Intel's Impacts on the US Economy

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Since its founding, Intel has been at the forefront of innovation in the United States. As the largest U.S. owned semiconductor manufacturer, Intel is the only leading-edge U.S. semiconductor company that both develops and fabricates its own technology.

We are also the only company that has built leading edge fabs in the U.S. during the last five years. Unlike many companies, Intel's intellectual property still resides here at home. We are making significant investments in U.S. manufacturing and R&D over the next several years. And Intel's technology is helping the U.S. to build better by supporting the development of smart infrastructure to address the nation's economic and security needs.

We celebrate our American origins and the important role we play as a global technology leader. In that spirit, I am pleased to share with you this report detailing the scope and scale of Intel's economic impact and investment in the U.S. Intel's economic contributions extend nationwide and throughout all sectors of the economy. Some highlights:

- We employ approximately 52,000 people across the country.
- Each job at Intel is estimated to support 13 other jobs elsewhere, meaning Intel directly or indirectly supported more than 700,000 full-time and part-time jobs in the U.S.
- Intel directly contributed $25.9 billion to U.S. GDP in 2019.
- Our total direct and indirect GDP impact on the U.S. economy, $102.0 billion in 2019, accounted for one half of 1 percent of U.S. GDP.

There is much more in the full report.

While I am proud of the role Intel plays in fueling U.S. economic growth and development, I know there is more we can do.

The entire world is becoming digital, driven by four superpowers: the cloud, connectivity, artificial intelligence and the intelligent edge. In this landscape of rapid digital disruption – which has been accelerated even more by the global pandemic – the technology and products Intel develops and manufactures are more critical than ever.

Intel has always been defined by its ambition and faith in the power of technology to help humankind and by its relentless pursuit of excellence. We are committed to doing our part to ensure the U.S. continues to be the leader in semiconductor manufacturing.

As we continue to invest in and strengthen the U.S. economy, I know Intel's best days are ahead of us.

I hope you enjoy the report.

Pat Gelsinger
CEO, Intel

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Executive Summary

Intel Corporation ("Intel") designs and manufactures advanced integrated digital technology platforms that power an increasingly connected world. A platform consists of a microprocessor and chipset, and may be enhanced by additional hardware, software, and services. The platforms are used in a wide range of applications, such as PCs, laptops, servers, tablets, smartphones, automobiles, automated factory systems, and medical devices. Intel is also in the midst of a corporate transformation that has seen its data-centric businesses capture an increasing share of its revenue.

This report provides economic impact estimates for Intel in terms of employment, labor income, and gross domestic product ("GDP") for the most recent historical year, 2019.[1]

[1] A company's GDP is also known as its value added, i.e., the additional value created at a particular stage of production. It is equal to the company's sales less its purchases from other businesses. It can also be measured as the sum of employee compensation, proprietors' income, income to capital owners from property, and indirect business taxes (including excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses).

Key Findings

Intel, the world's largest semiconductor manufacturer,[2] has a widespread economic impact throughout all sectors of the US economy through its operational spending, capital investments, and distribution channels. Intel not only supports a large number of jobs for US workers, but also invests heavily in the United States. Intel is ranked the sixth largest in terms of R&D spending among US publicly traded companies.[3] Intel is also ranked the sixth largest non-financial company by US capital expenditures in 2019.[4] In addition, Intel's products and services support overall US economic productivity.

Table E-1 *summarizes Intel's overall impact on the US economy in 2019.*

	Direct Impacts	Indirect and Induced Impacts		Distribution Channel Impacts	Total Impacts	Total / Direct ("Multiplier")[c]
		Operational	Capital Investment			
Employment (thousands of jobs)[a]	51.9	376.6	146.1	146.7	721.3	13.9
Labor Income ($ billions)[b]	$11.7	$26.5	$9.5	$9.9	$57.7	4.9
Value Added (GDP) ($ billions)	$25.9	$43.2	$14.7	$18.0	$102.0	3.9

Source: Calculations using the IMPLAN modeling system (2018 database). Details may not add to totals due to rounding.
[a] Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
[b] Labor income is defined as wages and salaries and benefits as well as proprietors' income.
[c] Economic multiplier represents the overall impact (including direct, operational, capital investment, and distribution channel impacts) relative to the direct impact.

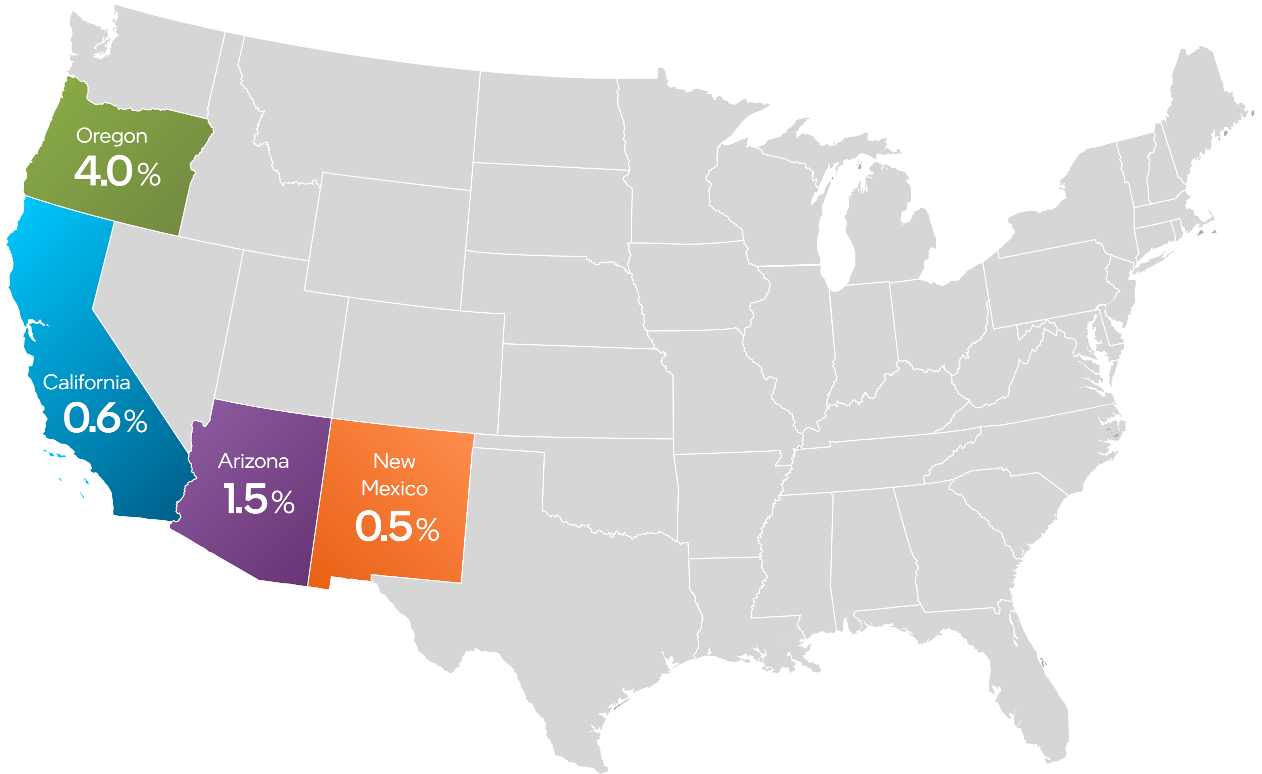
- In 2019, Intel directly employed an average of 51,900 full- and part-time American workers throughout the year. Each job at Intel is estimated to support 13 other jobs elsewhere in the US economy.
- Intel paid out a total of $11.7 billion in wages and salaries and benefits and directly contributed $25.9 billion to US GDP in 2019.
- Counting economic impacts through direct operations, supply chain, capital investments, and distribution channels, Intel's total impact on the US economy in 2019 was 721,300 jobs, $57.7 billion in labor income (including wages, salaries, benefits, and proprietors' income), and $102.0 billion in GDP.

[2] See IBISWorld Industry Report 33441a, "Semiconductor and Circuit Manufacturing in the US," June 2020.
[3] Tabulations based on CapitalIQ for fiscal year 2019.
[4] Michael Mandel and Elliott Long, "Investment Heroes 2020," Progressive Policy Institute, July 2020.
https://www.progressivepolicy.org/blogs/investment-heroes-2020/

Figure E-1 highlights Intel's direct, operational, capital investment, and distribution channel employment impacts for Arizona, California, New Mexico, and Oregon. As a share of statewide employment, Intel's largest total employment impact was in Oregon, totaling 105,100 jobs or 4.0 percent of statewide employment in 2019. Intel's total employment impact in Arizona was 58,600 jobs or 1.5 percent of statewide employment. Intel's total employment impact was 142,900 in California and 6,000 in New Mexico, making up 0.6 and 0.5 percent of each respective state's total employment.

While Intel's direct activities are concentrated in the four highlighted states, Intel's economic impact is felt across the country. On average, Intel directly or indirectly supported 0.2 percent of the employment in the rest of the country in 2019.

