The Importance of Licensed Spectrum and Wireless Telecommunications to the American Economy

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I. EXECUTIVE SUMMARY

Between 1985 and 2020, wireless (mobile) network operators have spent more than $600 billion in capital investment, not including over $120 billion paid to the federal government for the right to use spectrum to power the networks and support the wireless services that consumers demand.

During the past decade alone, spectrum auctions pertaining to wireless services have raised $155 billion in revenues. During the decade, wireless network operators invested $265 billion in infrastructure, deployed hundreds of thousands of cell sites and other antenna structures, and cut the cost of mobile data by 98%, even while delivering nearly 50x the volume of data, at higher speeds.

The substantial investments in licensed spectrum and infrastructure during the past decade have allowed the industry to deliver wireless services to hundreds of millions of consumers throughout the U.S., contributing nearly $9.5 trillion in gross output and $5.4 trillion in GDP to the American economy, and employing an annual average of more than three million people. See Table 1. **In 2020 alone, the wireless industry contributed over $1.3 trillion in gross output, $825 billion in GDP, and nearly 4.5 million jobs to the American economy.**

These trillions in output and millions of jobs include the direct effects of the core wireless industry (mobile network operators and resellers) on the economy, as well as the secondary effects of the wireless supply chain and select downstream market segments that rely heavily upon wireless and mobile broadband services (including smartphone app developers, search engines, digital advertising agencies, mobile gaming, and social networking sites). It does not take into account the contributions made by other sectors that also depend on and use wireless services that could represent hundreds of billions in additional gross output and GDP, as well as millions of workers. Therefore, the estimates presented in this study are a baseline, or lower bound, for the contributions made by wireless-related sectors to the American economy.

For the wireless industry to continue to provide these considerable, widespread positive effects to the American economy, it is necessary to provide mobile network operators access to dedicated, licensed spectrum. It is also important to allow potential licensees to compete to acquire the spectrum licenses, and, once acquired, to allow the licensees to determine the optimal allocation and usage of that spectrum in the economy based on economic market forces. This will promote economic efficiency in the distribution and allocation of spectrum—a scarce resource—and will allow the wireless industry to continue to grow and provide numerous, substantial economic benefits to the American economy.

Table 1 – Summary of Economic Benefits to the U.S. Economy, 2011-2020

	Gross Output ($B)	GDP ($B)	Employment (Annual Avg.)
Direct Effects: Core Wireless (MNOs, MVNOs)	$2,702.3	$1,329.9	252,022
Secondary Effects: Core Wireless Supply Chain	$3,794.7	$2,431.4	1,568,011
Direct Effects: Selected Downstream App and Mobile Industries	$1,478.9	$753.5	270,267
Secondary Effects: Selected Downstream App and Mobile Industry Supply Chains	$1,501.2	$857.7	982,154
Total	**$9,477.1**	**$5,372.6**	**3,072,454**

II. Overview of Spectrum and the Wireless Industry

A. Overview of Spectrum and Spectrum Licensees

Radio spectrum is the radio frequency part of the electromagnetic spectrum. The Federal Communications Commission (FCC) oversees licensed spectrum for commercial use, while the National Telecommunications and Information Administration oversees licensed spectrum for federal use. Commercially licensed spectrum enables services such as mobile broadband (BB), broadcast television, broadcast radio, and satellite communications. A spectrum band is acquired through a license from the FCC, typically specifying a given geographic area, time period, and operating rules that a licensee must follow.

In contrast to licensed spectrum, unlicensed spectrum involves radio frequencies that the FCC manages generally without licenses. Unlicensed spectrum often includes near-range and low-power services, such as Wi-Fi, certain wireless devices, Bluetooth devices, and so-called internet-of-things devices. Unlike licensed spectrum, which guarantees licensees have exclusive rights to a particular frequency range, unlicensed spectrum is dedicated to public and commercial use. This report focuses on the economic benefits of licensed spectrum.

During the five-year period FY 1997 to 2001, the FCC had 24 spectrum auctions, resulting in 12,545 licenses won, generating about $5.5 billion. Two decades later, during FY 2017 to 2021, this grew to 49,245 licenses won, generating about $115 billion. See Table 2. Since FY 1994, the FCC's spectrum auctions program has generated $233 billion, with an expense of $2.3 billion, for the U.S. government.[1] Between 2011 and 2020, spectrum auctions pertaining to wireless services have raised $155 billion in auction revenues.[2] As of 2020, the FCC reported that 5,693 MHz of licensed spectrum are available for the use and provision of mobile wireless services.[3]

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[1] FCC, 2023 Budget Estimates to Congress, March 2022, p. 48. FCC aggregate figures reflect some auctions that may not be applicable to wireless network operators or wireless services that are discussed within this paper, such as FM Broadcast auctions. CTIA estimates suggest that such auctions account for only about $4 billion of the $233 billion.

[2] This includes auctions 92, 96-97, 101-103, 105, 107 and 1002. See FCC, "Auction 92: 700 MHz Band," available at https://www.fcc.gov/auction/92; FCC, "Auction 96: H Block," available at https://www.fcc.gov/auction/96; FCC, "Auction 97: Advanced Wireless Services (AWS-3)," available at https://www.fcc.gov/auction/97; FCC, "Winning Bidders Announced For Auction of 28 GHz Upper Microwave Flexible Use Service Licenses (Auction 101)," available at https://docs.fcc.gov/public/attachments/DA-19-484A1.pdf; FCC, "Auction of 24 GHz Upper Microwave Flexible Use Service Licenses Closes," available at https://docs.fcc.gov/public/attachments/DA-19-485A1.pdf; FCC, "Auction 103 – Upper 37 GHz, 39 GHz, and 47 GHz," available at https://auctiondata.fcc.gov/public/projects/auction103; FCC, "Auction 105 - 3.5 GHz," available at https://auctiondata.fcc.gov/public/projects/auction105; FCC, "FCC Announces Winning Bidders In C-Band Auction," available at https://docs.fcc.gov/public/attachments/DOC-370267A1.pdf; FCC, "Forward Auction," available at https://auctiondata.fcc.gov/public/projects/1000.

[3] FCC, 2020 Communications Marketplace Report, December 31, 2020, pp. 22-23. This includes mmW spectrum. The FCC's spectrum screen includes spectrum that the FCC finds "suitable and available for the provision of mobile wireless services." See Id., n.92.

Table 2 – FCC Auction Statistics

	1994 - 1996	1997 - 2001	2002 - 2006	2007 - 2011	2012 - 2016	2017 - 2021	Thru Jan. 2022	Total
Number of Auctions	10	24	30	16	7	10	1	98
Licenses Won	2,759	12,545	14,534	6,463	5,189	49,245	4,041	94,776
Amount Generated (billions)	$10.9	$5.5	$16.4	$19.2	$43.3	$115.3	$22.4	$233.0

Source: FCC, 2023 Budget Estimates to Congress, March 2022, p. 48.
Data ranges are based on fiscal years (FY 2021 = Oct 1, 2020 to Sept 30. 2021).

Deploying licensed spectrum for wireless consumer services requires wireless infrastructure. Mobile network operators (MNOs) have invested significantly in the U.S. to build and maintain the infrastructure that enables high-quality, low-cost wireless and mobile BB services to consumers. Between 1985 and 2020, wireless operators in the U.S. had collectively made over $600 billion in capital investments.[4] During the decade spanning 2011 to 2020 alone, the cumulative investment was over $265 billion.[5]

Extensive capital spending in the U.S. by MNOs has allowed for a rapidly growing wireless infrastructure. Wireless service providers deploy cell sites to expand or to improve coverage in existing service areas and to accommodate newer technologies.[6] CTIA estimates that the number of cell sites in commercial use has increased from 283,385 in 2011 to 417,215 in 2020.[7]

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[4] CTIA, CTIA's Wireless Industry Indices Report (July 2021), Table 14 and Appendix B. Excludes the cost of licenses.

[5] Id.

[6] FCC, 2020 Communications Marketplace Report, December 31, 2020, p. 25.

[7] CTIA, CTIA's Wireless Industry Indices Report (July 2021), Chart 19 and Appendix B. CTIA notes that "[t]he 417,215 cell sites in active service at year-end 2020 include traditional macro cells, small cells, DAS nodes, and other cell-extending devices. The cell site count originally included repeaters and other cell-extending devices, some of which have been rendered obsolete by new technology generations. The extent to which one category or another may have grown or shrunk is not reported. While CTIA tracks the total number of cell sites in service as of the end of each

As described next, MNOs use the licensed spectrum and their wireless infrastructure to deliver wireless services to hundreds of millions of consumers throughout the U.S., including selling access to their wireless networks to mobile virtual network operators (MVNOs), also known as resellers, at wholesale rates, which MVNOs use to sell their own wireless services to consumers. Consumers of wireless services, including mobile BB, have benefitted from lower prices, higher output, and higher quality over time associated with the investments made by MNOs in licensed spectrum and wireless infrastructure.

B. Consumers Have Benefited From Substantial Investments Made by Wireless Operators

The extensive investments in spectrum and wireless infrastructure by MNOs, coupled with a competitive wireless industry, have delivered to consumers low prices, high output, and high-quality wireless services over the past few decades, promoting consumer welfare and thus fulfilling a well-established goal of competition policy in the U.S.[8]

Price indices published by the Bureau of Labor Statistics (BLS) demonstrate declining prices for wireless services. Both wireless consumer and producer price indices have fallen steadily and markedly over the years. Between 2000 and 2021, the wireless services consumer price index (CPI) declined by nearly 37%, and the wireless carriers producer price index (PPI) declined by over 50%.[9] In contrast, the CPI for all items in the U.S. increased by 57% between 2000 and 2021. See Figure 1. Similarly, average revenue

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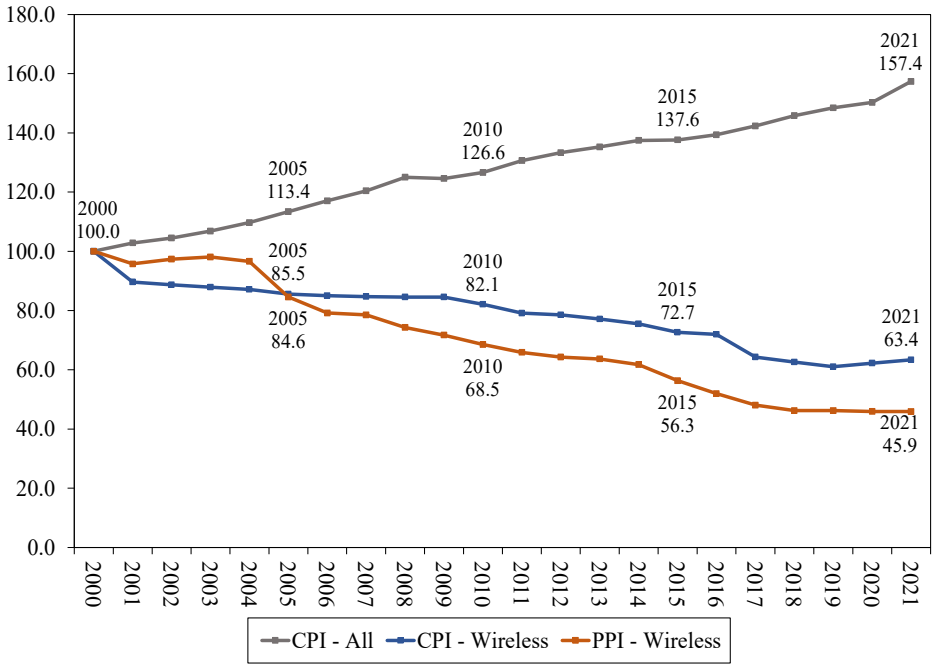
survey period, it does not track the number that are removed from service, nor the number of newly added cell sites in any specific survey period, though we know that such removals and additions have occurred as new generations of technology have been deployed. Nor do we track base stations." Id., p. 54.

[8] The consumer welfare standard employed by the antitrust agencies and courts in the U.S. is intended to promote competition and protect consumers. See, e.g., Opening Statement of Professor Carl Shapiro, Senate Judiciary Committee – Subcommittee on Antitrust, Consumer Protection and Consumer Rights, "The Consumer Welfare Standard in Antitrust: Outdated, or a Harbor in a Sea of Doubt," December 13, 2017, p. 2, available at https://www.judiciary.senate.gov/imo/media/doc/12-13-17%20Shapiro%20Testimony.pdf.

[9] Wireless CPI is based on Wireless Telephone Services (CUUR0000SEED03). Wireless PPI is based on Wireless Telecommunications Carriers (PCU517312517312).

per unit (ARPU)—that is, the average revenue per subscriber per month for wireless services—has declined from $48.6 to $35.3, or about 27%, between 2000 and 2020.[10] Finally, the average service revenue per gigabyte (GB) of mobile data has declined from $195.9/GB in 2011 to just $4.5/GB in 2020, representing a decline of about 98%.[11]

Figure 1 – BLS Price Indices, 2000-2021



Source: BLS Data Series CUSR0000SA0, CUUS0000SA0, CUUR0000SEED03, PCU517312517312.

While prices have been falling, output in the wireless industry has steadily grown over time. The estimated number of wireless connections increased from approximately 109 million in 2000 to 469 million in 2020 in the U.S., representing a four-fold increase.[12] Pew Research reports that ownership of cellular phones in the U.S. increased from 83% in May

[10] CTIA, CTIA's Wireless Industry Indices Report (July 2021), Chart 17 and Appendix B. The FCC notes that while "[…] it is difficult to directly compare prices between providers or over time, because providers offer a variety of plans […]," measures of ARPU are "frequently used as a proxy for price […]." See FCC, 2020 Communications Marketplace Report, December 31, 2020, pp. 31-33.

[11] CTIA, CTIA's Wireless Industry Indices Report (July 2021), Charts 2 and 14.

[12] Id., Table 5.

