NIST Advanced Manufacturing Series 100-28

Annual Manufacturing Review: 2019

Douglas S. Thomas

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National Institute of
Standards and Technology
U.S. Department of Commerce

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U.S. Department of Commerce
Wilbur L. Ross, Jr., Secretary

National Institute of Standards and Technology
Walter Copan, NIST Director and Undersecretary of Commerce for Standards and Technology

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Preface

This study was conducted by the Applied Economics Office (AEO) in the Engineering Laboratory (EL) at the National Institute of Standards and Technology (NIST). The study provides aggregate manufacturing industry data and industry subsector data to develop a quantitative depiction of the US manufacturing industry.

Disclaimer

Certain trade names and company products are mentioned in the text in order to adequately specify the technical procedures and equipment used. In no case does such identification imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the products are necessarily the best available for the purpose.

Acknowledgements

The author wishes to thank all those who contributed so many excellent ideas and suggestions for this report. Special appreciation is extended to Stanley Gilbert and David Butry of EL's AEO and to Erica Kuligowski for their thorough reviews and many insights. The author also wishes to thank Nicos Martys, of the Materials and Structural Systems Division for his review.

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List of Acronyms

ASE: Annual Survey of Entrepreneurs
ASM: Annual Survey of Manufactures
BEA: Bureau of Economic Analysis
GDP: Gross Domestic Product
IBRD: International Bank for Reconstruction and Development
IDA: International Development Association
ISIC: International Standard Industrial Classification
MAPI: Manufacturers Alliance for Productivity and Innovation
NAICS: North American Industry Classification System
NIST: National Institute of Standards and Technology
PPP: Purchasing Power Parity
SIC: Standard Industrial Classification
UNSD: United Nations Statistics Division

Executive Summary

This report provides an overview of the US manufacturing industry. There are three aspects of US manufacturing that are considered: (1) how the US industry compares to other countries, (2) the trends in the domestic industry, and (3) the industry trends compared to those in other countries. The US remains a major manufacturing nation; however, other countries are rising rapidly. US manufacturing was significantly impacted by the previous recession and has only recently returned to pre-recession levels of production and still remains below pre-recession employment levels.

Although US manufacturing performs well in many respects, there are opportunities for advancing competitiveness. This will require strategic placement of resources to ensure that US investments have the highest return possible.

Competitiveness – Manufacturing Growth: US compound real (i.e., controlling for inflation) annual growth between 1992 and 2017 (i.e., 25-year growth) was 2.5 %, which places the US below the 50th percentile. The compound annual growth for the US between 2012 and 2017 (i.e., 5-year growth) was 1.2 %. This puts the US just above the 25th percentile below Canada and Germany among others.

Competitiveness – Manufacturing Industry Size: US manufacturing value added, as measured in constant 2010 dollars, is the second largest behind that of China (See Figure 2.3). In current dollars, the US produced $1.9 trillion in manufacturing valued added while China produced $3.2 trillion. Among the ten largest manufacturing countries, the US is the 4th largest manufacturing value added per capita (see Figure 2.4). Out of all countries the most recent US rank is 19th, as illustrated in Figure 2.5. The US ranks 1st in 7 manufacturing industries out of 16 total, while China was the largest for the other industries, as seen in Figure 2.6.

Competitiveness – Productivity: Labor productivity for manufacturing increased 0.7 % from 2017 to 2018 and has had a slight upward trend, as seen in Figure 4.7. For US manufacturing, multifactor productivity declined 1.4 % from 2016 to 2017 and has had a downward trend in recent years, as seen in Figure 4.8. US productivity is relatively high compared to other countries. As illustrated in Figure 4.9, the US is ranked fourth in output per hour among 65 countries using data from the Conference Board. In recent years, productivity growth has been negative or has come to a plateau in many countries and the US seems to be following this pattern of slow growth. There are competing explanations for why productivity has slowed, such as an aging population, inequality, or it could be the result of the economic recovery. A number of the explanations equate to low levels of capital investment. It is also important to note that productivity is difficult to measure and even more difficult to compare across countries. Moreover, the evidence does not seem to support any particular explanation over another as to why productivity appears to have stalled.

Competitiveness – Economic Environment: There is no agreed upon measure for research, innovation, and other factors for doing business, but there are a number of common measures that are used. The ranking of the US in these measures has mixed results, ranking high in some and low in others. For instance, the US ranks 3rd in patent applications but ranks 16th in researchers per capita and 21st in journal article publications per capita. The IMD World Competitiveness Index, which measures competitiveness for conducting business, ranked the US 3rd and the World Economic Forum, which assesses the competitiveness in determining productivity, ranked the US 1st. Note that neither of these are specific to manufacturing, though. A third index specific to manufacturing, the Deloitte Global Manufacturing Index, ranks China 1st and the US 2nd. The Competitive Industrial Performance Index, which measures capacity to produce and export manufactured goods; technological deepening and upgrading; and world impact, ranked the Germany 1st and the US 3rd.

Domestic Specifics – Types of Goods Produced: The largest manufacturing subsector in the US is chemical manufacturing, followed by computer and electronic products and food, beverage, and tobacco products, as seen in Figure 2.13. Discrete technology products accounted for 36 % of US manufacturing.

Domestic Specifics – Economic Recovery: US Manufacturing declined significantly in 2008 and has only recently returned to its pre-recession peak level, which occurred in 2007. Manufacturing value added declined more than total US GDP, creating a persistent gap. The result is that first quarter GDP in 2019 is 20.0 % above its pre-recession peak level while manufacturing is at 2.7 % above its peak level. Between January 2006 and January 2010, manufacturing employment declined by 19.4 %. As of July 2019, employment is still 9.5 % below its 2006 level.

Domestic Specifics – Manufacturing Supply Chain Costs: High cost supply chain industries/activities, which might pose as opportunities for advancing competitiveness, include energy related industries, management, transportation, semiconductor manufacturing, and machinery manufacturing. Production occupations is the largest labor cost activity, followed by management, office and administrative support, transportation and material moving, and business and financial operations.

Domestic Specifics – Manufacturing Safety, Compensation, and Profits: As seen in Figure 4.5, employee compensation, which includes benefits, has had a five-year compound annual growth of 0.7 %. In terms of safety in manufacturing, the number of fatal injuries decreased 26.2 % between 2016 and 2017 (see Table 4.4). Nonfatal injuries decreased along with the injury rate (see Table 4.5). However, the incident rate for nonfatal injuries in manufacturing remains higher than that for all private industry. As seen in Figure 4.2, fatalities, injuries, and the injury rate have had an overall downward trend since 2000.

Nonfarm proprietors' income for manufacturing has had a five-year compound annual growth rate of -6.1 %, as illustrated in Figure 4.6. Corporate profits have had a five-year compound annual growth of -9.0 %.

1 Introduction

1.1 Background

Public entities have a significant role in the US innovation process.[1] The federal government has had a substantial impact in developing, supporting, and nurturing numerous innovations and industries, including the Internet, telecommunications, aerospace, semiconductors, computers, pharmaceuticals, and nuclear power among others, many of which may not have come to fruition without public support.[2] Although the Defense Advanced Research Projects Agency (DARPA), Small Business Innovation Research Program (SBIR), and Advanced Technology Program (ATP) have received attention in the scholarly community, there is generally limited awareness of the government's role in US innovation. The vastness and diversity of US federal research and development programs along with their changing nature make them difficult to categorize and evaluate,[3] but their impact is often significant. For instance, the origins of Google are rooted in a public grant through the National Science Foundation.[4, 5] One objective of public innovation is to enhance economic security and improve our quality of life[6], which is achieved in part by advancing efficiency in which resources are consumed or impacted by production. This includes decreasing inputs and negative externalities (e.g., environmental impacts) while increasing output and the function of the product, as seen in Figure 1.1. In pursuit of this goal, the National Institute of Standards and Technology (NIST) has expended resources on a number of projects, such as support for the development of the International Standard for the Exchange of Product Model Data (STEP),[7] which reduces the need for duplicative efforts such as re-entering design data. Another effort to advance efficiency is the development of the Core Manufacturing Simulation Data (CMSD) specification, which enables data exchange for manufacturing simulations.[8]

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[1] Block, Fred L and Matthew R. Keller. State of Innovation: The US Government's Role in Technology Development. New York, NY; Taylor & Francis; 2016.
[2] Wessner CW and Wolff AW. Rising to the Challenge: US Innovation Policy for the Global Economy. National Research Council (US) Committee on Comparative National Innovation Policies: Best Practice for the 21st Century. Washington (DC): National Academies Press (US). 2012. http://www.ncbi.nlm.nih.gov/books/NBK100307/
[3] Block, Fred L and Matthew R. Keller. State of Innovation: The US Government's Role in Technology Development. New York, NY; Taylor & Francis; 2016. 27.
[4] National Science Foundation. (2004). "On the Origins of Google." https://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=100660
[5] Block, Fred L and Matthew R. Keller. State of Innovation: The US Government's Role in Technology Development. New York, NY; Taylor & Francis; 2016: 23.
[6] National Institute of Standards and Technology. (2018). "NIST General Information." http://www.nist.gov/public_affairs/general_information.cfm
[7] Robert D. Niehaus, Inc. (2014). Reassessing the Economic Impacts of the International Standard for the Exchange of Product Model Data (STEP) on the US Transportation Equipment Manufacturing Industry. November 26, 2014. Contract SB1341-12-CN-0084.
[8] Lee, Yung-Tsun Tina, Frank H. Riddick, and Björn Johan Ingemar Hohansson (2011). "Core Manufacturing Simulation Data – A Manufacturing Simulation Integration Standard: Overview and Case Studies." International Journal of Computer Integrated Manufacturing. vol 24 issue 8: 689-709.

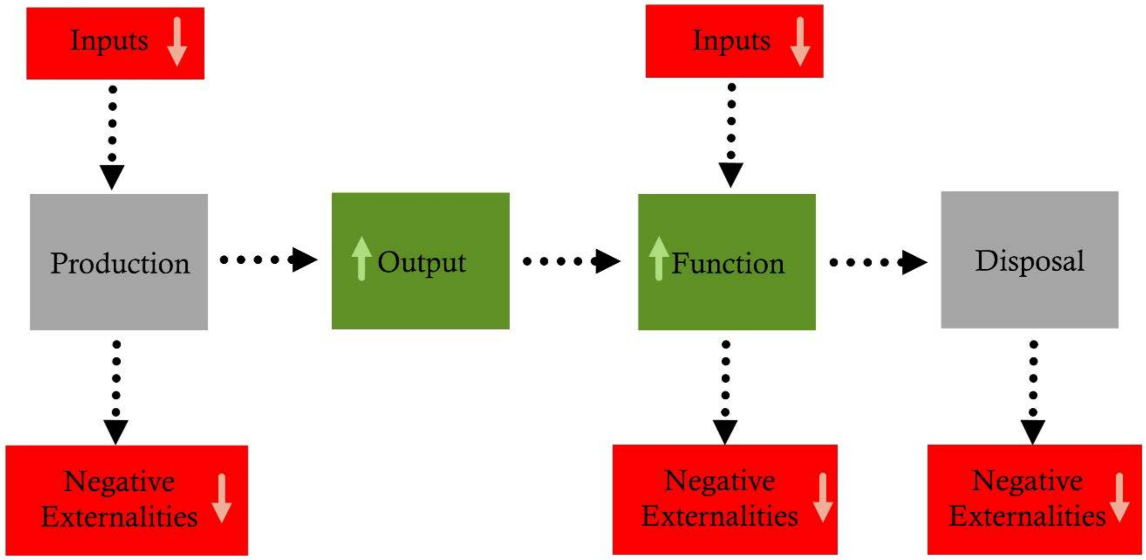


Figure 1.1: Illustration of Objectives – Drive Inputs and Negative Externalities Down while Increasing Production Output and Product Function

1.2 Purpose of this Report

The purpose of this report is to characterize US innovation and industrial competitiveness in manufacturing, as it relates to the objectives illustrated in Figure 1.1. It includes tracking domestic manufacturing activity and its supply chain in order to develop a quantitative depiction of US manufacturing in the context of the domestic economy and global industry. There are five aspects that encapsulate the information discussed in this report:

- **Growth and Size**: The size of the US manufacturing industry and its growth rate as compared to other countries reveals the relative competitiveness of the industry.
    - ***Metrics***: Value added, value added per capita, assets, and compound annual growth

- **Productivity**: It is necessary to use resources efficiently to have a competitive manufacturing industry. Productivity is a major driver of the growth and size of the industry.
    - ***Metrics***: Labor productivity index, multifactor productivity index, output per hour

- **Economic Environment**: A number of factors, including research, policies, and societal trends, can affect the productivity and size of the industry.
    - ***Metrics***: Research and development expenditures as a percent of GDP, journal articles per capita, researchers per capita, competitiveness indices

- **Stakeholder Impact**: Owners, employees, and other stakeholders invest their resources into manufacturing with the purpose of receiving some benefit. The costs and return that they receive can drive industry productivity and growth. However, data is limited on this topic area.
  - ***Metrics***: Number of employees, compensation, safety incidents, profits

- **Areas for Advancement**: It is important to identify areas of investment that have the potential to have a high return, which can facilitate productivity and growth in manufacturing.
  - ***Metrics***: High cost supply chain components

Currently, this annual report discusses items related to inputs for production and outputs from production. It does not discuss negative externalities, the inputs that are used in the function of a product (e.g., gasoline for an automobile), or the function of the product; however, these items might be included in future reports.

Manufacturing metrics can be categorized by stakeholder, scale, and metric type (see Figure 1.2). Stakeholders include the individuals that have an interest in manufacturing. All the metrics in this report relate directly or indirectly to all or a selection of stakeholders. The benefits for some stakeholders are costs for other stakeholders. For instance, the price of a product is a cost to the consumer but represents compensation and profit for the producers. The scale indicates whether the metric is nominal (e.g., the total US manufacturing revenue) or is adjusted to a notionally common scale (e.g., revenue per capita). The metric type distinguishes whether the metric measures manufacturing activities directly (e.g., total employment) or measures those things that affect manufacturing (e.g., research and development). These metrics are then compared over time and/or between industries to provide context to US manufacturing activities.

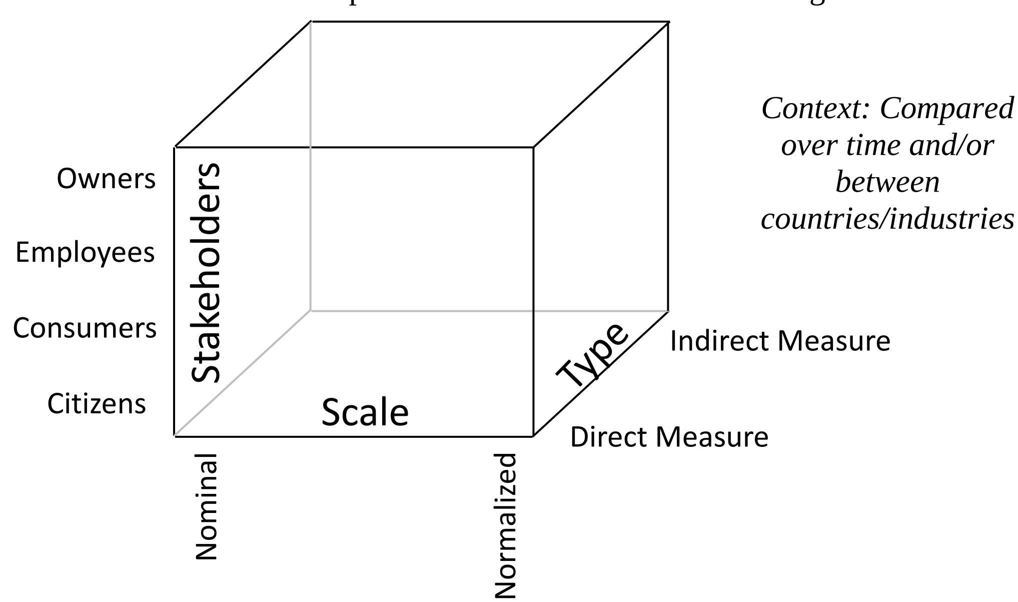


Figure 1.2: Data Categorization for Examining the Economics of Manufacturing

1.3 Scope and Approach

There are numerous aspects one could examine in manufacturing. This report discusses a subset of stakeholders and focuses on US manufacturing. Among the many datasets available, it utilizes those that are prominent and are consistent with economic standards. These criteria are further discussed below.

Stakeholders: This report focuses on the employees and the owners/investors, as the data available facilitates examining these entities. Future work may move toward examining other stakeholders in manufacturing, such as the consumers and general public.

Geographic Scope: Many change agents are concerned with a certain group of people or organizations. Since NIST is concerned with "US innovation and competitiveness," this report focuses on activities within national borders. In a world of globalization, this effort is challenging, as some of the parts and materials being used in US-based manufacturing activities are imported. The imported values are a relatively small percentage of total activity, but they are important in regards to a firm's production. NIST, however, promotes US innovation and industrial competitiveness; therefore, consideration of these imported goods and services are outside of the scope of this report.

Standard Data Categorization: US domestic data tends to be organized using NAICS codes, which are the standard used by federal statistical agencies classifying business establishments in the United States. NAICS was jointly developed by the US Economic Classification Policy Committee, Statistics Canada, and Mexico's Instituto Nacional de Estadística y Geografía, and was adopted in 1997. NAICS has several major categories each with subcategories. Historic data and some organizations continue to use the predecessor of NAICS, which is the Standard Industrial Classification system (SIC). NAICS codes are categorized at varying levels of detail. The broadest level of detail is the two-digit NAICS code, which has 20 categories. More detailed data is reported as the number of digits increase; thus, three-digit NAICS provide more detail than the two-digit and the four-digit provides more detail than the three-digit. The maximum is six digits. Sometimes a two, three, four, or five-digit code is followed by zeros, which do not represent categories. They are null or place holders. For example, the code 336000 represents NAICS 336. International data tends to be in the International Standard Industrial Classification (ISIC) version 3.1, a revised United Nations system for classifying economic data. Manufacturing is broken into 23 major categories (ISIC 15 through 37), with additional subcategorization. This data categorization works similar to NAICS in that additional digits represent additional detail.

Data Sources: Thomas (2012) explores a number of data sources for examining US manufacturing activity.[9] This report selects from sources that are the most prominent and reveal the most information about the US manufacturing industry. These data include the United Nations Statistics Division's National Accounts Main Aggregates Database and the US Census Bureau's Annual Survey of Manufactures, among others. Because the data

[9] Thomas, Douglas S. (2012). The Current State and Recent Trends of the US Manufacturing Industry. NIST Special Publication 1142. http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1142.pdf

sources are scattered across several resources, there are differences in what yearly data is available for a particular category or topic. In each case, the most-up-to-date and available information is provided for the relevant category.

Data Limitations: Like all collections of information, the data on manufacturing has limitations. In general, there are 3 aspects to economic data of this type: 1) breadth of the data, 2) depth of the data, and 3) the timeliness of the data. The breadth of the data refers to the span of items covered, such as the number of countries and years. The depth of the data refers to the number of detailed breakouts, such as value added, expenditures, and industries. In general, breadth and depth are such that when the number of items in each are multiplied together it equals the number of observations in the dataset. For instance, if you have value added data on 5 industries for 20 countries, then you would have 100 observations (i.e., 5 x 20 = 100). The timeliness of the data refers to how recently the data was released. For instance, is the data 1 year old or 5 years old at release. In general, data can perform well in 2 of these 3 criteria, but it is less common to perform well on all 3 due to feasibility of data collection (see Figure 1.3). Moreover, in this report there is data that is very recent (timeliness) and spans numerous subsectors (depth), but it only represents the US. On the other hand, there is data that spans multiple countries (breadth) and subsectors of manufacturing (depth); however, this data is from 5 years ago. Fortunately, industry level trends change slowly; thus, the data may not be from the most recent years, but it is still representative.