Figure E-1. *Intel's Total Employment Impact as a Share of Total Statewide Employment – Arizona, California, New Mexico, and Oregon*



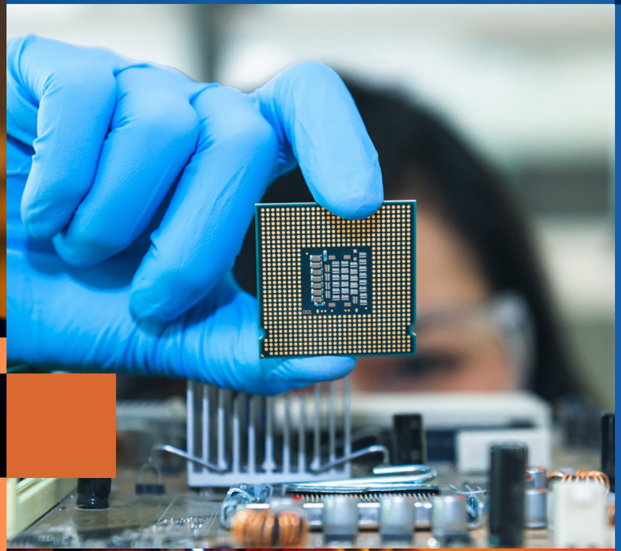
Introduction

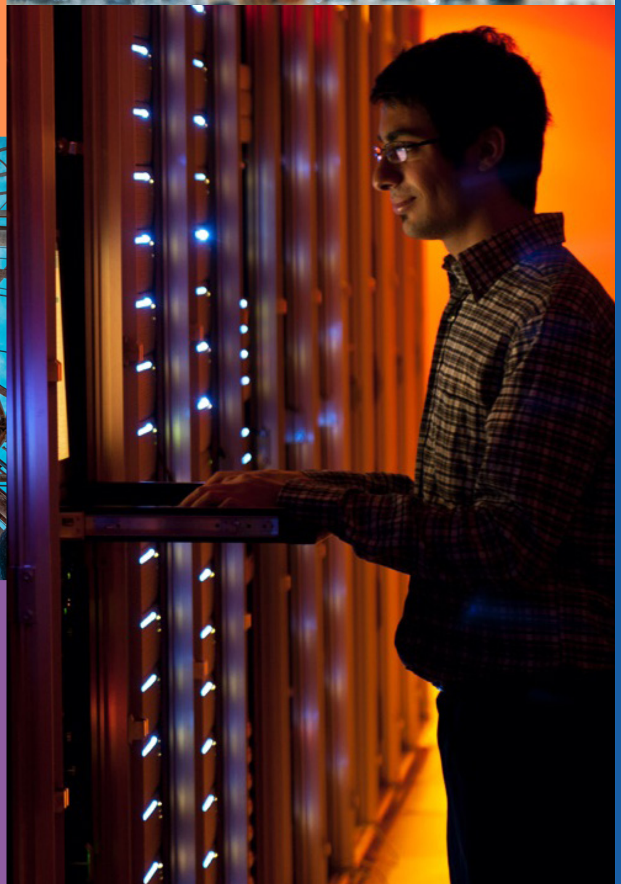
This report estimates the impact of Intel Corporation ("Intel") on the US economy and that of four of its key states (Arizona, California, New Mexico, and Oregon) in terms of employment, labor income, and gross domestic product (or value added) for the most recent historical year, 2019.

The IMPLAN model, an input-output model based on federal government data, was used to quantify the economic impact.[5] As described below, four types of economic impacts attributable to Intel – direct, indirect, induced, and distribution channel – were quantified:

- **Direct impact** measures Intel's jobs, labor income, and gross domestic product ("GDP").
- **Indirect impact** measures the jobs, labor income, and GDP occurring throughout Intel's operational supply chain.
- **Induced impact** measures the jobs, labor income, and GDP resulting from household spending of labor income earned either directly or indirectly from Intel's spending.
- **Distribution channel impact** measures the jobs, labor income and GDP attributable to the distribution of Intel's products and other products incorporating Intel components through its wholesalers, distributors, and retailers.

[5] *The IMPLAN input-output economic modeling system is developed by the IMPLAN Group LLC. The IMPLAN model is based on input-output tables that map the flow of value along the supply chain for different industries in the economy.*





For the indirect and induced impacts, the report distinguishes between **operational impacts** (due to purchases of intermediate inputs and payments of labor compensation) and **capital investment impacts** (due to investment in new structures and equipment).

This report also separately estimates the impact of Intel's **products** on other sectors of the US economy, such as through productivity enhancement.

This report reflects Intel's gross contribution to US employment, labor income, and GDP, and does not account for potential redeployment of labor and capital in the absence of Intel's US operations.

The rest of this report is organized as follows.

- **Section II** estimates Intel's operational spending, capital investment, and distribution channel impacts on the US economy for 2019.
- **Section III** estimates Intel's economic impact by US industrial sector.
- **Section IV** discusses the economic impacts of Intel's products on other sectors of the US economy.
- **Section V presents** Intel's economic impacts in Arizona, California, New Mexico, and Oregon.
- A description of the data and methodology used in this report is in **Appendix A.**
- **Appendix B** provides additional detail on Intel's economic impacts in the four selected states.
- **Appendix C** summarizes the economic literature on the Information and Communications Technology ("ICT") sector's impact on productivity and economic growth.

Intel's Economic Impact through its

Operations, Capital Investments, and Distribution Channels

Key Findings:

- In 2019, Intel employed an average of 51,900 full-and part-time workers in the United States throughout the year. Each job at Intel supported 13 other jobs elsewhere in the US economy.
- Intel's total impact on US labor income was $57.7 billion in 2019.
- Intel's total impact on US GDP was $102.0 billion in 2019.

This section presents Intel's upstream and downstream impact on the US economy. **Upstream impacts** arise from Intel's **operational spending** (due to purchases of intermediate inputs, payments of labor compensation, and dividend payouts to its stockholders) and **capital investment** (due to its investment in new structures and equipment). Each business in Intel's upstream supply chain provides jobs and labor income and generates GDP. **Downstream** impacts arise from the **distribution channel** for Intel products and other products incorporating Intel components. The distribution channel includes wholesalers, distributers, and retailers. Each business in the distribution channel also provides jobs and labor income and generates GDP.

The IMPLAN input-output model was used to estimate Intel's economic impacts on the US economy in 2019.

Employment

In 2019, Intel directly employed an average of 51,900 US workers throughout the year. In addition, Intel indirectly supported 669,400 full-time and part-time jobs elsewhere in the US economy:

- **376,600** indirect and induced jobs from Intel's operational spending;
- **146,100** indirect and induced jobs from Intel's capital investment; and
- **146,700** jobs from Intel's distribution channel.

Combining the direct, indirect, induced, and distribution channel impacts, Intel's total employment impact on the US economy is estimated to be 721,300 full-time and part-time jobs in 2019, roughly four-tenths of 1 percent of total US employment (see **Figure 1**). The largest component of Intel's total employment impact is attributable to its operational supply chain.

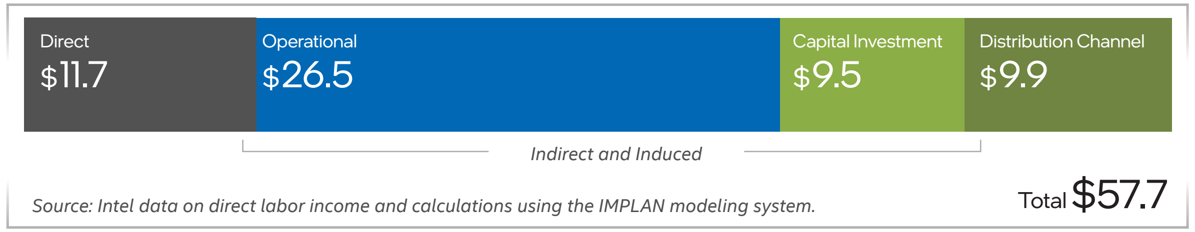
Figure 1. Intel's Total Impact on US Employment, 2019 (Thousands of Jobs)

Source: Intel data on direct employment and calculations using the IMPLAN modeling system.

Labor Income

In 2019, Intel paid $11.7 billion in wages, salaries and fringe benefits to its US employees. Including the labor income indirectly supported by Intel through its operational spending, capital investment, and distribution channel, the total impact on US labor income (including wages and salaries and benefits as well as proprietors' income) is estimated to be $57.7 billion in 2019 (see **Figure 2**).

Figure 2. Intel's Impact on US Labor Income, 2019 ($ Billions)



Source: Intel data on direct labor income and calculations using the IMPLAN modeling system.

Value Added

It is estimated that Intel directly contributed $25.9 billion of value added or GDP to the US economy in 2019. Intel's operational spending indirectly contributed an additional $43.2 billion to the US economy in 2019, while its capital investment and distribution channel impact added another $14.7 billion and $18.0 billion of GDP, respectively. Combining the operational spending, capital investment, and distribution channel impacts, Intel's total GDP impact on the US economy was $102.0 billion, accounting for one half of 1 percent of US GDP in 2019 (see **Figure 3**).