2011 to 97% in February 2021, and smartphone ownership increased from 35% to 85% during the same period.[13] The number of active smartphones increased from 111.5 million to over 296 million between 2011 and 2020, and the number of wireless-enabled laptops, tablets, and routers active on networks more than doubled from 20.2 million to 41.3 million in the same period.[14] This is especially noteworthy given that an increasing share of households are relying on mobile data. Between 2016 and 2019, the share of internet-subscribing households with mobile data had increased from 83.3% to 90.0%.[15] Moreover, the share of internet-subscribing households with *only* mobile data plans had increased from 13.2% to 14.1% in the same period.[16]

Another key measure of output is mobile data traffic. As shown in Figure 2, total mobile data traffic in the U.S. grew nearly 50-fold from 867 billion megabytes (MB) in 2011 to over 42 trillion MB in 2020. Mobile data usage per device also increased markedly during the same period, with the average monthly data traffic per average smartphone growing over 21-fold from 0.5 GB in 2011 to 10.8 GB in 2020. See Figure 3. Minutes of use experienced modest growth within the same period, increasing from 2.3 trillion to 2.9 trillion minutes between 2011 and 2020.[17]

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[13] Pew Research, "Mobile Fact Sheet," April 7, 2021, available at https://www.pewresearch.org/internet/fact-sheet/mobile/.

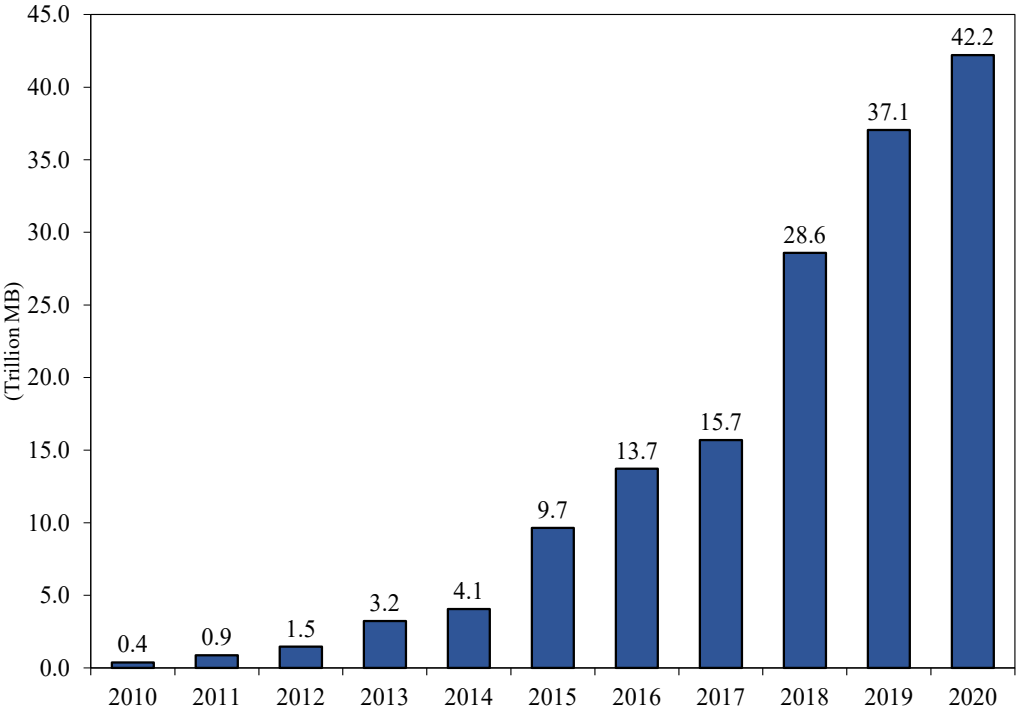
[14] CTIA, CTIA's Wireless Industry Indices Report (July 2021), Appendix B.

[15] FCC, 2020 Communications Marketplace Report, December 31, 2020, Fig. II.B.33.

[16] Id., Fig. II.B.32.

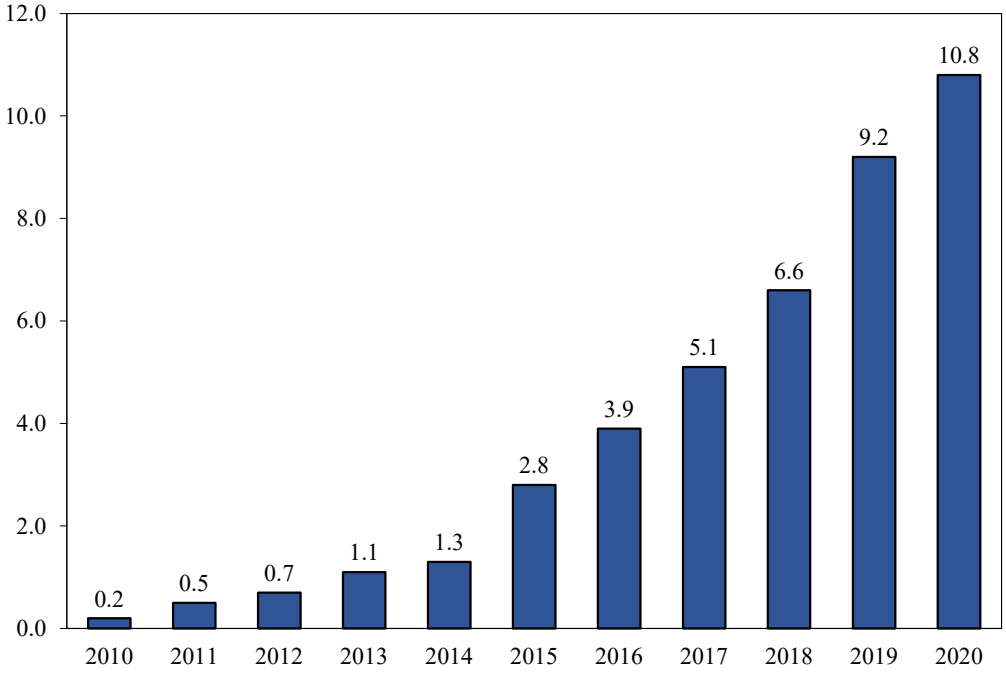
[17] CTIA, CTIA's Wireless Industry Indices Report (July 2021), Chart 2 and Appendix B.

Figure 2 – Total Mobile Data Traffic, 2010-2020



Source: CTIA 2020 Indices Report, Chart 2 and Appendix B.

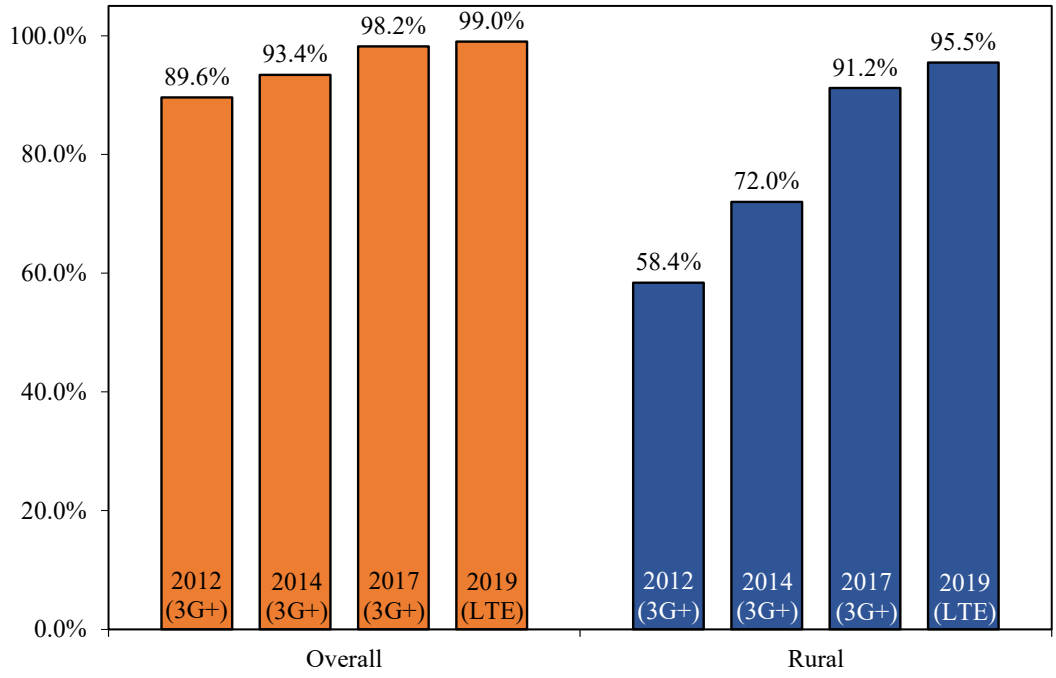
Figure 3 – Average GB Per Average Smartphone Per Month, 2010-2020



Source: CTIA 2020 Indices Report, Chart 4.

In addition, as a result of the considerable investments in licensed spectrum and wireless infrastructure, wireless service coverage has expanded in the U.S. In January 2012, 89.6% of the population in the U.S. was covered by at least three service providers (3G or better). By January 2017, the coverage had increased to 98.2%. By December 2019, the share of population covered by at least three LTE providers had increased to 99%. See Figure 4. Increased wireless coverage also has occurred in rural areas. As of May 2020, there were 2,885 counties (89%) nationwide with three or more tower or cell site operations and 2,457 counties (76%) with four or more tower operators.[18] Moreover, in January 2012, the share of the rural population covered by at least three service providers was about 58%, increasing to just over 91% five years later. The share of rural population covered by at least three LTE providers had reached 95.5% by 2019. See Figure 4.

Figure 4 – Share of U.S. Population With Three or More Providers



Source: FCC Communications Marketplace Reports.

[18] FCC, 2020 Communications Marketplace Report, December 31, 2020, Fig. II.A.17.

While prices have been falling and output has been increasing, wireless service quality has been increasing. An important measure of performance and quality in the wireless industry is mobile BB speed. Higher mobile BB speeds can enhance user experience (e.g., streaming video) and facilitate new software applications (e.g., virtual reality). The median download speed for 4G LTE nationwide more than doubled from 11 megabits per second (Mbps) to 26.2 Mbps between 2014 and 2019.[19] Moreover, data from Ookla shows that the overall average mobile download speed in the U.S. increased from 19.3 Mbps in July 2016 to 31.2 Mbps in November 2018, and further increased to 128.3 Mbps by June 2022.[20] According to Ookla, median mobile download speed in the U.S. increased from 36 Mbps in October 2020 to 59.5 Mbps in June 2022.[21]

Other measures of quality, such as consumer satisfaction, also have increased over time. The American Customer Satisfaction Index (ASCI)—a national indicator of the quality of economic output for goods and services as experienced by consumers—shows that the ASCI for wireless phone service increased from 63 in 2005 to 74 in 2021.[22]

C. Demand for Wireless Services and Mobile Broadband is Projected to Continue to Grow

It is clear that there has been immense growth in wireless services and service quality, primarily driven by mobile BB. The growth in output and increasing quality of mobile BB,

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[19] Id., Fig. II.A.29.

[20] Ookla, "Speedtest," July 2017, available at https://web.archive.org/web/20170812155126/http://www.speedtest.net/global-index/united-states; Ookla, "Speedtest," November 2019, available at https://web.archive.org/web/20200106224809/https://www.speedtest.net/global-index/united-states; Ookla "Speedtest," June 2022, available at https://web.archive.org/web/20220728224651/https://www.speedtest.net/global-index/united-states.

[21] Ookla, "Speedtest," October 2021, available at https://web.archive.org/web/20211130112014/https://www.speedtest.net/global-index/united-states; Ookla "Speedtest," June 2022, available at https://web.archive.org/web/20220728224651/https://www.speedtest.net/global-index/united-states.

[22] American Customer Satisfaction Index, Wireless Phone Service, available at https://www.theacsi.org/industries/telecommunications-and-information/wireless-phone-service/.

as well as declining prices, in the U.S. has been facilitated by extensive investments by MNOs to acquire spectrum licenses and associated capital spending on wireless infrastructure to meet growing consumer demand. The growth in demand for mobile BB is expected to continue. Industry market research reports predict that demand for wireless and mobile BB services will increase, primarily driven by the growth in 5G mobile BB technology.

A GSMA report finds that 5G connections represented only 3% of total connections in the U.S. in 2020 but is projected to grow to represent 68% of total connections by 2025.[23] GSMA also estimates that mobile BB users as a share of the population in the U.S. will increase from 78% to 82% between 2020 and 2025.[24]

According to a report by Ericsson, 400 million 5G subscriptions in North America are anticipated by the end of 2027, accounting for 90% of all mobile subscriptions, and average data usage is expected to reach 52 GB per smartphone per month in 2027.[25] As shown in Figure 3, the average monthly data traffic per smartphone was about 10.8 GB in 2020. Therefore, Ericsson's projection suggests an almost five-fold increase in data traffic per smartphone by 2027.

IBISWorld notes that the wireless telecommunications carriers industry "is well-positioned for growth over the five years to 2027," and that "enhanced speed of fourth-generation (4G) and LTE networks has already driven more customers to abandon landlines altogether."[26] The report also notes that the share of households in the U.S. with only wireless service will continue increasing, while the share of households with both wireline

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[23] GSMA, The Mobile Economy – North America, 2021, p. 6, available at https://www.gsma.com/mobileeconomy/wp-content/uploads/2021/10/GSMA_ME_NorthAmerica_2021_WebSingles.pdf.

[24] Id., p. 12.

[25] Ericsson, Mobility Report, June 2022, pp. 7, 16, available at https://www.ericsson.com/49d3a0/assets/local/reports-papers/mobility-report/documents/2022/ericsson-mobility-report-june-2022.pdf.

[26] IBISWorld, Wireless Telecommunications Carriers in the US, March 2022, pp. 14-15.

and wireless service is projected to decline, attributable to the rollout of 5G networks.[27] IBISWorld forecasts that the number of mobile internet connections will grow from 334 million in 2022 to 348 million in 2028.[28]

III. The Core Wireless Industry Contributes Substantially to the American Economy

The core wireless industry—comprised of MNOs (wireless carriers) and MVNOs (resellers) that provide wireless services to consumers—has played a critical role in the American economy, both in terms of growing output and providing relatively high-paying jobs compared to the rest of the private sector. As a result of its investments in spectrum and wireless infrastructure, the core wireless industry provides goods and services to consumers in the U.S. that amounted to $2.7 trillion in gross output and over $1.3 trillion in GDP during the decade spanning 2011 to 2020, as well as over 250,000 jobs on average per year during the same period. In 2020 alone, the core wireless industry generated over $300 billion in gross output and over $160 billion in GDP, as well as nearly 218,000 jobs. See Table 1 and Appendix A.