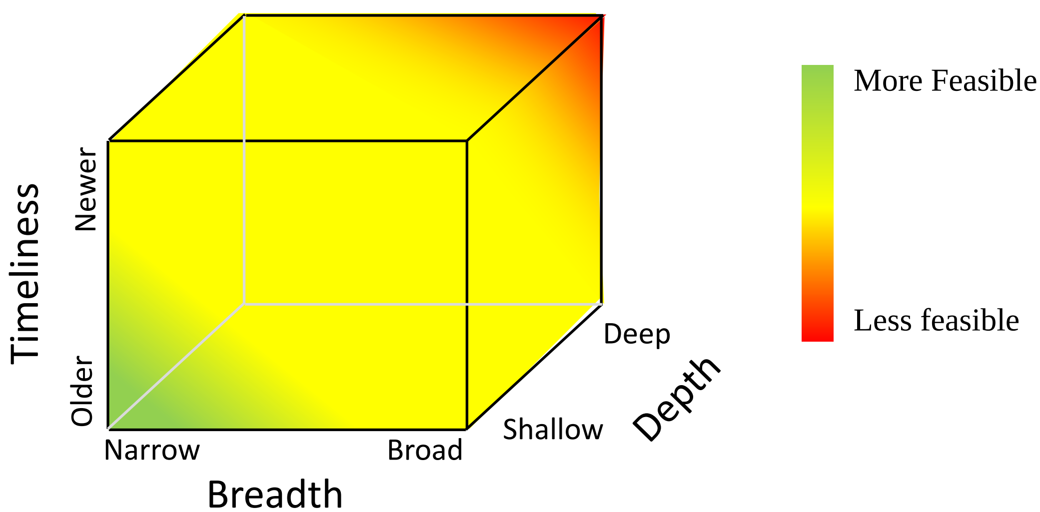


Figure 1.3: Illustration of the Feasibility of Data Collection and Availability

2 Value Added

Value added is the primary metric used to measure economic activity. It is defined as the increase in the value of output at a given stage of production; that is, it is the value of output minus the cost of inputs from other establishments.[10] The primary elements that remain after subtracting inputs is taxes, compensation to employees, and gross operating surplus; thus, the sum of these also equal value added. Gross operating surplus is used to calculate profit, which is gross operating surplus less the depreciation of capital such as buildings and machinery. The sum of all value added for a country is that nation's Gross Domestic Product (GDP).

2.1 International Comparison

There are a number of sources of international estimates of value added for manufacturing. The United Nations Statistics Division National Accounts Main Aggregates Database has a wide-ranging dataset that covers a large number of countries over a significant period of time. In 2017, there was $13.1 trillion of value added (i.e., GDP) in global manufacturing in constant 2010 dollars, which is 17.3 % of the value added by all industries ($75.9 trillion), according to the United Nations Statistics Division.[11] Since 1970, manufacturing ranged between 14.0 % and 17.3 % of global GDP. The top 10 manufacturing countries accounted for $9.1 trillion or 69.8 % of global manufacturing value added: China (24.2 %), United States (14.5 %), Japan (10.0 %), Germany (6.4 %), India (3.4 %), South Korea (3.0 %), Italy (2.5 %), France (2.3 %), Indonesia (1.8 %), and the United Kingdom (1.8 %).[12]

As seen in Figure 2.1, US compound real (i.e., controlling for inflation) annual growth between 1992 and 2017 was 2.5 %, which places the US below the 50th percentile. This growth exceeded that of Germany, France, Canada, Japan, and Australia; however, it is slower than the average (2.9 %) and that of many emerging economies. It is important to note that emerging economies can employ idle or underutilized resources and adopt technologies that are already proven in other nations to achieve high growth rates. Developed countries are already utilizing resources and are employing advanced technologies; thus, comparing US growth to the high growth rates in China or India has limited meaning. As seen in Figure 2.2, the compound annual growth for the US between 2012 and 2017 was 1.2 %. This puts the US just above the 25th percentile below Canada and Germany among others.

As seen in Figure 2.3, among the largest manufacturing nations, US manufacturing value added, as measured in constant 2010 dollars, is the second largest. In current dollars, the US produced $1.9 trillion in manufacturing valued added while China produced $3.2 trillion. Among the ten largest manufacturing countries, the US has the 4th largest

[10] Dornbusch, Rudiger, Stanley Fischer, adn Richard Startz. (2000). Macroeconomics. 8th ed. London, UK: McGraw-Hill.

[11] In current prices, global manufacturing accounts for $11.7 trillion and global value added is $70.6 trillion

[12] United Nations Statistics Division. (2019). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp

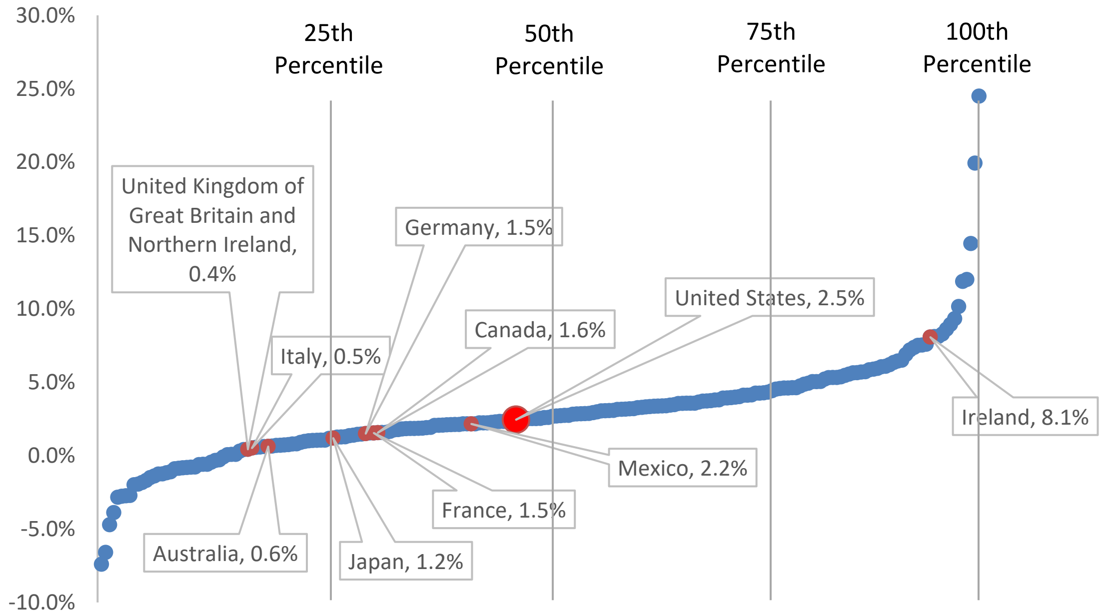


Figure 2.1: National 25-Year Compound Annual Growth, by Country (1992 to 2017): Higher is Better
Data Source: United Nations Statistics Division. (2019). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp

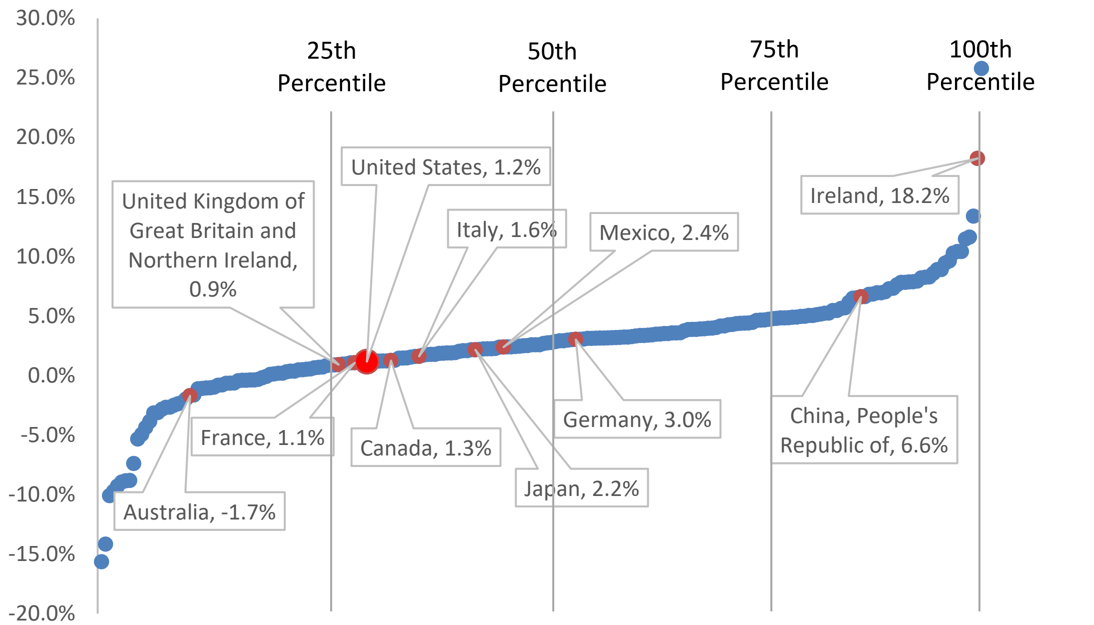


Figure 2.2: National 5-Year Compound Annual Growth, by Country (2012 to 2017): Higher is Better
Data Source: United Nations Statistics Division. (2019). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp

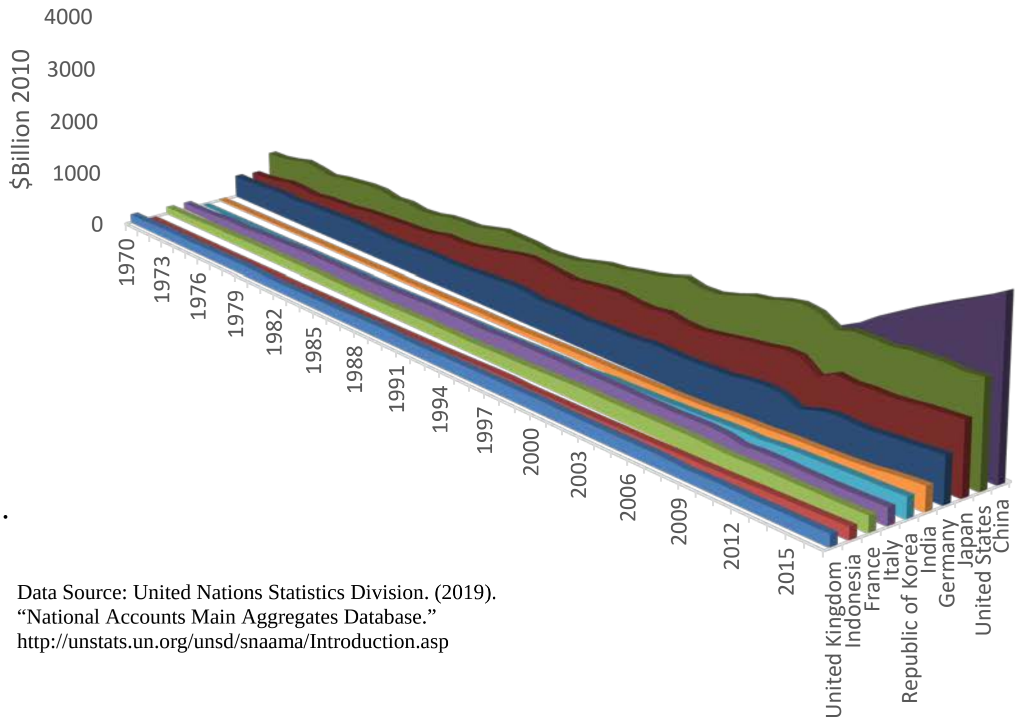


Figure 2.3: Manufacturing Value Added, Top 10 Manufacturing Countries (1970 to 2017)

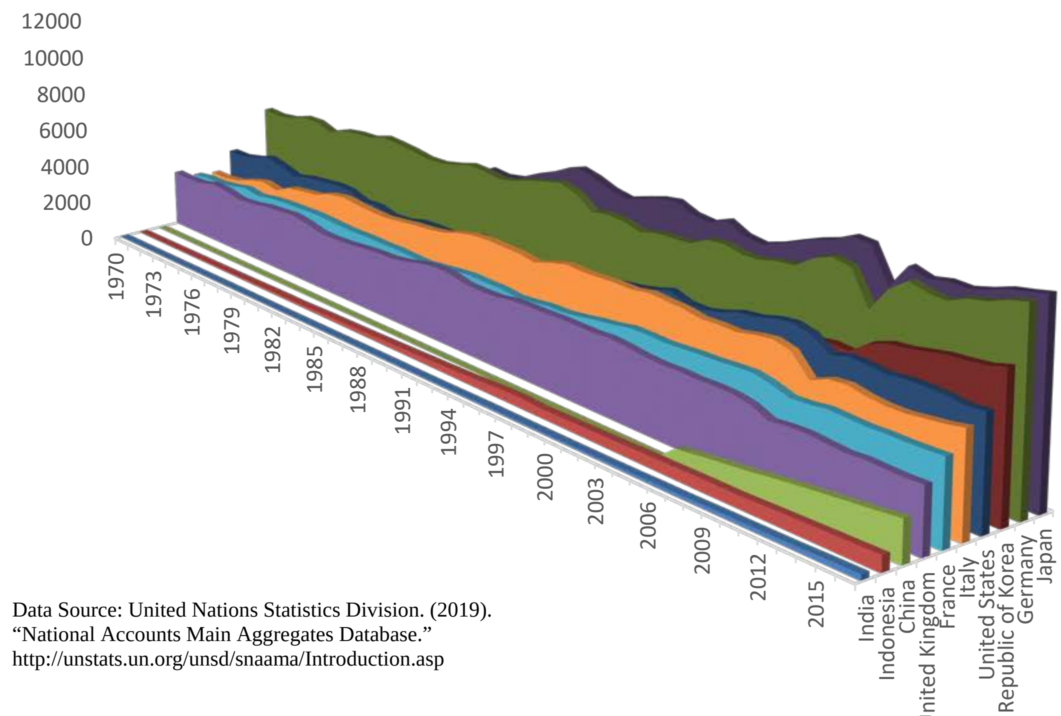


Figure 2.4: Manufacturing Value Added Per Capita, Top 10 Largest Manufacturing Countries (1970 to 2017): Higher is Better

manufacturing value added per capita, as seen in Figure 2.4. Out of all countries the US ranks 19th, as seen in Figure 2.5. This ranking is improved from the 1980's and 1990's where it was ranked as low as the 24th. Since 1970, the US ranking has ranged between 16th and 24th. It is important to note that there are varying means for adjusting data that can change the rankings. The UNSD data uses market exchange rates while others might use purchasing power parity (PPP) exchange rates. PPP is the rate that a currency in one country would have to be converted to purchase the same goods and services in another

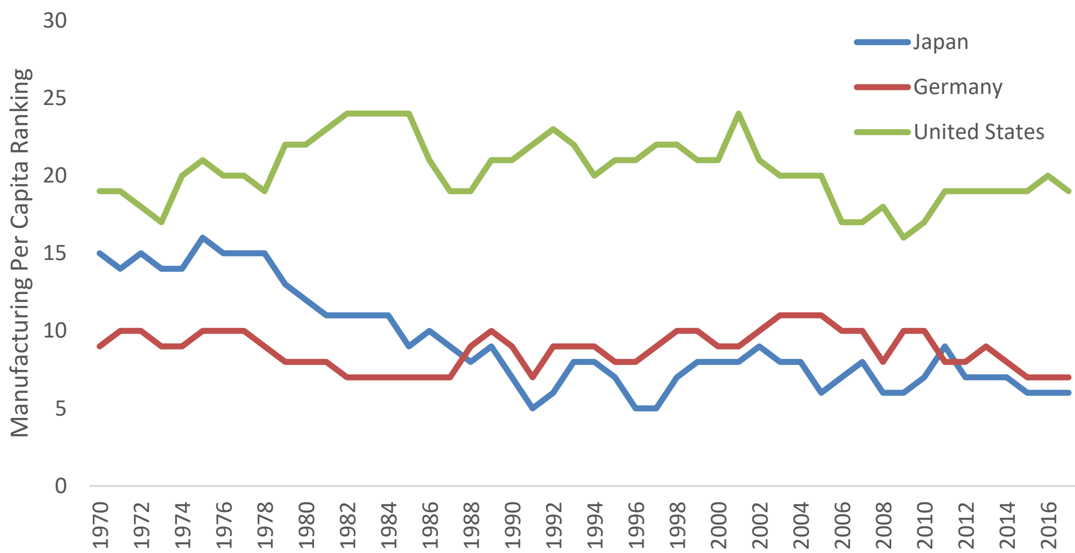


Figure 2.5: Manufacturing Per Capita Ranking, 1970-2017: Lower is Better
Data Source: United Nations Statistics Division. (2019). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp

country. The drawback of PPP is that it is difficult to measure and methodological questions have been raised about some surveys that collect data for these calculations.[13] Market based rates tend to be relevant for internationally traded goods;[14] therefore, this report utilizes these rates.

In terms of subsectors of manufacturing, the US ranks 1st in 7 industries out of 16 total, as seen in Figure 2.6 while China was the largest for the other industries. Since this data covers multiple industries for multiple years (i.e., it has breadth and depth), it is a few years old (i.e., 2015). Nonetheless, it likely provides an accurate representation, as national activity generally moves slowly.

2.2 Domestic Details

Bureau of Economic Analysis – Chained Dollars: There are two primary methods for adjusting value added for inflation. The first is using chained dollars, which uses a

[13] Callen, Tim. March. (2007). PPP Versus the Market: Which Weight Matters? Finance and Development. Vol 44 number 1. http://www.imf.org/external/pubs/ft/fandd/2007/03/basics.htm
[14] Ibid.

changing selection of goods to adjust for inflation. The second uses an unchanging selection of goods to adjust for inflation. [15] Both are discussed in this report, as there has been some dispute about the accuracy of chained dollars for some goods. The BEA estimate for manufacturing value added in 2018 was $2334.6 billion. Using chained dollars from the BEA shows that manufacturing increased by 4.5 % from 2017 to 2018.[16]

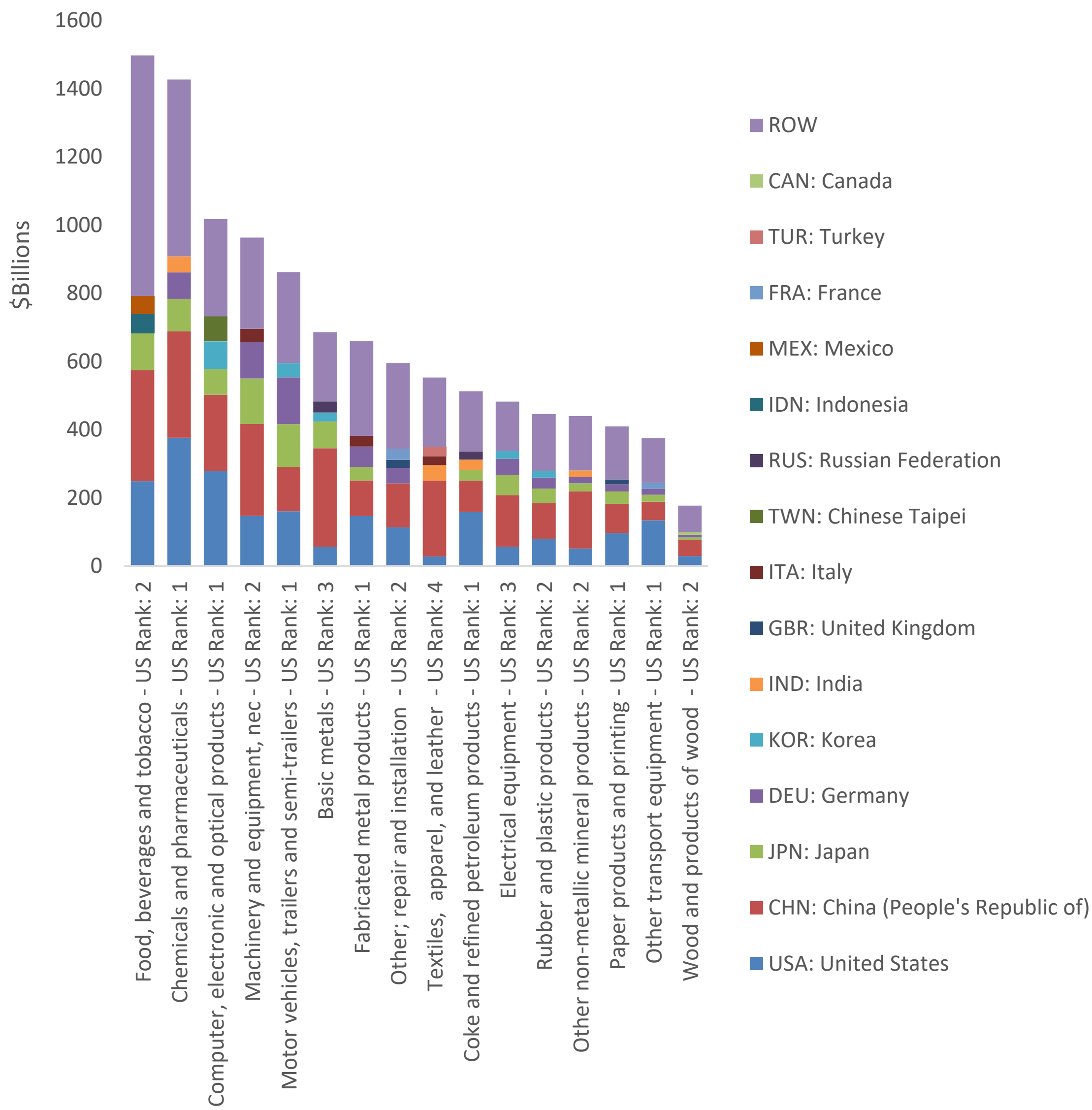


Figure 2.6: Global Manufacturing Value Added by Industry, Top Five Producers and Rest of World (ROW) (2015) – 64 Countries
Source: OECD. STAN Input-Output Tables. https://stats.oecd.org/

[15] Dornbusch, Rudiger, Stanley Fischer, adn Richard Startz. (2000). Macroeconomics. 8th ed. London, UK: McGraw-Hill. 32.
[16] Billions of chained dollars seasonally adjusted at annual rates

As illustrated in Figure 2.7, manufacturing declined significantly in 2008 and has only recently returned to its pre-recession peak level, which occurred in 2007. Manufacturing value added declined more than total US GDP, creating a persistent gap. The result is that first quarter GDP in 2019 is 20.0 % above its pre-recession peak level while manufacturing is at 2.7 % above its peak level. In 2017, manufacturing finally surpassed its pre-recession peak.[17]

Figure 2.8 and Figure 2.9 provide more detailed data on durable and nondurable goods. As seen in Figure 2.8, value added for a number of durable goods is higher in 2018 than it was in 2006, including computer and electronic products and motor vehicles. The growth in durable goods is largely driven by computer and electronic products, which should be viewed with some caution, as there has been some dispute regarding the price adjustments for this sector, which affects the measured growth. Recall that the US is also the largest producer of computer and electronic products. As seen in Figure 2.9, in 2018 only one non-durable sector is above its 2006 value. The largest manufacturing subsector in the US is computer and electronic products followed by chemical manufacturing, and food, beverage, and tobacco products, as seen in Figure 2.10. Note that this is based on chained dollars. Adjustments using other methods or the nominal value can have different results.