Figure 3. Intel's Value-Added Impact, 2019 ($ Billions)

Source: Calculations using the IMPLAN modeling system.

Intel's economic impact results for 2019 are summarized in **Table 1**.

Table 1. Intel's Direct, Operational, Capital Investment, and Distribution Channel Impacts on the US Economy, 2019

	Direct Impacts	Indirect and Induced Impacts		Distribution Channel Impacts	Total Impacts	Total / Direct ("Multiplier")[c]
		Operational	Capital Investment			
Employment (thousands of jobs)[a]	51.9	376.6	146.1	146.7	721.3	13.9
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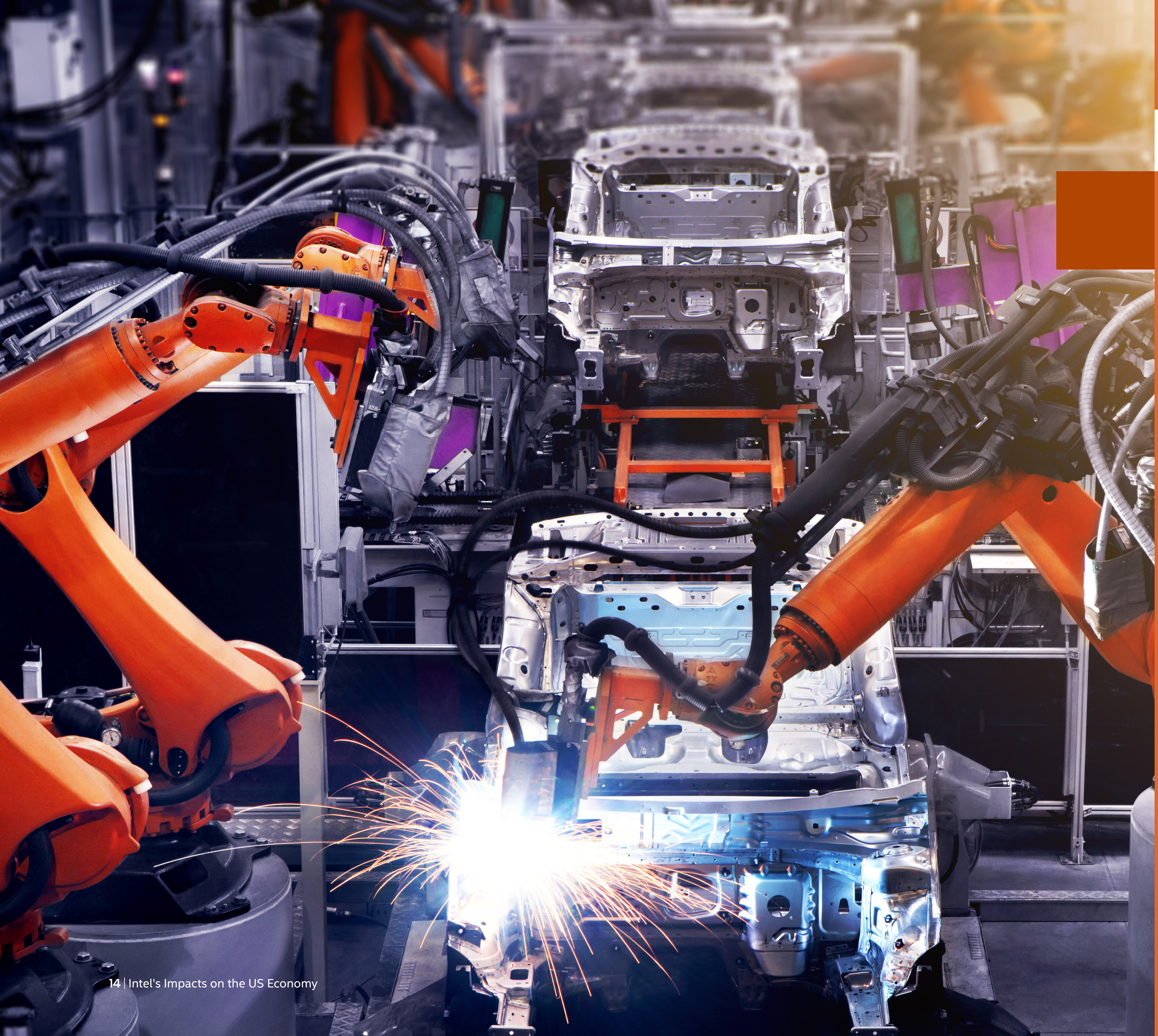
Source: Calculations using the IMPLAN modeling system (2018 database). Details may not add to totals due to rounding.
[a] Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
[b] Labor income is defined as wages and salaries and benefits as well as proprietors' income.
[c] Economic multiplier represents the overall impact (including direct, operational, capital investment, and distribution channel impacts) relative to the direct impact.



Intel's Economic Impact by Sector

Key Findings:

- Intel has a direct impact on the semiconductor and related manufacturing industry and a widespread economic impact throughout all sectors of the US economy.
- In 2019, the Services sector accounted for the largest number of indirect and induced jobs attributable to Intel's operational spending, capital investment, and distribution channel impacts, followed by the Wholesale and Retail Trade sector, and the Finance, Insurance, Real Estate, Rental and Leasing sector.

Intel purchases intermediate inputs and capital goods from a variety of other US industries, supporting jobs in these industries and spurring additional rounds of input purchases by these industries. Other economic impacts are generated by the personal spending of Intel employees and out of the additional income earned by employees in the supply chain to Intel. The jobs, labor income (including wages and salaries and benefits as well as proprietors' income), and GDP supported by this cycle of spending, or multiplier process, are referred to as the indirect and induced economic impacts.

Further, the distribution of Intel's products and other products incorporating Intel components through its wholesalers, distributors, and retailers support additional jobs, labor income, and GDP in the US economy.



Table 2 shows Intel's operational spending, capital investment, and distribution channel economic impacts by receiving sectors. It is estimated that at the national level, each direct job at Intel supported 13 jobs elsewhere in the US economy in 2019. That is, in addition to the 51,900 jobs directly provided by Intel, 669,400 additional jobs were supported in the US economy through Intel's operational spending, capital investment, and distribution channel impacts.

Intel's purchase of intermediate inputs from other US suppliers supported 376,600 jobs in other industries across the country in 2019. Intel's capital investment supported 146,100 additional jobs across the US economy and Intel's distribution channel supported another 146,700 jobs. Combined, Intel directly or indirectly supported 721,300 jobs in the US economy in 2019. The Services sector, the largest sector in the US economy, accounted for the largest number of Intel's operational spending, capital investment and distribution channel impacts on jobs (344,900) in 2019, followed by the Wholesale and Retail Trade sector (112,700), the Finance, Insurance, Real Estate, Rental and Leasing sector (63,800), the Manufacturing sector (49,700), and the Transportation and Warehousing sector (39,600).

It is estimated that in 2019 the $11.7 billion in employee compensation directly paid out by Intel led to an additional $46.0 billion in labor income elsewhere in the US economy – a multiplier effect of 4.9. In addition, Intel's direct GDP contribution of $25.9 billion in 2019 resulted in an additional $76.0 billion of GDP to the US economy – a multiplier effect of 3.9.

Table 2. Intel's Operational, Capital Investment, and Distribution Channel Impacts on the US Economy, by Receiving Industry, 2019 (Thousands of jobs; Billions of dollars)

Sector	Employment[a]			Labor Income[b]			Value Added (GDP)		
	Indirect and Induced		Distribution channel	Indirect and Induced		Distribution channel	Indirect and Induced		Distribution channel
	Operational	Capital Investment		Operational	Capital Investment		Operational	Capital Investment	
Agriculture	4.4	1.5	1.2	$0.1	*	*	$0.2	$0.1	$0.1
Mining	1.6	0.5	0.3	$0.1	*	*	$0.3	$0.1	$0.1
Utilities	2.7	0.5	0.5	$0.4	$0.1	$0.1	$1.3	$0.2	$0.2
Construction	2.5	21.9	0.7	$0.2	$1.4	*	$0.2	$1.7	$0.1
Manufacturing	33.4	11.8	4.5	$3.7	$1.0	$0.3	$7.0	$1.7	$0.7
Wholesale and retail trade	44.7	13.8	54.2	$2.6	$0.8	$4.0	$4.7	$1.4	$8.4
Transportation and warehousing	21.2	6.2	12.2	$1.3	$0.4	$0.7	$1.6	$0.5	$0.9
Information	7.2	2.3	2.4	$1.1	$0.3	$0.4	$2.4	$0.8	$0.8
Finance, insurance, real estate, rental and leasing	36.4	15.4	12.0	$2.3	$0.8	$0.7	$7.6	$2.5	$2.6
Services	216.2	71.6	57.1	$14.3	$4.6	$3.4	$17.2	$5.7	$4.1
Other	6.3	0.6	1.6	$0.5	*	$0.1	$0.7	$0.1	$0.2
Total	**376.6**	**146.1**	**146.7**	**$26.5**	**$9.5**	**$9.9**	**$43.2**	**$14.7**	**$18.0**

Source: Calculations using the IMPLAN modeling system (2018 database). Details may not add to totals due to rounding.
[a] Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
[b] Labor income is defined as wages and salaries and benefits as well as proprietors' income.
** Less than $0.1 billion.*

intel.