For the wireless industry to continue to play a major role in the American economy, especially in a climate of continued expected growth in demand for mobile BB, extensive investments in spectrum licenses and accompanying investments in wireless infrastructure by MNOs will be required.

[27] Id.

[28] Id.

A. The Core Wireless Industry Contributes Substantially to Output

Annual gross output[29] from the core wireless industry[30] grew from $222.3 billion in 2011 to $303.7 billion by 2020, or approximately a 37% increase. Wireless mobile network operators contributed about 85% of this growth (approximately $69 billion), and wireless resellers accounted for the remaining 15% (approximately $12.3 billion).[31] In comparison, gross output from the wired telecommunications industry had only increased from approximately $316 billion to $339 billion during the same decade.[32]

During the decade spanning 2011 to 2020, the core wireless industry directly contributed over $2.7 trillion in gross output to the U.S. economy, or an annual average of about $270 billion. See Table 3. In terms of value added (GDP), during the decade spanning 2011 to 2020, the core wireless industry directly contributed $1.3 trillion to the American economy.[33] See Table 3.

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[29] Gross output is a measure of sales or revenue from production for most industries, although it is measured as sales or revenue less cost of goods sold for margin industries like retail and wholesale trade. See BEA, "What is gross output by industry and how does it differ from gross domestic product (or value added) by industry?" February 12, 2018, available at https://www.bea.gov/help/faq/1197.

[30] NAICS 517312 reflects the 2017 NAICS code for the wireless carriers. The NAICS code was updated to 517112 in 2022. See Census Bureau, North American Industry Classification System - Wireless Telecommunications Carriers (except Satellite), available at https://www.census.gov/naics/?input=51&chart=2022&details=517112.

America Movil Quarter Filings; FCC Local Telephone Competition reports; FCC Voice Telephone Services reports.

[31] Gross output for MVNOs is estimated as the product of TracFone's monthly average revenue per user (including equipment revenues) and the FCC's estimates of the number of MVNO subscribers each year.

[32] Bureau of Economic Analysis, Gross Output by Industry, available at https://apps.bea.gov/iTable/iTable.cfm?reqid=150&step=2&isuri=1&categories=ugdpxind.

[33] Value added (GDP) for MVNOs is estimated by calculating the MVNO revenues (see n.31) as a share of total output from IMPLAN's *Satellite, telecommunications resellers, and all other telecommunications* sector, and applied to IMPLAN's estimates of value added for this sector.

Between 2011 and 2020, nominal GDP in the U.S. grew by $5.3 trillion.[34] During the same period, nominal GDP for MNOs alone grew by $54 billion, representing just over 1% of the growth in GDP in the economy.[35] By comparison, the wired telecommunications industry experienced an increase of just $8 billion in GDP during the same period, representing just 0.15% share of total GDP growth in the U.S.[36] MNOs rank 33 out of 138 sub-industries within the American economy in terms of all sub-industries' share of GDP growth between 2011 and 2020 in the U.S.[37] By comparison, wired telecommunications ranks 94 out of 138.

Table 3 – Total Core Wireless Industry, Select Economic Data

	Wireless Carriers			Wireless Resellers			Core Total		
	Gross Output ($B)	GDP ($B)	Employees	Gross Output ($B)	GDP ($B)	Employees	Gross Output ($B)	GDP ($B)	Employees
2011	$216.7	$99.4	238,071	$5.6	$2.3	28,337	$222.3	$101.7	266,408
2012	$230.5	$101.6	230,101	$7.2	$3.0	31,547	$237.7	$104.6	261,648
2013	$238.2	$118.3	230,409	$9.3	$3.8	33,411	$247.5	$122.1	263,820
2014	$256.9	$117.8	232,169	$10.6	$4.2	35,782	$267.5	$122.0	267,951
2015	$261.6	$126.3	235,818	$10.6	$4.2	34,556	$272.2	$130.5	270,374
2016	$265.2	$130.9	216,537	$11.7	$4.7	36,541	$276.9	$135.6	253,078
2017	$263.8	$131.4	207,324	$12.8	$5.1	40,741	$276.6	$136.5	248,065
2018	$281.5	$147.7	206,855	$13.9	$5.5	40,215	$295.4	$153.2	247,070
2019	$287.1	$156.8	188,639	$15.4	$6.3	35,355	$302.5	$163.1	223,994
2020	$285.7	$153.4	179,460	$18.0	$7.2	38,356	$303.7	$160.6	217,816
Total	**$2,587.2**	**$1,283.6**		**$115.1**	**$46.3**		**$2,702.3**	**$1,329.9**	
Average	**$258.7**	**$128.4**	**216,538**	**$11.5**	**$4.6**	**35,484**	**$270.2**	**$133.0**	**252,022**

Sources: Gross Output: BEA, Gross Output by Industry; IMPLAN.
Value Added (GDP): BEA, Value Added by Industry; IMPLAN.
Employees: CTIA 2020 Indices Report, Table 17, Appendix B.
IMPLAN, America Movil Quarter Filings; FCC Local Telephone Competition reports; FCC Voice Telephone Services reports.

[34] Bureau of Economic Analysis, Value Added by Industry, available at https://apps.bea.gov/iTable/iTable.cfm?reqid=150&step=2&isuri=1&categories=ugdpxind.

[35] Id.

[36] Id.

[37] The most disaggregated industry category available in each industry group is used for the purpose of comparison, resulting in 138 industries. The category "Addenda" is excluded from this analysis.

B. The Core Wireless Industry Employs a Large Number of People and Provides High-Wage Jobs

The core wireless industry employed an average of 252,022 employees per year during the decade spanning 2011 to 2020. See Table 3. This average is comprised of 216,538 wireless network operators' employees[38] and an estimated 35,484 wireless reseller employees.[39]

The average weekly wage earned by wireless network operator employees is considerably higher than wages earned in the private sector broadly. The average weekly wage for employees of the wireless network operators was $1,880 in 2020, over 52% higher than the average overall private sector weekly wage ($1,236) in the same year. Average wages among employees of the wireless network operators have consistently been substantially higher than average private sector wages the entire decade spanning 2011 to 2020. See Figure 5. Moreover, the average weekly wage for employees of the wireless network operators in 2020 has been higher than the average private sector weekly wage for 45 out of 47 states with available data.[40] This shows that the above-average wages to wireless network operator employees is shared by nearly all states in the U.S., including relatively higher-income states (e.g., New York, California, and Washington) and relatively lower-income states (e.g., Montana, Mississippi, and Idaho).

Growth in the average weekly wage among employees of the wireless network operators also has outpaced the growth in wages in the overall private sector. The average weekly wage earned by employees of wireless network operators increased by $583 (45%

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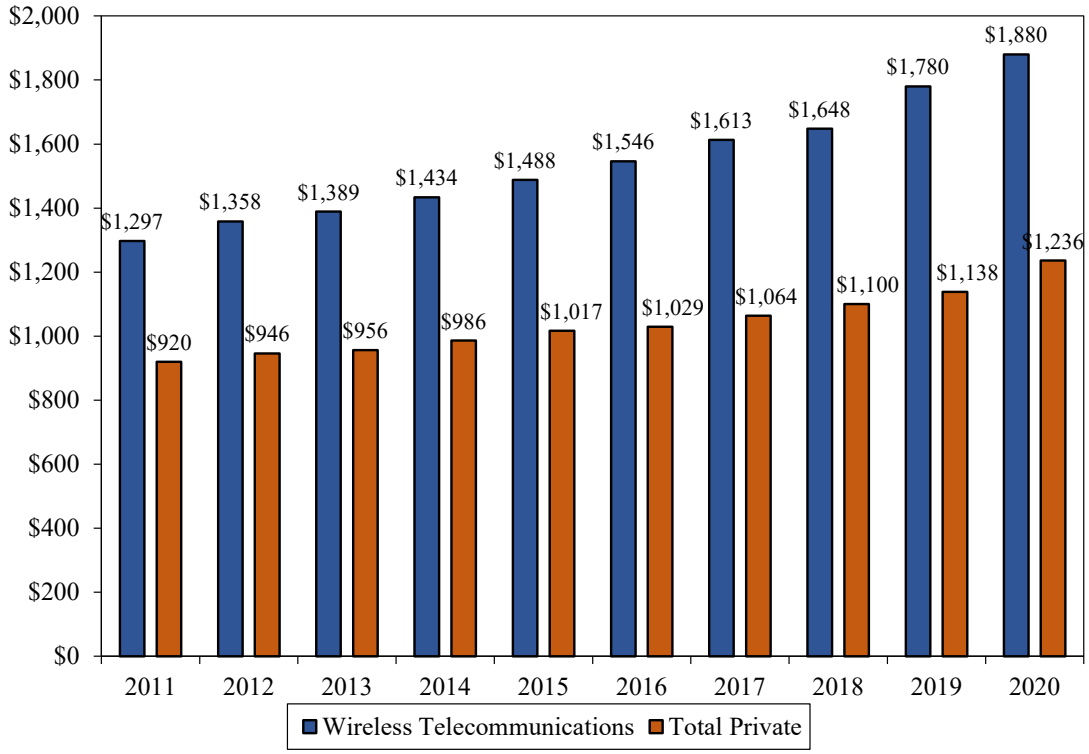
[38] Unlike BLS estimates, CTIA employment figures for the wireless carriers include the types of positions that may be classified by the BLS into other sectors of the economy (such as call centers), as well as headquarters personnel.

[39] MVNO employment figures are estimated by first calculating MVNO revenues (see n.31) as a share of total output from IMPLAN's *Satellite, telecommunications resellers, and all other telecommunications* sector, and applied to IMPLAN's employment estimates for this sector.

[40] BLS, Quarterly Census of Employment and Wages. Average weekly wage data for the wireless telecommunications industry (wireless network operators) is not available from BLS for Delaware, North Dakota, and Vermont in 2020. Massachusetts and West Virginia had lower wireless average weekly wages compared to their respective average private sector weekly wages in 2020.

growth) between 2011 and 2020, while the average weekly wage of all private sectors increased by $316 (34% growth) during the same period. See Figure 5.

Figure 5 – Average Weekly Wage, 2011-2020



Source: BLS, Quarterly Census of Employment and Wages.

IV. THE CORE WIRELESS INDUSTRY GENERATES ADDITIONAL, SECONDARY BENEFITS TO THE AMERICAN ECONOMY

In addition to the direct positive effects of the core wireless industry on the American economy (described above), there are even greater secondary effects that result from spending by the core wireless industry throughout the supply chain and spending by employees of the core wireless industry and its supply chain. These secondary effects accounted for nearly $3.8 trillion in additional gross output and approximately $2.4 trillion in GDP during the decade spanning 2011 to 2020, as well as over 1.5 million jobs on average per year during the same period. In 2020 alone, secondary effects generated over $400 billion in gross output and nearly $289 billion in GDP, as well as over 1.6 million jobs on average each year. See Table 1 and Appendix A.

A. The Core Wireless Industry Generates Additional Economic Output

While the direct impact by itself is substantial, there are secondary, positive effects on economic output from the wireless industry—namely, indirect effects and induced effects. Indirect effects are the business-to-business purchases in the supply chain that stem from the initial input purchases by the core wireless industry.[41] As the core wireless industry spends more for inputs from its suppliers, such spending creates economic output from those suppliers. In turn, those suppliers of intermediate goods will also purchase more of their inputs. Induced effects primarily encompass spending by employees of the core wireless industry and employees of suppliers to the wireless industry. That is, the induced effects are generated from spending by employees within the core wireless industry's supply chain on goods and services in the U.S. economy.[42]

A simplified example can be drawn from the deployment of 5G technology. The rollout of 5G requires considerable investment in new infrastructure that will drive an increase in demand for broadcast and wireless communication equipment. To meet this higher demand, domestic broadband and wireless equipment producers will increase their production and purchase more inputs, such as semiconductors, printed circuits, and other electronic components. This continues throughout the supply chain. Additionally, each of these industries in the supply chain may need to increase employment to meet the increase in demand, thereby increasing employee compensation and household income. This increase in household income can be spent throughout many sectors of the U.S. economy.

The indirect and induced effects continue throughout the economy in a diminishing manner due to leakages, such as demand fulfilled by imported goods or demand dampened by higher rates of household savings. Purchasing imported goods, either as an intermediate input to manufacturing, or as final goods and services, means that domestic producers do not increase production to meet demand, and therefore there are no "flow-through" effects from

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[41] Bureau of Economic Analysis, "RIMS II User Guide: An essential tool for regional developers and planners," December 2013, available at https://www.bea.gov/sites/default/files/methodologies/RIMSII_User_Guide.pdf, pp. 3-5, and G-2.

[42] Id.

increased spending. Similarly, higher rates of household savings out of income, which result in less consumer spending out of income, will result in less of an increase in demand elsewhere in the economy. These leakages multiply throughout the economy, such that, eventually, there is virtually no more effect from the initial industry stimulus. A way to estimate the secondary impact resulting from the wireless industry —that is, induced and indirect effects—is by applying a multiplier to the core wireless industry's gross output. Appendix B provides details on this approach.

Table 4 below provides the core wireless industry's total direct and secondary effects on gross output in the U.S. economy based on a multiplier approach. As described earlier, the direct effect is $2.7 trillion for the decade spanning 2011 to 2020. The estimated secondary effects amount to nearly $3.8 trillion for the same period, reflecting $2.3 trillion from indirect effects and nearly $1.5 trillion from induced effects. The total effect on gross output generated during the decade is about $6.5 trillion, or $650 billion on average per year.

