of return. To maintain comparability, we include capital gains/losses in the capital services for all durable goods assets, digital and non-digital. To decompose the value of capital services into price and quantity, we assume that the real service flow growth rate in each period is proportional to the change in the real net stock $Q_{a,t}$. Therefore, price change in the capital services is measured as the growth rate in $(r_t + \delta_a - \pi_{a,t})P_{a,t}$, which corresponds to the user cost of capital. We aggregate across assets using a Tornqvist index.

⁶ [Schreyer and Diewert \[2014\]](#) provide the theoretical basis for valuing HP hours. [Bridgman \[2016\]](#) expands this method to include capital services.

4. The Growing Digital Economy with Consumer Durables

Before analyzing how consumer durable services impact measures of the digital economy, we recognize that including the service flow from consumer durables changes the official measure of GDP. We conceptualize these services as new value added within the “other” services sector in BEA’s industry economic accounts. Essentially, this sector purchases (invests in) new consumer durables and provides services from these durables to the household. Similar to the accounting for owner occupied housing, the underlying assumption is that the nominal value of these services equals the rental value. But unlike the official measures of owner-occupied housing, the data for the rental market of consumer durable services is relatively thin, so we rely on the implicit cost of capital approach discussed in section 3.⁷

Including consumer durables capital services in GDP raises nominal GDP and real GDP growth over the period that we cover. In 2005, we estimate that total consumer durable services (digital and non-digital) were about \$700 billion and about 5 percent of nominal (redefined) GDP. As a point of comparison, in 2005 total personal consumption expenditures of Food and beverages purchased for off-premises consumption was about \$668 billion, Motor vehicle fuels about \$260 billion, Household utilities about \$250 billion, and Hospitals and nursing home services about \$700 billion. Over 2005–2021, consumer durable services averaged 5.5 percent of GDP and about 10 percent of personal consumption expenditures. Clearly, consumer durables services are an important part of household consumption.

Including the total service flow from consumer durables raises real GDP growth over the period. Official GDP grew by about 1.7 percent per year on average between 2005 and 2021, while real consumer durable services grew by 4.9 percent per year. Including real consumer durables services in GDP raises the growth rate to about 1.9 percent per year. Though we do not have a long enough time series to analyze how including consumer durable services impacts business cycle fluctuations like the slowdown in trend growth after the Great Recession in 2008 and 2009, the data suggest that including consumer durable services would not impact the measured GDP slowdown that occurred after 2010. On the other hand, including consumer durable service flows mitigated the measured downturn over the 2007–2009 period. Official GDP fell by around 1.3 percent per year during this period; after including real consumer durable services, measured GDP fell by about 1.1 percent on average. The intuition for this is that the stock of consumer durables evolves more slowly than aggregate GDP (because the current stock depends mostly on past purchases), thus the service flow from the stock has a dampening effect on measured GDP growth when consumer durable services are included.

In the top portion of Table 1 we show how including the service flow from consumer durables impacts the nominal values in BEA’s Digital Economy Satellite Account. We have aggregated industry detail due to space constraints. Underlying information at the same industry level of detail as in the digital economy

⁷ The increase in nominal GDP on the output and value added sides of the account is balanced by the same increase in payments to capital services on the income side of the account.

satellite account is available upon request. In 2005, the service flow from information technology related consumer durables was about \$102 billion. This total amounts to about 9 percent of (augmented) digital economy value added in 2005 and about 10 percent of augmented digital economy value added on average over the 2005–2021 period. Including this service flow in the “other services” sector makes this sector one of the largest sectors producing digital value added. The only sectors producing more digital value added in 2005 were the computer and electronic products, wholesale trade, broadcasting and telecommunications, and computer systems design and related services sectors.⁸ This emphasizes the importance of considering the service flow from consumer durables when measuring the size of the digital economy. The production value of goods like cell phones and personal computers is captured in the existing BEA Digital Economy Satellite Account, but the ongoing flow that these services yield in each period is excluded without the measures that we have added into in Table 1.

The household sector is an important contributor to the digital economy despite not producing many digital services. While a relatively small share of the total household production can be attributed to digital equipment, the household sector is large relative to the market economy. Also, households’ holdings of digital durable goods has expanded over the period we examine. Telephone stocks have expanded a great deal with widespread adoption of smart phones.

In the bottom portion of Table 1 we show how including the service flow from consumer durables impacts real growth rates in BEA’s Digital Economy Satellite Account.⁹ Including the consumer durable service flow raises the average annual growth rate of the digital economy between 2005 and 2021 from about 6.4 percent per year to 6.9 percent per year. Including consumer durable services in the “other” services sector results in this sector being one of the largest contributors to the growth in the digital economy; between 2005 and 2021, only the computer systems design sector made larger a contribution to digital GDP growth.¹⁰

The above analysis serves as a lower bound on the impact of including the household sector on size of the digital economy. As discussed above, we cannot include the value of online shopping time, since we lack the source data to separate out online shopping time. Since the market digital economy includes e-commerce, ideally we would like to include this activity.

How much value are we missing? Shopping time (not including travel time) was 12.6 percent of HP time in 2005. It declined as a share to 10.3 percent in 2021. The share of retail sales accounted for by online sales rose from 5 percent to 15 percent over the same time period. If we assume that shopping time by mode is proportional to retail sales by mode, shopping time went from less than 1 percent of

⁸ This industry detail is based on underlying data that is not presented in this paper.