Intel's Economic Impact by Product

Key Findings:

- Users of Intel's products benefit from productivity enhancements and cost reductions.
- Intel's products contribute to the growth of productivity and GDP through capital deepening and total factor productivity.
- In terms of its capital deepening impact, Intel is estimated to have contributed $2 billion to US economic growth in 2018, the most recent year for which required data are available. Intel's impact through the total factor productivity channel is not directly measurable.
- US productivity growth has slowed down in the recent decade. Increasingly higher levels of investment and output from firms like Intel are required to support the base of future economic growth.

This section reviews the latest economic literature on the impact of the Information and Communications Technology ("ICT") sector on US economic growth and assesses the portion attributable to Intel's products.

Contribution of the ICT Sector to US Economic Growth

Historically, the ICT sector contributed significantly to economic growth through improved labor productivity and lower prices. Sustained growth in the production of semiconductors and computer equipment continues to this day. Sustained growth in this sector has been so stable that the phenomenon is characterized as a law of continued improvement. Named after Intel co-founder Gordon Moore, Moore's Law states that the number of transistors on integrated circuits doubles approximately every two years – implying a 32-fold increase after 10 years. The capabilities of computers and other semiconductor-dependent devices from the widespread use of smartphones to the internet of things are strongly linked to Moore's Law. Computing power, processing speeds, and memory capacity have all increased exponentially. From the early 1970s to 2000, the power of microprocessors increased by a factor of 7,000 while the cost of storing one megabit of data fell from more than $5,000 to just 17 cents.[6] A large body of economic research finds that the ICT sector fueled technological change and productivity growth across all sectors of the economy through the early 2000s. Today, ICT is an embedded component of day-to-day economic activity.

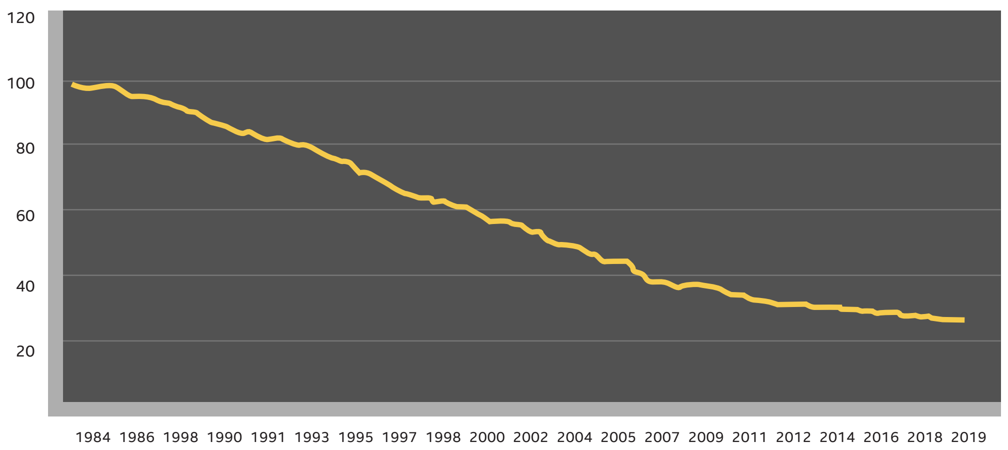
Since 2000, the rate of Moore's Law has attenuated and called into question the historically stable rate of progress in the production of modern microprocessors and semiconductors.[7] In the microprocessor manufacturing industry, total factor productivity – that is, the increase in output not directly attributable to increases in capital and labor – fell from 50.2 percent per year during 1990-2000 to 22.9 percent during 2001-2008.[8] In the past decade, producers of semiconductors and microprocessors like Intel have faced sharper economic trade-offs in order to achieve the continued rate of semiconductor improvements stated in Moore's Law. Transistor counts for Intel's microprocessors grew roughly 40 percent per year from 2000-2010. That rate dropped to 20 percent per year in the years following. Increases in transistor counts of Intel's microprocessor units (MPUs) stalled in the 2000s but then started to grow again at 25 percent per year.[9] Moore's Law in practice depends on firms like Intel to take on the costs, time, and effort to sustain that rate of improvement. That is how Moore's Law benefits end users and gives consumers access to increasingly improved semiconductors at continuously low prices.

One way to observe the economic benefit of Moore's Law is through the change in the real price of semiconductors produced over time. Although the capacity and power of semiconductors have changed significantly since earlier periods, the producer price index of semiconductor manufacturing is intended to reflect quality improvements and thereby provides a high-level view of the increase in the technical capacity of semiconductors over time per dollar of cost.

[6] Rauch, Jonathan. *"The New Old Economy: Oil, Computers, and the Reinvention of the Earth." The Atlantic Monthly. January 2001.*
[7] Rotman, David. *"The End of the Greatest Prediction on Earth." MIT Technology Review. February 2020.*
[8] Jorgenson, Dale, Mun Ho, and Jon Samuels. *"Long-term Estimates of U.S. Productivity and Growth." Third World KLEMS Conference. May 19-20, 2014.*
[9] Davis, Shannon. *"Transistor Count Trends Continue to Track with Moore's Law." Semiconductor Digest. March 10, 2020.*
https://www.semiconductor-digest.com/2020/03/10/transistor-count-trends-continue-to-track-with-moores-law/

Figure 4 shows the real price of semiconductors and other electronic components decreased 74 percent between 1984 and 2019. The most dramatic drop in the real price of semiconductors and other electronic components occurred between 1985 and 2010, dropping 65 percent over that period. Since 2010, the change in the real price of semiconductors slowed slightly, dropping 23 percent over the period between 2010 and 2019.

Figure 4. *Semiconductor and Other Electronic Component Manufacturing Real Producer Price Index [1984=100], 1984-2019*



Source: Producer Price Index: Semiconductor and Other Electronic Component Manufacturing. GDP Implicit Price Deflator. Federal Reserve Economic Data, FRED. Accessed November 2020.

Manufacturers of intermediate goods – such as microprocessors and semiconductors used in the production of other goods and services – contribute to productivity growth primarily through:

Capital deepening

Increased investment in capital equipment (including computers and other information technology) allows workers to be more efficient and more productive.

Total factor productivity (or multifactor productivity)

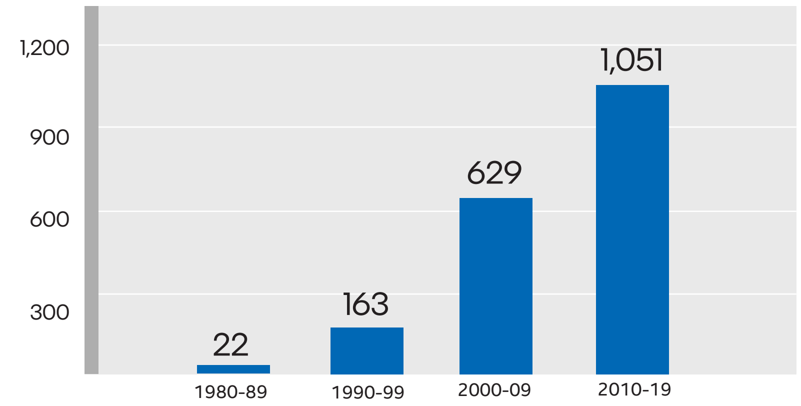
Technological progress and innovations in business systems or organizational structure.

Capital Deepening

According to the US Bureau of Economic Analysis ("BEA"), information processing equipment accounted for 10.7 percent of private sector investment, 3.3 percent of the total net stock of private fixed assets, and 1.8 percent of GDP in 2019. In terms of volume, the quantity of computers and peripheral equipment grew at an average annual rate of 23.5 percent between 1970 and 2019, far outpacing the growth in the quantity of private fixed investment, 3.6 percent per year, over the same period.

Figure 5 shows the relative intensity of the quantity of computers and peripheral equipment investment to the quantity of all private fixed investment by decade. Relative to 1970-1979, the quantity of computers and peripheral equipment investment compared to the quantity of all fixed investment jumped from 22 in the 1980s and 163 in the 1990s to 629 in the 2000s and 1,051 in the 2010s.

Figure 5. *Relative Intensity of the Quantity of Computers and Peripheral Equipment Investment to the Quantity of Private Fixed Investment by Decade, 1980-2019, [Relative to Intensity in 1970-1979=1]*



Source: US Bureau of Economic Analysis, Fixed Asset Accounts, Table 5.3.3.

In other words, growth in the volume of computer investment significantly outpaced growth in the volume of all tangible fixed investment in every decade since the 1970s.

Intel operates in the ICT sector by designing and manufacturing microprocessors, motherboard chipsets, integrated circuits, and other similar products. Microprocessors represent a large (but no longer the most dominant) segment of Intel's business. Intel is the world's largest supplier of semiconductors in terms of sales, with a global market share of 16.2 percent in 2019, according to one estimate.[10] The microprocessors that Intel produces are components of computers and many other commonly used electronic devices. As electronic devices become more efficient (e.g., increased computing power, higher-resolution graphics, etc.), so does the productivity of the households and firms that use them.