Table 4 – Estimated Effects of the Core Wireless Industry on Gross Output

	Wireless Carriers			Wireless Resellers			Core Total			
	Direct ($B)	Indirect ($B)	Induced ($B)	Direct ($B)	Indirect ($B)	Induced ($B)	Direct ($B)	Indirect ($B)	Induced ($B)	Total ($B)
2011	$216.7	$182.6	$123.8	$5.6	$4.9	$6.2	$222.3	$187.6	$130.0	$539.9
2012	$230.5	$201.0	$134.4	$7.2	$6.4	$7.4	$237.7	$207.4	$141.8	$586.9
2013	$238.2	$193.4	$131.2	$9.3	$8.2	$8.3	$247.5	$201.6	$139.5	$588.6
2014	$256.9	$225.0	$147.5	$10.6	$9.4	$9.3	$267.5	$234.4	$156.8	$658.6
2015	$261.6	$222.8	$141.7	$10.6	$9.3	$9.0	$272.2	$232.1	$150.6	$654.9
2016	$265.2	$227.1	$141.5	$11.7	$10.4	$9.4	$276.9	$237.5	$151.0	$665.4
2017	$263.8	$229.3	$139.4	$12.8	$11.4	$10.5	$276.6	$240.8	$149.9	$667.3
2018	$281.5	$247.2	$147.2	$13.9	$12.5	$10.9	$295.4	$259.7	$158.1	$713.2
2019	$287.1	$240.5	$142.8	$15.4	$13.5	$12.0	$302.5	$253.9	$154.8	$711.3
2020	$285.7	$243.7	$134.8	$18.0	$15.8	$13.0	$303.7	$259.5	$147.8	$711.0
Total	**$2,587.2**	**$2,212.6**	**$1,384.4**	**$115.1**	**$101.8**	**$95.9**	**$2,702.3**	**$2,314.4**	**$1,480.3**	**$6,497.0**
Average	**$258.7**	**$221.3**	**$138.4**	**$11.5**	**$10.2**	**$9.6**	**$270.2**	**$231.4**	**$148.0**	**$649.7**

Sources: BEA, Gross Output by Industry; IMPLAN. IMPLAN, America Movil Quarter Filings; FCC Local Telephone Competition reports; FCC Voice Telephone Services reports.

Similarly, Table 5 illustrates the core wireless industry's total direct and secondary effects on value added (GDP) in the U.S. economy. As described earlier, during the decade spanning 2011 to 2020, the core wireless industry has directly contributed $1.3 trillion to U.S. GDP. The estimated secondary effects amount to an additional $2.4 trillion, reflecting

nearly $1.5 trillion in indirect effects and $960 billion in induced effects. During the decade, the core wireless industry contributed a grand total of over $3.76 trillion to GDP in the U.S., or about $376 billion on average per year.

Table 5 - Estimated Effects of the Wireless Industry on Value Added (GDP)

	Wireless Carriers			Wireless Resellers			Core Total			
	Direct ($B)	Indirect ($B)	Induced ($B)	Direct ($B)	Indirect ($B)	Induced ($B)	Direct ($B)	Indirect ($B)	Induced ($B)	Total ($B)
2011	$99.4	$103.7	$72.7	$2.3	$2.7	$3.4	$101.7	$106.4	$76.1	$284.2
2012	$101.6	$113.8	$77.9	$3.0	$3.4	$4.0	$104.6	$117.3	$81.9	$303.8
2013	$118.3	$114.5	$78.9	$3.8	$4.4	$4.5	$122.1	$118.9	$83.4	$324.5
2014	$117.8	$135.0	$91.1	$4.2	$5.1	$5.1	$122.0	$140.1	$96.2	$358.3
2015	$126.3	$138.4	$90.1	$4.2	$5.1	$5.0	$130.5	$143.5	$95.1	$369.1
2016	$130.9	$144.7	$93.3	$4.7	$5.7	$5.3	$135.6	$150.4	$98.6	$384.6
2017	$131.4	$149.1	$93.7	$5.1	$6.2	$5.8	$136.5	$155.4	$99.6	$391.4
2018	$147.7	$177.6	$108.7	$5.5	$6.8	$6.1	$153.2	$184.4	$114.8	$452.3
2019	$156.8	$165.1	$101.6	$6.3	$7.4	$6.7	$163.1	$172.4	$108.3	$443.8
2020	$153.4	$173.6	$99.0	$7.2	$8.7	$7.4	$160.6	$182.3	$106.3	$449.2
Total	**$1,283.6**	**$1,415.5**	**$906.8**	**$46.3**	**$55.6**	**$53.5**	**$1,329.9**	**$1,471.1**	**$960.3**	**$3,761.3**
Average	**$128.4**	**$141.6**	**$90.7**	**$4.6**	**$5.6**	**$5.3**	**$133.0**	**$147.1**	**$96.0**	**$376.1**

Sources: BEA, Value Added by Industry; IMPLAN. IMPLAN, America Movil Quarter Filings; FCC Local Telephone Competition reports; FCC Voice Telephone Services reports.

B. The Core Wireless Industry Contributes Significantly to the Employment of People in Other Industries

As described earlier, during the decade spanning 2011 to 2020, the core wireless industry employed over 252,000 workers per year on average. The impact of the core wireless industry goes beyond this direct effect on the U.S. economy. There also are secondary effects—both indirect and induced—that the industry is responsible for with respect to employment. Indirect effects capture the employment effects of business-to-business transactions throughout the supply chain, while induced effects capture the employment effects stemming from increased household demand for goods and services in the economy as employment and incomes increase.

Table 6 provides the core wireless industry's direct, indirect, and induced effects on employment in the U.S. economy. Direct employment in the core wireless industry is 252,022 employees on average during the decade spanning 2011 to 2020. The estimated secondary effects amount to over 1.56 million employees on average each year during the

same period, including 865,764 and 702,247 additional employees from indirect and induced effects, respectively. Together, the total employment effects on the U.S. economy from the core wireless industry is over 1.8 million employees on average each year during the decade spanning 2011 to 2020.[43]

Table 6 – Estimated Effects of the Core Wireless Industry on Employment

	Wireless Carriers			Wireless Resellers			Core Total			
	Direct	Indirect	Induced	Direct	Indirect	Induced	Direct	Indirect	Induced	Total
2011	238,071	750,582	634,723	28,337	25,703	41,537	266,408	776,285	676,261	1,718,953
2012	230,101	803,619	663,477	31,547	32,402	48,000	261,648	836,021	711,477	1,809,145
2013	230,409	771,528	647,683	33,411	40,617	53,374	263,820	812,146	701,056	1,777,022
2014	232,169	824,340	670,475	35,782	46,604	58,468	267,951	870,944	728,943	1,867,838
2015	235,818	829,157	671,559	34,556	45,388	55,980	270,374	874,545	727,539	1,872,459
2016	216,537	815,203	643,971	36,541	49,869	58,749	253,078	865,072	702,720	1,820,869
2017	207,324	799,513	613,995	40,741	53,928	63,186	248,065	853,441	677,181	1,778,686
2018	206,855	826,926	631,158	40,215	55,417	63,806	247,070	882,343	694,964	1,824,378
2019	188,639	863,930	644,236	35,355	57,522	68,428	223,994	921,451	712,664	1,858,110
2020	179,460	898,028	616,212	38,356	67,361	73,458	217,816	965,389	689,670	1,872,874
Average	**216,538**	**818,282**	**643,749**	**35,484**	**47,481**	**58,499**	**252,022**	**865,764**	**702,247**	**1,820,033**

Sources: BLS, CEU5051731201; CTIA 2020 Indices Report, Table 17 and Appendix B; IMPLAN. IMPLAN; America Movil Quarter Filings; FCC Local Telephone Competition reports; FCC Voice Telephone Services reports.

V. THERE ARE BROADER, DOWNSTREAM ECONOMIC BENEFITS FROM WIRELESS AND MOBILE BROADBAND SERVICES

The services offered by the core wireless industry—in particular mobile BB powered by licensed spectrum—are an important contributing factor to the growth of many sectors in the U.S. economy, including mobile devices, IT, the app economy, as well as education and

[43] There are differences in the numbers of wireless carrier employees reported by CTIA and the BLS. BLS does not include employees working in positions that may be classified as part of other sectors of the economy (e.g., call centers) or headquarters personnel. For the current analysis, CTIA data are relied on for the total number of wireless carrier employees. Because part of these figures may fall under different industries within IMPLAN's multipliers database, a more conservative set of multipliers is applied to the remaining CTIA employment figures that exceed BLS estimates to measure indirect and induced employment effects. That is, two sets of multipliers are used to estimate secondary employment effects of the wireless carriers: Multipliers from IMPLAN's *Wireless telecommunications carriers (except satellite)* industry are applied to the portion of employment that is equal in size to BLS estimates, and the remaining employment that makes up the rest of CTIA's estimates is instead applied with smaller multiplier values to conservatively estimate the total effects from indirect and induced employment from wireless carriers.

health care, among other sectors. As general-purpose technologies, wireless and mobile BB services have been able to transform the economy, broadly promoting economic growth in the U.S.

This section quantifies the output and employment of selected downstream industries, including social networking, mobile gaming, smartphone app developers, search engines, and digital advertising agencies. These industries sell goods and services that are highly reliant on wireless and BB services, and thus would not be what they are today without the wireless and mobile BB infrastructure created by MNOs. Including direct and secondary effects, during the decade spanning 2011 to 2020, these industries accounted for nearly $3 trillion in gross output, contributed over $1.6 trillion in GDP to the U.S. economy, and employed an annual average of 1.25 million workers in the U.S.[44] In 2020 alone, these industries generated over $600 billion in gross output and over $375 billion in GDP, as well as nearly 2.6 million jobs. See Table 1 and Appendix A.

It is important to note that there are substantial benefits to the broader economy not quantified in the analyses presented here. Several other sectors of the American economy also will continue to benefit from enhanced wireless and mobile BB services, including, e.g., the healthcare sector,[45] financial services,[46] and energy,[47] to name a few. The additional benefits to the American economy from these sectors and many others, driven in part by wireless and mobile BB services, could represent hundreds of billions in additional gross output and GDP, as well as millions of workers, that are not captured in the analyses

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[44] Includes indirect and induced effects from downstream industries on the U.S. economy.

[45] See, e.g., PwC, "5G in healthcare," available at https://www.pwc.com/gx/en/industries/tmt/5g/pwc-5g-in-healthcare.pdf.

[46] See, e.g., Oracle, "Accelerating the next generation of financial services with 5G," May 10, 2022, available at https://blogs.oracle.com/oracle-communications/post/accelerating-the-next-generation-of-financial-services-with-5g.

[47] See, e.g., Dash Energy, "What Does 5G Mean For The Energy Sector?" available at https://dash.energy/2022/02/17/what-does-5g-mean-for-the-energy-sector/.

presented below. Thus, the estimates of the benefits to the American economy from the wireless industry presented in this study should be considered to be a lower bound.

A. Social Networking Sites

The social networking industry has benefitted significantly from mobile BB and an uptake in smartphone use. Facebook has noted that "[t]he most important factor driving advertising revenue growth was an increase in revenue from ads on mobile devices."[48] In 2012, mobile advertising revenue made up approximately 11% of Facebook's advertising revenue; by 2018, it had reached approximately 92%.[49] As of December 2021, Facebook (excluding WhatsApp and Instagram) had 2.9 billion monthly active users (MAUs) worldwide.[50] Mobile's share of Facebook's worldwide MAUs grew from 28% in December 2009 to 91% in December 2015.[51]

Similarly, Twitter has noted that "[m]obile has become the primary driver of our business. Our mobile products are critical to the value we create for our users, and they enable our users to create, distribute and discover content in the moment and on-the-go."[52] In the three months ending December 2013, 76% of Twitter's average MAUs accessed the platform from a mobile device and over 75% of its advertising revenue was generated from mobile devices.[53] By December 2018, 93% of Twitter's advertising revenue was generated from mobile devices.[54] Moreover, Pinterest also has documented the importance of mobile

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[48] Facebook Inc., SEC Form 10-K, for the fiscal year ended December 31, 2018, p. 44.

[49] Facebook Inc., SEC Form 10-K, for the fiscal year ended December 31, 2012, p. 47; Facebook Inc., SEC Form 10-K, for the fiscal year ended December 31, 2018, p. 44.

[50] Facebook, SEC Form 10-K, for the fiscal year ended December 31, 2021, p. 57.

[51] Facebook Inc., SEC Form 10-K, for the fiscal year ended December 31, 2015, pp. 35-36; Facebook Inc., SEC From 10-K, for the fiscal year ended December 31, 2012, pp. 37, 39. Facebook does not provide data on worldwide mobile MAUs after 2015.

[52] Twitter, Inc., SEC Form 10-K, for the fiscal year ended December 31, 2013, p. 6.

[53] Id.

[54] Twitter, Inc., SEC Form 10-K, for the fiscal year ended December 31, 2018, p. 35.

devices—namely that 85% of its 400 million MAUs access its platform via a mobile device.[55]

As the increasing number of mobile internet connections has encouraged companies and their advertisers to target mobile devices, mobile revenues for the social networking industry have increased from approximately $500 million in 2012 to $53.3 billion in 2020 in the U.S.[56] The estimated secondary effects amount to an additional $286.6 billion, reflecting $137.3 billion in indirect effects and $149.3 billion in induced effects.[57] During the period spanning 2012 to 2020, the social networking industry (mobile) has generated a combined total of $484 billion in gross output in the U.S.[58] See Table 7.

The industry's value added (GDP) from mobile grew from $200 million in 2012 to $33.7 billion in 2020. During the period spanning 2012 to 2020, the social networking industry contributed $133 billion to GDP in the U.S. The estimated secondary effects amount to an additional $252.8 billion, reflecting $122.2 billion in indirect effects and $130.6 billion in induced effects. During the period spanning 2012 to 2020, the social networking industry (mobile) has contributed a combined total of nearly $386 billion to GDP in the U.S. See Table 7.

