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Annual Report on the U.S. Manufacturing Economy: 2023

Douglas Thomas

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NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
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Annual Report on the U.S. Manufacturing Economy: 2023

Douglas Thomas
Applied Economics Office
Engineering Laboratory

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National Institute of Standards and Technology
Laurie E. Locascio, NIST Director and Under Secretary of Commerce for Standards and Technology

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Abstract

This report provides a statistical review of the U.S. manufacturing industry. There are three aspects of U.S. manufacturing that are considered: (1) how the U.S. industry compares to other countries, (2) the trends in the domestic industry, and (3) the industry trends compared to those in other countries.

Keywords

manufacturing; economy; supply chain; value added; statistics

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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 U.S. manufacturing industry.

Executive Summary

This report provides a statistical review of the U.S. manufacturing industry. There are three aspects of U.S. manufacturing that are considered: (1) how the U.S. industry compares to other countries, (2) the trends in the domestic industry, and (3) the industry trends compared to those in other countries. The U.S. remains a major manufacturing nation; however, other countries are rising rapidly.

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

Competitiveness – Manufacturing Industry Size: In 2021, there was $14.5 trillion of value added (i.e., GDP) in global manufacturing in constant 2015 dollars. The U.S. accounted for $2.4 trillion (16.3 %) in manufacturing valued added while China accounted for $4.5 trillion (30.9 %). Direct and indirect (i.e., purchases from other industries) manufacturing accounts for 24.1 % of GDP. Among the ten largest manufacturing countries, the U.S. is the 4th largest manufacturing value added per capita (see Figure 2.5) and out of all countries the most recent U.S. rank is 14th, as illustrated in Figure 2.6. In 2020, China outranked the U.S. in all of 6 major subsectors (see Figure 2.8)

Competitiveness – Manufacturing Growth: Compound real (i.e., controlling for inflation) annual growth in the U.S. between 1996 and 2021 (i.e., 25-year growth) was 2.1 %, which places the U.S. below the 50th percentile. The compound annual growth for the U.S. between 2016 and 2021 (i.e., 5-year growth) was 2.2 %. This puts the U.S. just above the 50th percentile, above Canada and Germany among others.

Competitiveness – Productivity: Labor productivity for manufacturing decreased by 1.0 % between the second quarter of 2022 and the second quarter of 2023, as illustrated in Figure 4.9. The five-year compound annual growth is -0.6 %. For U.S. manufacturing, total factor productivity increased 3.6 % from 2020 to 2021 and has a 5-year compound annual growth rate of 0.7 %, as illustrated in Figure 4.10. Productivity in the U.S. is relatively high compared to other countries. As illustrated in Figure 4.11, the U.S. is ranked ninth in output per hour among 142 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 U.S. 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 other factors. 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 U.S. in these measures has mixed results, ranking high in some and lower in others. For instance, the U.S. ranks 4th in patent applications per million people but ranks 17th in researchers per capita and 24th in journal article publications per capita. The IMD World Competitiveness Index, which measures competitiveness for conducting business, ranked the U.S. 9th in competitiveness for conducting business and the World Economic Forum, which assesses the competitiveness in determining productivity, ranked the U.S. 2nd. 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 U.S. 2nd. The Competitive Industrial Performance Index, which measures capacity to produce and export manufactured goods; technological deepening and upgrading; and world impact, ranked the U.S. as 5th.

Domestic Specifics – Types of Goods Produced: The largest manufacturing subsector in the U.S. is computer and electronic products followed by chemical manufacturing and food, beverage, and tobacco products, as seen in Figure 2.12. Discrete technology products accounted for 37 % of U.S. manufacturing.

Domestic Specifics – Economic Disruptions: From the pre-recession peak in the 4th quarter of 2007 to the 1st quarter of 2009 manufacturing declined 17 percentage points. Manufacturing didn't return to its pre-recession level until 2017. During the recent pandemic, manufacturing value added declined 17 percentage points between the third quarter of 2019 and second quarter of 2020, but returned to similar levels within a year. As of July 2023, employment was still 8.9 % below its 2005 level. As a result of the pandemic, between January 2005 and January 2010, manufacturing employment declined by 19.6 %, as seen in Figure 4.1.