[10] Statista. "Market share held by semiconductor vendors worldwide from 2008 to 2019." July 2020. https://www.statista.com/statistics/294804/semiconductor-revenue-of-intel-worldwide-market-share/

As part of the ICT sector, Intel's products contribute to economic growth through their contribution to **capital deepening**, which is directly measurable.

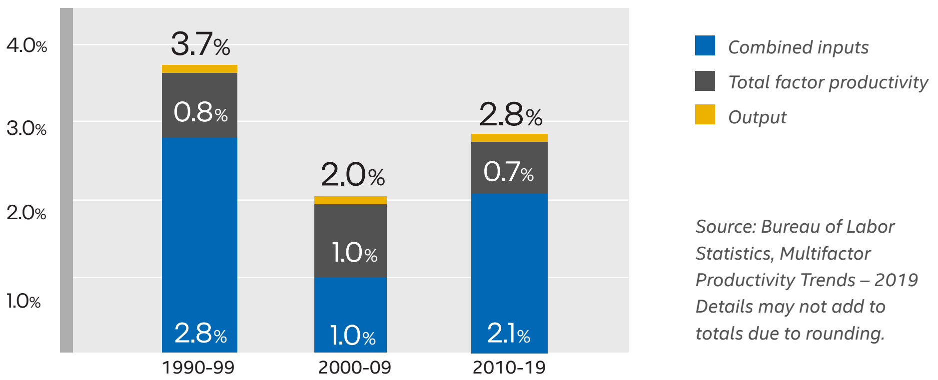
The increase in capital services from all business investment contributed 1.1 percentage points out of the 3.5 percentage point increase in the private nonfarm business sector's real GDP in 2018, the most recent historical year for which capital services data are available. Using data from the Bureau of Labor Statistics ("BLS"), we estimate that computers and related equipment accounted for approximately 0.04 percentage points of the increase in the private nonfarm business sector's real GDP in 2018 (or $5.5 billion measured in 2012 dollars).[11]

Based on data from Intel and the IMPLAN model, we estimate that Intel's nationwide market share of microprocessors in the United States was 33.8 percent in 2018. Thus, assuming this represents the proportion of computers in the United States using an Intel microprocessor, we estimate that Intel's contribution to real GDP growth through capital deepening was $1.8 billion in 2018 (measured in 2012 dollars), or $2.0 billion in nominal GDP (measured in current dollars).[12] In other words, Intel's products contributed $2.0 billion of nominal GDP through capital deepening in 2018.

Total factor productivity (TFP)

TFP accounts for changes in productivity not directly attributable to capital or labor. TFP generally results from technological improvements as well as changes in business organizational structures or processes that allow companies to better utilize new or existing technologies. TFP has noticeably decreased in the past decade relative to the 1990s and 2000s. On an annual average basis, TFP contributed 0.8 percent to real output growth in the 1990-99 period, increased to 1.0 percent in the 2000-2009 period, and has contributed 0.7 percent to real output growth since 2010 (see **Figure 6**).

Figure 6. *Annual Average Growth in Output, Combined Inputs, and TFP in US Private Non-Farm Sector, 1990-2019*



Source: Bureau of Labor Statistics, Multifactor Productivity Trends – 2019 Details may not add to totals due to rounding.

[11] BLS, Multifactor Productivity Trends – 2019. Various asset shares can be found in the MFP comprehensive tables. https://www.bls.gov/news.release/pdf/prod3.pdf

[12] This analysis implicitly assigns all of the value of a personal computer with an Intel chip to Intel and excludes the value of Intel's chips used in other types of communications and electronic equipment.

The ICT sector has been a significant source of TFP in the United States. However, since 2010, ICT's contribution to TFP has decreased. From 199o to 1999, the computer and electronic products manufacturing sector (NAICS 334), data processing, internet publishing, and other information services sector (NAICS 518 and 519), and computer systems design and related services sector (NAICS 5415) contributed 58.2 percent of TFP growth. In the 2000s, those same industries contributed 38.6 percent of TFP growth. Since 2010, ICT's contribution to TFP declined to 26.5 percent (see **Figure 7**).

The latest BLS data show that computers and electronics manufacturing accounted for 0.29 percentage points of the 0.83 percentage point increase in annual private nonfarm business TFP from 1987 to 2018, the latest year for which asset share contributions to TPF are reported. In other words, computers and electronics manufacturing accounted for more than one-third of the TFP growth in the private nonfarm business sector over this 31-year period.[13]

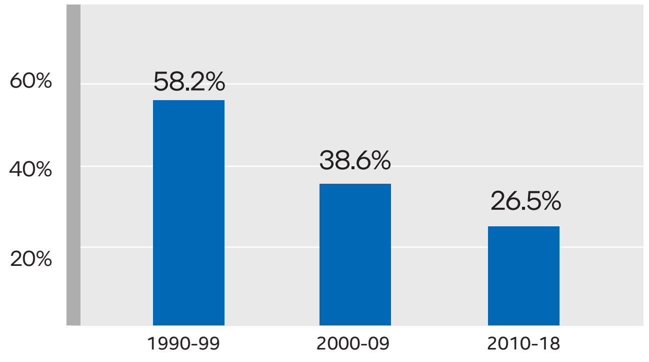


Figure 7. *ICT's Share of TFP by Decade, 1990-2018*

Sources: Bureau of Labor Statistics, Division of Major Sector Productivity, Multifactor Productivity Trends – 2019 Bureau of Economic Analysis KLEMS NIPA Tables. July 21, 2020.

Recent US Productivity Growth Slowdown

Economic productivity is defined as the ratio of outputs to inputs. It measures how efficiently inputs, such as capital and labor, are used to produce a given level of output.[14] Productivity growth reflects a positive change in the level of productivity over time.

ICT assets, products, and services are an embedded part of the US economy. Productivity gains from the ICT sector realized in prior decades are now part of the base of economic activity. The US economy's current level of productivity has benefited from contributions from the ICT sector. Additional contributions to productivity growth have since become more difficult and costly to gain and maintain. As reported in official statistics, both overall productivity growth and ICT's contribution to productivity growth in the US economy has stalled in the past decade.

[13] *US Bureau of Labor Statistics, Multifactor Productivity Trends - 2019, March 24, 2020, available at https://www.bls.gov/news.release/pdf/prod3.pdf US Bureau of Labor Statistics, Multifactor Productivity Trends in Manufacturing - 2018, January 28, 2020, available at https://www.bls.gov/news.release/pdf/prod5.pdf*

[14] *OECD. Productivity Statistics. https://www.oecd.org/sdd/productivity-stats/40526851.pdf*

Using Moore's Law as an example, the number of researchers required to maintain the annual doubling of computer chip density is roughly 18 times larger today than what was required in the early 1970s.[15] Research productivity in the production of semiconductors declined sharply from a constant growth rate of 35 percent per year (for nearly half a century) to 7 percent per year today. The production of new ideas and methods – to maintain the annual doubling of computer chip density in semiconductors, for example – is getting harder to find (Bloom et. al., 2020).

Part of the productivity slowdown is due to composition and lag effects. Prices for ICT assets have rapidly declined in the past decade. Moving from "installation phase" to the "deployment phase" of the New Digital economy, ICT investment has shifted from products to services such as computer system design, cloud computing, data storage, and information processing. Implementing new tangible ICT assets require higher levels of knowledge to maintain and support them.[16] The timing of ICT's contribution to productivity has also lagged. For a positive contribution to take place, economies may first go through a negative relationship between ICT investment and productivity. ICT-using sectors need to learn how to apply the recently embedded ICT technology.[17] Productivity gains from ICT products and services require a longer learning period to be realized (Liao et. al., 2016). In recent years, the contribution of ICT assets to productivity have appeared through the purchase of services such as cloud storage and data analytics. Contributions of those services may not be fully accounted for in the standard narrative of ICT's contribution to economic productivity nor in official statistics.[18]

Some research has investigated whether the productivity slowdown was due to mismeasurement. Recent productivity gains may not yet be fully reflected in official statistics because the value of some new goods (such as ICT services) as an increasing portion of the value accrues as consumer surplus rather than formally measured revenues.[19] Today there is a tremendous amount of consumer surplus that appears in the form of non-market activity such as internet search, social networks, and the ubiquitous use of smartphones.[20]

In summation, the US experienced a productivity slowdown in recent years, and ICT's contribution to productivity grew smaller. The US economy has greatly benefited from the ICT sector and past ICT investments have boosted the level of productivity. Ongoing productivity enhancements and cost reductions in the ICT sector are the norm but require increasingly higher levels of investment and output from firms like Intel to maintain that base of economic activity and contribute to growth.