During 2012 to 2020, the social networking industry employed an average of 38,087 workers per year that is estimated to be attributable to the mobile segment. Including secondary effects, this amounts to an additional 381,056 workers, reflecting 178,226 in indirect employment and 202,830 in induced employment. Within the period, the mobile

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[55] Pinterest, "A brief history," available at https://newsroom.pinterest.com/en/company.

[56] To estimate this industry's gross output, value added (GDP), and employment attributable to mobile wireless, Facebook's reported mobile ad revenue as a share of total ad revenues is applied to revenue, GDP, and employment data, respectively, from IBISWorld.

[57] Indirect and induced effects are estimated by using multipliers from IMPLAN's *Internet publishing and broadcasting and web search portals* industry, which includes social networking sites. See IMPLAN, 546 Industries, Conversions, Bridges, & Construction - 2018 Data, available at https://support.implan.com/hc/en-us/articles/360034896614-546-Sector-Industries-Conversions-Bridges-Construction-2018-Data.

[58] In 2011, the share of Facebook mobile ad revenues is negligible.

social networking industry contributed nearly 420,000 workers to total employment in the U.S. See Table 7.

Table 7 – Social Networking Sites – Selected Economic Data

	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
2011	-	-	-	-	-	-	-	-	-	-	-	-
2012	$0.5	$0.4	$0.4	$1.3	$0.2	$0.3	$0.3	$0.8	1,065	6,040	5,907	13,012
2013	$2.8	$2.3	$2.5	$7.5	$1.7	$1.9	$2.1	$5.6	6,097	29,729	34,642	70,468
2014	$6.3	$4.9	$5.2	$16.4	$4.2	$4.3	$4.6	$13.1	13,894	62,909	71,947	148,750
2015	$11.1	$8.3	$9.1	$28.4	$6.7	$6.7	$7.3	$20.7	22,389	99,292	115,581	237,262
2016	$17.7	$12.9	$14.1	$44.7	$11.8	$11.4	$12.4	$35.6	33,312	153,544	178,020	364,875
2017	$25.5	$18.1	$19.7	$63.3	$19.4	$17.8	$19.2	$56.4	46,583	216,910	247,797	511,289
2018	$34.7	$20.0	$24.0	$78.7	$25.6	$16.2	$19.0	$60.8	58,672	220,230	283,314	562,216
2019	$45.4	$34.4	$35.7	$115.5	$29.6	$32.6	$33.4	$95.6	73,313	381,333	415,048	869,694
2020	$53.3	$36.1	$38.6	$128.0	$33.7	$31.1	$32.4	$97.2	87,457	434,050	473,215	994,722
Total	**$197.4**	**$137.3**	**$149.3**	**$484.0**	**$133.0**	**$122.2**	**$130.6**	**$385.9**				
Average	**$21.9**	**$15.3**	**$16.6**	**$53.8**	**$14.8**	**$13.6**	**$14.5**	**$42.9**	**38,087**	**178,226**	**202,830**	**419,143**

Sources: IBISWorld Report; IMPLAN; Facebook Annual Reports.

B. Mobile Gaming

As mobile internet connections and the demand for smartphones have increased, so too has the demand for mobile games.[59] In the U.S., revenues from the mobile segment of video games publishers reached $19.1 billion in 2020, over a 600% increase from $2.6 billion in 2011.[60] Gross output from the mobile gaming industry during 2011 to 2020 was over $100 billion. The estimated secondary effects contribute an additional $75 billion, reflecting $13.5 billion in indirect effects and $61.5 billion in induced effects.[61] During the

[59] IBISWorld, Video Game Software Publishing in the US, July 2022, p. 9.

[60] IBISWorld, Video Game Software Publishing in the US, July 2022, p. 49; IDC, Gaming Spotlight – 2022 Review, p. 4.

Mobile gaming's shares of the total video games publishing industry are calculated by applying IDC's reported share of consumer spending from mobile gaming to IBISWorld figures.

[61] Indirect and induced effects are estimated by using multipliers from IMPLAN's *Software publishers* industry, which includes video game publishers. See IMPLAN, 546 Industries, Conversions, Bridges, & Construction - 2018 Data, available at https://support.implan.com/hc/en-us/articles/360034896614-546-Sector-Industries-Conversions-Bridges-Construction-2018-Data.

decade spanning 2011 to 2020, the mobile games publishing industry has generated a combined total of over $176 billion in gross output in the U.S. See Table 8.

The industry's value added (GDP) grew from approximately $600 million in 2011 to $6.8 billion in 2020. During the same period, the estimated secondary effects amount to an additional $16.1 billion, reflecting $2.9 billion in indirect effects and $13.2 billion in induced effects. During the decade spanning 2011 to 2020, this industry has contributed a combined total of nearly $51 billion in GDP to the U.S. economy. See Table 8.

During the decade, the mobile games publishing industry employed an average of 32,587 workers each year. Including secondary effects, this amounts to an additional 63,358 workers, reflecting 10,902 in indirect employment and 52,456 in induced employment. During 2011 to 2020, the mobile games publishing industry contributed an annual average of nearly 96,000 employees. See Table 8.

Table 8 – Mobile Video Games Publishers – Select Economic Data

	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
2011	$2.6	$0.6	$1.6	$4.8	$0.6	$0.1	$0.3	$1.0	3,567	2,301	6,919	12,787
2012	$3.6	$0.7	$2.2	$6.5	$1.0	$0.1	$0.4	$1.5	6,164	3,258	11,156	20,578
2013	$5.0	$1.0	$3.0	$9.0	$1.5	$0.2	$0.6	$2.3	10,651	5,960	19,594	36,204
2014	$6.2	$1.2	$3.8	$11.1	$1.8	$0.2	$0.7	$2.7	13,945	7,467	25,462	46,874
2015	$8.1	$1.3	$5.1	$14.5	$2.6	$0.3	$1.1	$4.0	22,925	9,809	40,432	73,166
2016	$10.2	$1.6	$6.3	$18.1	$3.5	$0.4	$1.4	$5.2	37,409	15,542	63,442	116,393
2017	$13.3	$1.6	$8.1	$23.0	$4.9	$0.4	$1.9	$7.1	55,843	16,355	88,287	160,486
2018	$15.4	$2.4	$9.2	$27.1	$5.7	$0.6	$2.2	$8.4	55,171	23,052	94,954	173,177
2019	$17.5	$1.6	$10.8	$29.8	$6.1	$0.3	$2.3	$8.8	58,930	12,117	86,289	157,335
2020	$19.1	$1.8	$11.4	$32.2	$6.8	$0.4	$2.5	$9.7	61,265	13,160	88,024	162,449
Total	**$101.1**	**$13.5**	**$61.5**	**$176.1**	**$34.4**	**$2.9**	**$13.2**	**$50.6**				
Average	**$10.1**	**$1.4**	**$6.2**	**$17.6**	**$3.4**	**$0.3**	**$1.3**	**$5.1**	**32,587**	**10,902**	**52,456**	**95,945**

Sources: IBISWorld Report; IMPLAN; IDC Gaming Spotlight 2022 Review.

It is noteworthy that the importance of the mobile gaming industry is emphasized through various discussions and reported figures from game companies in the U.S. Activision Blizzard has noted the importance of mobile gaming, explaining that the mobile

segment was "the largest and fastest growing platform."[62] Activision Blizzard's global revenue from their "Mobile and ancillary" category[63] was approximately $3.2 billion in 2021, growing substantially from $703 million in 2012.[64] Mobile and ancillary is the company's largest source of revenues as of 2021.[65]

Another example is Roblox Corporation, which developed the Roblox gaming platform. As of Q4 2021, there were about 11.2 million daily active users (DAUs) in the U.S. and Canada, a significant increase compared to 4.4 million DAUs as of Q1 2018.[66] About 75% of global users access the Roblox gaming platform through their mobile devices.[67]

Mobile gaming is expected to grow with the emergence of 5G mobile BB technology. The increased capabilities provided by 5G will result in faster speeds, lower latency, and seamless, portable gameplay.[68] According to Verizon, the latency of 5G is expected to be "significantly lower" than with 4G. Verizon further explains 5G will provide smoother

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[62] Activision Blizzard, SEC Form 10-K, for the fiscal year ended December 31, 2021, p. 4.

[63] Net revenues from "Mobile and ancillary" include revenues from mobile devices, as well as non-platform-specific game-related revenues, such as standalone sales of toys and accessories. Blizzard has explained that revenue increases in this segment between 2017 to 2021 are mainly attributable to in-game ads and purchases and increased monetization in their mobile games, such as Candy Crush and Call of Duty. See Activision Blizzard, SEC Form 10-K, for the fiscal year ended December 31, 2021, p. 51; Activision Blizzard, SEC Form 10-K, for the fiscal year ended December 31, 2019, p. 45; Activision Blizzard, SEC Form 10-K, for the fiscal year ended December 31, 2018, p. 56.

[64] Activision Blizzard, SEC Form 10-K, for the fiscal year ended December 31, 2021, p. 51; Activision Blizzard, SEC Form 10-K, for the fiscal year ended December 31, 2014, p. 62. In 2021, the Americas region represented 56% of the company's net revenues. See Activision Blizzard, SEC Form 10-K, for the fiscal year ended December 31, 2021, p. F-33.

[65] Activision Blizzard, SEC Form 10-K, for the fiscal year ended December 31, 2021, p. 51.

[66] ROBLOX Corporation, SEC Form 10-K, for the fiscal year ended December 31, 2021, p. 75.

[67] Id., p. 9.

[68] Verizon, "5G Gaming: What can we expect from a 5G network for gaming?" available at https://www.verizon.com/business/resources/articles/s/what-can-we-expect-from-a-5g-network-for-gaming/.

gameplay even with large numbers of users on the network.[69] These improvements in user experience attributable to advances in mobile BB will drive increased consumer demand for mobile gaming, resulting in additional future output and employment in the U.S.

C. Smartphone App Developers

Smartphone app developers have benefitted immensely from mobile BB adoption in the U.S. IBISWorld notes that "[…] as the number of mobile internet connections rises, so does the number of smartphones," and "[t]he smartphone's instant popularity and high adoption rate among consumers has prompted high demand for developers to introduce new apps."[70] As described earlier, the number of active smartphones in the U.S. has grown from 111.5 million to 296.1 million (a 2.7-fold increase) between 2011 and 2020. Pew Research notes that the share of adults in the U.S. who own a smartphone increased from 35% in 2011 to 85% in 2021.[71] As 5G adoption accelerates, consumer uptake of 5G-enabled smartphones will facilitate even greater usage of mobile apps. As noted by IBISWorld, "[t]he proliferation of smartphone devices with application capabilities as a key part of daily life for consumers and businesses had facilitated substantial revenue growth over the five years to 2022."[72]

The estimated revenue attributable to smartphone app developers increased from $10.1 billion in 2011 to $150.8 billion in 2020 in the U.S. Gross output from the industry during the decade spanning 2011 to 2020 was nearly $825 billion. The estimated secondary effects amount to an additional $613.2 billion, comprised of $110.3 billion in indirect effects

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[69] Id.

[70] IBISWorld, Smartphone App Developers, June 2022, pp. 9-10.

[71] Pew Research, "Mobile Fact Sheet," April 7, 2021, available at https://www.pewresearch.org/internet/fact-sheet/mobile/.

[72] IBISWorld, Smartphone App Developers, June 2022, p. 11.

and $502.9 billion in induced effects.[73] During 2011 to 2020, smartphone app developers have generated a combined total of approximately $1.4 trillion in gross output in the U.S. See Table 9.

The industry's value added (GDP) grew from $3.5 billion in 2011 to $87 billion in 2020. The industry contributed nearly $364 billion to GDP during 2011 to 2020. The estimated secondary effects amount to an additional $170 billion in GDP, comprised of $30 billion in indirect effects and $140 billion in induced effects. During the decade spanning 2011 to 2020, smartphone app developers have contributed a combined total of nearly $534 billion to GDP in the U.S. See Table 9.

During 2011 to 2020, smartphone app developers employed an annual average of 157,773 workers. With secondary effects included, this amounts to an additional 311,043 workers, reflecting 54,755 in indirect employment and 256,288 in induced employment. In total, the industry contributed an annual average of nearly 469,000 workers. See Table 9.

Table 9 – Smartphone App Developers – Select Economic Data

	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
2011	$10.1	$2.2	$6.2	$18.5	$3.5	$0.5	$1.5	$5.5	18,723	12,078	36,316	67,117
2012	$19.1	$3.5	$11.5	$34.1	$6.8	$0.8	$2.7	$10.3	35,664	18,850	64,550	119,064
2013	$36.1	$6.8	$21.8	$64.7	$13.1	$1.7	$5.2	$20.0	67,935	38,012	124,977	230,924
2014	$46.9	$8.8	$28.8	$84.5	$17.0	$2.1	$6.8	$25.9	83,905	44,931	153,203	282,039
2015	$88.7	$14.2	$55.9	$158.8	$32.8	$3.4	$13.3	$49.5	159,827	68,386	281,877	510,090
2016	$104.8	$16.7	$64.5	$186.0	$40.5	$4.2	$16.2	$60.9	197,555	82,075	335,032	614,662
2017	$113.9	$13.7	$69.6	$197.2	$47.3	$3.6	$17.9	$68.8	233,292	68,325	368,829	670,446
2018	$122.4	$18.9	$73.2	$214.5	$51.0	$5.2	$19.8	$76.0	243,711	101,832	419,450	764,993
2019	$132.0	$11.8	$81.3	$225.0	$64.7	$3.5	$24.2	$92.5	251,735	51,761	368,608	672,103
2020	$150.8	$13.9	$90.0	$254.7	$87.0	$5.0	$32.2	$124.3	285,387	61,301	410,042	756,729
Total	**$824.7**	**$110.3**	**$502.9**	**$1,437.9**	**$363.7**	**$30.1**	**$139.8**	**$533.6**				
Average	**$82.5**	**$11.0**	**$50.3**	**$143.8**	**$36.4**	**$3.0**	**$14.0**	**$53.4**	**157,773**	**54,755**	**256,288**	**468,817**

Sources: IBISWorld Report; IMPLAN.