Domestic Specifics – Manufacturing Supply Chain Costs: High-cost supply chain industries/activities, which might pose as opportunities for advancing competitiveness, include various forms of energy production and/or transmission, various forms of transportation, the management of companies and enterprises among other items listed in Table 3.6.

Domestic Specifics – Manufacturing Safety, Compensation, and Profits: As illustrated in Figure 4.5, employee compensation in manufacturing, which includes benefits, has had a five-year compound annual growth of -1.0 %, but remains 6.3 % above total private industry compensation. In May of 2018 the average hourly wages for the total private sector exceeded that of manufacturing, which was not the case before that time. Compensation in manufacturing, which includes benefits, still exceeds that of the total private industry; however, the difference has narrowed significantly. In terms of safety in manufacturing, fatalities, injuries, and the injury rate have generally trended downward since 2002, as seen in Figure 4.2. However, there has been a slight uptick. Between 2020 and 2021, fatal occupational injuries increased 12.6 % and nonfatal injuries/illnesses increased 3.2 %.

For those that invest in manufacturing, corporate profits have had a five-year compound annual growth of 10.4 %, as illustrated Figure 4.7, and nonfarm proprietors' income for manufacturing has had a five-year compound annual growth rate of -8.4 %, as illustrated in Figure 4.8.

1. Introduction

1.1. Background

Public entities have a significant role in the U.S. 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 U.S. innovation. The vastness and diversity of U.S. 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, which amount to costs, and negative externalities (e.g., environmental impacts) while increasing output, (i.e., the products produced), and the function of the product (e.g., the usefulness or quality 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.

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[1] Block, Fred L and Matthew R. Keller. State of Innovation: The U.S. Government's Role in Technology Development. New York, NY; Taylor & Francis; 2016.
[2] Wessner CW and Wolff AW. Rising to the Challenge: U.S. 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 U.S. 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 U.S. 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 U.S. Transportation Equipment Manufacturing Industry. November 26, 2014. Contract SB1341-12-CN-0084.

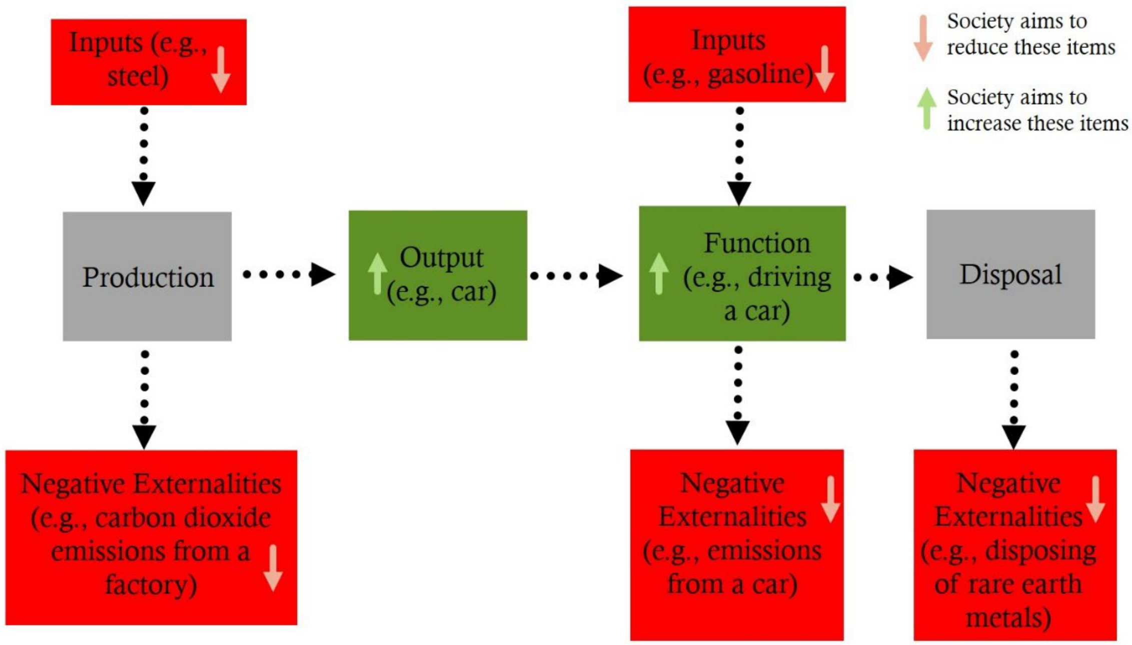


Figure 1.1: Illustration of Objectives – Drive Inputs and Negative Externalities Down while Increasing Production Output and Product Function