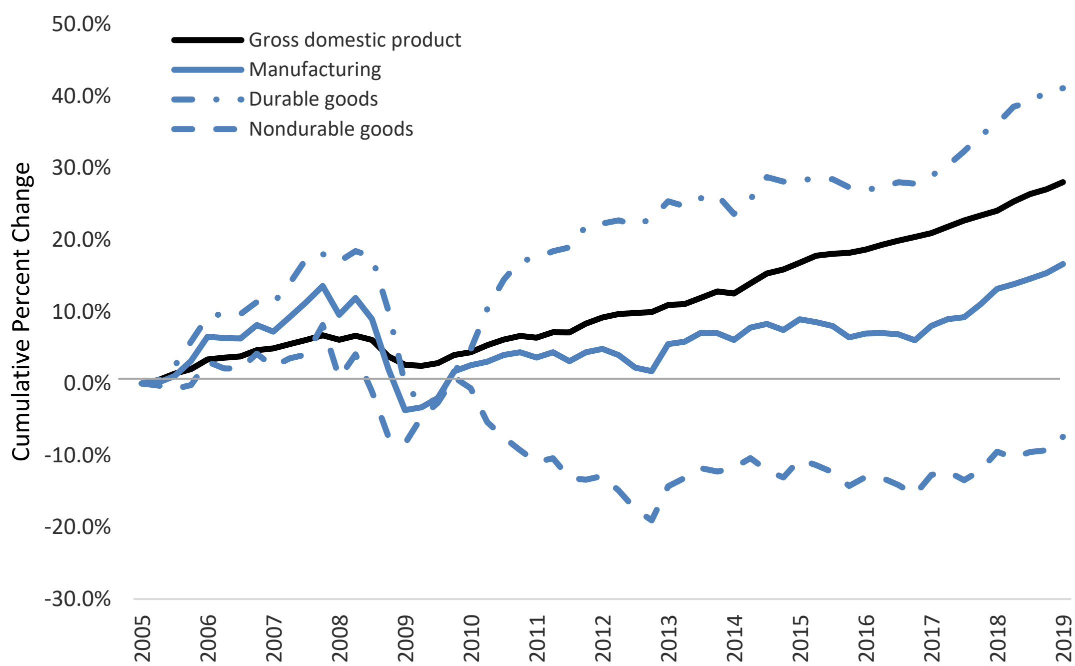
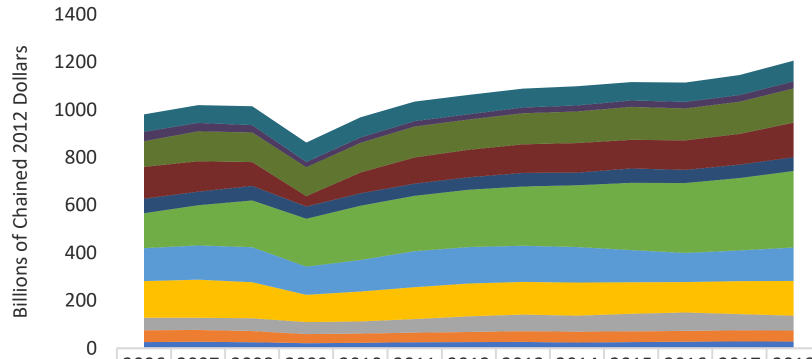


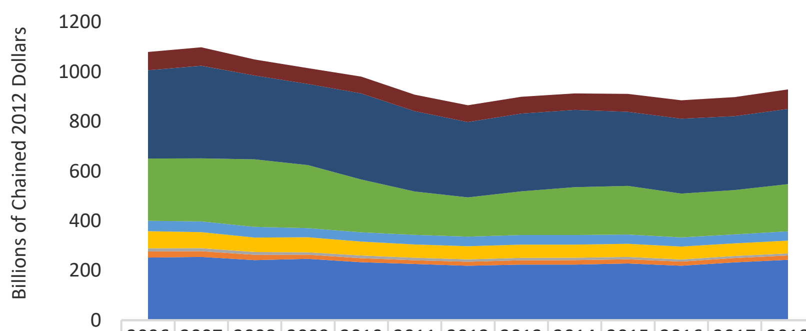
Figure 2.7: Cumulative Percent Change in Value Added (2012 Chained Dollars)
Bureau of Economic Analysis. "Industry Economic Accounts Data." http://www.bea.gov/iTable/index_industry_gdpIndy.cfm

[17] Bureau of Economic Analysis. "Industry Economic Accounts Data." http://www.bea.gov/iTable/index_industry_gdpIndy.cfm



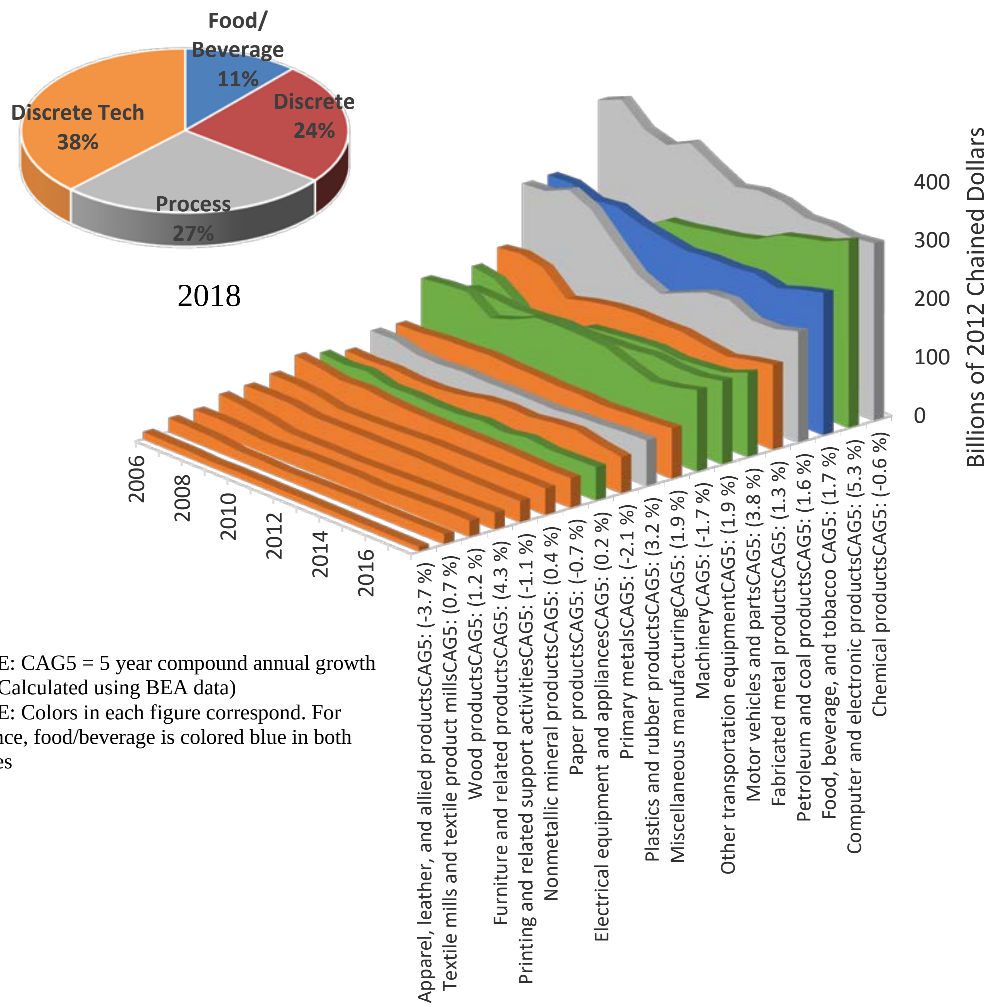
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Miscellaneous manufacturing	73	74.3	79.2	81	84.1	81.8	81.2	79.1	80.1	77.6	80.8	83.3	86.9
Furniture and related products	39.8	36.1	30.9	22.5	22.6	22.9	22.4	23.9	25.3	26.8	27.2	28.5	29.5
Other transportation equipment	106.9	125	124.3	121.2	124.3	129.2	126.5	130.1	132.4	138	133.7	134.5	143.1
Motor vehicles and parts	133.8	127.6	99.5	43.3	87	110.1	115.3	120.3	123.7	120	123.8	128.7	145
Electrical equipment and appliances	60.9	57.1	61.3	51.2	52.7	50.9	52	57.2	53.2	60	55.1	56.5	57.9
Computer and electronic products	146.2	168	195.8	200.6	226.8	232	240.4	247.8	258.7	281.5	292.7	302.7	320.7
Machinery	138.1	143.7	146.5	118.2	132.1	151	152.5	151.7	149.1	134.8	122.2	128.9	139.5
Fabricated metal products	153.4	159.2	151	114.3	125.5	133.4	137.6	136.8	138.4	132.1	127.4	137.9	145.8
Primary metals	52.3	51.3	53.8	50.2	50.9	56.4	65.5	69.5	67.3	73.6	77.4	68.6	62.6
Nonmetallic mineral products	49.7	49.6	46.8	37.9	38.7	40.4	42.6	45.1	45.4	45.4	45.5	46.1	46
Wood products	25.9	27.1	25.3	21.5	22.9	25.4	25.8	26.4	24	25.7	27.2	28.8	28

Figure 2.8: Value Added for Durable Goods by Type (billions of chained dollars), 2006-2018
Data Source: Bureau of Economic Analysis. “Industry Economic Accounts Data.”
http://www.bea.gov/iTable/index_industry_gdpIndy.cfm



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Plastics and rubber products	73.5	74.5	64.6	63.9	67.6	66.2	67.5	67.2	66.6	71.8	73.7	77	78.5
Chemical products	355.4	372.9	337.6	326.7	346.5	323.5	303.4	313	310.9	298.5	301.7	297.5	303
Petroleum and coal products	250.3	253.4	271.8	253.7	212.7	174.7	158	175.8	192.4	195.8	176.4	178.2	190.2
Printing and related support activities	42.3	43.4	42.9	37	37.5	38.5	38.3	39	38.6	37.2	36.9	36.2	36.9
Paper products	68.9	64.7	57.8	60.6	55.8	53.6	53	53.3	53.4	53.3	51.9	50.6	51.5
Apparel, leather, and allied products	12.9	12	11.8	9.6	10.6	10.5	10	10	9.6	9.1	8.7	8.5	8.3
Textile mills and textile product mills	24	23	21.5	16.7	16.6	14.7	15.9	16.9	17.6	16.9	16.6	17.3	17.5
Food, beverage, and tobacco	252.5	254.9	241.6	246.9	233.3	226.4	219.3	224.1	224.1	228.5	219.4	233.1	243.4

Figure 2.9: Value Added for Nondurable Goods by Type (billions of chained dollars), 2006-2018: Higher is Better
Data Source: Bureau of Economic Analysis. “Industry Economic Accounts Data.”
http://www.bea.gov/iTable/index_industry_gdpIndy.cfm



NOTE: CAG5 = 5 year compound annual growth rate (Calculated using BEA data)
NOTE: Colors in each figure correspond. For instance, food/beverage is colored blue in both figures

Figure 2.10: Manufacturing Value Added by Subsector (billions of chained dollars)
Data Source: Bureau of Economic Analysis. "Industry Economic Accounts Data." http://www.bea.gov/iTable/index_industry_gdpIndy.cfm

Bureau of Economic Analysis – Constant Dollars: Some concerns have been raised regarding the use of chained dollars to adjust for inflation[18]; therefore, it is prudent to examine manufacturing value added using the producer price index. Figure 2.11 and Figure 2.12 presents value added for durable and nondurable goods adjusted using the producer price index from the Bureau of Labor Statistics. The general trends are similar to those calculated using chained dollars; however, there are some differences. For instance, chemical products went down when calculated using chained dollars while the other did not decline as much. As seen in Figure 2.13, the five-year compound annual growth in computer and electronic manufacturing is 4.0 % while it is 5.3 % using chained dollars.

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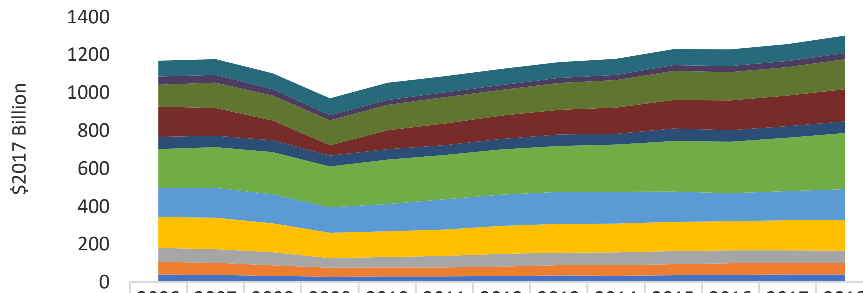
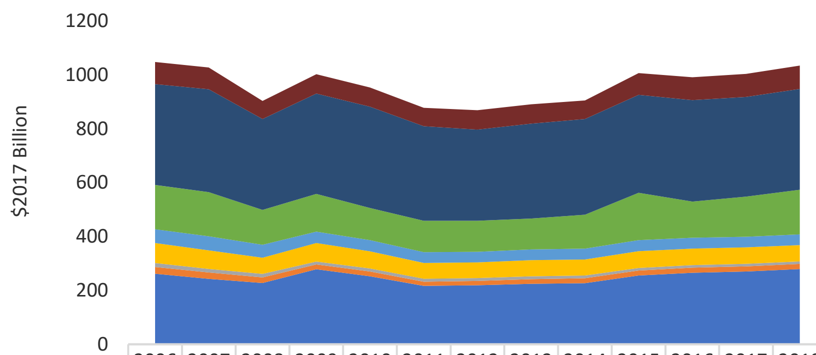
[18] Bureau of Economic Analysis. (1997). BEA's Chain Indexes, Time Series, and Measures of Long-Term Economic Growth. https://www.bea.gov/scb/account_articles/national/0597od/maintext.htm



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Miscellaneous manufacturing	83	83	85	90	91	86	85	84	85	84	88	90	92
Furniture and related products	43	40	33	26	25	25	25	26	27	30	32	32	33
Other transportation equipment	115	134	132	132	135	139	136	141	145	154	149	150	158
Motor vehicles and parts	160	147	104	54	99	114	124	131	139	150	158	161	169
Electrical equip. and appliances	64	59	63	57	56	51	54	60	56	66	61	61	62
Computer and electronic products	206	215	223	216	234	234	239	243	249	266	271	282	296
Machinery	152	157	153	134	144	159	164	168	168	159	148	154	163
Fabricated metal products	163	166	153	134	136	139	148	152	152	155	153	158	162
Primary metals	74	72	69	50	55	61	67	66	67	69	69	66	65
Nonmetallic mineral products	66	64	56	48	48	47	51	54	55	59	61	62	62
Wood products	41	38	33	29	30	30	32	35	34	36	39	41	40

Figure 2.11: Value Added for Durable Goods by Type (constant dollars), 2006-2018
Adjusted using the Producer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. "Industry Economic Accounts Data."
http://www.bea.gov/iTable/index_industry_gdpIndy.cfm



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Plastics and rubber	82	81	67	72	71	69	72	72	69	81	85	85	87
Chemical products	374	382	338	372	376	351	338	352	355	364	377	370	374
Petroleum and coal products	164	164	130	140	119	117	115	114	126	175	134	148	166
Printing and related support activities	51	52	48	42	42	40	40	40	40	41	41	40	40
Paper products	74	69	60	69	64	59	58	60	60	62	61	61	61
Apparel and leather and allied products	15	13	13	11	11	11	11	11	10	10	10	9	9
Textile mills and textile product mills	25	24	21	18	18	15	16	17	18	18	19	19	19
Food and beverage and tobacco	262	243	227	278	252	217	219	224	227	255	265	270	279

Figure 2.12: Value Added for Nondurable Goods by Type (constant dollars, billions), 2006-2018
Adjusted using the Producer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. "Industry Economic Accounts Data."
http://www.bea.gov/iTable/index_industry_gdpIndy.cfm

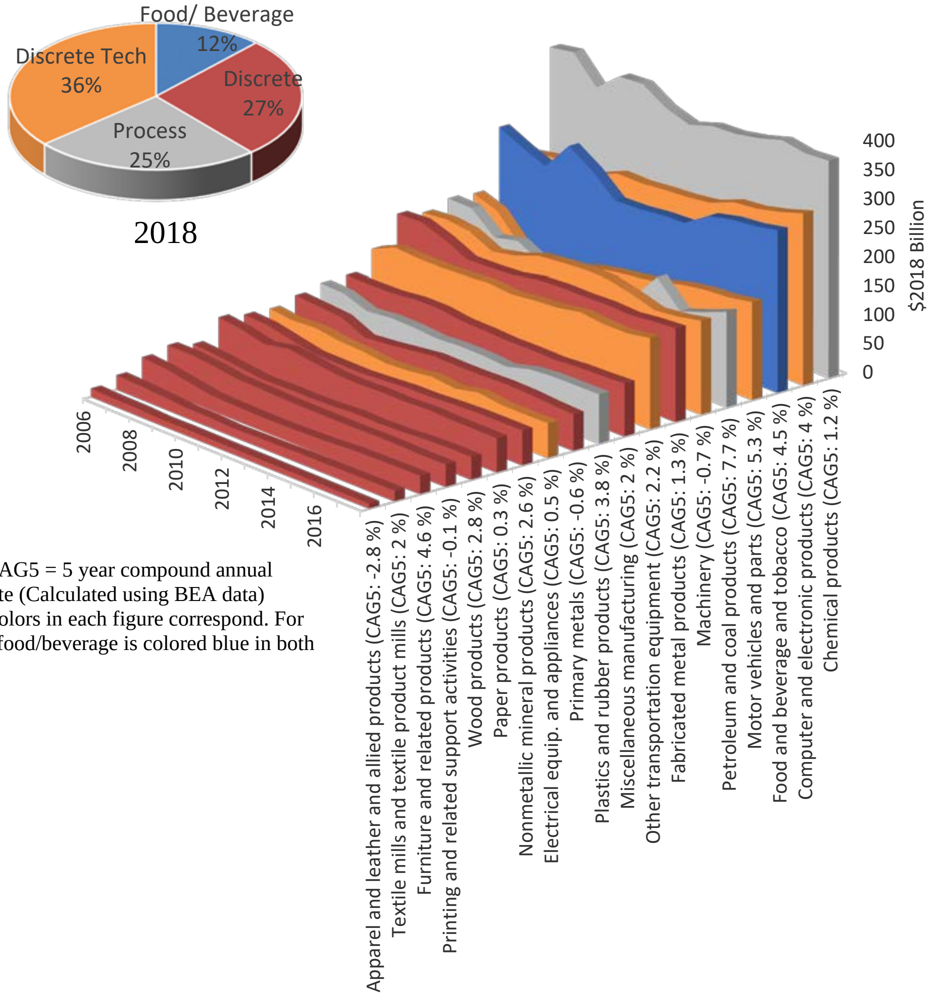
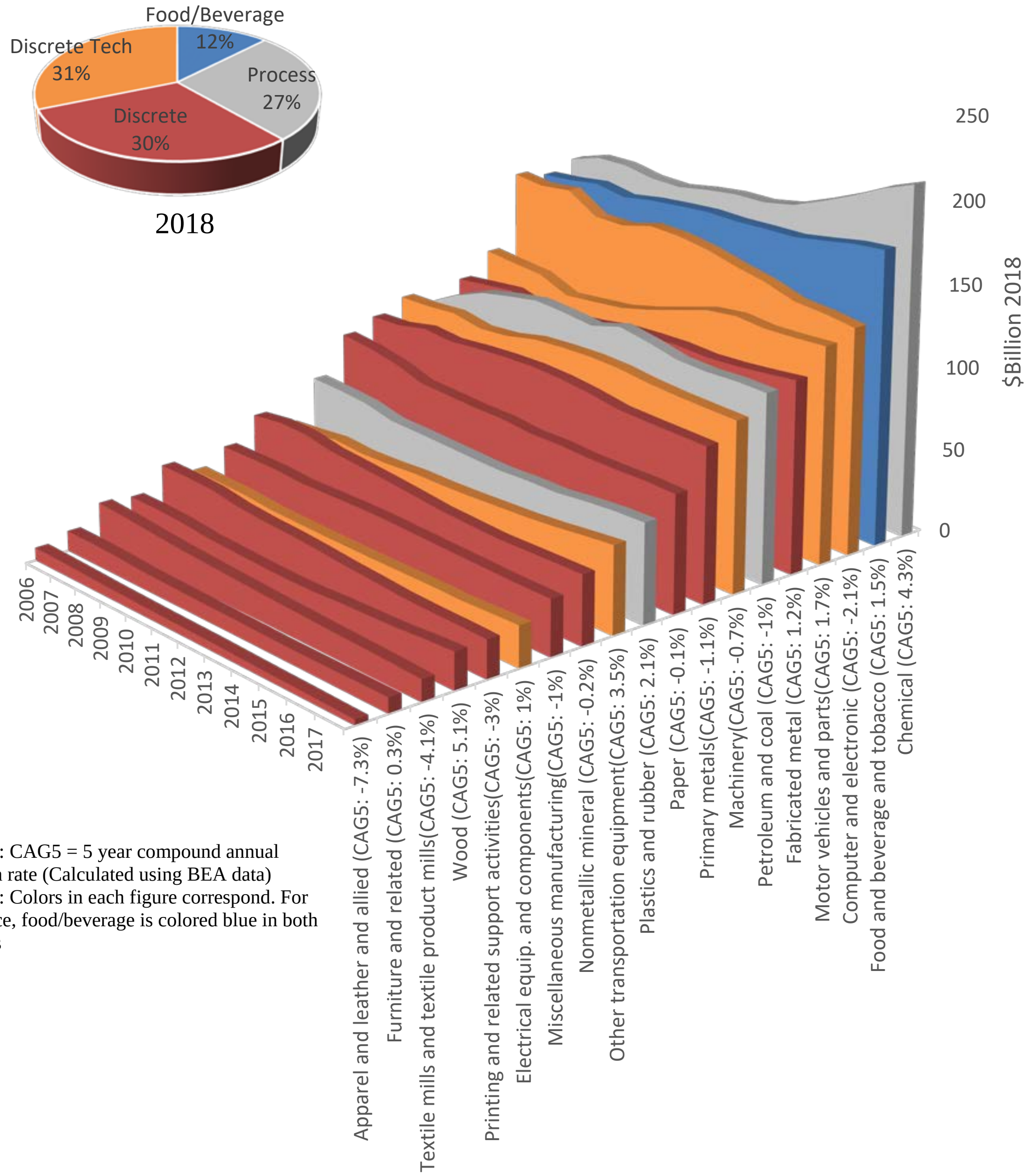