[15] *Bloom, Nicholas, Charles Jones, John Van Reenen, and Michael Webb. "Are Ideas Getting Harder to Find?" American Economic Review (April 2020).*

[16] *Van Ark, Bart. "The Productivity Paradox of the New Digital Economy." International Productivity Monitor. Number 31. Fall, 2016.*

[17] *Liao, Hailin, Bin Wang, Baibing Li, and Tom Weyman-Jones. "ICT as a General-Purpose Technology: The Productivity of ICT in the United States Revisited." Information Economics and Policy (2016).*

[18] *Byrne, David and Carol Corrado. "ICT Services and their Prices: What do they tell us about Productivity and Technology." Finance and Economics Discussion Series, Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board. 2017. Byrne and Corrado looked at new measures of ICT price changes (for both products and services) that are not captured in official price indices. Assuming ICT asset prices reflect the relative productivity of the sector, they found no evidence in support of a decline in the relative productivity of ICT capital over the past decade.*

[19] *Byrne, David, John Fernald, and Marshall Reinsdorf. "Does the United States Have a Productivity Slowdown or a Measurement Problem?" Federal Reserve Bank of San Francisco Working Paper Series (April 2016).*

[20] *Syverson, Chad. "Challenges to Mismeasurement Explanations for the US Productivity Slowdown." Journal of Economic Perspectives. Vol. 31. Num. 2. Spring, 2017.*

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Intel's Economic Impacts on Selected States

Key Findings:

- Intel's most significant direct economic footprint in 2019 is found in Oregon (20,400 direct jobs, $4.2 billion in employee compensation, and $10.3 billion in GDP), followed by California (14,800 direct jobs, $4.0 billion in employee compensation, and $8.0 in GDP), Arizona (10,300 direct jobs, $2.0 billion in employee compensation, and $3.9 billion in GDP), and New Mexico (1,200 direct jobs, $243 million in employee compensation, and $400 million in GDP).
- Including direct, operational supply chain, capital investment, and downstream impacts, Intel's total economic footprint in 2019 is most significant in California (142,900 jobs, $14.2 billion in labor income, and $24.9 billion in GDP), followed by Oregon (105,100 jobs, $10.0 billion in labor income, and $19.3 billion in GDP), Arizona (58,600 jobs, $4.9 billion in labor income, and $8.6 billion in GDP), and New Mexico (6,000 jobs, $479 million in labor income, and $825 million in GDP).
- Relative to the state economy, Intel's total employment impact is most significant in Oregon (4.0 percent of statewide employment), followed by Arizona (1.5 percent), California (0.6 percent), and New Mexico (0.5 percent).

Intel's economic impact reaches all 50 states and the District of Columbia. The impact varies from state to state, depending on factors such as each state's industry mix, wage structure, spending and saving patterns, and connections to other economies. This section focuses on four key states with the most significant Intel activities: Arizona, California, New Mexico, and Oregon. Intel's economic impact at the state level reflects the indirect and induced effects attributable to direct activity within each state's borders, as well as indirect and induced activity within a state that is attributable to direct activity in other states.[21]

Figures 8, 9, and 10 present employment, labor income, and value added for the top four states ranked by direct impacts. In terms of employment, Intel's biggest presence is in Oregon employing 20,400 workers there in 2019. Intel had 14,800 employees in California, 10,300 employees in Arizona, and 1,200 employees in New Mexico in the same year (see **Figure 8**).

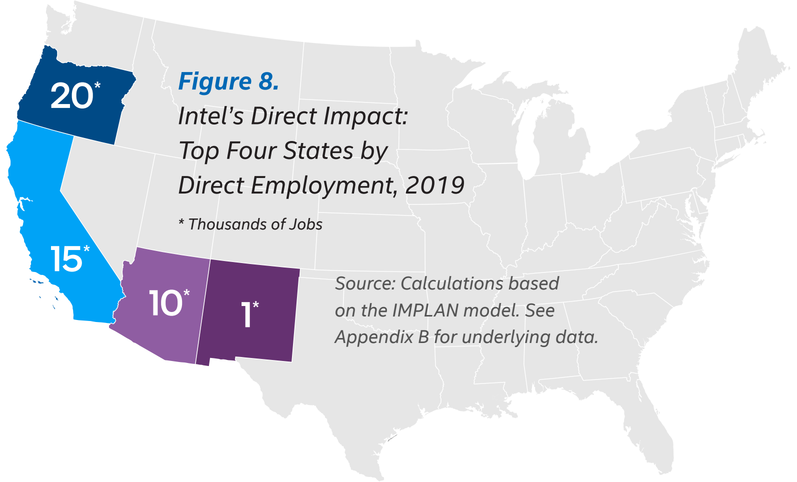


Figure 8.
Intel's Direct Impact: Top Four States by Direct Employment, 2019

** Thousands of Jobs*

Source: Calculations based on the IMPLAN model. See Appendix B for underlying data.

Figure 9 breaks out Intel's direct labor income by state. In 2019, Intel directly contributed the most labor income in Oregon, totaling $4.2 billion, followed by California ($4.0 billion), Arizona ($2.0 billion), and New Mexico ($243 million). **Figure 10** shows Intel's direct value-added impact by state. In 2019, Intel directly contributed $10.3 billion in GDP to the state of Oregon, $8.0 billion in GDP to California, $3.9 billion in GDP to Arizona, and $400 million in GDP to New Mexico.

Figure 9. *Intel's Direct Impact: Top Four States by Direct Labor Income, 2019*

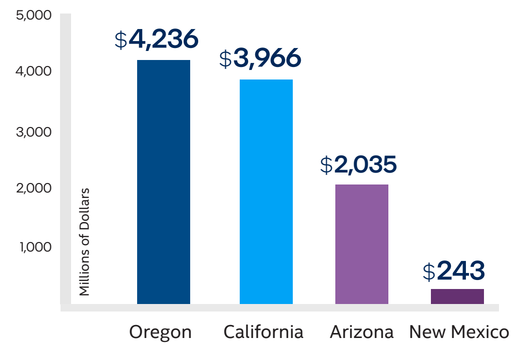
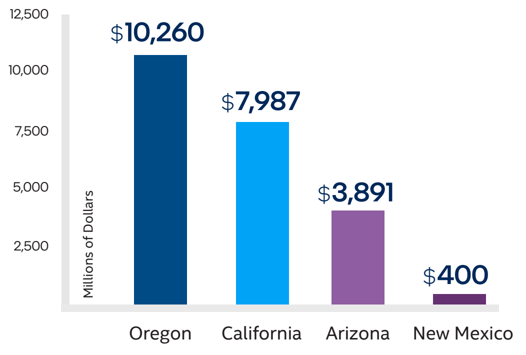


Figure 10. *Intel's Direct Impact: Top Four States by Direct Value Added, 2019*



Source: Calculations based on the IMPLAN model. See Appendix B for underlying data.

Figures 11, 12, and 13 present employment, labor income, and value-added impacts for the top four states ranked by total impact (including the direct, operational supply chain, capital investment, and distribution channel impacts).

Figure 11 shows Intel's total employment impact by state in 2019. Intel's total employment impact was most significant in California (142,900 jobs), followed by Oregon (105,100 jobs), Arizona (58,600 jobs), and New Mexico (6,000 jobs).

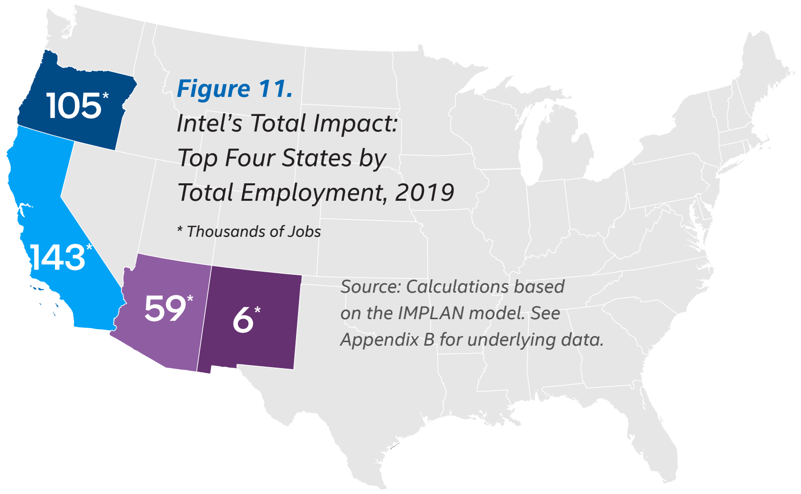


Figure 11.
Intel's Total Impact: Top Four States by Total Employment, 2019

** Thousands of Jobs*

Source: Calculations based on the IMPLAN model. See Appendix B for underlying data.

Figure 12 shows Intel's total labor income impact by state. In 2019, Intel contributed a total of $14.2 billion in labor income (including wages, salaries, fringe benefits, and proprietors' income) in California, the highest among the four states. Intel's total labor income contribution was $10.0 billion in Oregon, $4.9 billion in Arizona, and $479 million in New Mexico. **Figure 13** shows Intel's total value-added contribution by state in 2019. Intel's total contribution to GDP in California was $24.9 billion, the highest among the four states. Intel's total value-added contribution was $19.3 billion in Oregon, $8.6 billion in Arizona, and $825 million in New Mexico.