1.2. Purpose of this Report

The purpose of this report is to characterize U.S. 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 U.S. 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 U.S. 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, total factor 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, inflation, patents

- **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, exports, hours worked

- **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, country comparison indices

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

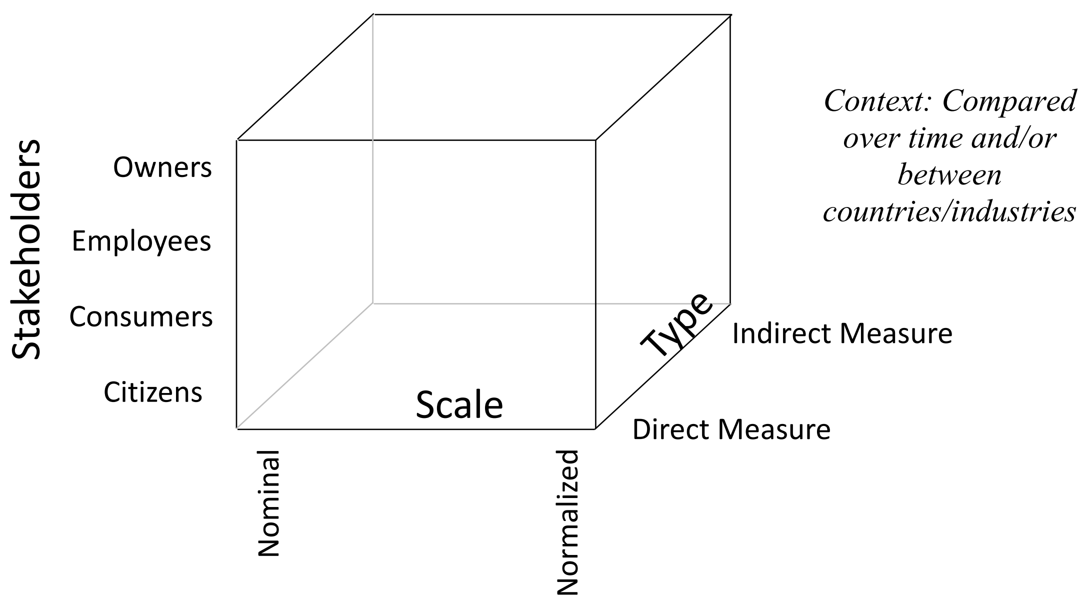


Figure 1.2: Data Categorization for Examining the Economics of Manufacturing

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 U.S. 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 U.S. manufacturing activities.

1.3. Scope and Approach

There are numerous aspects one could examine in manufacturing. This report discusses a subset of stakeholders and focuses on U.S. 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 "U.S. 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 U.S.-based manufacturing activities are imported. The imported values are a relatively small percentage of total activity, but they are important in regard to a firm's production. NIST, however, promotes U.S. innovation and industrial competitiveness; therefore, consideration of these imported goods and services are outside of the scope of this report.

Standard Data Categorization: Domestic data in the U.S. 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 U.S. 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 U.S. manufacturing activity.[8] This report selects from sources that are the most prominent and reveal the most information about the U.S. manufacturing industry. These data include the United Nations Statistics Division's National Accounts Main Aggregates Database and the U.S. Census Bureau's Annual Survey of Manufactures, among others. Because the data 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 a particular time period. For instance, if you have value added data on 5 industries for 20 countries for a single year, 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 United States. On the other hand, there is data that spans multiple countries (breadth) and subsectors of manufacturing (depth); however, this data is from several years ago. Fortunately, industry level trends change slowly; thus, the data may not be from the most recent years, but it is still representative.