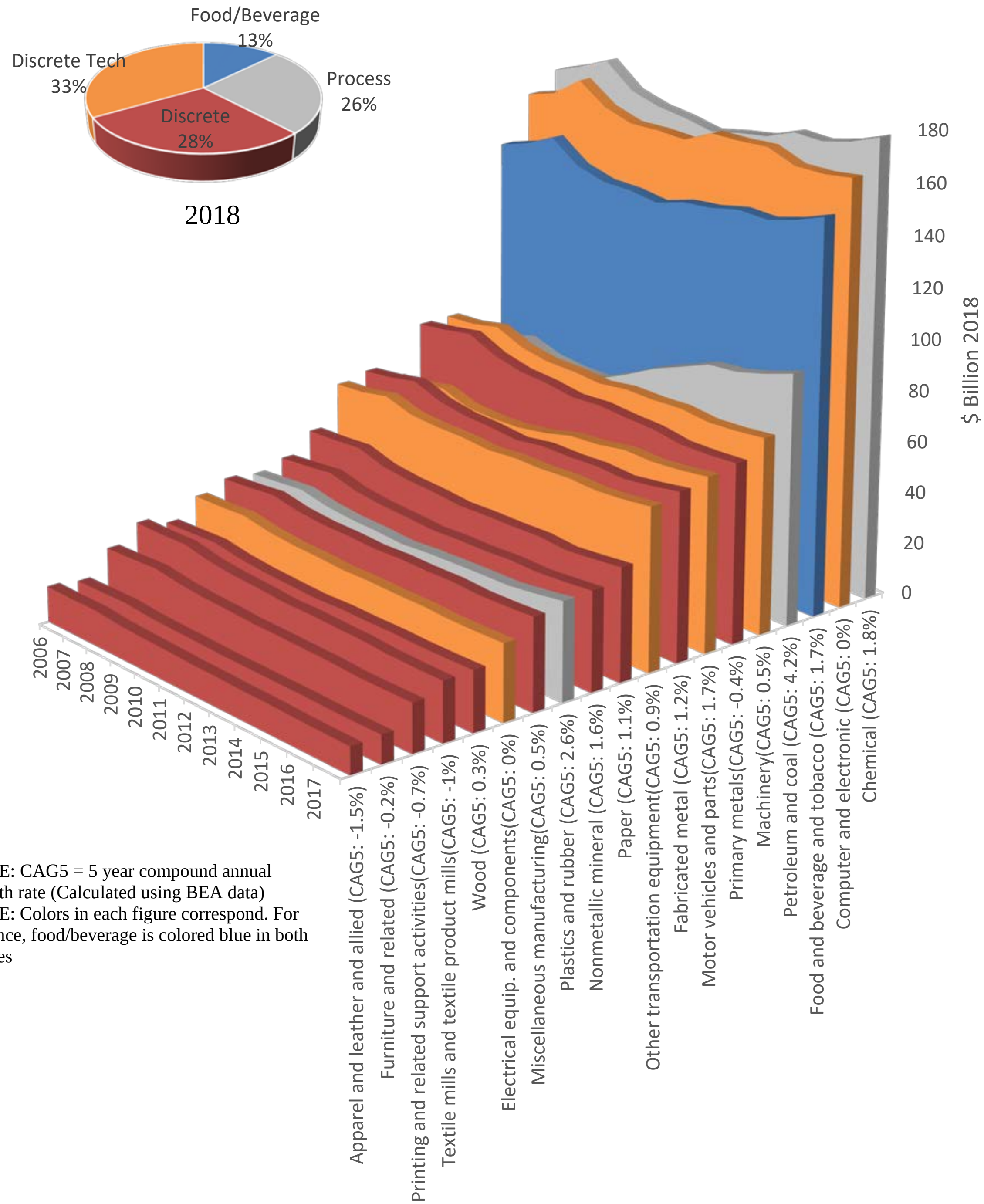
Figure 2.13: Manufacturing Value Added by Subsector, BEA (constant dollars, billions), 2006-2018
Adjusted using the Producer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. "Industry Economic Accounts Data." http://www.bea.gov/iTable/index_industry_gdpIndy.cfm

In addition to examining manufacturing value added, it is useful to examine the capital stock in manufacturing, as it reflects the value of machinery, buildings, and intellectual property in the industry (see Figure 2.14, Figure 2.15, Figure 2.16, and Figure 2.17). Discrete technology manufacturing (i.e., computer manufacturing, transportation equipment manufacturing, machinery manufacturing, and electronics manufacturing) account for 31 % of all manufacturing equipment and 33 % of structures. The 5-year compound annual growth in computer and electronic manufacturing equipment has declined and there has been no growth in structures. Recall that in 2014, the US was the largest producer of these goods and it is the second largest subsector of US manufacturing.



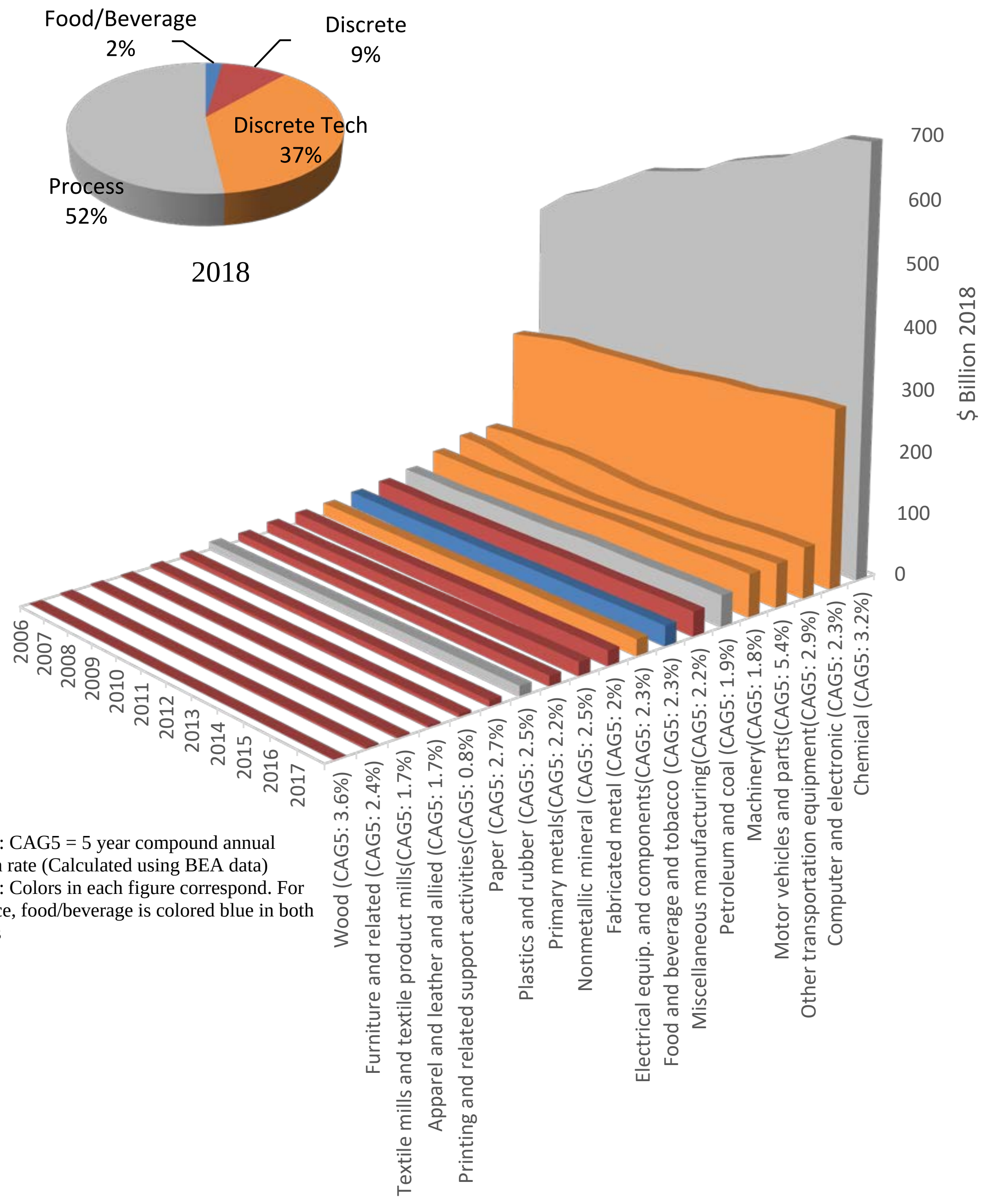
NOTE: CAG5 = 5 year compound annual growth rate (Calculated using BEA data)
NOTE: Colors in each figure correspond. For instance, food/beverage is colored blue in both figures

Figure 2.14: Current-Cost Net Stock: Private Equipment, Manufacturing (2006-2018)
Adjusted using the Consumer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. “Fixed Assets Accounts Tables.” https://apps.bea.gov/iTable/iTable.cfm?ReqID=10&step=2



NOTE: CAG5 = 5 year compound annual growth rate (Calculated using BEA data)
NOTE: Colors in each figure correspond. For instance, food/beverage is colored blue in both figures

Figure 2.15: Current-Cost Net Stock: Private Structures, Manufacturing (2006-2018)
Adjusted using the Consumer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. "Fixed Assets Accounts Tables."
https://apps.bea.gov/iTable/iTable.cfm?ReqID=10&step=2



NOTE: CAG5 = 5 year compound annual growth rate (Calculated using BEA data)
NOTE: Colors in each figure correspond. For instance, food/beverage is colored blue in both figures

Figure 2.16: Current-Cost Net Stock: Intellectual Property Products, Manufacturing (2006-2018)
Adjusted using the Consumer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. “Fixed Assets Accounts Tables.” https://apps.bea.gov/iTable/iTable.cfm?ReqID=10&step=2

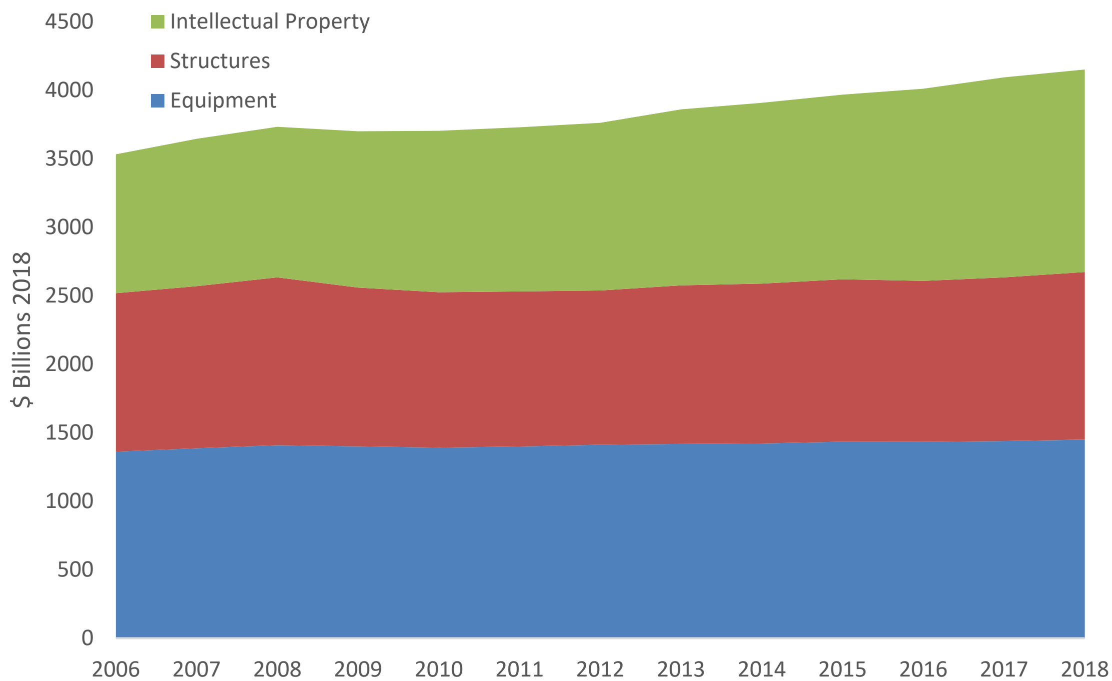


Figure 2.17: Current-Cost Net Stock, by Type (2006-2018)
Adjusted using the Consumer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. "Fixed Assets Accounts Tables."
https://apps.bea.gov/iTable/iTable.cfm?ReqID=10&step=2

3 US Manufacturing Supply Chain

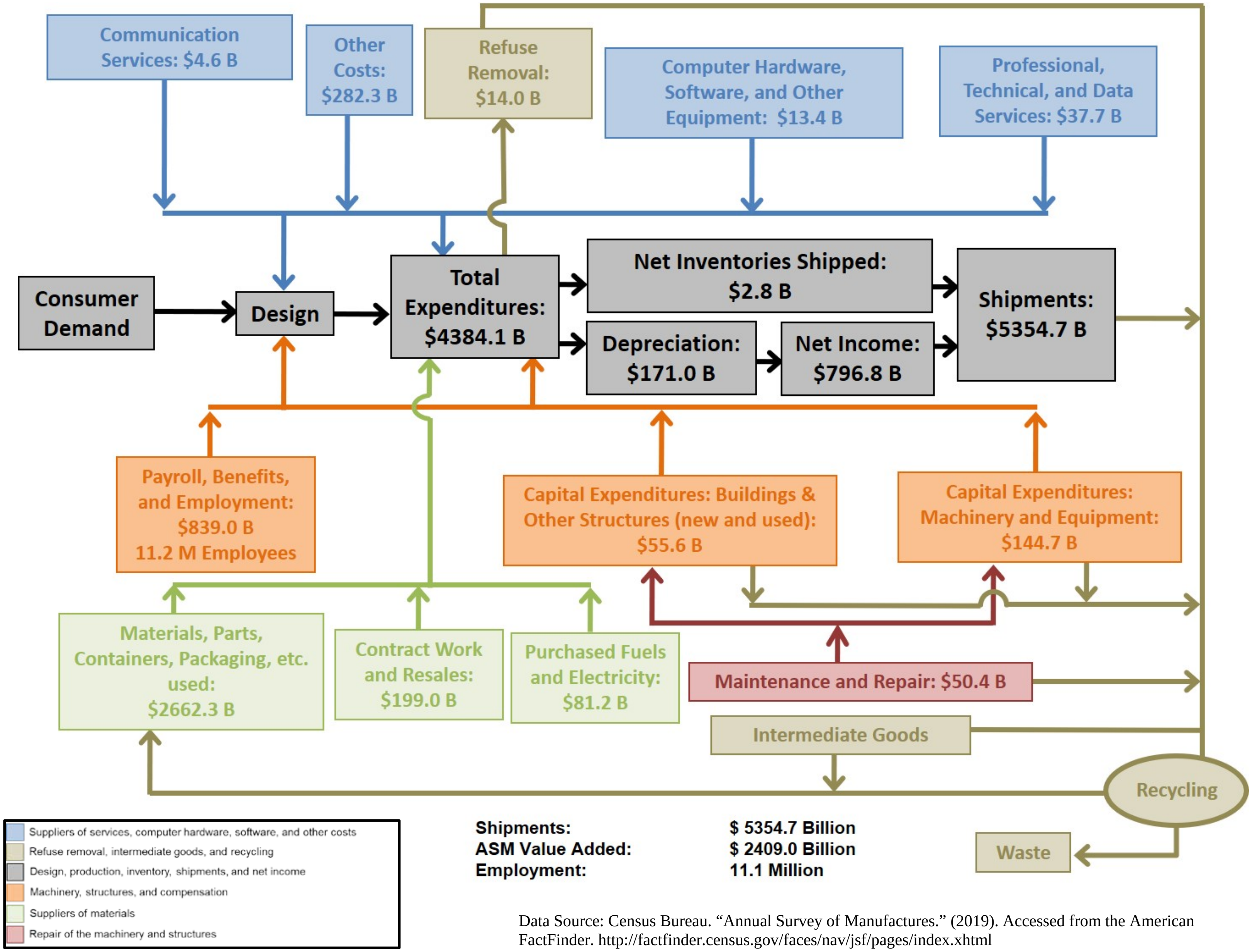
There are many suppliers of goods and services that have a stake in manufacturing; these include resellers, providers of transportation and warehousing, raw material suppliers, suppliers of intermediate goods, and suppliers of professional services. Using data from the Annual Survey of Manufactures,[19] Table 3.1 presents and Figure 3.1 maps the purchases that the manufacturing industry made for production, which is disaggregated into five categories: suppliers of services, computer hardware, software, and other costs (blue); refuse removal (gold); machinery, structures, and compensation (orange); repair of the machinery and structures (red); and suppliers of materials (green). These items all feed into the design and production of manufactured goods which are inventoried and/or shipped (gray). The depreciation of capital and net income is also included in Figure 3.1, which affects the market value of shipments. In addition to the stakeholders, there are also public vested interests, the end users, and financial service providers to be considered.