Figure 12. *Intel's Total Impact: Top Four States by Total Labor Income, 2019*

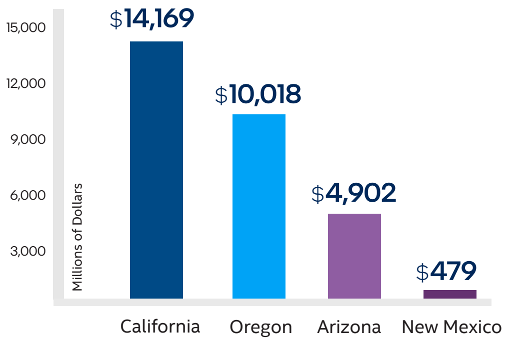
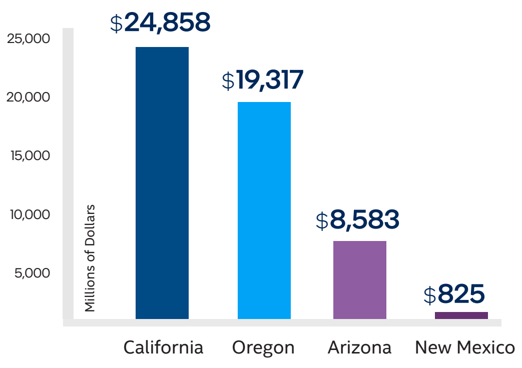


Figure 13. *Intel's Total Impact: Top Four States by Total Value Added, 2019*



Source: Calculations based on the IMPLAN model. See Appendix B for underlying data.

[21] *We have allocated the indirect and induced effects by industry attributable to direct activity in other states based on the overall level of economic activity of that industry in each state.*

Appendix A:
Data Sources and Methodology

This Appendix describes the methodology used to derive the results for the study. It first discusses the IMPLAN model which was used to estimate many of the impacts in this report. It also discusses the data sources utilized to develop estimates of Intel's direct employment, labor income, and GDP impacts and capital investment impacts. It then describes the use and adjustment of the IMPLAN model to capture a more complete estimate of Intel's overall impact on the US economy. These adjustments capture capital investment impacts and distribution channel impacts which are not necessarily incorporated into other economic impact analyses.

The IMPLAN model, an input-output ("I-O") model based on Federal government data, was used to estimate Intel's overall economic impact. I-O modeling is typically employed to analyze how a change in economic activity in one sector of the economy affects activities in other sectors of the economy. In a so-called "marginal" impact analysis, I-O model results can be viewed as showing the impact of small changes in activity in one sector (e.g., semiconductor manufacturing) on the rest of the economy before any price adjustments and before businesses, workers, and consumers adjust their activities. The ultimate economic impact of a change in activity will be less pronounced than shown by I-O results, particularly if induced price changes are large.

I-O models can also be used in an economic contribution analysis, as done in this study. By simulating a "complete shutdown" of an existing sector, an economic contribution study attempts to quantify the portion of an economy that can be attributed to such an existing sector. It uses the I-O model to identify all backward (i.e., upstream) linkages in the study area. An economic contribution analysis, when compared with the entire study area economy, offers insights into the relative extent and magnitude of a company or an industry in the study area. However, this is not to say that a complete shutdown of Intel would result in the permanent loss of the jobs and output attributable to the company through this exercise. In this unlikely event, the resources currently allocated to semiconductor manufacturing may find employment in other industries, which would compensate in part for the loss of the jobs and output from the semiconductor sector.

The latest version of the IMPLAN model, which is used for this study, incorporates the input-output relationships for 2018.

Estimating the Direct Jobs, Direct Labor Income and Direct GDP

This report uses data on direct employment, employee compensation, and capital expenditures provided by Intel. The employment data include both full-time and part-time workers. Employee compensation includes wages, salaries and fringe benefits.

Intel's contribution to GDP was estimated based on Intel's employment and the semiconductor industry's average GDP to employment ratio from the IMPLAN model.

Estimating the Indirect and Induced Economic Impacts

Estimates of the indirect and induced economic impacts of Intel were derived based on the IMPLAN model for the United States. The IMPLAN model is built around an "input-output" table that relates the purchases that each industry has made from other industries to the value of the output of each industry. To meet the demand for goods and services from an industry, purchases are made in other industries according to the patterns recorded in the input-output table. These purchases in turn spark still more purchases by the industry's suppliers, and so on. Additionally, employees and business owners make personal purchases out of the additional income that is generated by this process, sending more new demands rippling through the economy.

Multipliers describe these iterations. The Type I multiplier measures the direct and indirect effects of a change in economic activity. It captures the inter-industry effects only, i.e., industries buying from local industries. The Type II (Social Accounting Matrix or SAM) multiplier captures the direct and indirect effects and, in addition, it also reflects induced effects (i.e., changes in spending from households as income increases or decreases due to the changes in production). The indirect and induced impacts by Intel on other sectors of the economy in terms of employment, labor income (including wages and salaries and benefits as well as proprietors' income), and GDP were calculated through the multiplier process built into the model.[22]

Estimating Capital Investment Impact

To quantify Intel's capital investment impact, Intel's expenditure on structures and equipment are mapped into purchases of capital assets by type using the so-called "capital flow matrix" from the US Department of Commerce. Intel's R&D expenditures are modeled as a change to the NAICS R&D sector.

Estimating Distribution Channel Impacts

Intel's share of the semiconductor industry's distribution margin is estimated from the IMPLAN model to capture impacts associated with the distribution of Intel's products. In addition, IMPLAN is used to estimate the distribution margins of other products incorporating Intel components. Based on these margins, we estimated the related impacts on employment, labor income, and GDP.

[22] Because the IMPLAN models are used for total impact analysis (as opposed to marginal impact analysis) in this study, necessary adjustments are made to the initial indirect and induced impact estimates to prevent double counting. For instance, the indirect and induced effects from the estimates that are mapped to the semiconductor industry are adjusted downward to reflect Intel's market share.

Appendix B: Intel's Detailed Economic Impacts on Selected States

Table B-1. *Intel's Economic Impact on Selected States: Summary Statistics, 2019 (Thousands of jobs; Millions of dollars)*

States	Employment[a]			Labor Income[b]			Value Added (GDP)		
	Direct	Total	% of US or State Total	Direct	Total	% of US or State Total	Direct	Total	% of US or State Total
US Total	51.9	721.3	0.4%	$11,725	$57,725	0.4%	$25,946	$101,954	0.5%
Arizona	10.3	58.6	1.5%	$2,035	$4,902	2.2%	$3,891	$8,583	2.3%
Califonia	14.8	142.9	0.6%	$3,966	$14,169	0.8%	$7,987	$24,858	0.8%
New Mexico	1.2	6.0	0.5%	$243	$479	0.8%	$400	$825	0.8%
Oregon	20.4	105.1	4.0%	$4,236	$10,018	6.3%	$10,260	$19,317	7.7%
Rest of the country	5.3	408.8	0.2%	$1,245	$28,157	0.3%	$3,408	$48,371	0.3%

Source: Calculations based on the IMPLAN modeling system (2018 database). Details may not add to totals due to rounding.
[a] Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
[b] Labor income is defined as wages and salaries and benefits as well as proprietors' income.

Table B-2. *Intel's Economic Impact in Arizona, 2019*

Thousands of jobs/ Millions of dollars	Direct Impacts	Indirect and Induced Impacts		Distribution Channel Impacts	Total Impacts	Total / Direct ("Multiplier")[c]
		Operational	Capital Investment			
Employment (thousands of jobs)[a]	10.3	41.1	2.8	4.4	58.6	5.7
Labor Income ($ billions)[b]	$2,035	$2,443	$153	$271	$4,902	2.4
Value Added (GDP) ($ billions)	$3,891	$3,959	$242	$491	$8,583	2.2

Source: Calculations using the IMPLAN modeling system (2018 database).
[a] Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
[b] Labor income is defined as wages and salaries and benefits as well as proprietors' income.
[c] Economic multiplier represents the overall impact (including direct, operational, capital investment, and distribution channel impacts) relative to the direct impact.

Table B-3. *Intel's Economic Impact in California, 2019*

Thousands of jobs/ Millions of dollars	Direct Impacts	Indirect and Induced Impacts		Distribution Channel Impacts	Total Impacts	Total / Direct ("Multiplier")[c]
		Operational	Capital Investment			
Employment (thousands of jobs)[a]	14.8	81.0	17.9	29.2	142.9	9.6
Labor Income ($ billions)[b]	$3,966	$6,606	$1,402	$2,195	$14,169	3.6
Value Added (GDP) ($ billions)	$7,987	$10,635	$2,180	$4,055	$24,858	3.1

Source: Calculations using the IMPLAN modeling system (2018 database).
[a] Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
[b] Labor income is defined as wages and salaries and benefits as well as proprietors' income.
[c] Economic multiplier represents the overall impact (including direct, operational, capital investment, and distribution channel impacts) relative to the direct impact.