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

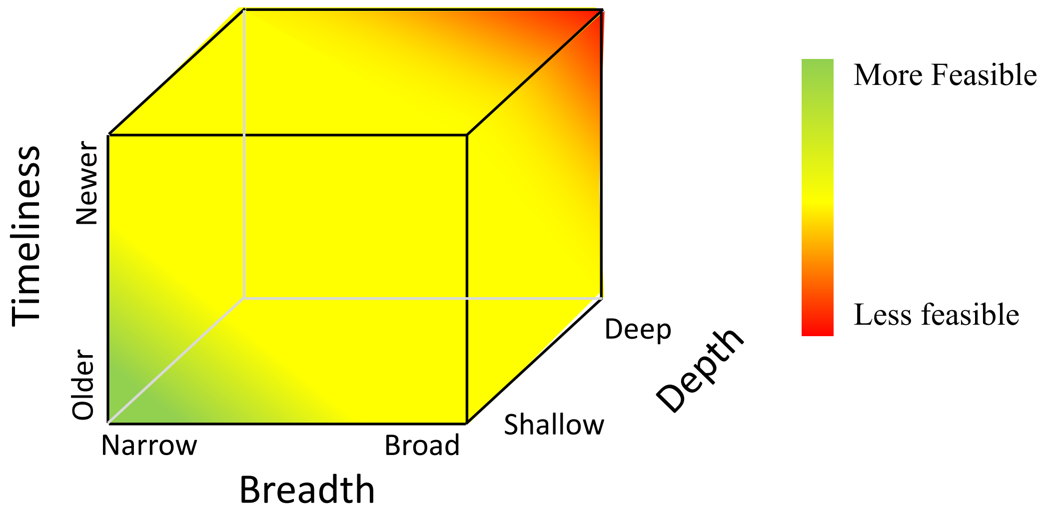


Figure 1.3: Illustration of the Feasibility of Data Collection and Availability

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.[9] 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 2021, there was $14.5 trillion of value added (i.e., GDP) in global manufacturing in constant 2015 dollars, which is 17.5 % of the value added by all industries ($82.7 trillion), according to the United Nations Statistics Division. Since 1970, manufacturing ranged between 13.7 % and 17.5 % of global GDP. The top 10 manufacturing countries accounted for $10.4 trillion or 71.7 % of global manufacturing value added: China (30.9 %), United States (16.3 %), Japan (6.1 %), Germany (4.9 %), South Korea (3.2 %), India (3.0 %), United Kingdom (2.2 %), Italy (1.9 %), France (1.7 %), and Indonesia (1.5 %).[10]

As seen in Figure 2.1, U.S. compound real (i.e., controlling for inflation) annual growth between 1996 and 2021 was 2.1 %, which places the U.S. below the 50th percentile. This growth exceeded that of Germany, France, Canada, Japan, and Australia; however, it is slower than that for the world (3.8 %) 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 U.S. 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 U.S. between 2016 and 2021 was 2.2 %. This puts the U.S. just above the 50th percentile above Canada and Germany among others but still below the world growth of 2.9 %.

As seen in Figure 2.3, among the 10 largest manufacturing nations, U.S. manufacturing value added, as measured in constant 2015 dollars, is the second largest. In current

[9] Dornbusch, Rudiger, Stanley Fischer, and Richard Startz. (2000). Macroeconomics. 8th ed. London, UK: McGraw-Hill.
[10] United Nations Statistics Division. (2021). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp

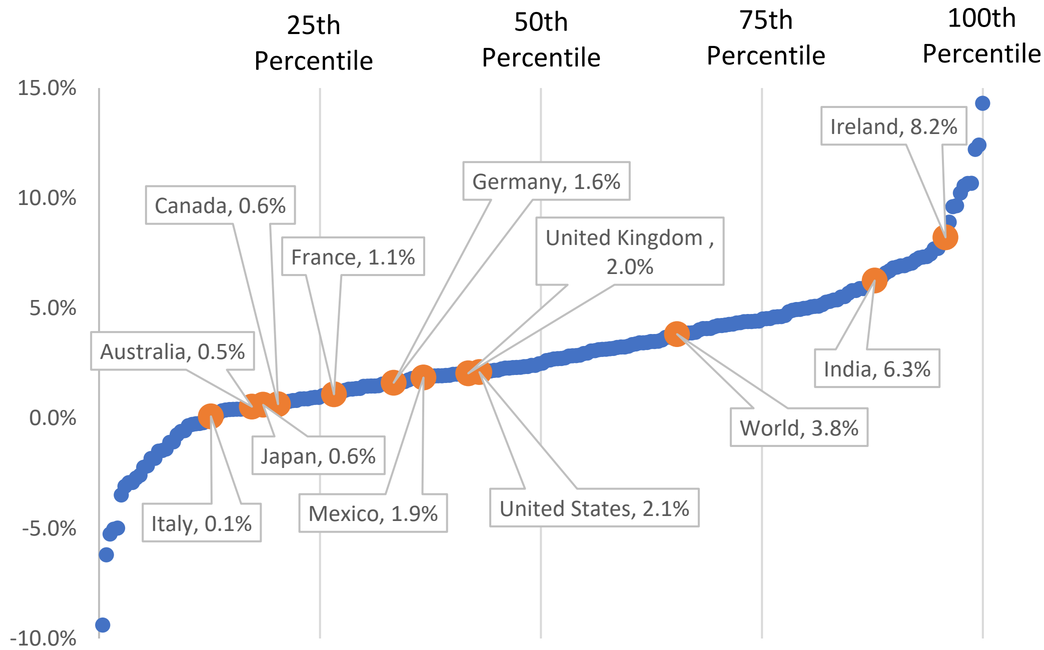


Figure 2.1: National 25-Year Compound Annual Growth, by Country (1996 to 2021): Higher is Better

Data Source: United Nations Statistics Division. (2023). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp

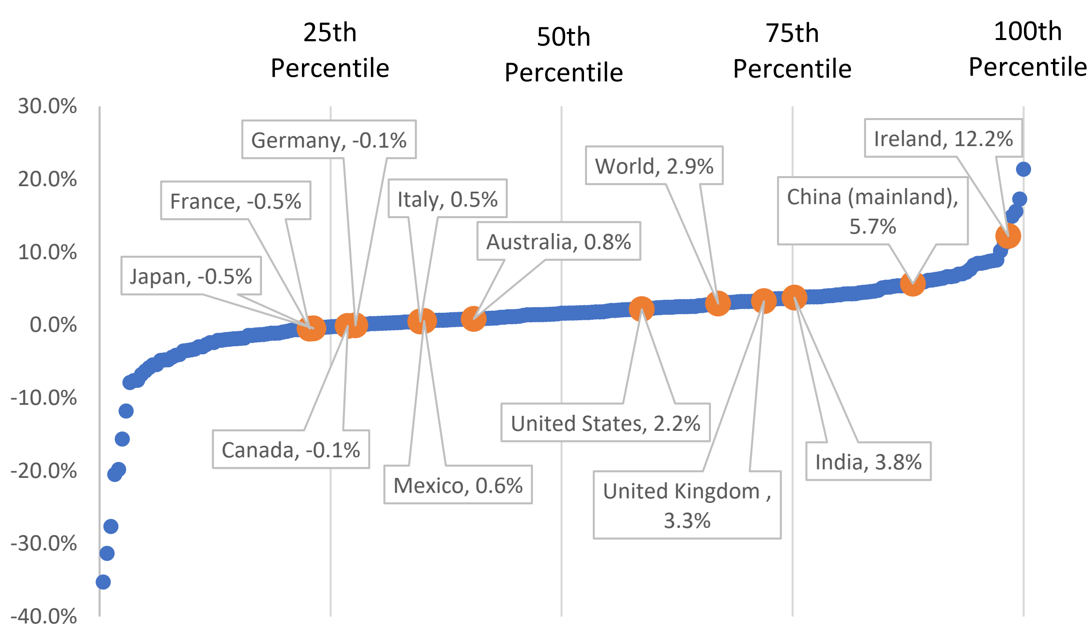
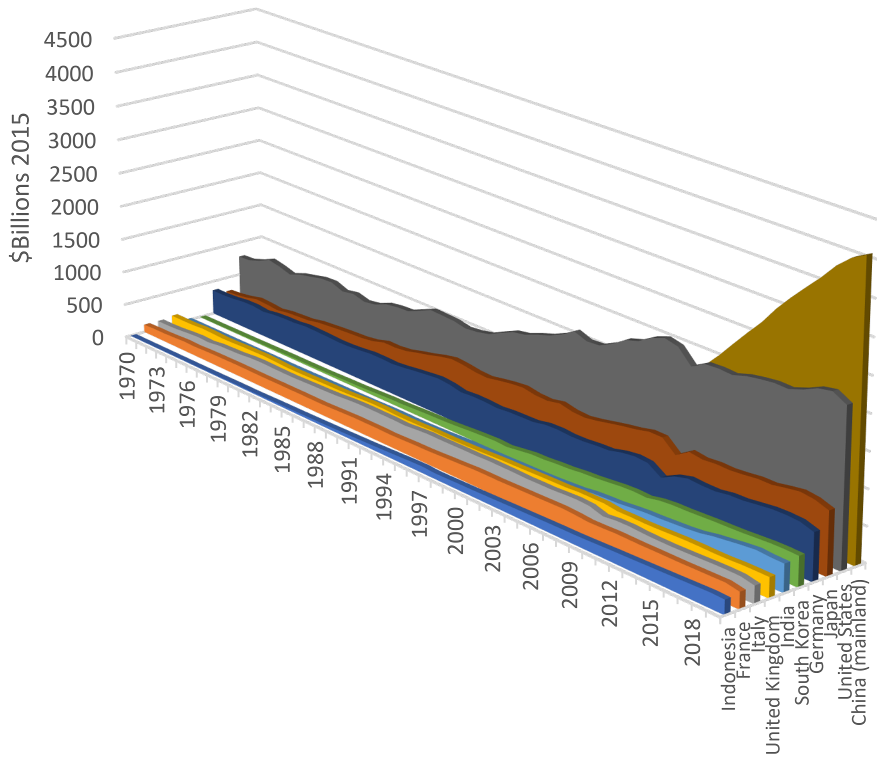