[73] Indirect and induced effects are estimated by using multipliers from IMPLAN's *Software publishers* industry. See IMPLAN, 546 Industries, Conversions, Bridges, & Construction - 2018 Data, available at https://support.implan.com/hc/en-us/articles/360034896614-546-Sector-Industries-Conversions-Bridges-Construction-2018-Data.

D. Search Engines

Like many web-related industries, consumers are shifting their activities on search engines towards mobile platforms. IBISWorld notes that "[t]he number of mobile internet connections and search engine usage on mobile platforms is becoming an increasingly important demand determinant for industry operators. Google reported that more searches took place on the site through mobile platforms than on desktop computers for the first time in 2015, a proportion that has risen significantly since, as well."[74] One study reports that by 2019, about 63% of Google's organic search traffic in the U.S. originated from mobile devices.[75] This is a significant increase when compared to Comscore estimates suggesting that U.S. mobile queries were only about 25% of total search volumes as of Q4 2013.[76]

As the share of mobile searches has grown, estimated mobile revenue for the search engine industry in the U.S. has grown over 10-fold from $6.2 billion in 2011 to $64.2 billion in 2020.[77] For the decade spanning 2011 to 2020, gross output was $289 billion. The estimated secondary effects amount to an additional $426 billion, comprised of $204.9 billion in indirect effects and $221.1 billion in induced effects.[78] During the decade spanning 2011

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[74] IBISWorld, Search Engines in the US, June 2022, p. 18.

[75] Oberlo, "10 Google Search Statistics You Need to Know in 2022," January 2, 2022, available at https://www.oberlo.com/blog/google-search-statistics.

[76] Search Engine Land, "It's Official: Google Says More Searches Now On Mobile Than On Desktop," May 5, 2015, available at https://searchengineland.com/its-official-google-says-more-searches-now-on-mobile-than-on-desktop-220369.

[77] For the purpose of attributing share of online searches to mobile, Comscore's estimates are used as a baseline for 2013 and 2014 and Oberlo's reported estimates are used for 2019. Using these two sources, the compounded annual growth rate for the shares between 2013 and 2019 is used to estimate the share of mobile searches for the remaining years with insufficient data (2011-2012, and 2015-2018.) To be conservative, the share for 2020 is assumed to be the same as 2019. Calculated shares of online searches from mobile are then applied to revenues, GDP, and employment data, respectively, from IBISWorld.

[78] Indirect and induced effects are estimated by using multipliers from IMPLAN's *Internet publishing and broadcasting and web search portals* industry. See IMPLAN, 546 Industries, Conversions, Bridges, & Construction - 2018 Data, available at https://support.implan.com/hc/en-us/articles/360034896614-546-Sector-Industries-Conversions-Bridges-Construction-2018-Data.

to 2020, the mobile search engine industry has generated a combined total of about $715 billion in gross output in the U.S. See Table 10.

The industry's value added (GDP) grew from $4 billion in 2011 to $44.6 billion in 2020. During 2011 to 2020, the search engine industry contributed nearly $194 billion to GDP in the U.S. The estimated secondary effects resulted in an additional $379.3 billion, reflecting $184.1 billion in indirect effects and $195.2 billion in induced effects. During the decade spanning 2011 to 2020, the industry contributed a total of 573 billion to GDP in the U.S. See Table 10.

Between 2011 and 2020, the mobile search engine industry employed an average of 22,679 workers each year. Secondary effects add 227,071 workers, comprised of 106,510 workers in indirect employment and 120,561 workers in induced employment. During the decade spanning 2011 to 2020, the industry contributed an average of 249,751 workers to total employment in U.S. economy each year. See Table 10.

Table 10 – Search Engines – Select Economic Data

	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
2011	$6.2	$4.7	$4.5	$15.5	$4.0	$3.8	$3.7	$11.6	6,079	26,980	27,941	61,001
2012	$8.5	$7.7	$7.1	$23.3	$5.7	$8.5	$7.8	$22.0	7,975	45,218	44,228	97,422
2013	$11.7	$9.3	$10.3	$31.3	$8.0	$8.8	$9.7	$26.5	10,463	51,020	59,451	120,934
2014	$14.7	$11.3	$12.1	$38.1	$9.5	$9.7	$10.5	$29.7	13,513	61,180	69,970	144,662
2015	$19.2	$14.4	$15.8	$49.4	$12.3	$12.3	$13.4	$38.1	16,705	74,083	86,237	177,024
2016	$26.4	$19.2	$20.9	$66.5	$17.4	$16.7	$18.1	$52.2	21,643	99,759	115,662	237,064
2017	$34.2	$24.2	$26.4	$84.8	$23.1	$21.2	$22.8	$67.1	27,680	128,890	147,243	303,813
2018	$44.9	$25.9	$31.1	$101.9	$30.0	$19.0	$22.3	$71.4	34,157	128,210	164,935	327,302
2019	$59.0	$44.7	$46.4	$150.1	$39.0	$43.0	$44.1	$126.1	42,573	221,440	241,019	505,031
2020	$64.2	$43.4	$46.4	$154.0	$44.6	$41.1	$42.7	$128.4	46,005	228,324	248,926	523,255
Total	**$289.0**	**$204.9**	**$221.1**	**$714.9**	**$193.7**	**$184.1**	**$195.2**	**$573.0**				
Average	**$28.9**	**$20.5**	**$22.1**	**$71.5**	**$19.4**	**$18.4**	**$19.5**	**$57.3**	**22,679**	**106,510**	**120,561**	**249,751**

Sources: IBISWorld Report; IMPLAN; Oberlo; Comscore.

E. Digital Advertising Agencies

The digital advertising landscape also has shifted towards mobile advertising. PwC's Internet Advertising Revenue Report notes that digital advertising revenue has grown from $31.7 billion to $139.8 billion between 2011 and 2020, and mobile advertising revenue as a

share of total digital advertising revenue grew from 5% to 70% during the same period.[79] As a result, digital advertising agencies are expected to increasingly adapt their business strategies towards a mobile-oriented marketplace. IBISWorld notes that "the shift from desktop to mobile has bolstered demand for [digital advertising agency] industry services," and that "[m]obile advertising is growing fast in the internet age, and companies are continuing to invest strongly in the format. This trend is facilitated by the number of mobile internet connections, which is expected to increase over the five years to 2027."[80]

Between 2011 and 2020, mobile revenue from digital advertising agencies grew from approximately $200 million to $19.2 billion.[81] During the decade spanning 2011 to 2020, gross output from this industry was $66.8 billion. Secondary effects added $100.3 billion in output to the economy, comprised of $38.8 billion in indirect effects and $61.5 billion in induced effects.[82] For the decade, mobile digital advertising agencies generated a total of over $167 billion in gross output in the U.S. See Table 11.

The industry's value added (GDP) attributable to mobile grew from about $100 million in 2011 to $7.5 billion in 2020. During the decade spanning 2011 to 2020, the industry's contribution to GDP amounted to $28.7 billion. The estimated secondary effects amount to an additional $39.4 billion, reflecting $15.2 billion in indirect effects and $24.2 billion in induced effects. During the decade, this industry has contributed a total of over $68 billion to GDP in the U.S. See Table 11.

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[79] PwC, Internet Advertising Revenue Report 2020, April 2022, available at https://www.iab.com/wp-content/uploads/2022/04/IAB_Internet_Advertising_Revenue_Report_Full_Year_2021.pdf, pp. 14-15.

[80] IBISWorld, Digital Advertising Agencies, October 2022, pp. 10, 13.

[81] Mobile's shares of digital advertising agencies are calculated by applying PwC's reported shares of digital advertising revenues from mobile (see n.79), to revenue, GDP, and employment data respectively, from IBISWorld.

[82] Indirect and induced effects are estimated by using multipliers from IMPLAN's *Advertising, public relations, and related services* industry. See IMPLAN, 546 Industries, Conversions, Bridges, & Construction - 2018 Data, available at https://support.implan.com/hc/en-us/articles/360034896614-546-Sector-Industries-Conversions-Bridges-Construction-2018-Data.

During the same decade, mobile digital advertising agencies employed an annual average of 22,949 workers. Including secondary effects results in an additional 37,730 workers employed in the economy, comprised of 14,865 workers from indirect employment and 22,865 workers from induced employment. In total, the industry contributed an annual average of 60,680 workers in the U.S. See Table 11.

Table 11 – Digital Advertising Agencies – Select Economic Data

	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
2011	$0.2	$0.1	$0.2	$0.4	$0.1	$0.0	$0.1	$0.2	824	624	948	2,396
2012	$0.4	$0.2	$0.4	$1.1	$0.2	$0.1	$0.2	$0.6	1,983	1,439	2,255	5,676
2013	$1.1	$0.6	$1.1	$2.9	$0.6	$0.3	$0.5	$1.4	4,772	3,421	5,376	13,568
2014	$2.0	$1.1	$2.0	$5.1	$1.0	$0.5	$0.9	$2.4	8,276	5,856	9,094	23,226
2015	$3.4	$1.9	$3.3	$8.6	$1.6	$0.8	$1.4	$3.9	13,419	9,332	14,460	37,211
2016	$6.2	$3.8	$6.1	$16.0	$3.0	$1.7	$2.8	$7.5	23,861	18,461	27,051	69,373
2017	$8.5	$5.3	$8.3	$22.0	$3.8	$2.2	$3.5	$9.5	30,871	24,270	33,814	88,955
2018	$11.7	$7.0	$11.2	$29.9	$5.0	$2.8	$4.4	$12.1	39,498	28,830	42,091	110,419
2019	$14.2	$9.0	$13.0	$36.2	$5.9	$3.5	$5.1	$14.5	46,605	28,427	44,931	119,962
2020	$19.2	$9.7	$16.0	$44.9	$7.5	$3.3	$5.4	$16.2	59,383	27,994	48,632	136,010
Total	**$66.8**	**$38.8**	**$61.5**	**$167.2**	**$28.7**	**$15.2**	**$24.2**	**$68.2**				
Average	**$6.7**	**$3.9**	**$6.2**	**$16.7**	**$2.9**	**$1.5**	**$2.4**	**$6.8**	**22,949**	**14,865**	**22,865**	**60,680**

Sources: IBISWorld Report; IMPLAN; PwC IAB Report 2021.

VI. CONCLUSION

Wireless telecommunications services, including mobile broadband, have grown substantially in the U.S., attributable to extensive investments made by mobile network operators to both acquire licensed spectrum and to deploy the spectrum with the necessary wireless infrastructure. This has led to more wireless connections, higher coverage throughout the U.S. (including to populations in rural areas), higher mobile broadband data usage, lower service prices, faster mobile broadband speeds, and greater consumer satisfaction with wireless services. Several projections and forecasts suggest that the demand for mobile broadband, fueled by 5G technologies, will continue to grow in the coming years.

The wireless industry—including the core industry (wireless carriers and resellers), the wireless supply chain, and certain downstream industries that are highly reliant on wireless and mobile broadband services—has generated an estimated $9.5 trillion in gross output during the decade spanning 2011 to 2020 in the U.S., enabled by extensive

investments in licensed spectrum and wireless infrastructure. It also has contributed $5.4 trillion to GDP during the decade, and contributed an annual average of more than three million jobs to the American economy. In 2020 alone, the wireless industry generated over $1.3 trillion in gross output, $825 billion in GDP, and nearly 4.5 million jobs.

For the wireless industry to continue to provide these considerable, widespread positive effects to the American economy, it is necessary to provide mobile network operators access to dedicated, licensed spectrum. It is also important to allow potential licensees to compete to acquire the spectrum licenses, and, once acquired, to allow the licensees to determine the optimal allocation and usage of that spectrum in the economy based on economic market forces. This will promote economic efficiency in the distribution and allocation of spectrum—a scarce resource—and will allow the wireless industry to continue to grow and provide numerous, substantial economic benefits to the American economy.

About the Author

Aren Megerdichian is an Executive Vice President at Compass Lexecon. He conducts economic analyses on behalf of clients on a wide range of matters involving litigation and regulatory investigations. Dr. Megerdichian has applied his expertise in econometrics and forecasting, demand estimation, oligopoly pricing models, and competition policy to numerous cases involving mergers, regulatory proceedings, price fixing, and damages. Dr. Megerdichian has submitted white papers and declarations to the FCC and DOJ, presented to the FTC and DOJ on the potential competitive effects of mergers, and has submitted expert reports and testified in U.S. District Court. Prior to joining Compass Lexecon, Dr. Megerdichian was an Associate Lecturer with the College of Business at San Diego State University and Teaching Associate and Lecturer with the Department of Economics at the University of California, San Diego. He holds a Ph.D. in Economics from the University of California, San Diego.