⁹ Real growth rates are reconstructed as Tornqvist indexes. Nominal values of each component are discussed above. We assume that the real consumer durable service flow of each asset is proportional to the growth rate of the net stock. This aligns with how IT capital services are estimated in [Jorgenson et al. \[2005\]](#).

¹⁰ A contribution is defined as nominal value share weighted real growth rate.

HP time to 1.5 percent of HP time. This implies an online shopping value rising from \$14 billion to \$57 billion. Compared to the household digital output of \$303 billion in 2021, this exercise suggests that online shopping represents a significant household digital activity.

E-commerce has likely been important in reducing household production hours by reducing shopping time. The expansion of online shopping has coincided with a decline in shopping hours and travel time in support of shopping. This may reflect that finding and buying the same items takes less time over the internet. It also reflects a shift of activity from the household to the market, as goods are delivered to the home by market firms rather than household members traveling to stores.

Table 1: Digital Economy Value Added by Industry including Consumer Durable Services

		2005	2010	2015	2020	2021
[Millions of current dollars]						
1	All Industries	1,122,475	1,452,705	1,874,576	2,398,230	2,631,285
2	Private industries	1,111,090	1,438,829	1,863,821	2,386,014	2,619,475
3	Agriculture, forestry, fishing, and hunting	4	-
4	Mining	194	355	571	502	564
5	Utilities	402	450	488	417	460
6	Construction	171	164	255	482	423
7	Manufacturing	189,511	196,659	192,764	215,184	243,288
8	Durable goods	181,154	184,955	181,809	206,785	231,173
9	Nondurable goods	8,357	11,704	10,954	8,400	12,115
10	Wholesale trade	179,760	260,411	358,503	417,384	453,681
11	Retail trade	28,731	52,696	91,996	165,637	196,335
12	Transportation and warehousing	6,044	5,345	6,632	9,965	10,064
13	Information	434,211	533,624	656,303	885,881	984,470
14	Finance, insurance, real estate, rental, and leasing	5,287	6,319	6,929	8,904	13,904
15	Professional and business services	148,961	224,947	319,552	433,228	470,368
16	Educational services, health care, and social assistance	9,298	11,906	13,693	14,827	15,017
17	Arts, entertainment, recreation, accommodation, and food services	245	377	559	647	860
18	Other services, except government	108,271	145,577	215,576	232,953	230,042
19	Government	11,385	13,876	10,755	12,216	11,810
[Millions of chained (2012) dollars]						
1	All Industries	974,835	1,434,878	1,913,977	2,645,219	2,925,245
2	Private industries	963,676	1,421,007	1,903,168	2,632,825	2,913,522
3	Agriculture, forestry, fishing, and hunting
4	Mining	210	348	504	411	407
5	Utilities	407	453	490	426	472
6	Construction	173	165	256	493	434
7	Manufacturing	101,820	182,947	207,008	254,755	289,417
8	Durable goods	92,269	170,876	197,093	248,594	279,350
9	Nondurable goods	10,780	12,084	10,172	7,527	10,831
10	Wholesale trade	233,900	277,642	344,552	360,823	366,239
11	Retail trade	28,828	51,088	92,057	154,140	169,784
12	Transportation and warehousing	6,776	5,727	5,889	7,937	7,182
13	Information	390,145	529,704	694,860	1,025,361	1,156,416
14	Finance, insurance, real estate, rental, and leasing	5,364	6,369	6,907	9,000	14,073
15	Professional and business services	137,877	221,582	330,330	472,410	522,002
16	Educational services, health care, and social assistance	12,031	12,763	13,148	13,601	13,828
17	Arts, entertainment, recreation, accommodation, and food services	200	377	552	640	842
18	Other services, except government	71,905	133,121	207,204	361,068	426,142
19	Government	11,303	13,879	10,825	12,543	12,039

5. Conclusion

BEA estimates that the net stock of digital goods owned by households was about \$800 billion in 2021, more than the total value of the net stock of automobiles owned by households, and about half the value of light trucks.¹¹ Under the official GDP measures, the service flow of assets is not reflected in GDP growth. When we augment the official GDP accounting to treat consumer durables symmetrically with other capital assets held by the private business sector and with the treatment of owner occupied housing, we find that the accumulation of durables goods is an important contributor to size and growth of digital economy GDP growth. Including the consumer durable service flow raises the average annual growth rate of the digital economy between 2005 and 2021 from 6.4 percent per year to 6.9 percent per year. In 2021, digital economy consumer durables added about \$220 billion to digital economy GDP that is not captured with the existing methods used in BEA's Digital Economy Satellite Account.

6. Data Appendix

This section provides the details of the HP and DESA data sources.

Durable goods data are drawn from BEA's Detailed Consumer Durable Goods Tables, September 30, 2022, available at: <https://apps.bea.gov/national/FA2004/Details/xls/DetailCDG.xlsx>. We use data from sheets "Net Stock (Current-Cost)," "Net Stock (Fixed-Cost)," and "Depreciation (Current-Cost)." The implicit price indices are calculated as the ratio of current cost and fixed cost net stocks.

The rate of return is the household financial rate of return from [Bridgman et al. \[2022\]](#).

The Digital Economy Satellite Account data were released November 22, 2022, available at: https://www.bea.gov/system/files/2022-11/DigitalEconomy_2005-2021.xlsx.

¹¹ See the BEA fixed assets accounts for consumer durable goods.

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