Table 3.1: Supply Chain Entities and Contributions, Annual Survey of Manufactures

	2015 ($Billions 2015)	**2016 ($Billions 2016)**	**Percent Change**
I. Services, Computer Hardware, Software, and Other Expenditures			
a. Communication Services	4.61	4.55	-1.2%
b. Computer Hardware, Software, and Other Equipment	12.74	13.40	5.2%
c. Professional, Technical, and Data Services	37.79	37.70	-0.2%
d. Other Expenditures	285.14	282.31	-1.0%
e. TOTAL	**340.27**	**337.96**	**-0.7%**
II. Refuse Removal Expenditures	**14.09**	**13.98**	**-0.8%**
III. Machinery, Structures, and Compensation Expenditures			
a. Payroll, Benefits, and Employment	829.74	839.03	1.1%
b. Capital Expenditures: Structures (including rental)	59.94	55.55	-7.3%
c. Capital Expenditures: Machinery/Equipment (including rental)	149.01	144.65	-2.9%
d. TOTAL	**1038.69**	**1039.23**	**0.1%**
IV. Suppliers of Materials Expenditures			
a. Materials, Parts, Containers, Packaging, etc… Used	2,815.14	2,662.33	-5.4%
b. Contract Work and Resales	213.12	199.01	-6.6%
c. Purchased Fuels and Electricity	85.97	81.22	-5.5%
d. TOTAL	**3,114.22**	**2,942.56**	**-5.5%**
V. Maintenance and Repair Expenditures	**49.51**	**50.42**	**1.8%**
VI. Shipments			
a. Expenditures	4,556.78	4,384.14	-3.8%
b. Net Inventories Shipped	-0.41	2.82	782.0%
c. Depreciation	176.23	170.98	-3.0%
d. Net Income	786.43	796.76	1.3%
E. TOTAL	**5,519.02**	**5,354.69**	**-3.0%**

Note: Colors correspond with those in Figure 3.1

[19] Census Bureau. (2019) "Annual Survey of Manufactures." Accessed from the American FactFinder. http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml



Data Source: Census Bureau. "Annual Survey of Manufactures." (2019). Accessed from the American FactFinder. http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

Figure 3.1: Manufacturing Supply Chain, 2016

Direct and Indirect Manufacturing: As previously mentioned, to achieve economy-wide efficiency improvements, researchers have suggested that "the supply chain must become the focus of policy management, in contrast to the traditional emphasis on single technologies/industries." [20] As seen in Table 3.2, there is an estimated $2037 billion in manufacturing value added with an additional $1861 billion in indirect value added from other industries for manufacturing, as calculated using input-output analysis.[21]

In 2017, the US imported approximately 19.7 % of its intermediate goods, as seen in Table 3.3. As a proportion of output and imports (i.e., a proportion of the total inputs), intermediate imports represented 11.0 %. As can be seen in Table 3.3, these proportions

Table 3.2: Direct and Indirect Manufacturing Value Added ($millions 2012)

		Value Added ($ million 2012)	
NAICS	Description	Direct	Indirect
31-33	Total Manufacturing*	2 036 737	1 861 213
333-336	Discrete Technology Products	838 297	397 201
313-323, 327-332, 337-339	Discrete Products	574 447	400 455
324-326	Process Products	612 026	856 387
311-312	Food, Beverage, and Tabaco	331 891	459 622

* The sum of the 3 digit NAICS does not equal total manufacturing due to overlap in supply chains.
Note: Calculated using the NIST Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide.

Table 3.3: Imported Intermediate Manufacturing ($millions)

Year	Intermediate Manufacturing	Intermediate Imports for Manufacturing	Total Manufacturing Output	Intermediate Imports as a Percent of Intermediates	Intermediate imports as a Percent of Total Industry Output
2006	3 299 672	695 846	5 093 516	21.1%	12.0%
2007	3 559 286	728 349	5 404 029	20.5%	11.9%
2008	3 692 895	839 531	5 493 740	22.7%	13.3%
2009	2 808 930	536 158	4 511 064	19.1%	10.6%
2010	3 222 093	672 003	5 019 103	20.9%	11.8%
2011	3 725 305	845 454	5 592 871	22.7%	13.1%
2012	3 844 239	840 279	5 771 297	21.9%	12.7%
2013	3 947 424	819 413	5 939 327	20.8%	12.1%
2014	3 992 230	833 091	6 039 580	20.9%	12.1%
2015	3 591 636	699 886	5 714 657	19.5%	10.9%
2016	3 487 847	666 596	5 573 015	19.1%	10.7%
2017	3 709 837	729 377	5 889 469	19.7%	11.0%

Source Data: Bureau of Economic Analysis. (2019). Input-Output Accounts Data. https://www.bea.gov/industry/input-output-accounts-data

[20] Tassey Gregory. (2010) "Rationales and Mechanisms for Revitalizing US Manufacturing R&D Strategies." *Journal of Technology Transfer*. 35. 283-333.
[21] This analysis uses the Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide

have not changed dramatically in recent years. As seen in Table 3.4, Canada is the primary source of imported supply chain items for the US with China being second.

Many of the direct costs are caused by losses due to waste or defects. Unfortunately, there is limited data and information on these losses. The research that does exist is often case studies within various industries and countries, which provide only limited insight to US national trends. Tabikh estimates from survey data in Sweden that the percent of planned production time that is downtime amounts to 13.3 %.[22] In addition to downtime, defects result in additional losses. It is not clear what the defect rate is in manufacturing; however, the USGS estimates that 15 % of steel mill products end up as scrap in the manufacturing process.[23] Other sources cite that at least 25 % of liquid steel and 40 % of liquid aluminum does not make it into a finished product due primarily to metal quality (25 % of steel loss and 40 % of aluminum loss), the shape produced[24] (10 % to 15 % of loss), and defects in the manufacturing processes (5 % of loss).[25] Material losses mean there is the possibility of producing the same goods using less material, which could have rippling effects up and down the supply chain. There would be reductions in the burden of transportation, material handling, machinery, inventory costs, and energy use along with many other activities associated with handling and altering materials.

Table 3.4: Percent of US Manufacturing Industry Supply Chain, by Country of Origin (2014)

Country	US Manufacturing Supply Chain (percent)
USA	83.0
CAN	3.1
CHN	1.8
MEX	1.5
DEU	0.8
JPN	0.8
GBR	0.5
KOR	0.5
RUS	0.4
ROW	7.6

Note: Calculated using NIST. Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide.

[22] Tabikh, Mohamad. (2014). "Downtime Cost and Reduction Analysis: Survey Results." Master Thesis. KPP321. M?lardalen University. http://www.diva-portal.org/smash/get/diva2:757534/FULLTEXT01.pdf
[23] Fenton, M. D. (2001) "Iron and Steel Recycling in the United States in 1998." Report 01-224. US Geological Survey: 3. https://pubs.usgs.gov/of/2001/of01-224/
[24] The steel and aluminum industry often produce standard shapes rather than customized shapes tailored to specific products. This results in needing to cut away some portion of material, which ends up as scrap.
[25] Allwood, J. M. & Cullen, J. M. (2012). Sustainable Materials with Both Eyes Open. Cambridge Ltd. 185. http://www.withbotheyesopen.com/

Manufacturing costs also accumulate in assets such as buildings, machinery, and inventory. In addition to the estimates provided in Figure 2.14, Figure 2.15, Figure 2.16, and Figure 2.17, data on assets is published periodically in the Economic Census. Thomas and Kandaswamy (2015) use this data to break the estimate into buildings and machinery, as seen in Table 3.5.[26] Total depreciable assets amount to $2.8 trillion with $2.3 trillion being machinery and equipment. As mentioned previously, an estimated 13.3 % of planned production time is downtime; thus, 13.3 % or $377 billion of the capital sits idle.

Table 3.5: Depreciable Assets and the Rate of Change, 2012 ($million 2012)

	Buildings	Machinery and Equipment	Total
Gross value of depreciable assets (acquisition costs), end of year	545 316	2 290 718	2 836 034
Retirements	9224	39 466	48 690
Capital Expenditures	30 859	132 031	162 890
Capital Expenditures less Retirements	21 635	92 565	114 200
Percent of Depreciable Assets that are Replaced	1.69%	1.72%	1.72%
Percent of Depreciable Assets that are New	3.97%	4.04%	4.03%
Percent of Depreciable Assets that are New or Replaced	5.66%	5.76%	5.74%

Source: Thomas, Douglas S. and Anand Kandawsamy. (2017) “Identifying high resource consumption areas of assembly-centric manufacturing in the United States.” Journal of Technology Transfer. https://link.springer.com/article/10.1007%2Fs10961-017-9577-9

A frequently invoked axiom suggests that roughly 80 % of the problem is due to 20 % of the cause, a phenomenon referred to as the Pareto principle. [27] That is, a small portion of the cause accounts for a large portion of the problem. Identifying that small portion can facilitate making large efficiency improvements in manufacturing. Industries are categories of production activities. A larger industry suggests that there is more of a particular type of activity occurring; thus, an increase in productivity has a larger impact for a large cost area than a small cost area. Additionally, statistical evidence suggests that a dollar of research and development in a large cost supply chain entity has a higher return on investment than a small cost one.[28] Table 3.6 provides a list of the top 20 % of domestic supply chain industries for US manufacturing by value added. Supply chain items were also identified for discrete technology products; discrete products; process products; and food, Beverage, and Tabaco. If a supply chain industry appears in the top 5 %, 10 %, or 20 % of all supply chain industries, it is indicated with 1, 2, or 3 asterisks. Various forms of energy production and/or transmission appear in the top 20 %. Various forms of transportation are also present along with the management of companies and enterprises. Table 3.7 provides compensation by occupation and management occupations is the 2nd largest.

[26] Thomas, Douglas S. and Anand Kandaswamy. (2017) “Identifying high resource consumption areas of assembly-centric manufacturing in the United States.” Journal of Technology Transfer. https://link.springer.com/article/10.1007%2Fs10961-017-9577-9
[27] Hopp, Wallace J. and Mark L. Spearman. (2008). Factory Physics. Third Edition. (Waveland Press, Long Grove, IL.
[28] Thomas, Douglas. (2018). "The Effect of Flow Time on Productivity and Production." National Institute of Standards and Technology. Advanced Manufacturing Series 100-25. https://nvlpubs.nist.gov/nistpubs/ams/NIST.AMS.100-25.pdf

Figure 3.2 shows a selection of cost items as a percent of revenue using data from the Annual Survey of Manufactures. It is important to note that the previously discussed tables that use input-output analysis present data in terms of value added while Figure 3.2 is utilizing shipments (i.e., also known as output or revenue). Additionally, the costs are broken-up differently. The input-output analysis breaks costs into industries. For example, the value added for the coal used to produce electricity consumed by manufacturing is found in the mining industry. The data from the Annual Survey of Manufactures in Figure 3.2 lumps all the costs for electricity together. In 2016, payroll, purchased fuels, and electricity were equal to 12.0 %, 0.6 %, and 1.0 % of revenue, respectively. Materials, parts, containers, and packaging were 49.7 %, attesting to the fact that a large portion of costs are in the supply chain. Note that these items also use labor, energy, and other resources; thus, this data does not strictly separate the costs of producing a product. Machinery and buildings were equivalent to 2.8 % and 1.0 % of revenue, respectively.

Table 3.6: Top 20 % of Domestic Supply Chain Entities, Value Added ($millions 2012)

NAICS Code	Industry Description	Val. Add.	NAICS Code	Industry Description	Val. Add.
211000***	Oil and gas extraction	429 685	325414	Biological product (except diagnostic)	20 779
324110**	Petroleum refineries	159 423	325211	Plastics material and resin	20 518
550000***	Management of companies and enterprises	113 188	31161A	Animal (except poultry) slaughtering and processing	20 257
325412	Pharmaceutical preparation	69 615	21311A	Other support activities for mining	20 248
424A00***	Other nondurable goods merchant wholesalers	68 994	1111A0	Oilseed farming	20 245
423A00**	Other durable goods merchant wholesalers	60 950	325310	Fertilizer	19 840
221100***	Electricity generation/transmission/distribution	53 666	336413	Other aircraft parts and auxiliary equipment	19 450
336411	Aircraft	51 645	325180	Other Basic Inorganic Chemical	19 090
484000**	Truck transportation	49 213	561700*	Services to buildings and dwellings	18 786
531ORE***	Other real estate	48 963	311810	Bread and bakery product	18 293
312200	Tobacco product	42 308	423600	Household appliances/electrical/electronic goods	18 040
325110	Petrochemical	41 837	5241XX	Insurance carriers, except direct life	18 033
334413*	Semiconductor and related device	41 112	339113	Surgical appliance and supplies	17 665
334511	Search, detection, and navigation instruments	36 896	230301	Nonresidential maintenance and repair	17 632
325190	Other basic organic chemical	36 003	524200*	Insurance agencies, brokerages, and related activities	17 382
52A000**	Monetary auth. and depos. credit intermediation	34 797	322120	Paper mills	16 154
323110	Printing	33 966	423100	Motor vehicle and motor vehicle parts and supplies	15 823
424700	Petroleum and petroleum products	33 748	541610*	Management consulting services	15 789
336112	Light truck and utility vehicle	33 236	5419A0	Misc. professional, scientific, and technical services	15 536
331110	Iron and steel mills and ferroalloy	31 568	33291A	Valve and fittings other than plumbing	15 469
326190	Other plastics product	30 542	3259A0	All other chemical product and preparation	15 410
423800*	Machinery, equipment, and supplies	29 508	336111	Automobile	15 216
1121A0	Beef cattle ranching and farming…	29 260	115000	Support activities for agriculture and forestry	14 988
336412	Aircraft engine and engine parts	29 063	325620	Toilet preparation	14 789
561300**	Employment services	27 962	332310	Plate work and fabricated structural product	14 655
541300*	Architectural, engineering, and related services	25 670	332320	Ornamental and architectural metal products	14 506
541100*	Legal services	25 530	332800	Coating, engraving, heat treating and allied activities	14 295
424400	Grocery and related product wholesalers	25 272	336390	Other Motor Vehicle Parts	14 259
1111B0	Grain farming	24 733	541800*	Advertising, public relations, and related services	14 228
112A00	Animal production (excl. cattle, poultry, eggs)	23 196	322210	Paperboard container	14 112
332710	Machine shops	23 159	33441A	Other electronic component	13 882
334220	Broadcast and wireless comm. equipment	22 838	221200	Natural gas distribution	13 807
533000	Lessors of nonfinancial intangible assets	22 753	425000	Wholesale electronic markets and agents and brokers	13 725
325610	Soap and cleaning compound	22 542	541512*	Computer systems design services	13 719
522A00*	Nondepository credit intermediation activities	22 110	532400	Commercial/industrial machinery/equipment rental	13 455
482000**	Rail transportation	21 953	332720	Turned product and screw, nut, and bolt	13 446
339112	Surgical and medical instrument	21 792	333120	Construction machinery	13 388
334510	Electromedical and electrotherapeutic apparatus	21 733	333415	Air conditioning, refrigeration, and heating equipment	13 387
486000	Pipeline transportation	21 528	311615	Poultry processing	13 354
541200*	Accounting, tax prep, and payroll services	21 378	48A000	Scenic/sightseeing transport and support for transport.	13 290
			333130	Mining and oil and gas field machinery	13 189

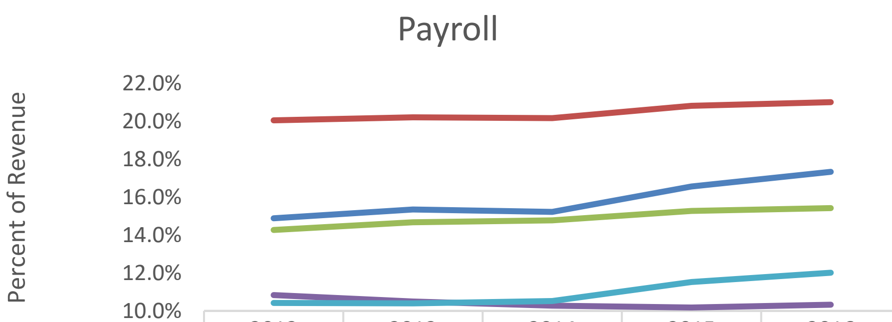
*** Appears in top 20 % of all 4 subcategories in Table 3.2
** Appears in top 10 % of all 4 subcategories in Table 3.2
* Appears in top 5 % of all 4 subcategories in Table 3.2

Note: Calculated using the NIST Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide.

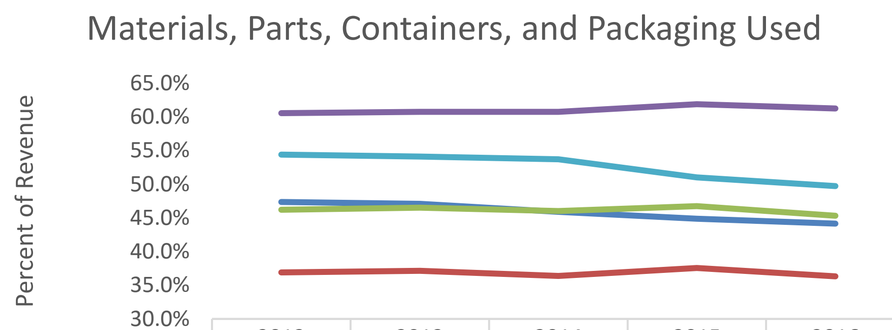
Table 3.7: Total Domestic Compensation for Manufacturing and its Supply Chain, by Occupation

SOC Code	Description	Compensation ($billion 2012)
510000	Production Occupations	389.1
110000	Management Occupations	249.0
430000	Office and Administrative Support Occupations	162.3
530000	Transportation and Material Moving Occupations	130.1
130000	Business and Financial Operations Occupations	129.5
170000	Architecture and Engineering Occupations	127.4
410000	Sales and Related Occupations	105.8
150000	Computer and Information Analysts	93.1
490000	Installation, Maintenance, and Repair Occupations	90.9
470000	Construction and Extraction Occupations	39.2
190000	Life, Physical, and Social Science Occupations	22.3
270000	Arts, Design, Entertainment, Sports, and Media Occupations	17.0
230000	Legal Occupations	16.8
450000	Farming, Fishing, and Forestry Occupations	14.9
370000	Building and Grounds Cleaning and Maintenance Occupations	14.6
290000	Healthcare Practitioners and Technical Occupations	10.1
350000	Food Preparation and Serving Related Occupations	10.0
330000	Protective Service Occupations	6.1
390000	Personal Care and Service Occupations	2.3
250000	Education, Training, and Library Occupations	1.5
310000	Healthcare Support Occupations	1.2
210000	Community and Social Service Occupations	0.9
	All Occupations	1 636.9

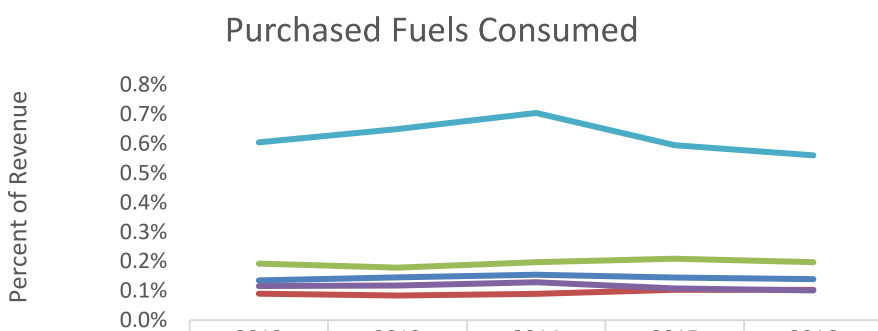
Note: Calculated using the NIST Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide.