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APPENDIX A: ADDITIONAL TABLES SUMMARIZING GROSS OUTPUT, GDP, AND EMPLOYMENT

Total CY 2011-2020	Gross Output ($B)				GDP ($B)				Employment (Annual Average)			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$2,587.2	$2,212.6	$1,384.4	$6,184.2	$1,283.6	$1,415.5	$906.8	$3,606.0	216,538	818,282	643,749	1,678,570
Wireless Resellers	$115.1	$101.8	$95.9	$312.8	$46.3	$55.6	$53.5	$155.4	35,484	47,481	58,499	141,464
Total Core	**$2,702.3**	**$2,314.4**	**$1,480.3**	**$6,497.0**	**$1,329.9**	**$1,471.1**	**$960.3**	**$3,761.3**	**252,022**	**865,764**	**702,247**	**1,820,033**
Downstream												
Video Games Software Pub.	$101.1	$13.5	$61.5	$176.1	$34.4	$2.9	$13.2	$50.6	32,587	10,902	52,456	95,945
Social Networking Sites	$197.4	$137.3	$149.3	$484.0	$133.0	$122.2	$130.6	$385.9	34,278	160,404	182,547	377,229
Smartphone App Developers	$824.7	$110.3	$502.9	$1,437.9	$363.7	$30.1	$139.8	$533.6	157,773	54,755	256,288	468,817
Search Engines	$289.0	$204.9	$221.1	$714.9	$193.7	$184.1	$195.2	$573.0	22,679	106,510	120,561	249,751
Digital Advertising Agencies	$66.8	$38.8	$61.5	$167.2	$28.7	$15.2	$24.2	$68.2	22,949	14,865	22,865	60,680
Total Downstream	**$1,478.9**	**$504.8**	**$996.4**	**$2,980.1**	**$753.5**	**$354.6**	**$503.1**	**$1,611.3**	**270,267**	**347,436**	**634,718**	**1,252,421**
Total	**$4,181.2**	**$2,819.2**	**$2,476.7**	**$9,477.1**	**$2,083.5**	**$1,825.8**	**$1,463.4**	**$5,372.6**	**522,289**	**1,213,200**	**1,336,965**	**3,072,454**

CY 2020	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$285.7	$243.7	$134.8	$664.2	$153.4	$173.6	$99.0	$425.9	179,460	898,028	616,212	1,693,699
Wireless Resellers	$18.0	$15.8	$13.0	$46.8	$7.2	$8.7	$7.4	$23.3	38,356	67,361	73,458	179,175
Total Core	**$303.7**	**$259.5**	**$147.8**	**$711.0**	**$160.6**	**$182.3**	**$106.3**	**$449.2**	**217,816**	**965,389**	**689,670**	**1,872,874**
Downstream												
Video Games Software Pub.	$19.1	$1.8	$11.4	$32.2	$6.8	$0.4	$2.5	$9.7	61,265	13,160	88,024	162,449
Social Networking Sites	$53.3	$36.1	$38.6	$128.0	$33.7	$31.1	$32.4	$97.2	87,457	434,050	473,215	994,722
Smartphone App Developers	$150.8	$13.9	$90.0	$254.7	$87.0	$5.0	$32.2	$124.3	285,387	61,301	410,042	756,729
Search Engines	$64.2	$43.4	$46.4	$154.0	$44.6	$41.1	$42.7	$128.4	46,005	228,324	248,926	523,255
Digital Advertising Agencies	$19.2	$9.7	$16.0	$44.9	$7.5	$3.3	$5.4	$16.2	59,383	27,994	48,632	136,010
Total Downstream	**$306.5**	**$104.8**	**$202.4**	**$613.8**	**$179.6**	**$80.9**	**$115.3**	**$375.8**	**539,497**	**764,829**	**1,268,839**	**2,573,165**
Total	**$610.2**	**$364.3**	**$350.2**	**$1,324.7**	**$340.2**	**$263.2**	**$221.6**	**$825.0**	**757,313**	**1,730,218**	**1,958,509**	**4,446,039**

CY 2019	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$287.1	$240.5	$142.8	$670.3	$156.8	$165.1	$101.6	$423.4	188,639	863,930	644,236	1,696,804
Wireless Resellers	$15.4	$13.5	$12.0	$40.9	$6.3	$7.4	$6.7	$20.4	35,355	57,522	68,428	161,305
Total Core	**$302.5**	**$253.9**	**$154.8**	**$711.3**	**$163.1**	**$172.4**	**$108.3**	**$443.8**	**223,994**	**921,451**	**712,664**	**1,858,110**
Downstream												
Video Games Software Pub.	$17.5	$1.6	$10.8	$29.8	$6.1	$0.3	$2.3	$8.8	58,930	12,117	86,289	157,335
Social Networking Sites	$45.4	$34.4	$35.7	$115.5	$29.6	$32.6	$33.4	$95.6	73,313	381,333	415,048	869,694
Smartphone App Developers	$132.0	$11.8	$81.3	$225.0	$64.7	$3.5	$24.2	$92.5	251,735	51,761	368,608	672,103
Search Engines	$59.0	$44.7	$46.4	$150.1	$39.0	$43.0	$44.1	$126.1	42,573	221,440	241,019	505,031
Digital Advertising Agencies	$14.2	$9.0	$13.0	$36.2	$5.9	$3.5	$5.1	$14.5	46,605	28,427	44,931	119,962
Total Downstream	**$268.0**	**$101.5**	**$187.2**	**$556.6**	**$145.4**	**$82.9**	**$109.2**	**$337.5**	**473,155**	**695,077**	**1,155,894**	**2,324,126**
Total	**$570.5**	**$355.4**	**$342.0**	**$1,267.9**	**$308.5**	**$255.3**	**$217.6**	**$781.3**	**697,149**	**1,616,528**	**1,868,558**	**4,182,235**

CY 2018	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$281.5	$247.2	$147.2	$675.8	$147.7	$177.6	$108.7	$433.9	206,855	826,926	631,158	1,664,939
Wireless Resellers	$13.9	$12.5	$10.9	$37.3	$5.5	$6.8	$6.1	$18.4	40,215	55,417	63,806	159,439
Total Core	**$295.4**	**$259.7**	**$158.1**	**$713.2**	**$153.2**	**$184.4**	**$114.8**	**$452.3**	**247,070**	**882,343**	**694,964**	**1,824,378**
Downstream												
Video Games Software Pub.	$15.4	$2.4	$9.2	$27.1	$5.7	$0.6	$2.2	$8.4	55,171	23,052	94,954	173,177
Social Networking Sites	$34.7	$20.0	$24.0	$78.7	$25.6	$16.2	$19.0	$60.8	58,672	220,230	283,314	562,216
Smartphone App Developers	$122.4	$18.9	$73.2	$214.5	$51.0	$5.2	$19.8	$76.0	243,711	101,832	419,450	764,993
Search Engines	$44.9	$25.9	$31.1	$101.9	$30.0	$19.0	$22.3	$71.4	34,157	128,210	164,935	327,302
Digital Advertising Agencies	$11.7	$7.0	$11.2	$29.9	$5.0	$2.8	$4.4	$12.1	39,498	28,830	42,091	110,419
Total Downstream	**$229.2**	**$74.2**	**$148.7**	**$452.1**	**$117.3**	**$43.8**	**$67.7**	**$228.8**	**431,208**	**502,153**	**1,004,744**	**1,938,106**
Total	**$524.6**	**$333.9**	**$306.8**	**$1,165.3**	**$270.4**	**$228.2**	**$182.5**	**$681.1**	**678,279**	**1,384,496**	**1,699,708**	**3,762,483**

CY 2017	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$263.8	$229.3	$139.4	$632.5	$131.4	$149.1	$93.7	$374.3	207,324	799,513	613,995	1,620,832
Wireless Resellers	$12.8	$11.4	$10.5	$34.7	$5.1	$6.2	$5.8	$17.2	40,741	53,928	63,186	157,854
Total Core	**$276.6**	**$240.8**	**$149.9**	**$667.3**	**$136.5**	**$155.4**	**$99.6**	**$391.4**	**248,065**	**853,441**	**677,181**	**1,778,686**
Downstream												
Video Games Software Pub.	$13.3	$1.6	$8.1	$23.0	$4.9	$0.4	$1.9	$7.1	55,843	16,355	88,287	160,486
Social Networking Sites	$25.5	$18.1	$19.7	$63.3	$19.4	$17.8	$19.2	$56.4	46,583	216,910	247,797	511,289
Smartphone App Developers	$113.9	$13.7	$69.6	$197.2	$47.3	$3.6	$17.9	$68.8	233,292	68,325	368,829	670,446
Search Engines	$34.2	$24.2	$26.4	$84.8	$23.1	$21.2	$22.8	$67.1	27,680	128,890	147,243	303,813
Digital Advertising Agencies	$8.5	$5.3	$8.3	$22.0	$3.8	$2.2	$3.5	$9.5	30,871	24,270	33,814	88,955
Total Downstream	**$195.4**	**$62.8**	**$132.2**	**$390.4**	**$98.5**	**$45.1**	**$65.2**	**$208.8**	**394,269**	**454,750**	**885,970**	**1,734,989**
Total	**$472.0**	**$303.6**	**$282.1**	**$1,057.7**	**$235.0**	**$200.4**	**$164.8**	**$600.3**	**642,333**	**1,308,191**	**1,563,151**	**3,513,675**

CY 2016	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$265.2	$227.1	$141.5	$633.8	$130.9	$144.7	$93.3	$368.9	216,537	815,203	643,971	1,675,711
Wireless Resellers	$11.7	$10.4	$9.4	$31.6	$4.7	$5.7	$5.3	$15.7	36,541	49,869	58,749	145,159
Total Core	**$276.9**	**$237.5**	**$151.0**	**$665.4**	**$135.6**	**$150.4**	**$98.6**	**$384.6**	**253,078**	**865,072**	**702,720**	**1,820,869**
Downstream												
Video Games Software Pub.	$10.2	$1.6	$6.3	$18.1	$3.5	$0.4	$1.4	$5.2	37,409	15,542	63,442	116,393
Social Networking Sites	$17.7	$12.9	$14.1	$44.7	$11.8	$11.4	$12.4	$35.6	33,312	153,544	178,020	364,875
Smartphone App Developers	$104.8	$16.7	$64.5	$186.0	$40.5	$4.2	$16.2	$60.9	197,555	82,075	335,032	614,662
Search Engines	$26.4	$19.2	$20.9	$66.5	$17.4	$16.7	$18.1	$52.2	21,643	99,759	115,662	237,064
Digital Advertising Agencies	$6.2	$3.8	$6.1	$16.0	$3.0	$1.7	$2.8	$7.5	23,861	18,461	27,051	69,373
Total Downstream	**$165.3**	**$54.2**	**$111.8**	**$331.3**	**$76.1**	**$34.4**	**$50.8**	**$161.3**	**313,781**	**369,382**	**719,206**	**1,402,368**
Total	**$442.2**	**$291.7**	**$262.8**	**$996.7**	**$211.7**	**$184.8**	**$149.4**	**$546.0**	**566,859**	**1,234,453**	**1,421,926**	**3,223,238**

CY 2015	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$261.6	$222.8	$141.7	$626.1	$126.3	$138.4	$90.1	$354.8	235,818	829,157	671,559	1,736,534
Wireless Resellers	$10.6	$9.3	$9.0	$28.8	$4.2	$5.1	$5.0	$14.3	34,556	45,388	55,980	135,924
Total Core	**$272.2**	**$232.1**	**$150.6**	**$654.9**	**$130.5**	**$143.5**	**$95.1**	**$369.1**	**270,374**	**874,545**	**727,539**	**1,872,459**
Downstream												
Video Games Software Pub.	$8.1	$1.3	$5.1	$14.5	$2.6	$0.3	$1.1	$4.0	22,925	9,809	40,432	73,166
Social Networking Sites	$11.1	$8.3	$9.1	$28.4	$6.7	$6.7	$7.3	$20.7	22,389	99,292	115,581	237,262
Smartphone App Developers	$88.7	$14.2	$55.9	$158.8	$32.8	$3.4	$13.3	$49.5	159,827	68,386	281,877	510,090
Search Engines	$19.2	$14.4	$15.8	$49.4	$12.3	$12.3	$13.4	$38.1	16,705	74,083	86,237	177,024
Digital Advertising Agencies	$3.4	$1.9	$3.3	$8.6	$1.6	$0.8	$1.4	$3.9	13,419	9,332	14,460	37,211
Total Downstream	**$130.5**	**$40.0**	**$89.2**	**$259.8**	**$56.0**	**$23.6**	**$36.5**	**$116.1**	**235,265**	**260,902**	**538,587**	**1,034,754**
Total	**$402.6**	**$272.1**	**$239.9**	**$914.6**	**$186.6**	**$167.1**	**$131.6**	**$485.3**	**505,639**	**1,135,447**	**1,266,126**	**2,907,213**

CY 2014	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$256.9	$225.0	$147.5	$629.4	$117.8	$135.0	$91.1	$343.9	232,169	824,340	670,475	1,726,984
Wireless Resellers	$10.6	$9.4	$9.3	$29.3	$4.2	$5.1	$5.1	$14.4	35,782	46,604	58,468	140,854
Total Core	**$267.5**	**$234.4**	**$156.8**	**$658.6**	**$122.0**	**$140.1**	**$96.2**	**$358.3**	**267,951**	**870,944**	**728,943**	**1,867,838**
Downstream												
Video Games Software Pub.	$6.2	$1.2	$3.8	$11.1	$1.8	$0.2	$0.7	$2.7	13,945	7,467	25,462	46,874
Social Networking Sites	$6.3	$4.9	$5.2	$16.4	$4.2	$4.3	$4.6	$13.1	13,894	62,909	71,947	148,750
Smartphone App Developers	$46.9	$8.8	$28.8	$84.5	$17.0	$2.1	$6.8	$25.9	83,905	44,931	153,203	282,039
Search Engines	$14.7	$11.3	$12.1	$38.1	$9.5	$9.7	$10.5	$29.7	13,513	61,180	69,970	144,662
Digital Advertising Agencies	$2.0	$1.1	$2.0	$5.1	$1.0	$0.5	$0.9	$2.4	8,276	5,856	9,094	23,226
Total Downstream	**$76.0**	**$27.2**	**$51.9**	**$155.1**	**$33.5**	**$16.9**	**$23.5**	**$73.8**	**133,533**	**182,342**	**329,676**	**645,551**
Total	**$343.5**	**$261.6**	**$208.7**	**$813.8**	**$155.5**	**$156.9**	**$119.7**	**$432.1**	**401,483**	**1,053,287**	**1,058,619**	**2,513,390**

CY 2013	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$238.2	$193.4	$131.2	$562.9	$118.3	$114.5	$78.9	$311.7	230,409	771,528	647,683	1,649,620
Wireless Resellers	$9.3	$8.2	$8.3	$25.7	$3.8	$4.4	$4.5	$12.8	33,411	40,617	53,374	127,402
Total Core	**$247.5**	**$201.6**	**$139.5**	**$588.6**	**$122.1**	**$118.9**	**$83.4**	**$324.5**	**263,820**	**812,146**	**701,056**	**1,777,022**
Downstream												
Video Games Software Pub.	$5.0	$1.0	$3.0	$9.0	$1.5	$0.2	$0.6	$2.3	10,651	5,960	19,594	36,204
Social Networking Sites	$2.8	$2.3	$2.5	$7.5	$1.7	$1.9	$2.1	$5.6	6,097	29,729	34,642	70,468
Smartphone App Developers	$36.1	$6.8	$21.8	$64.7	$13.1	$1.7	$5.2	$20.0	67,935	38,012	124,977	230,924
Search Engines	$11.7	$9.3	$10.3	$31.3	$8.0	$8.8	$9.7	$26.5	10,463	51,020	59,451	120,934
Digital Advertising Agencies	$1.1	$0.6	$1.1	$2.9	$0.6	$0.3	$0.5	$1.4	4,772	3,421	5,376	13,568
Total Downstream	**$56.7**	**$20.0**	**$38.7**	**$115.5**	**$24.9**	**$12.9**	**$18.0**	**$55.7**	**99,917**	**128,141**	**244,040**	**472,097**
Total	**$304.2**	**$221.6**	**$178.2**	**$704.1**	**$147.0**	**$131.8**	**$101.4**	**$380.3**	**363,737**	**940,286**	**945,096**	**2,249,119**