Figure 2.2: National 5-Year Compound Annual Growth, by Country (2016 to 2021): Higher is Better

Data Source: United Nations Statistics Division. (2023). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp



Data Source: United Nations Statistics Division. (2023).
"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 2021)

dollars, the U.S. produced $2.4 trillion in manufacturing valued added while China produced $4.5 trillion. As illustrated in Figure 2.4, U.S. manufacturing value added was 11.5 % of national GDP in 2021. In comparison, Germany's manufacturing industry was 22.2 %, China was 28.4 %, and Japan was 20.6 % with the world average being 17.5 %. Although the U.S. is below average, this can be somewhat deceiving, as 2021 U.S. GDP per capita ($61 103) is significantly higher than both Japan ($34 603) and Germany ($38 217) along with most other countries, which makes the denominator disproportionally larger when calculating the proportion of the economy that manufacturing represents. Thus, a more meaningful measure might be manufacturing GDP (i.e., value added) per capita. Among the ten largest manufacturing countries, the U.S. has the 4th largest manufacturing value added per capita, as seen in Figure 2.5. Out of all countries the U.S. ranks 14th, as seen in Figure 2.6. Since 1970, the U.S. ranking has ranged between 11th and 16th. It is important to note that there are varying means for adjusting data that can change the rankings slightly. 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 country. The drawback of PPP is that it is difficult to measure and methodological questions have been raised about some surveys that collect