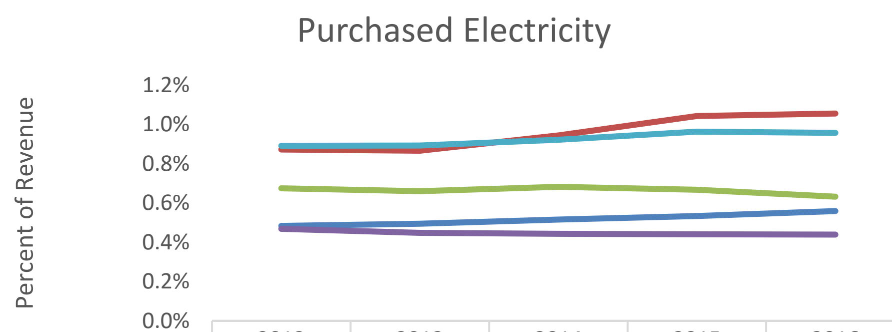
	2012	2013	2014	2015	2016
NAICS 333	14.9%	15.4%	15.2%	16.6%	17.3%
NAICS 334	20.1%	20.2%	20.2%	20.8%	21.0%
NAICS 335	14.3%	14.7%	14.8%	15.3%	15.4%
NAICS 336	10.8%	10.5%	10.3%	10.2%	10.3%
NAICS 31-33	10.4%	10.4%	10.5%	11.5%	12.0%



	2012	2013	2014	2015	2016
NAICS 333	47.4%	47.1%	45.9%	44.9%	44.1%
NAICS 334	36.9%	37.1%	36.4%	37.6%	36.3%
NAICS 335	46.2%	46.5%	46.0%	46.7%	45.3%
NAICS 336	60.5%	60.7%	60.7%	61.9%	61.2%
NAICS 31-33	54.4%	54.1%	53.7%	51.0%	49.7%



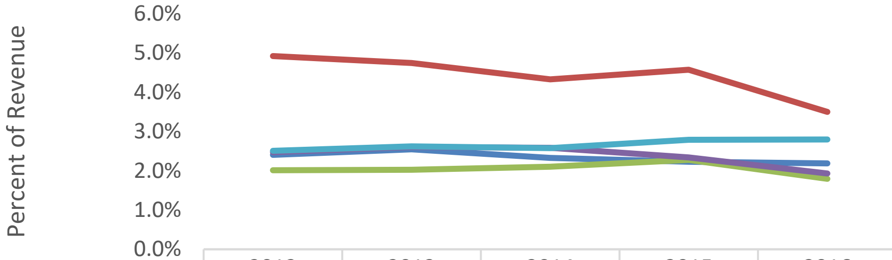
	2012	2013	2014	2015	2016
NAICS 333	0.1%	0.1%	0.2%	0.1%	0.1%
NAICS 334	0.1%	0.1%	0.1%	0.1%	0.1%
NAICS 335	0.2%	0.2%	0.2%	0.2%	0.2%
NAICS 336	0.1%	0.1%	0.1%	0.1%	0.1%
NAICS 31-33	0.6%	0.6%	0.7%	0.6%	0.6%



	2012	2013	2014	2015	2016
NAICS 333	0.5%	0.5%	0.5%	0.5%	0.6%
NAICS 334	0.9%	0.9%	0.9%	1.0%	1.1%
NAICS 335	0.7%	0.7%	0.7%	0.7%	0.6%
NAICS 336	0.5%	0.4%	0.4%	0.4%	0.4%
NAICS 31-33	0.9%	0.9%	0.9%	1.0%	1.0%

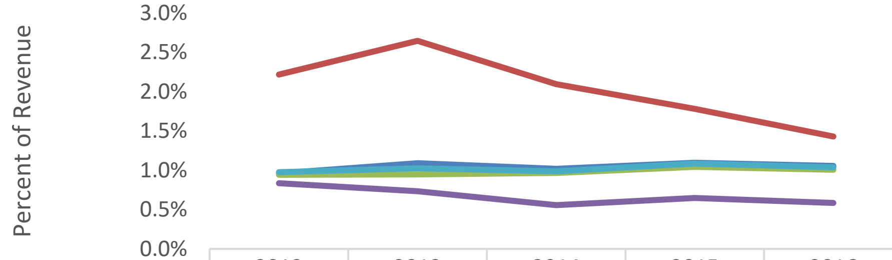
Figure 3.2: Breakdown of Expenditures as a Percent of Revenue, Annual Survey of Manufactures

Machinery - Rentals and Purchases



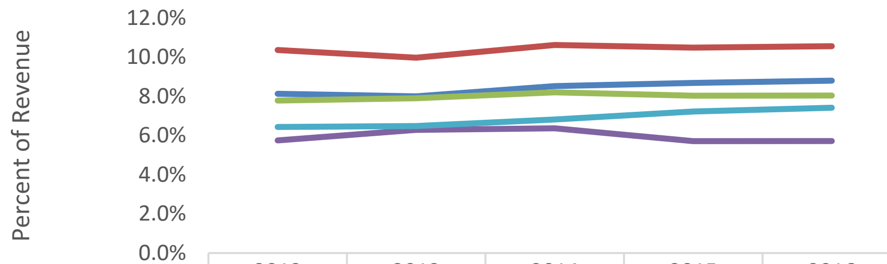
	2012	2013	2014	2015	2016
NAICS 333	2.4%	2.5%	2.3%	2.2%	2.2%
NAICS 334	4.9%	4.7%	4.3%	4.6%	3.5%
NAICS 335	2.0%	2.0%	2.1%	2.3%	1.8%
NAICS 336	2.5%	2.6%	2.6%	2.3%	1.9%
NAICS 31-33	2.5%	2.6%	2.6%	2.8%	2.8%

Buildings - Rentals and Purchases



	2012	2013	2014	2015	2016
NAICS 333	1.0%	1.1%	1.0%	1.1%	1.1%
NAICS 334	2.2%	2.6%	2.1%	1.8%	1.4%
NAICS 335	0.9%	0.9%	1.0%	1.0%	1.0%
NAICS 336	0.8%	0.7%	0.6%	0.6%	0.6%
NAICS 31-33	1.0%	1.0%	1.0%	1.1%	1.0%

Other Purchases



	2012	2013	2014	2015	2016
NAICS 333	8.1%	8.0%	8.5%	8.7%	8.8%
NAICS 334	10.4%	10.0%	10.6%	10.5%	10.6%
NAICS 335	7.8%	7.9%	8.2%	8.0%	8.0%
NAICS 336	5.7%	6.3%	6.4%	5.7%	5.7%
NAICS 31-33	6.4%	6.5%	6.8%	7.2%	7.4%

NAICS Code Definitions

NAICS 333	Machinery Manufacturing
NAICS 334	Computer and Electronic Product Manufacturing
NAICS 335	Electrical Equipment, Appliance, and Component Manufacturing
NAICS 336	Transportation Equipment Manufacturing
NAICS 31-33	Manufacturing

Figure 3.2 (Continued)

4 Employment, Compensation, Profits, and Productivity

The Annual Survey of Manufactures estimates that there were 11.1 million employees in the manufacturing industry in 2016, which is the most recent data available (see Table 4.1). The Current Population Survey and Current Employment Statistics have more recent data that estimate that there were 15.6 million and 12.7 million employees in 2018, respectively (see Table 4.2 and Table 4.3). Each of these estimates has its own method for how the data was acquired and its own definition of employment. The Current Population Survey considers an employed person to be any individual who did any work for pay or profit during the survey reference week or were absent from their job because they were ill, on vacation, or taking leave for some other reason. It also includes individuals who completed at least 15 hours of unpaid work in a family-owned enterprise operated by someone in their household. In contrast, the Current Employment Statistics specifically exclude proprietors, self-employed, and unpaid family or volunteer workers. Therefore, the estimates from the Current Employment Statistics are lower than the Current Population Survey estimates. Additionally, the Current Employment Statistics include temporary and intermittent employees. The Annual Survey of Manufactures considers an employee to include all full-time and part-time employees on the payrolls of operating establishments during any part of the pay period being surveyed excluding temporary staffing obtained through a staffing service. It also excludes proprietors along with partners of unincorporated businesses.

Table 4.1: Employment, Annual Survey of Manufactures

	2015 (employees)	2016 (employees)	Percent Change
Employees			
a. NAICS 324: Petroleum & coal products mfg	102 740	104 280	1.5%
b. NAICS 325: Chemical mfg	742 192	744 590	0.3%
c. NAICS 326: Plastics & rubber products mfg	730 005	741 224	1.5%
d. NAICS 327: Nonmetallic mineral product mfg	368 081	371 852	1.0%
e. NAICS 331: Primary metal mfg	379 426	364 199	-4.0%
f. NAICS 332: Fabricated metal product mfg	1 372 326	1 327 632	-3.3%
g. NAICS 333: Machinery mfg	1 042 664	988 688	-5.2%
h. NAICS 334: Computer & electronic product mfg	777 261	768 650	-1.1%
i. NAICS 335: Electrical equipment & component mfg	337 146	330 944	-1.8%
j. NAICS 336: Transportation equipment mfg	1 470 862	1 478 941	0.5%
k. NAICS 339: Miscellaneous mfg	512 988	513 593	0.1%
l. NAICS 311: Food mfg	1 390 907	1 417 046	1.9%
M. Other: apparel, wood product, and printing mfg	1 941 666	1 961 124	1.0%
N. TOTAL MANUFACTURING	**11 168 264**	**11 112 764**	**-0.5%**

Data Source: Data Source: Census Bureau. (2019). "Annual Survey of Manufactures." Accessed from the American FactFinder. http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

Table 4.2: Employment by Industry for 2017 and 2018 (Thousands): Current Population Survey

Industry	Total Employed 2017	Total Employed 2018	Employment Change	Percent Change
Mining	748	784	36	4.8%
Construction	10 692	11 181	489	4.6%
Manufacturing	15 408	15 560	152	1.0%
Wholesale and Retail Trade	20 314	20 270	-44	-0.2%
Transportation and Utilities	8 159	8 551	392	4.8%
Information	2 903	2 919	16	0.6%
Financial Activities	10 482	10 649	167	1.6%
Professional and Business Services	18 835	18 950	115	0.6%
Education and Health Services	34 483	35 043	560	1.6%
Leisure and Hospitality	14 291	14 268	-23	-0.2%
Other Services	7 485	7 742	257	3.4%
Public Administration	7 083	7 419	336	4.7%
Agriculture	2 454	2 425	-29	-1.2%
TOTAL*	153 337	155 761	2 424	1.6%

* The sum may not match the total due to rounding of annual averages

Source: Current Population Survey, Bureau of Labor Statistics. "Table 17: Employed Persons by Industry, Sex, Race, and Occupation." <http://www.bls.gov/cps>

Table 4.3: Manufacturing Employment (Thousands): Current Employment Statistics

	2017	2018	Percent Change
Manufacturing	12 439	12 689	2.0%
Durable Goods	7 741	7 945	2.6%
Nondurable Goods	4 699	4 743	0.9%

Source: Bureau of Labor Statistics. Current Employment Statistics. http://www.bls.gov/ces/home.htm

Between January 2006 and January 2010, manufacturing employment declined by 19.4 %, as seen in Figure 4.1. As of July 2019, employment is still 9.5 % below its 2006 level. In times of financial difficulty, large purchases are often delayed or determined to be unnecessary. Thus, it would be expected that during the recent recession durable goods would decline more than nondurable goods. As can be seen in Figure 4.1, durable goods declined more than manufacturing as a whole while nondurable goods did not decline as much. By January 2010, durable goods had declined 22.2 % while nondurables declined 14.5 %. As of July 2019, employment in durables was 10.0 % below its 2006 levels while that for nondurables was at 8.5 % below 2006 levels.

The employees that work in manufacturing offer their time and, in some cases, risk their personal safety in return for compensation. In terms of safety, the number of fatal injuries decreased 26.2 % between 2016 and 2017 (see Table 4.4). Nonfatal injuries decreased along with the injury rate (see Table 4.5). However, the incident rate for nonfatal injuries in manufacturing remains higher than that for all private industry. As seen in Figure 4.2, fatalities, injuries, and the injury rate have had an overall downward trend since 2000.

During the late 2000s recession, the number of hours worked per week declined, as seen in Figure 4.3. Unlike employment, however, the number of hours worked per week returned to its pre-recession levels or slightly higher. Average wages increased significantly during the recession and decreased during the following recovery, as can be seen in Figure 4.4. This is likely because low wage earners are disproportionately

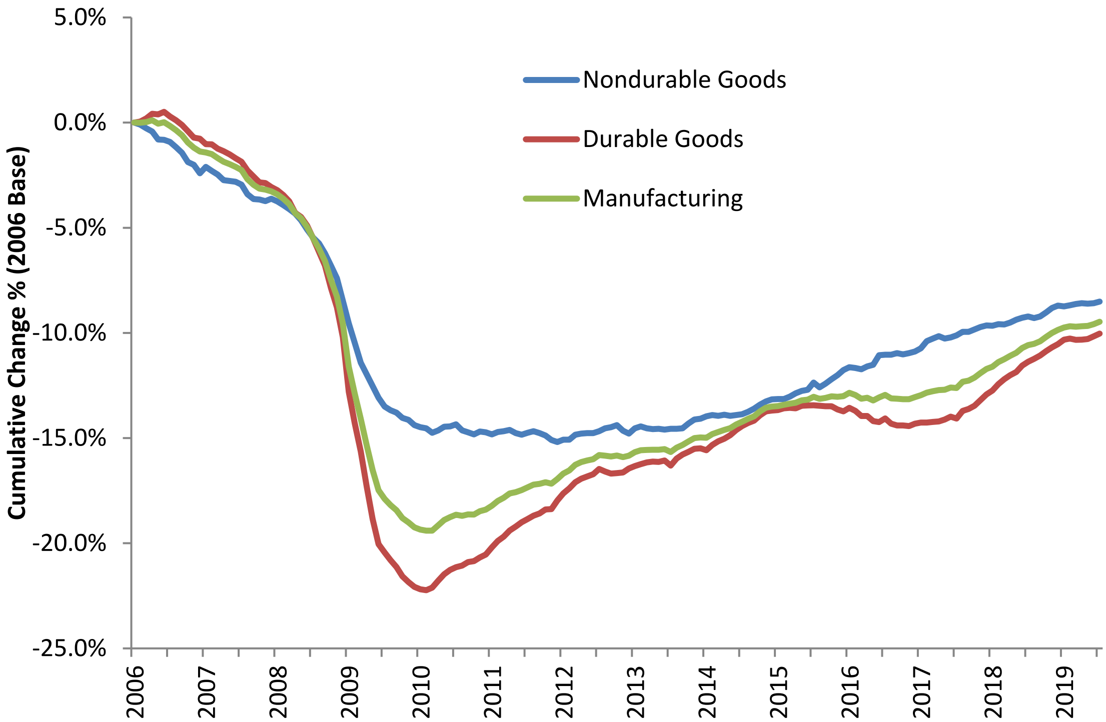


Figure 4.1: Cumulative Change in Percent in Manufacturing Employment (Seasonally Adjusted), 2006-2019
Source: Bureau of Labor Statistics. Current Employment Statistics. http://www.bls.gov/ces/

Table 4.4: Fatal Occupational Injuries by Event or Exposure

		Total	Violence and other injuries by persons or animals	Transportation Incidents	fires and explosions	Falls, slips, trips	exposure to harmful sub-stances or environments	Contact with objects and equipment
2016	Total	5190	866	2083	88	849	518	761
	Manufacturing	318	48	73	12	49	28	107
2017	Total	5147	807	2077	123	887	531	695
	Manufacturing	303	31	79	21	50	41	79
Percent Change	Total Private Industry	-0.8%	-6.8%	-0.3%	39.8%	4.5%	2.5%	-8.7%
	Manufacturing	-4.7%	-35.4%	8.2%	75.0%	2.0%	46.4%	-26.2%

Source: Bureau of Labor Statistics. Census of Fatal Occupational Injuries. "Industry by Event or Exposure." <http://stats.bls.gov/iif/oshcfoi1.htm>

Table 4.5: Total Recordable Cases of Nonfatal Injuries and Illnesses, Private Industry

		2016	2017	Percent Change
Manu-facturing	Incident Rate per 100 full time workers*	3.6	3.5	-2.8%
	Total Recordable Cases (thousands)	449.8	428.9	-4.6%
Private Industry	Incident Rate per 100 full time workers	2.9	2.8	-3.4%
	Total Recordable Cases (thousands)	2857.4	2811.5	-1.6%

Source: Bureau of Labor Statistics. Injuries, Illness, and Fatalities Program. 2010-2011. http://www.bls.gov/iif/

* The incidence rates represent the number of injuries and illnesses per 100 full-time workers and were calculated as: (N/EH) x 200,000, where

N = number of injuries and illnesses

EH = total hours worked by all employees during the calendar year
200,000 = base for 100 equivalent full-time workers (working 40 hours per week, 50 weeks per year)

impacted by employment reductions, which suggests that high wage earners not only receive more pay, they also have more job security. The compound annual growth rate in real dollars for private sector wages was 1.2 % between 2014 and 2019 while it was 0.7 % for manufacturing. As illustrated in Figure 4.5, employee compensation in manufacturing, which includes benefits, has had a five-year compound annual growth of 0.7 %.

For those that invest in manufacturing, nonfarm proprietors' income for manufacturing has had a five-year compound annual growth rate of -6.1 %, as illustrated in Figure 4.6. Corporate profits have had a five-year compound annual growth of -9.0 %.

The Bureau of Labor Statistics provides an index of labor productivity and multifactor productivity. Labor productivity for manufacturing increased 0.7 % from 2017 to 2018 and has had a slight upward trend, as seen in Figure 4.7. The Bureau of Labor Statistics multifactor productivity is "a measure of economic performance that compares the amount of goods and services produced (output) to the amount of combined inputs used to produce those goods and services. Inputs can include labor, capital, energy, materials, and purchased services." For US manufacturing, multifactor productivity declined 1.4 % from 2016 to 2017 and has had a downward trend in recent years, as seen in Figure 4.8. US productivity is relatively high compared to other countries. As illustrated in Figure 4.9, the US is ranked fourth in output per hour among 65 countries using data from the Conference Board.[29]

[29] Conference Board. Total Economy Database: Output, Labor and Labor Productivity. May 2017. https://www.conference-board.org/data/economydatabase/index.cfm?id=27762

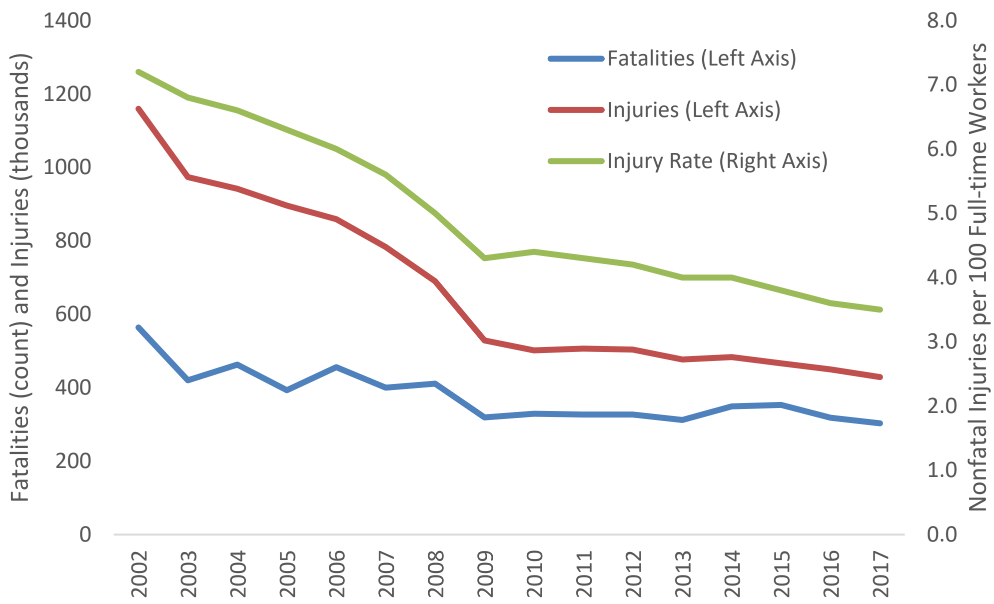


Figure 4.2: Manufacturing Fatalities and Injuries
Source: Bureau of Labor Statistics. Injuries, Illness, and Fatalities Program. http://www.bls.gov/iif/

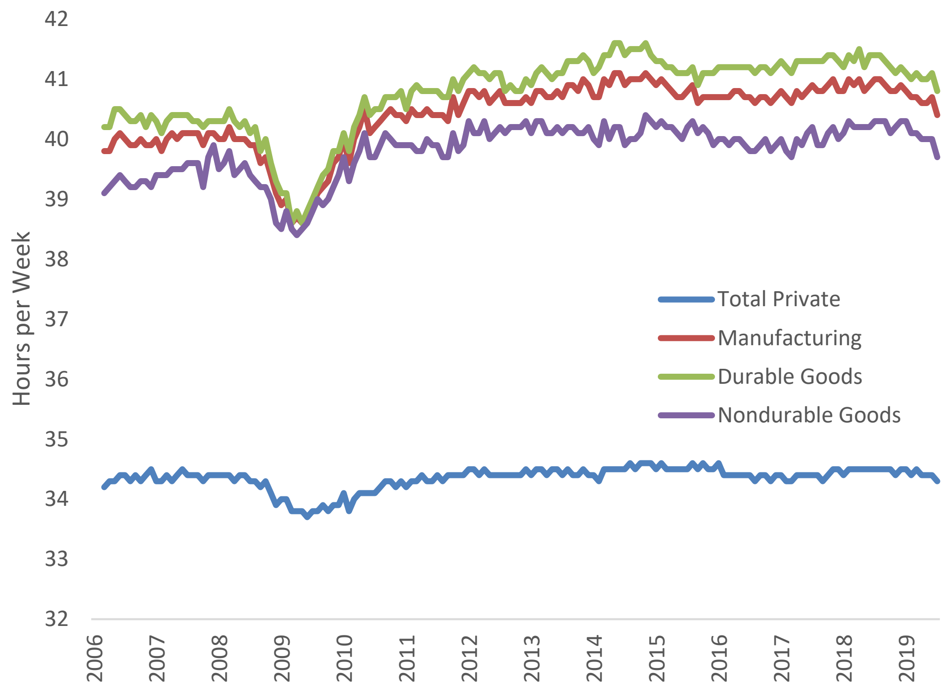


Figure 4.3: Average Weekly Hours for All Employees (Seasonally Adjusted)
Source: Bureau of Labor Statistics. Current Employment Statistics. http://www.bls.gov/ces/home.htm