Table B-4. *Intel's Economic Impact in New Mexico, 2019*

Thousands of jobs/ Millions of dollars	Direct Impacts	Indirect and Induced Impacts		Distribution Channel Impacts	Total Impacts	Total / Direct ("Multiplier")[c]
		Operational	Capital Investment			
Employment (thousands of jobs)[a]	1.2	3.4	0.7	0.7	6.0	5.1
Labor Income ($ billions)[b]	$243	$168	$36	$33	$479	2.0
Value Added (GDP) ($ billions)	$400	$300	$59	$66	$825	2.1

Source: Calculations using the IMPLAN modeling system (2018 database).
[a] Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
[b] Labor income is defined as wages and salaries and benefits as well as proprietors' income.
[c] Economic multiplier represents the overall impact (including direct, operational, capital investment, and distribution channel impacts) relative to the direct impact.

Table B-5. *Intel's Economic Impact in Oregon, 2019*

Thousands of jobs/ Millions of dollars	Direct Impacts	Indirect and Induced Impacts		Distribution Channel Impacts	Total Impacts	Total / Direct ("Multiplier")[c]
		Operational	Capital Investment			
Employment (thousands of jobs)[a]	20.4	76.6	1.9	6.3	105.1	5.2
Labor Income ($ billions)[b]	$4,236	$5,245	$116	$422	$10,018	2.4
Value Added (GDP) ($ billions)	$10,260	$8,159	$179	$719	$19,317	1.9

Source: Calculations using the IMPLAN modeling system (2018 database).
[a] Employment is defined as the number of payroll and self-employed jobs, including part-time jobs.
[b] Labor income is defined as wages and salaries and benefits as well as proprietors' income.
[c] Economic multiplier represents the overall impact (including direct, operational, capital investment, and distribution channel impacts) relative to the direct impact.

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Appendix C: Literature Review

Table C-1. Summary of Findings

Author / Date	Title	Topic / Focus / Question	Geography / Sectors Covered	Time Period	Findings
BLS, 2020	**Multifactor Productivity Trends - 2019**	Trends of Capital, Labor, and Multifactor Productivity	US All sectors	2007-2019	Private nonfarm business sector MFP increased 0.9 percent in 2019. The increase reflects a 2.7 percent increase in output and 1.9 percent increase in the combined inputs of capital and labor.
BEA & BLS, 2019	**Integrated BEA/BLS Industry-Level Production Account and the Sources of U.S. Economic Growth**	New statistics for 2017 and updated statistics for 1998-2016	US All sectors	1998-2017	Fastest growing industries were data processing, internet publishing, and other information services. The largest contributor to the data processing, internet publishing, and other information services industry was the accumulation of capital input.
BLS, 2018	**Multifactor productivity in U.S. manufacturing**	Assesses contribution of manufacturing and ICT products on MFP	US All sectors Manufacturing	1992-2016	MFP in the manufacturing sector grew at annual average of 2 percent from 1992-2004. From 2004-2016, manufacturing MFP declined at an annual average of 0.3 percent. Since 2004, semiconductors and other electronic component manufacturing and computer and peripheral equipment manufacturing contributed the most to the slowdown.
Van Ark, 2016	**The Productivity Paradox of the New Digital Economy**	Impact of ICT capital and services on productivity growth	US, UK & Germany All sectors	1963-2015	Despite increases in spending on ICT capital and services, the New Digital Economy of the 2010's has not generated improvements in productivity growth. Rapidly declining prices in ICT assets resulted in a relative shift in investment over to services – an increase in knowledge used to support ICT assets.
Antonioli, Cecere, & Mazzanti, 2018	**Information communication technologies and environmental innovations in firms: joint adoptions and productivity effects**	Firm level interaction between ICT and industrial organization (Environmental Innovation)	Northeast Italy	2006-2011	According to survey findings of firms in NE Italy, there are still "wide margins to improve ICT and environmental innovation" integration in order to improve productivity. Single adoptions of ICT innovations do not impact business performance. Join adoption and combinations of EI and ICT appear to drive firm productivity.
Venturini, 2015	**The Modern Drivers of Productivity**	Cross-country panel investigation of impact of R&D and IT on productivity	Cross country panel including US	1980-2003	Both R&D and IT capital deepening matter for long-run TFP growth. R&D base of domestic producers of IT assets is a driver of economic growth in industrialized economies. Low degree of industry specialization in IT can only be partly compensated with trade openness (of importing R&D-intensive IT capital goods from other countries).
Diaz-Chao, Sainz-Gonzalez, & Torrent-Sellens, 2015	**ICT, innovation, and firm productivity : New evidence from small local firms**	Representative sample of small firms in Girona Spain to examine determinants of labor productivity	Girona, Spain	2009	Wages are the main determinants of labor productivity. Co-innovation does not directly affect small local firms' productivity. There is an indirect relationship between co-innovation and productivity in firms that initiate international expansion.
Liao, Wang, Li, & Weyman-Jones, 2016	**ICT as a general-purpose technology: The productivity of ICT in the United States revisited**	Revisiting findings of ICT as a general-purpose widespread technology and its impacts on productivity	US, EU, Japan	1977-2005	Using a two-level frontier-efficiency model, the authors examine ICT's direct and indirect impacts on differential components of productivity related to economic growth in the US. There is a positive, lagged ICT effect on technological progress. In order for a positive contribution of ICT to take place, economies first go through a negative relationship between ICT investment and productivity in conjunction with ICT-using sectors' capacity to learn from newly embedded ICT technology.

Appendix C: Literature Review

Table C-1. Summary of Findings

Author / Date	Title	Topic / Focus / Question	Geography / Sectors Covered	Time Period	Findings
Syverson, 2017	**Challenges to Mismeasurement Explanations for the US Productivity Slowdown**	Review of US output and growth calculations; identify missing output and productivity	US	1947-2015	Productivity growth rose to a trajectory of 2.8 percent average annual growth sustained over 1995-2004. Since then the US economy experienced a slowdown in measured labor productivity growth. From 2005-2015, labor productivity grew at an annual average of 1.3 percent. The productivity growth slowdown is not due to cyclical phenomena. Syverson considers the growth mismeasurement hypothesis. Recent productivity gains have not yet been reflected in productivity statistics either because new goods' total surplus has shifted from measured (formal) revenues to unmeasured (informal) consumer surplus or because prices are overstated.
Byrne & Corrado, 2017	**ICT Services and their Prices: What do they tell us about Productivity and Technology?**	Assesses link between ICT prices, technology, and productivity; extend a multi-sector model to include ICT services	US Multi-sector	1959-2014	In recent years, ICT technology diffuses through the economy through purchases of services such as cloud storage and data analytics that are not fully accounted for in the standard narrative on ICT's contribution to economic growth. The contribution of ICT on growth in output per hour going forward is much higher - 1.4 percentage points per year. ICT asset prices are found to substantially understate productivity of the sector. ICT service prices may diverge from asset prices and capture productivity gains from the management of ICT assets rather than the tangible property itself.
Byrne, Fernald, & Reinsdorf, 2016	**Does the United States Have a Productivity Slowdown or a Measurement Problem?**	Assessment of the nature of ICT investment in the US and how it appears or fails to appear in growth measurements	US Market & Nonmarket sectors	1978-2014	Little evidence of the productivity slowdown due to growing mismeasurement of gains from ICT goods and services. Mismeasurement of IT hardware is more significant prior to the slowdown when domestic production of IT fell. This effect on productivity is larger in the 1994-2004 period despite worse mismeasurement during this time period. Tremendous consumer surplus arose from, conceptually, non-market activity e.g. Google search, social networks, smartphones. Consumers became more productive in their nonmarket time. These benefits raise consumer welfare but do not imply market-sector productivity gains.
Goldman Sachs, 2016	**Productivity Paradox v2.0 Revisited**	Reassessing the US productivity paradox in the 21st century	US	1990-2013	True pace of increase in living standards may not have weakened as much as suggested by sharp slowdown in official productivity figures. True inflation may be somewhat lower than officially measured. Labor market remains key for gauging the progress of economic growth.
Ramey, 2020	**Secular stagnation or technological lull?**	Review of US era of secular stagnation	US	1930-2020	The nature of technological change leads to medium-run variations in productivity growth and long periods of sluggish growth. These are periods of technological lulls.
Mokyr, 2014	**Secular stagnation? Not in your life**	Opinion and reassessment of secular stagnation hypothesis	US	1930-2012	Technological progress in specific sectors such as computing, materials, and genetic engineering point to a more optimistic future of economic growth. Indirect effects of science on productivity may dwarf the direct effects in the long run.
Furman, 2020	**Jason Furman on Productivity, Competition, and Growth (Ep. 103)**	Interview with Tyler Cowen on the "Conversations with Tyler" podcast	US	1990-2020	Degree on the unmeasured benefits from the internet: Intermediate. "It's not like adding these are going to add to your measure of productivity growth in the year 2019 or the year 2018. They might add to the level of productivity, but they were in the level. They were in the base a while ago now. And they've just continued up. So, I certainly think there's some things we're not measuring."
Bloom, Jones, Van Reenen, & Webb, 2020	**Are Ideas Getting Harder to Find?**	Application of Solow growth model to the production of new ideas	US	1930-2020	Research effort has risen substantially while research productivity is declining sharply. In the context of Moore's Law, the number of researchers required today to achieve this doubling of computer chip density is 18 times larger today than the number required in the early 1970s.

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