CY 2012	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$230.5	$201.0	$134.4	$566.0	$101.6	$113.8	$77.9	$293.3	230,101	803,619	663,477	1,697,197
Wireless Resellers	$7.2	$6.4	$7.4	$20.9	$3.0	$3.4	$4.0	$10.5	31,547	32,402	48,000	111,948
Total Core	**$237.7**	**$207.4**	**$141.8**	**$586.9**	**$104.6**	**$117.3**	**$81.9**	**$303.8**	**261,648**	**836,021**	**711,477**	**1,809,145**
Downstream												
Video Games Software Pub.	$3.6	$0.7	$2.2	$6.5	$1.0	$0.1	$0.4	$1.5	6,164	3,258	11,156	20,578
Social Networking Sites	$0.5	$0.4	$0.4	$1.3	$0.2	$0.3	$0.3	$0.8	1,065	6,040	5,907	13,012
Smartphone App Developers	$19.1	$3.5	$11.5	$34.1	$6.8	$0.8	$2.7	$10.3	35,664	18,850	64,550	119,064
Search Engines	$8.5	$7.7	$7.1	$23.3	$5.7	$8.5	$7.8	$22.0	7,975	45,218	44,228	97,422
Digital Advertising Agencies	$0.4	$0.2	$0.4	$1.1	$0.2	$0.1	$0.2	$0.6	1,983	1,439	2,255	5,676
Total Downstream	**$32.2**	**$12.5**	**$21.7**	**$66.4**	**$13.9**	**$9.8**	**$11.3**	**$35.1**	**52,851**	**74,804**	**128,097**	**255,752**
Total	**$269.9**	**$219.9**	**$163.5**	**$653.3**	**$118.5**	**$127.1**	**$93.2**	**$338.8**	**314,499**	**910,825**	**839,573**	**2,064,897**

CY 2011	Gross Output ($B)				GDP ($B)				Employment			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
Core Wireless												
Wireless Carriers	$216.7	$182.6	$123.8	$523.1	$99.4	$103.7	$72.7	$275.8	238,071	750,582	634,723	1,623,376
Wireless Resellers	$5.6	$4.9	$6.2	$16.7	$2.3	$2.7	$3.4	$8.4	28,337	25,703	41,537	95,577
Total Core	**$222.3**	**$187.6**	**$130.0**	**$539.9**	**$101.7**	**$106.4**	**$76.1**	**$284.2**	**266,408**	**776,285**	**676,261**	**1,718,953**
Downstream												
Video Games Software Pub.	$2.6	$0.6	$1.6	$4.8	$0.6	$0.1	$0.3	$1.0	3,567	2,301	6,919	12,787
Social Networking Sites	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	-	-	-	-
Smartphone App Developers	$10.1	$2.2	$6.2	$18.5	$3.5	$0.5	$1.5	$5.5	18,723	12,078	36,316	67,117
Search Engines	$6.2	$4.7	$4.5	$15.5	$4.0	$3.8	$3.7	$11.6	6,079	26,980	27,941	61,001
Digital Advertising Agencies	$0.2	$0.1	$0.2	$0.4	$0.1	$0.0	$0.1	$0.2	824	624	948	2,396
Total Downstream	**$19.1**	**$7.5**	**$12.6**	**$39.2**	**$8.3**	**$4.5**	**$5.5**	**$18.3**	**29,193**	**41,984**	**72,124**	**143,300**
Total	**$241.5**	**$195.1**	**$142.5**	**$579.0**	**$110.0**	**$110.9**	**$81.6**	**$302.5**	**295,601**	**818,269**	**748,384**	**1,862,254**

APPENDIX B: ADDITIONAL DETAILS ON INPUT-OUTPUT ANALYSES AND MULTIPLIERS

As described in Section IV, a way to estimate the secondary impact—that is, induced and indirect effects—resulting from the wireless industry is by applying a multiplier to the core wireless industry's gross output. At a basic level, the multiplier approach in economics is based on the economy's marginal propensity to consume out of income, denoted by c. Suppose aggregate consumption, C, is equal to some base level of consumption (when income is zero) denoted by $\bar{C}$, plus the marginal propensity to consume applied to income Y net of taxes T, given by the equation

$$C = \bar{C} + c(Y - T).$$

Assume for simplicity that aggregate demand in the economy is based only on consumption; that is, aggregate demand (AD) equals aggregate consumption: $AD = C$. Thus, aggregate demand in the economy is $AD = \bar{C} + c(Y - T)$. Letting taxes be defined by some amount denoted $\bar{T}$, and rearranging terms, results in $AD = \bar{B} + cY$, where $\bar{B} = (\bar{C} - c\bar{T})$ is the baseline or autonomous part of aggregate demand that is independent of income, Y. In equilibrium, aggregate demand equals income, resulting in equilibrium income in the economy given by

$$Y^* = \frac{1}{1-c}\bar{B}.$$

The multiplier is defined as the change in equilibrium output resulting from a change in autonomous demand:

$$\frac{dY^*}{d\bar{B}} = \frac{1}{1-c}.$$

As an example, if the marginal propensity to consume is 0.6, the multiplier is 2.5, meaning that an additional dollar of (autonomous) demand in the economy results in $1 direct impact and $1.50 in secondary impact. The higher the marginal propensity to save out of income, the lower the marginal propensity to consume will be, resulting in a lower multiplier.

Industry-specific multipliers can be derived from Input-Output (I-O) accounts from the U.S. Bureau of Economic Analysis. These accounts show the relationships between all

the industries in the economy and all the commodities that these industries produce and use.[83] The I-O accounts are organized by NAICS industry at various levels of disaggregation.[84] Less detailed I-O tables showing fewer industries are produced on an annual basis, whereas detailed I-O tables with 405 industries, known as benchmark I-O tables, are produced every five years, coinciding with economic census years.[85] The latest benchmark I-O tables with a 2012 reference year were released in 2018. Both annual and benchmark I-O accounts consist of the following tables.[86]

Make table:[87] Provides the value of each commodity produced by each industry. Each row represents an industry, and each column represents a commodity. A row total shows the total value of commodities produced by each industry (i.e., industry output), while a column total shows the total value of that commodity produced by all industries (i.e., commodity output).

Use table:[88] Provides the uses of all commodities by intermediate and final users. In contrast to the make table, the columns in the use table represent an industry and the rows represent a commodity. A row total across all industries shows the total intermediate uses of that commodity. Similarly, a column total across all commodities shows the total intermediate use by that industry. In addition to the industry, commodity and intermediate

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[83] Bureau of Economic Analysis, "Input-Output Accounts," available at https://www.bea.gov/data/industries/input-output-accounts-data; Bureau of Economic Analysis, "Input-Output Accounts: Who Sells What To Whom," March 15, 2021, available at https://www.bea.gov/news/blog/2021-03-15/input-output-accounts-who-sells-what-whom.

[84] Bureau of Economic Analysis, "Concepts and Methods of the U.S. Input-Output Accounts," April 2009, available at https://www.bea.gov/sites/default/files/methodologies/IOmanual_092906.pdf, p. 4-1.

[85] Bureau of Economic Analysis, "Input-Output Accounts," available at https://www.bea.gov/data/industries/input-output-accounts-data.

[86] Bureau of Economic Analysis, "Concepts and Methods of the U.S. Input-Output Accounts," April 2009, available at https://www.bea.gov/sites/default/files/methodologies/IOmanual_092906.pdf, Chapter 12.

[87] Id., p. 1-2.

[88] Id., pp. 1-2 – 1-3.

use rows and columns, the use table also includes additional rows and columns to calculate value added and total final uses (GDP), respectively. Value-added components are shown in three additional rows: compensation of employees, taxes on production less subsidies, and gross operating surplus. Final-use components are also added in six additional columns: personal consumption expenditures, private fixed investment, change in private inventories, imports and exports of goods and services, and government consumption and gross investment. Value added is the difference between an industry's total output, and the industry's use of intermediate goods and services. Similarly, total final use of a commodity is the difference between that commodity's total output, and the use of that commodity as an intermediate input but industries. Gross Domestic Product (GDP) is measured as the total value added across all industries, or the total final uses of each commodity.

Direct requirements table:[89] Provides the intermediate commodities required by each industry to produce a dollar of output, as well as the value-added components that an industry requires to produce a dollar of output. It is derived from the use table by dividing each industry's use of each commodity by the industry's total output. The sum of each column equals 1.[90]

Total requirements tables:[91] Provides the relationships between final uses and gross outputs. They show production required, both directly and indirectly, to deliver a dollar of output to final uses. There are three total requirements tables: the industry-by-industry total requirements table; the industry-by-commodity total requirements table; and the commodity-by-commodity total requirements table.[92] These three tables are derived from the make and use columns and show the amount of direct and indirect production required of each commodity or by each industry per dollar of final use by the industry or of the commodity.

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[89] Id.

[90] Id., p. 12-10.

[91] Id., p. 12-15.

[92] Id., pp. 12-7 – 12-8.

Import matrix:[93] It is important to note that the use table described above includes each industry's use of both foreign and domestically produced inputs. Given the focus of the analysis here is on domestic effects, imported inputs to production from the use table based on the import matrix, which details the use of imported commodities by industries and final uses, are excluded in deriving multipliers.

Gross output multipliers are derived for the domestic U.S. economy based on the I-O tables.[94] The first step in this process is to derive a domestic direct requirements table, which provides information on the domestic inputs required to produce an additional dollar of output in each industry. A use table providing only domestically produced inputs is calculated by subtracting the import matrix from the total use table. Then, each industry's use of each domestic commodity is divided by the industry's total output to produce the domestic use coefficients. Similarly, using the make table, each commodity's production by industry is divided by the total output for that commodity to produce the make coefficients. Finally, the domestic use and make coefficients are multiplied together to create the domestic direct requirements table.

In order to estimate induced effects, rows and columns must be added to the domestic direct requirement tables to account for household earning and purchases, respectively.[95] The household column is calculated by first subtracting household imports from the personal consumption expenditure column of the use table. Secondly, these domestic personal consumption expenditures are divided by total personal consumption expenditures to derive personal expenditure coefficients. These coefficients are then multiplied by the make coefficients derived earlier to produce a column of expenditure coefficients on an industry basis. Lastly, these coefficients are adjusted to account for leakages stemming from savings

[93] Id., pp. 12-5 – 12-7.

[94] Bureau of Economic Analysis, "RIMS II," available at https://www.bea.gov/sites/default/files/methodologies/RIMSII_User_Guide.pdf, p. 2-7.

[95] Id., pp. 2-8 – 2-9.

and taxes (Federal, State and Local). The household row is simply compensation of employees, sole-proprietors, and partnerships, divided by the industry's total output.

Finally, an industry-by-industry domestic total requirements table provides information on the first and subsequent rounds of intermediate inputs required to produce an additional dollar of output in each industry.[96] This output multiplier table is derived by taking the Leontief inverse of the domestic direct requirements table described above. By summing the coefficients in a column of the domestic total requirements table, a final-demand output multiplier can be calculated for that industry. An industry's final demand output multiplier measures the total change in output across all industries resulting from a one dollar change in final demand in the given industry of interest. For example, if industry A's output multiplier is 2.5, a $1 increase in final demand for industry A's goods and services is expected to increase total domestic output by a further $1.50, resulting in a total effect on the economy of $2.50 in increased output.

There are two types of multipliers that can be derived from the domestic total requirements data: Type I multipliers that capture the direct and indirect effects stemming from business-to-business transactions within the supply chain; and Type II multipliers that capture the direct, indirect, and induced effects.[97] The direct effect multiplier is always 1.0. Therefore, indirect effects can be calculated as the Type I multiplier less 1.0. Similarly, the induced effects are calculated as the difference between the Type II and Type I multipliers. Employment multipliers are derived from output multipliers. Therefore, the type of employment multiplier depends on whether the Type I or Type II output multipliers are used. The direct-effect employment multiplier measures the total change in domestic jobs per change in jobs in the final-demand industry of interest.

IMPLAN is a third-party provider of the I-O tables and related data described above.[98] Although there are strong similarities between the discussion above and IMPLAN's

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[96] Id., pp. 2-9 – 2-11.

[97] Id., p. 3-5.

[98] IMPLAN, available at https://implan.com/.

methodology for deriving multipliers, one notable difference is that IMPLAN uses a Social Accounting Matrix (SAM) to capture information on non-market financial flows in the economy, in addition to the market flows detailed in the I-O tables.[99] These non-financial flows account for payments of taxes by individuals and businesses, transfers of government funds to people and businesses (e.g., social security, unemployment, etc.) and transfers of funds from people to people. IMPLAN's Type SAM multipliers build on the Type II multipliers derived from the BEA's I-O accounts by incorporating more information about household incomes, taxes, savings, and spending.[100] Additionally, IMPLAN provides annual updates to their SAM framework, capturing methodology changes from the BEA and other agencies, as well as changes in income, taxes, savings, and household spending.

[99] IMPLAN, "Introducing the SAM," available at https://support.implan.com/hc/en-us/articles/115009674708-Introducing-the-SAM-.

[100] IMPLAN, "Explaining the Type SAM Multiplier," April 15, 2015, available at https://support.implan.com/hc/en-us/articles/115009674768-Explaining-the-Type-SAM-Multiplier.