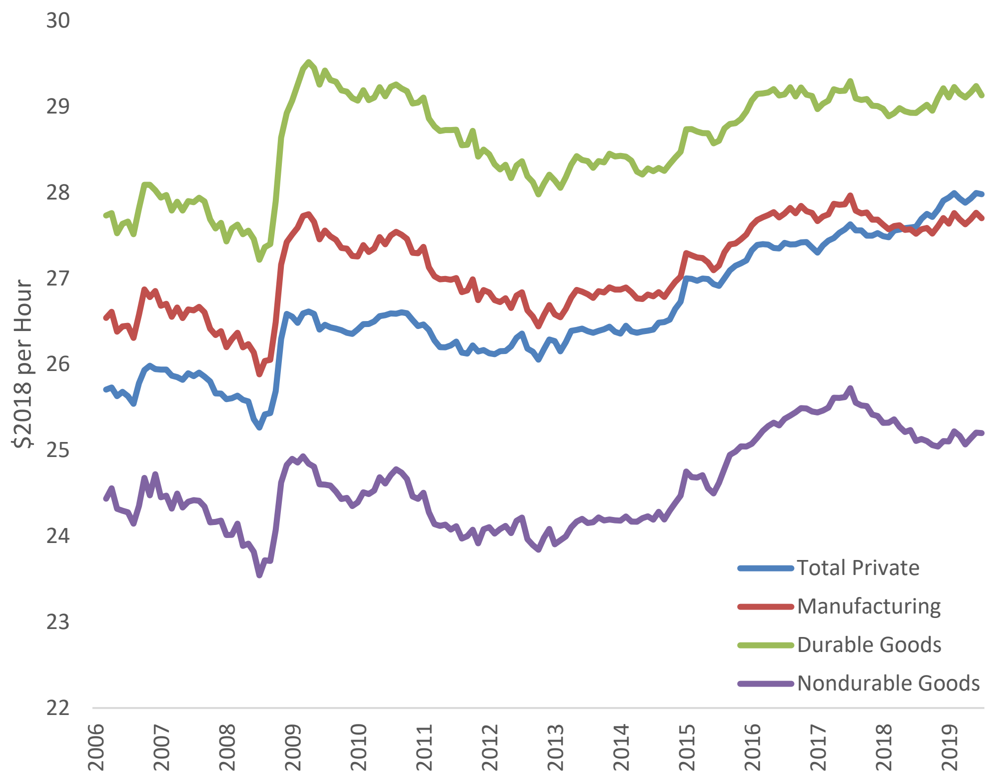


Figure 4.4: Average Hourly Wages for Manufacturing and Private Industry (Seasonally Adjusted)
Source: Bureau of Labor Statistics. Current Employment Statistics. http://www.bls.gov/ces/home.htm

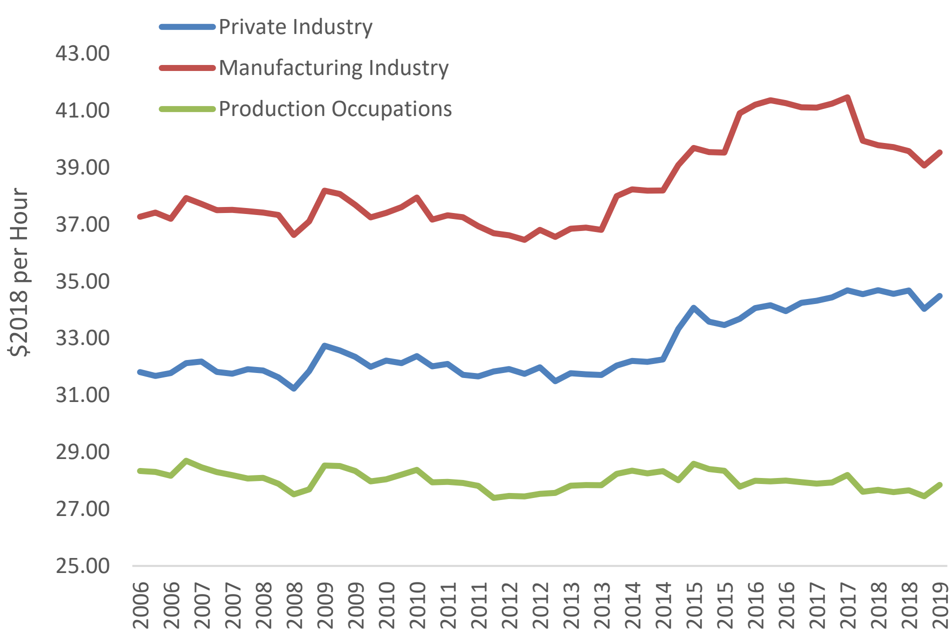


Figure 4.5: Employee Compensation (Hourly)
Source: Bureau of Labor Statistics. National Compensation Survey. http://www.bls.gov/ncs/
Adjusted using the Consumer Price Index for all consumers from the Bureau of Labor Statistics.

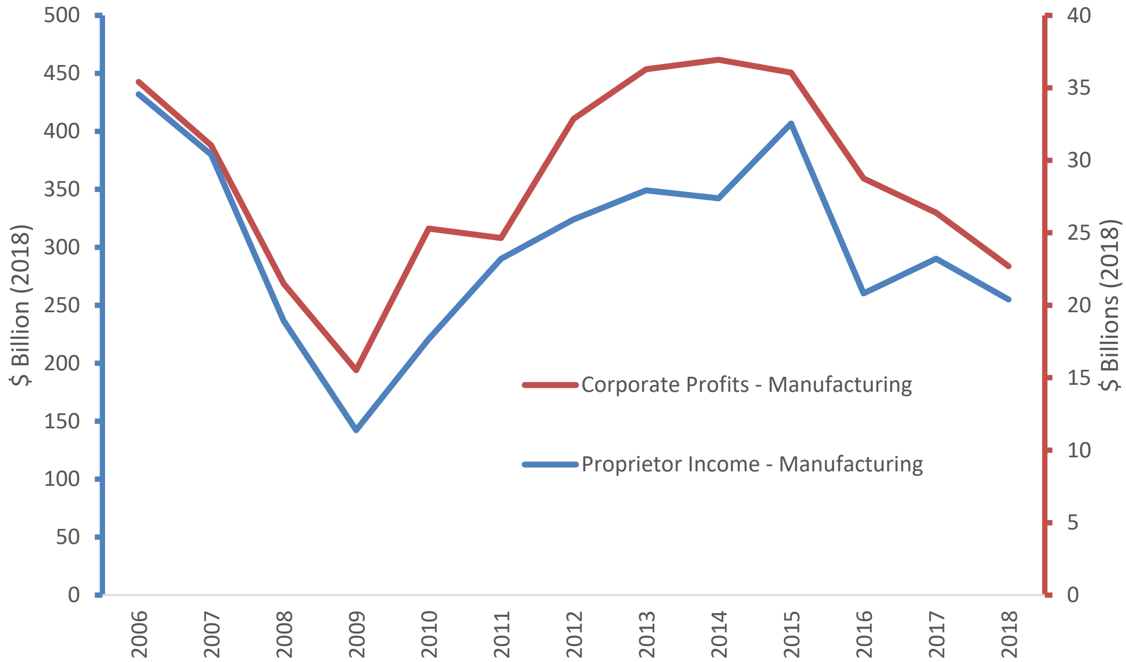


Figure 4.6: Profits for Corporations and Income Proprietorships
Source: Bureau of Economic Analysis. Income and Employment by Industry. Table 6.16D. Corporate Profits by Industry and Table 6.12D. Nonfarm Proprietors' Income. https://apps.bea.gov/iTable/index_nipa.cfm.

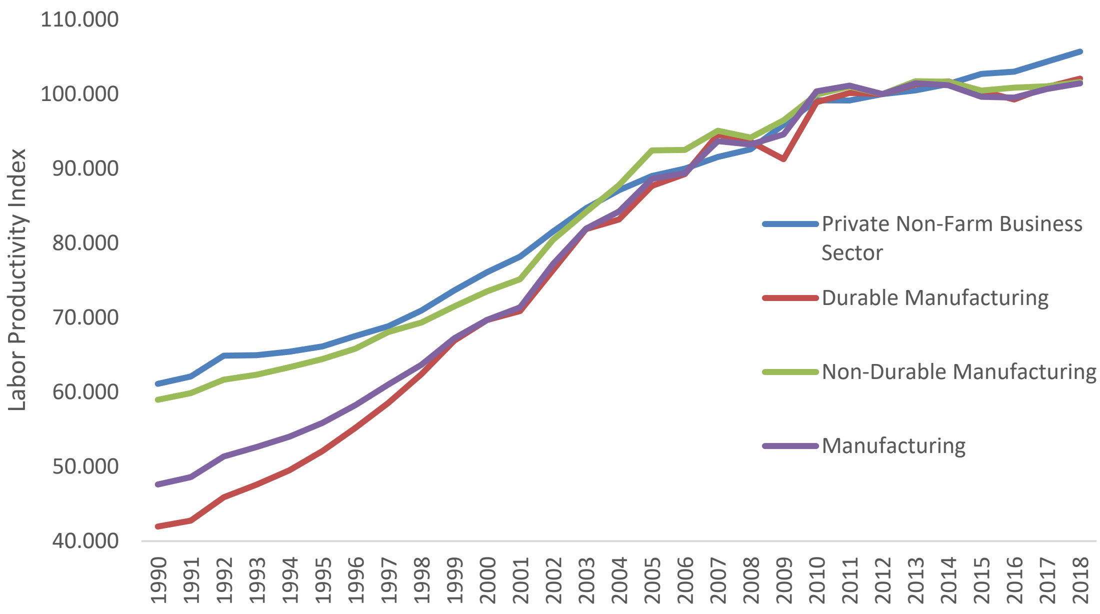


Figure 4.7: Manufacturing Labor Productivity Index (2012 Base Year = 100)
Source: Bureau of Labor Statistics. Productivity. https://www.bls.gov/mfp/

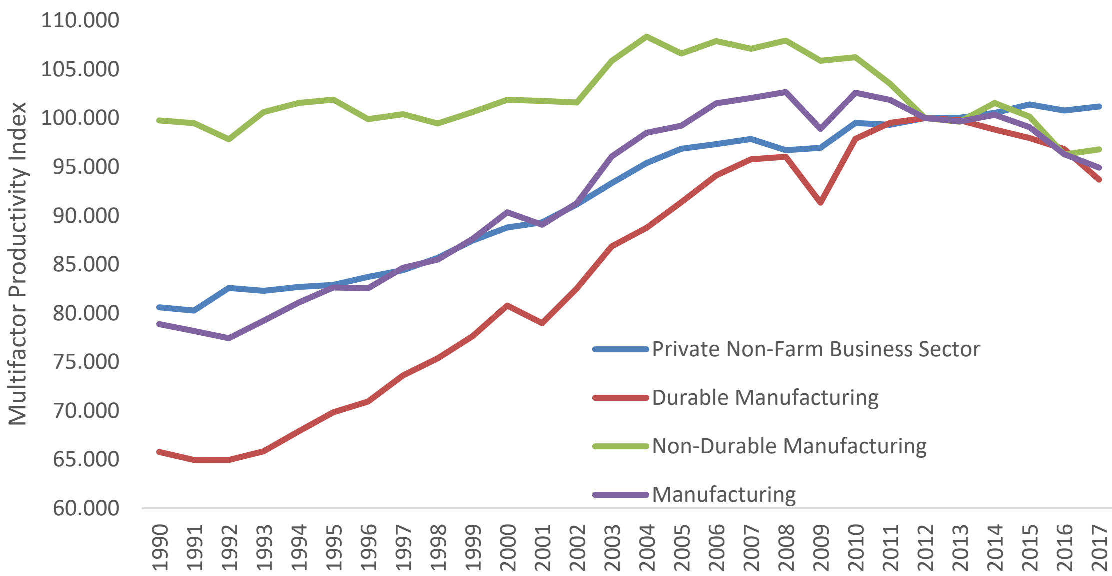


Figure 4.8: Manufacturing Multifactor Productivity Index (2012 Base Year = 100)
Source: Bureau of Labor Statistics. Productivity. 2017. https://www.bls.gov/mfp/

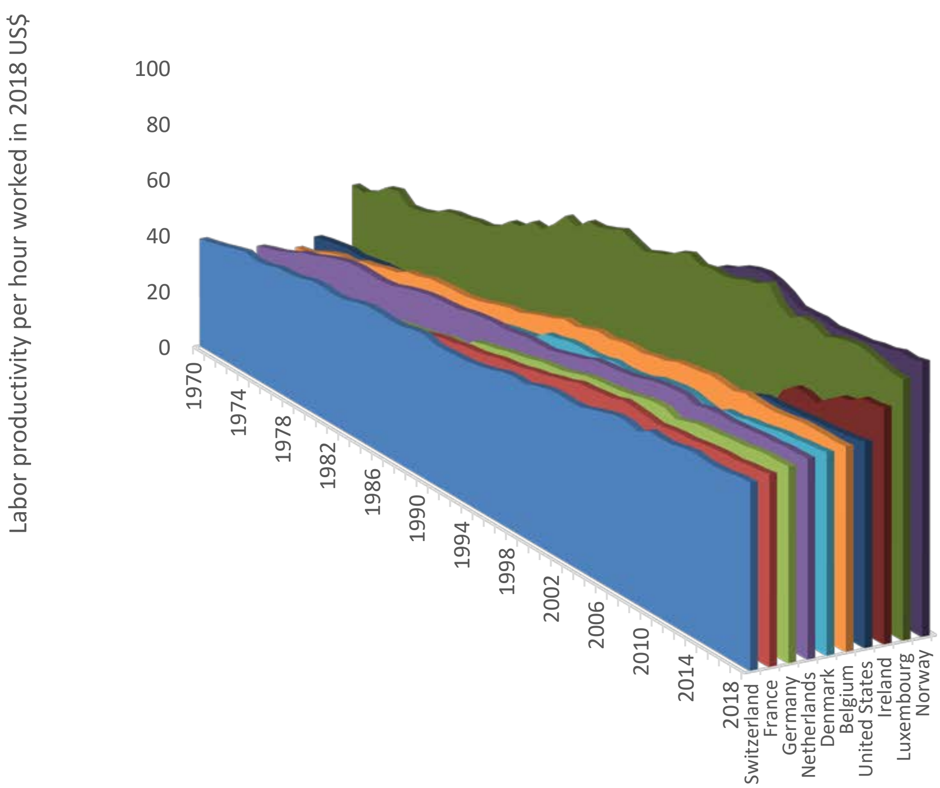


Figure 4.9: Output per Labor Hour (Top Ten Countries Out of 62)
Source: Conference Board. Total Economy Database: Output, Labor and Labor Productivity. May 2017. https://www.conference-board.org/data/economydatabase/index.cfm?id=27762
Note: CAG5 = 5-year compound annual growth rate (Calculated using Conference Board data)

5 Research, Innovation, and Factors for Doing Business

Manufacturing goods involves not only physical production, but also design and innovation. Measuring and comparing innovation between countries is problematic, however, as there is no standard metric for measuring this activity. Four measures are often discussed regarding innovation: number of patent applications, research and development expenditures, number of researchers, and number of published journal articles. As seen in Figure 5.1, the US ranked 3rd in 2017 in resident patent applications per million people, which puts it above the 95th percentile among 137 countries. Using patent application as a metric can be problematic though, as not all innovations are patented and some patents might not be considered innovation. The US ranked 9th in research and development expenditures as a percent of GDP in 2016, which puts it above the 90th percentile (see Figure 5.2) among 101 nations. As seen in Figure 5.3, enterprise research and development expenditures in manufacturing increased between 2014 and 2015 and has a compound annual growth rate of 1.9 % (not shown). In terms of researchers per million people, the US ranked 16th in 2015, putting it just above the 80th percentile (see Figure 5.4). In journal articles per million people it ranked 21st in 2016, and China had more articles than the US (see Figure 5.5).[30]

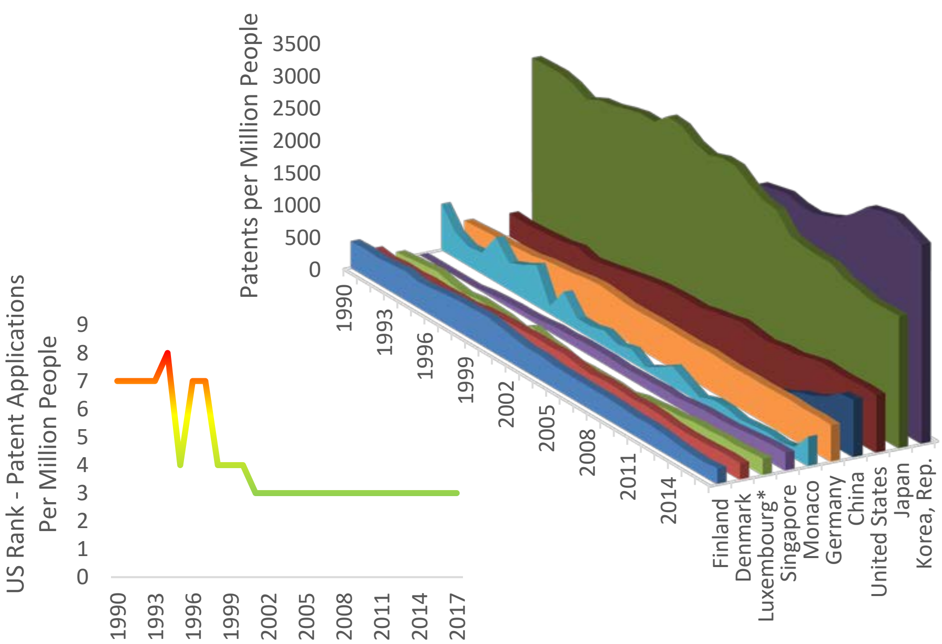


Figure 5.1: Patent Applications (Residents) per Million People, Top Ten
World Bank. 2018. World Development Indicators. https://data.worldbank.org/products/wdi
* Missing values were interpolated

[30] World Bank. World Development Indicators. http://data.worldbank.org/data-catalog/world-development-indicators

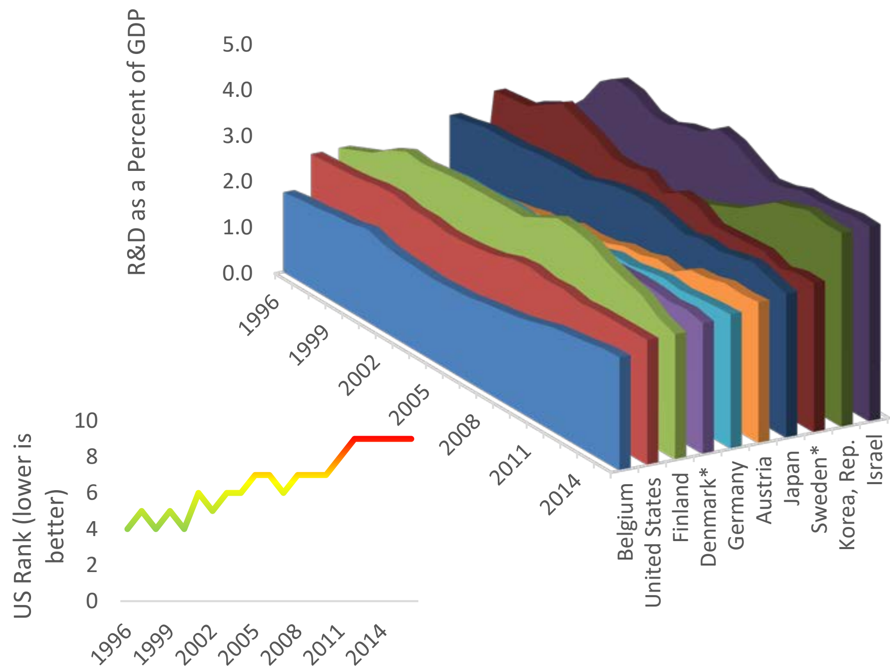


Figure 5.2: Research and Development Expenditures as a Percent of GDP
Source: World Bank. 2018. World Development Indicators. https://data.worldbank.org/products/wdi
* Missing data was interpolated

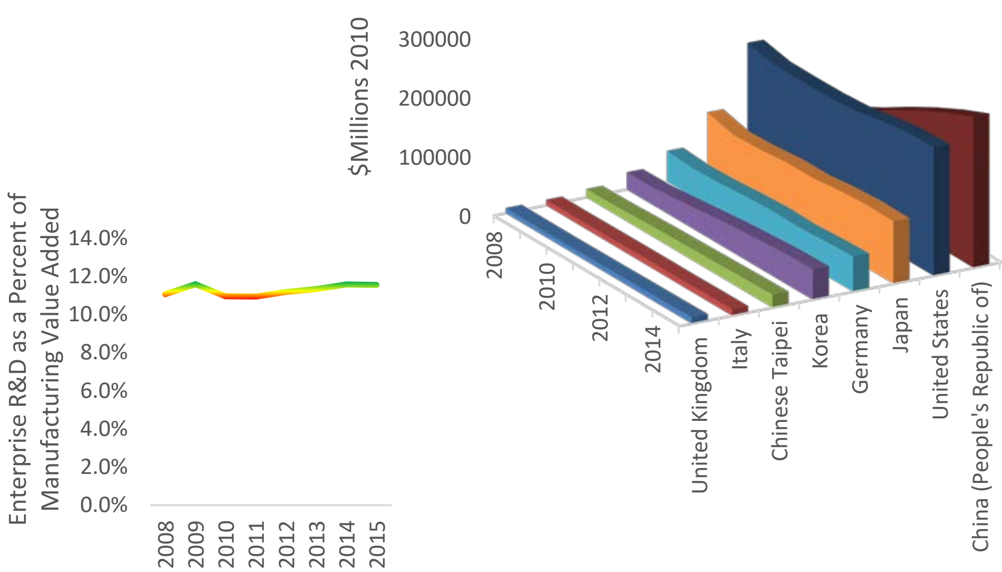


Figure 5.3: Manufacturing Enterprise Research and Development Expenditures
Source: OECD. Business Enterprise R-D Expenditure by Industry (ISIC 4). http://stats.oecd.org/#

In addition to some of the previously mentioned metrics, a number of indices have been developed to assess national competitiveness. The IMD World Competitiveness Index provides insight into the US innovation landscape. Figure 5.6 provides the US ranking for 20 measures of competitiveness. This provides some indicators to identify opportunities for improvement in US economic activity. In 2019, the US ranked low in public finance, prices, societal framework, and attitudes and values. Overall, the US ranked 3rd in competitiveness for conducting business.[31]

The 2016 Deloitte Global Manufacturing Competitiveness Index uses a survey of CEOs to rank countries based on their perception. The US was ranked 2nd out 40 nations with China being ranked 1st. High-cost labor, high corporate tax rates, and increasing investments outside of the US were identified as challenges to the US industry. Manufacturers indicated that companies were building high-tech factories in the US due to rising labor costs in China, shipping costs, and low-cost shale gas.[32] According to

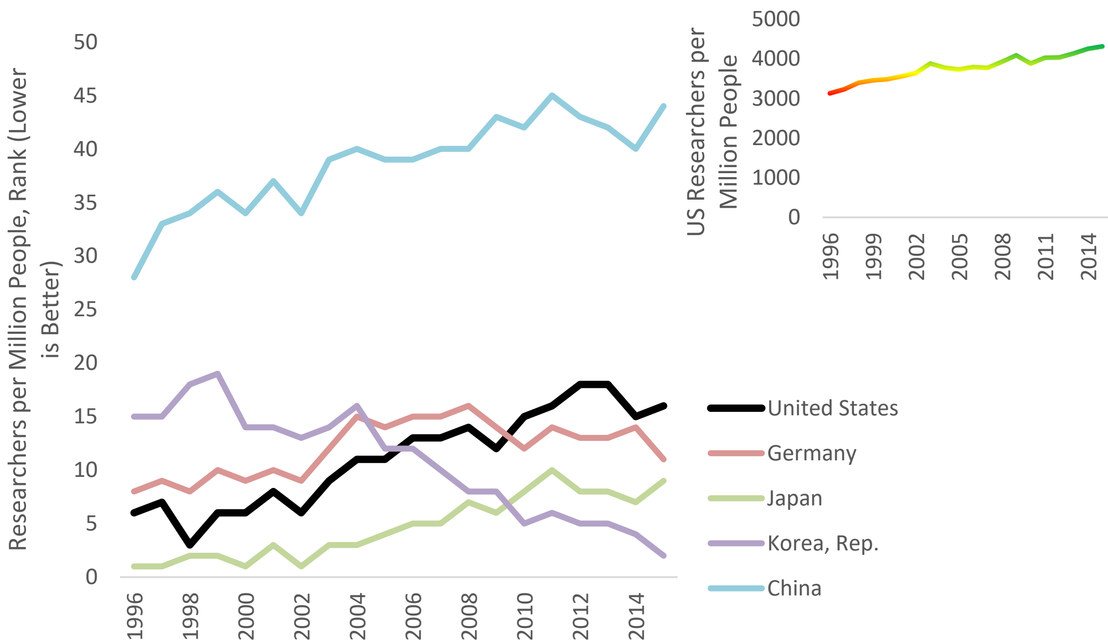


Figure 5.4: Researchers per Million People, Ranking
World Bank. 2018. World Development Indicators. https://data.worldbank.org/products/wdi

[31] IMD. (2019). IMD World Competiveness Country Profile: US. https://worldcompetitiveness.imd.org/countryprofile/US
[32] Deloitte. (2016). 2016 Global Manufacturing Competitiveness Index. http://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-gmci.pdf

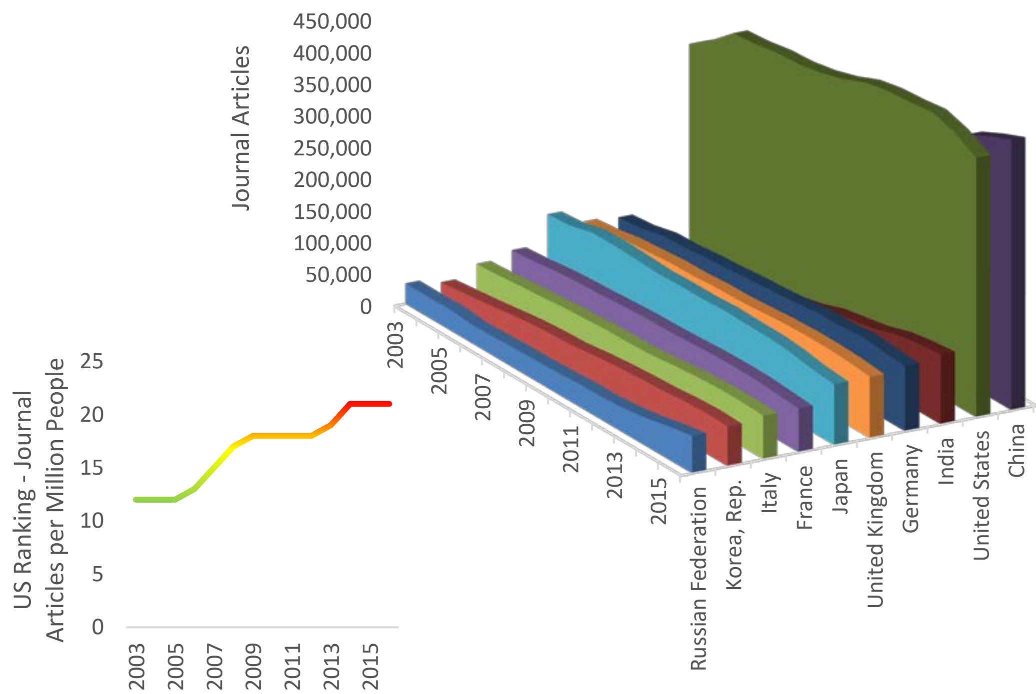


Figure 5.5: Journal Articles, Top 10 Countries
World Bank. 2018. World Development Indicators. https://data.worldbank.org/products/wdi

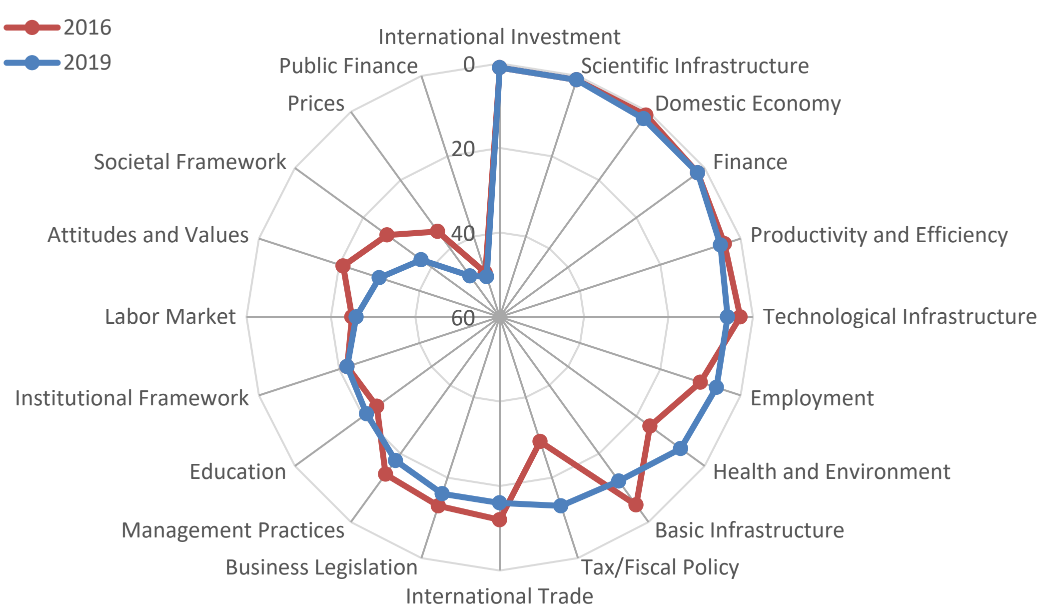


Figure 5.6: IMD World Competitiveness Rankings for the US: Lower is Better (i.e., a Rank of 1 is Better than a Rank of 60)

the Deloitte Global Manufacturing Competitiveness Index, advantages to US manufacturers included its technological prowess and size, productivity, and research support. China was ranked 1st with advantages in raw material supply, advanced electronics, and increased research and development spending. China has challenges in innovation, slowing economic growth, productivity, and regulatory inefficiency.

The World Economic Forum's 2018 Global Competitiveness Report uses 12 items to assess the competitiveness of 140 economies, which includes the set of "institutions, policies and factors that determine a country's level of productivity." The US was ranked 1st overall with various rankings in the 12 "pillars" that underly the ranking, as illustrated in Figure 5.7. Within the 12 "pillars," there were lower rankings in health, macroeconomic stability, and information/communication technology adoption.[33] The index uses a set of 90 factors to produce the 12 items in Figure 5.7. A selection of those that are relevant to standards, technology, and information dissemination are presented in Table 5.1. Those with that have poorer rankings might be opportunities for improvement. Among those selected in Table 5.1, the US ranks below the 90th percentile in both of the *crime* items, 1 of the 8 *transport* items, 6 of the 9 *utility* items, *labor-health*, 2 of the 9 *human capital* items, both *barrier to entry* items, and 2 of the 10 *innovation* items.

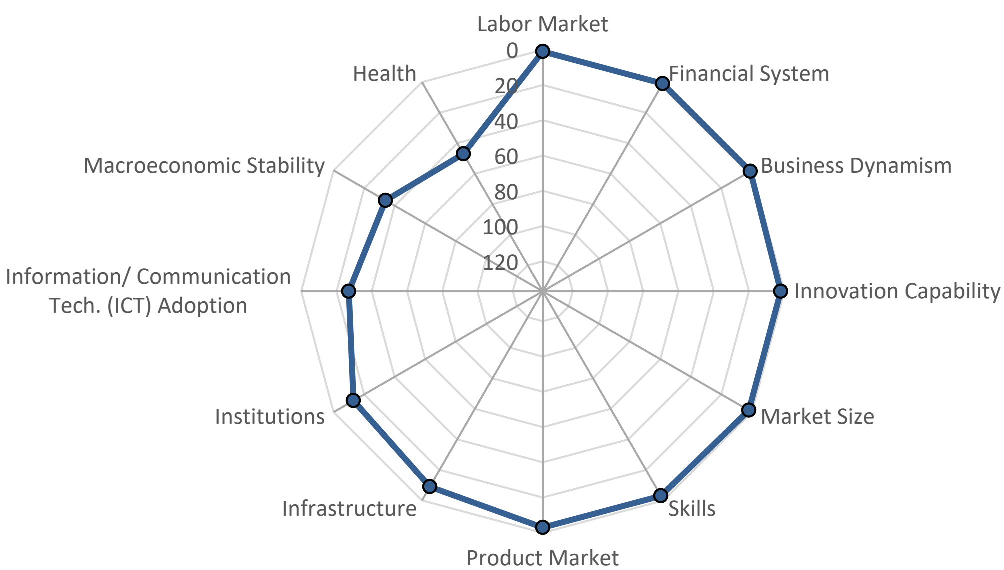


Figure 5.7: World Economic Forum 2018 Global Competitiveness Index: US Pillar Rankings: Lower is Better

[33] World Economic Forum. (2018). The Global Competitiveness Report 2018. http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf

Table 5.1: World Economic Forum Competitiveness Index Indicators – Selection of those Relevant to Standards, Technology, and Information Dissemination Solutions, Rankings Out of 140 Countries (Lower is Better)

Pillar	Component	US Rank	Application
1	Organized crime	53	Crime
1	Terrorism incidence	128	Crime
1	Intellectual property protection	13	IP Protection
2	Road connectivity index	1	Transport
2	Quality of roads	11	Transport
2	Railroad density (km of roads/square km)	33	Transport
2	Efficiency of train service	6	Transport
2	Airport connectivity	1	Transport
2	Efficiency of air transport services	8	Transport
2	Liner shipping connectivity index	7	Transport
2	Efficiency of seaport services	5	Transport
2	Electrification rate (% of population)	1	Utilities
2	Electric power transmission and distribution losses (% output)	26	Utilities
2	Exposure to unsafe drinking water (% of population)	1	Utilities
2	Reliability of water supply	27	Utilities
3	Mobile-cellular telephone subscriptions (per 100 people)	61	Utilities
3	Mobile-broadband subscriptions (per 100 people)	9	Utilities
3	Fixed-broadband internet subscriptions (per 100 people)	19	Utilities
3	Fibre internet subscriptions (per 100 people)	40	Utilities
3	Internet users (% of population)	40	Utilities
5	Healthy life expectancy	46	Labor - Health
6	Mean years of schooling	5	Human Capital
6	Extent of staff training	2	Human Capital
6	Quality of vocational training	2	Human Capital
6	Skillset of graduates	2	Human Capital
6	Digital skills among population	2	Human Capital
6	Ease of finding skilled employees	1	Human Capital
6	School life expectancy (expected years of schooling)	22	Human Capital
6	Critical thinking in teaching	1	Human Capital
6	Pupil-to-teacher ratio in primary education	43	Human Capital
11	Cost of starting a business (% GNI per capita)	26	Barriers to Entry
11	Time to start a business (days)	30	Barriers to Entry
11	Companies embracing disruptive ideas	1	Innovation
12	State of cluster development	1	Innovation
12	International co-inventions (applications/million people)	19	Innovation
12	Multi-stakeholder collaboration	1	Innovation
12	Scientific publications (H index)	1	Innovation
12	Patent applications (per million people)	13	Innovation
12	R&D expenditures (% of GDP)	11	Innovation
12	Quality of research institutions	1	Innovation
12	Buyer sophistication	1	Innovation
12	Trademark applications (per million people)	33	Innovation

Pillars: 1) Institutions, 2) Infrastructure, 3) Information and communication technology adoption, 4) macroeconomic policy, 5) Health, 6) Skills, 7) Product market, 8) Labor market, 9) Financial system, 10) Market size, 11) Business dynamism, and 12) Innovation capability.
Applications: The application categories were developed for this report in order to identify items that might be relevant to manufacturing

The Competitive Industrial Performance Index, published by the United Nations Industrial Development Organization, ranks countries based on 3 dimensions: 1) capacity to produce and export manufactured goods; 2) technological deepening and upgrading; and 3) world impact.[34] The US ranked below the 90th percentile on the first two dimensions and ranked 3rd overall, as seen in Table 5.2.

The Annual Survey of Entrepreneurs makes inquiries on US entrepreneurs concerning the negative impacts of eight items:

- Access to financial capital
- Cost of financial capital
- Finding qualified labor
- Taxes
- Slow business or lost sales
- Late or nonpayment from customers
- Unpredictability of business conditions
- Changes or updates in technology
- Other

As seen in Figure 5.8, there are five items where more than a third of the firms indicated negative impacts. Among them were taxes, slow business or lost sales, unpredictability of business conditions, finding qualified labor, and government regulations. [35]

Table 5.2: Rankings from the Competitive Industrial Performance Index 2018, 150 Total Countries

	Overall	Capacity to produce and export manufactured goods	Technological deepening and upgrading	World Impact
Germany	1	7	5	3
Japan	2	17	10	4
United States	3	27	28	2
China	4	48	9	1
Republic of Korea	5	13	1	5

Source: United Nations Industrial Development Organization. (2019). Competitive Industrial Performance Report 2018. https://www.unido.org/sites/default/files/files/2019-05/CIP.pdf

[34] United Nations Industrial Development Organization. (2019). Competitive Industrial Performance Report 2018. https://www.unido.org/sites/default/files/files/2019-05/CIP.pdf
[35] US Census Bureau. (2019) Annual Survey of Entrepreneurs. Accessed from the American Fact Finder. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

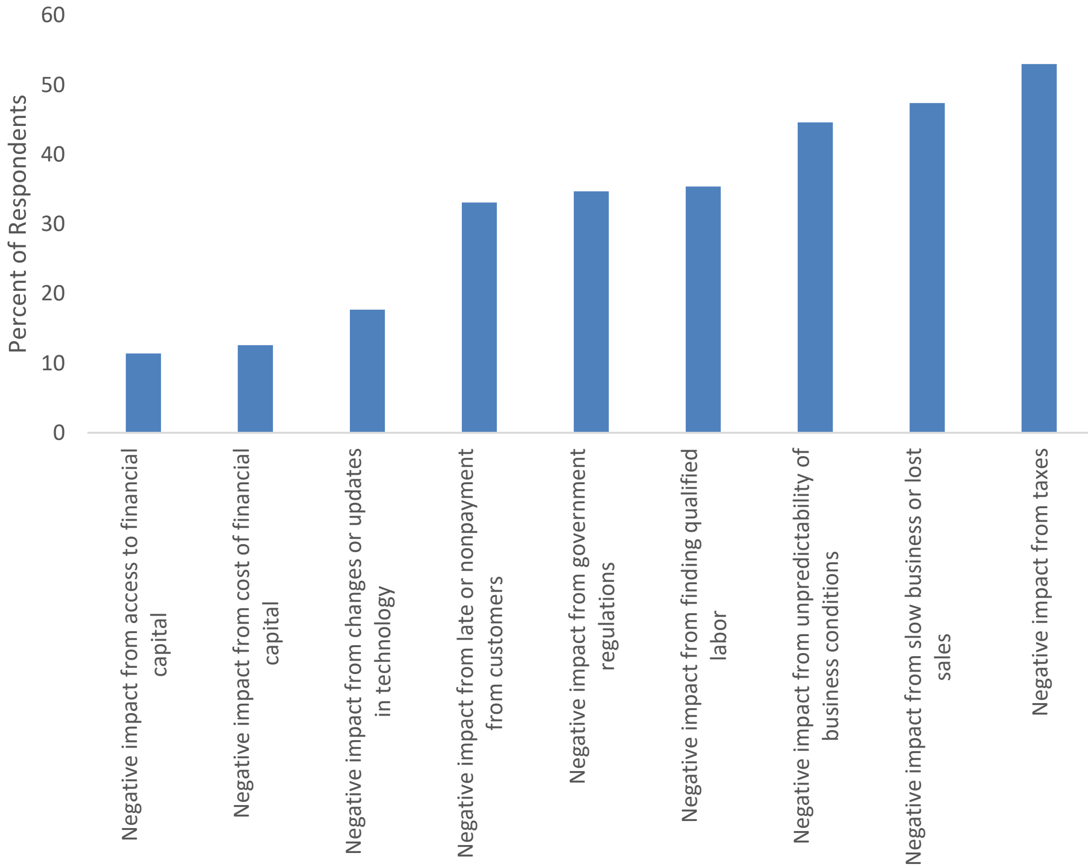


Figure 5.8: Factors Impacting US Business (Annual Survey of Entrepreneurs), 2016

6 Discussion

This report provides an overview of the US manufacturing industry. There are 3 aspects of US manufacturing that are considered: (1) how the US industry compares to other countries, (2) the trends in the domestic industry, and (3) the industry trends compared to those in other countries. The US remains a major manufacturing nation; however, other countries are rising rapidly. US manufacturing was significantly impacted by the previous recession and has only recently returned to pre-recession levels of production and still remains below pre-recession employment levels.

The US accounts for 14.5 % of global manufacturing, according to the United Nations Statistics Division National Accounts Main Aggregates Database, making it the second largest. US compound real (i.e., controlling for inflation) annual growth between 1992 and 2017 was 2.5 %, which places the US below the 50th percentile. the compound annual growth for the US between 2012 and 2017 was 1.2 %. This puts the US just above the 25th percentile below Canada and Germany among others. In terms of subsectors of manufacturing, the US ranks 1st in 7 industries out of 16 total while China was the largest for the other industries.

There is an estimated $2037 billion in manufacturing value added with an additional $1861 billion in indirect value added from other industries for manufacturing, as calculated using input-output analysis. In 2017, the US imported approximately 19.7 % of its intermediate imports, according to BEA data. Discrete technology products account for between 36 % and 38 % of manufacturing value added, according to BEA data.

US Manufacturing declined significantly in 2008 and has only recently returned to its pre-recession peak level, which occurred in 2007. Manufacturing value added declined more than total US GDP, creating a persistent gap. The result is that first quarter GDP in 2019 is 20.0 % above its pre-recession peak level while manufacturing is at 2.7 % above its peak level. Between January 2006 and January 2010, manufacturing employment declined by 19.4 %. As of July 2019, employment is still 9.5 % below its 2006 level.

High cost supply chain industries/activities, which might provide opportunities for advancing competitiveness, include energy related industries, management, transportation, semiconductor manufacturing, and machinery manufacturing. Production occupations is the largest labor cost activity, followed by management, office and administrative support, transportation and material moving, and business and financial operations.

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