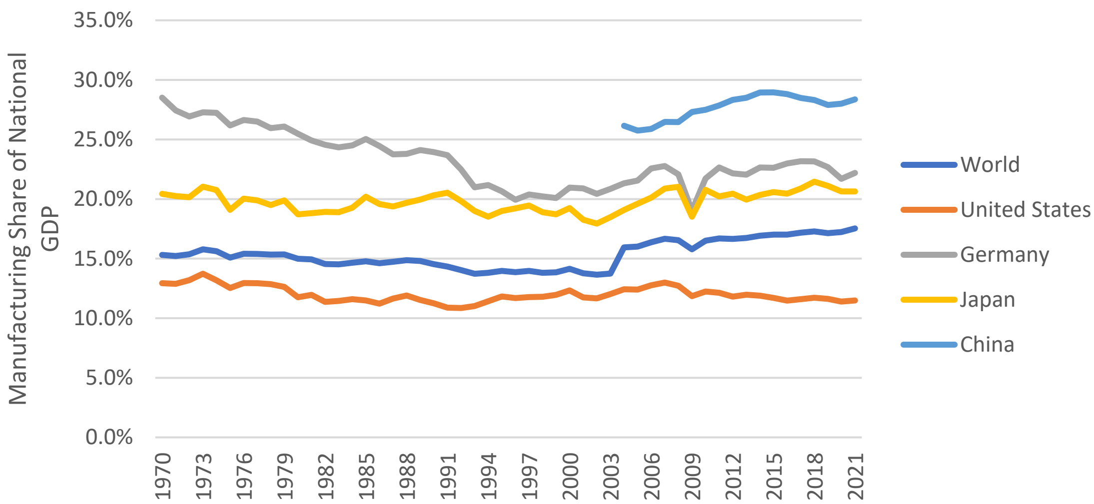
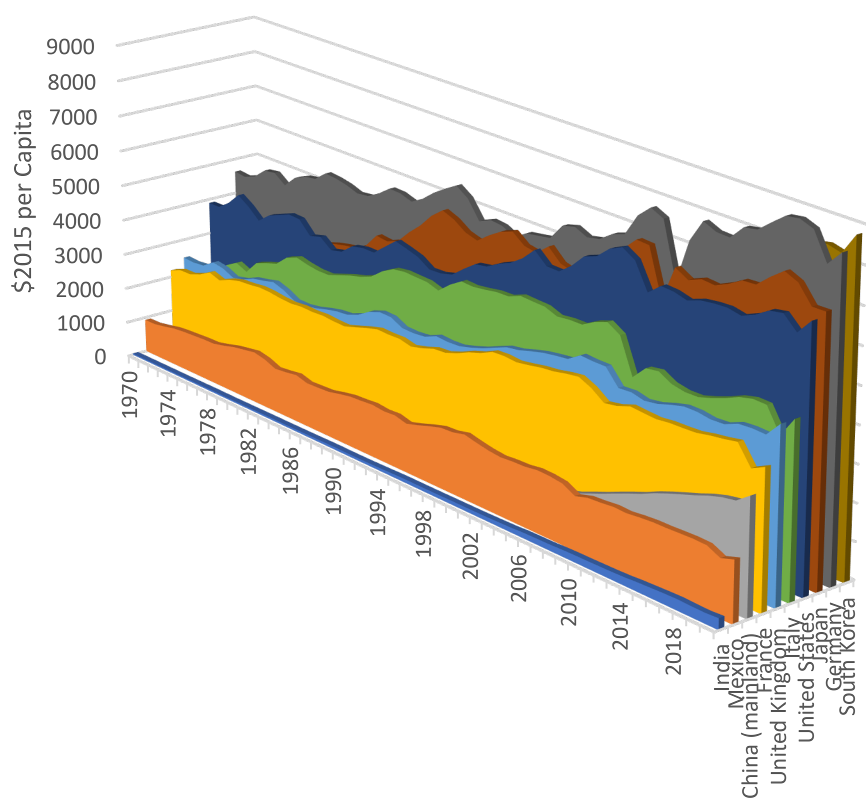


Figure 2.4: Manufacturing's Share of National GDP

Data Source: United Nations Statistics Division. (2023). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp



Data Source: United Nations Statistics Division. (2023). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp

Figure 2.5: Manufacturing Value Added Per Capita, Top 10 Largest Manufacturing Countries (1970 to 2021): Higher is Better

data for these calculations.[11] Market based rates tend to be relevant for internationally traded goods;[12] therefore, this report often utilizes these rates.

In terms of subsectors of manufacturing, the U.S. ranks 1st in 7 industries out of 16 total, as seen in Figure 2.7 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 a close representation, as national activity generally moves slowly.

A more recent estimate of manufacturing value added by subsector and country is provided in Figure 2.8, which provides estimates for 2020; however, the subsectors are broader than those in Figure 2.7. Data for some countries was not available, however, 76 countries have data for all six subsectors. These countries represent 91.3 % of global manufacturing. The data in Figure 2.8 shows the U.S. being the second largest country in terms of valued added for every subsector except textiles and clothing, where it is the fourth largest. China is the largest for all subsectors.

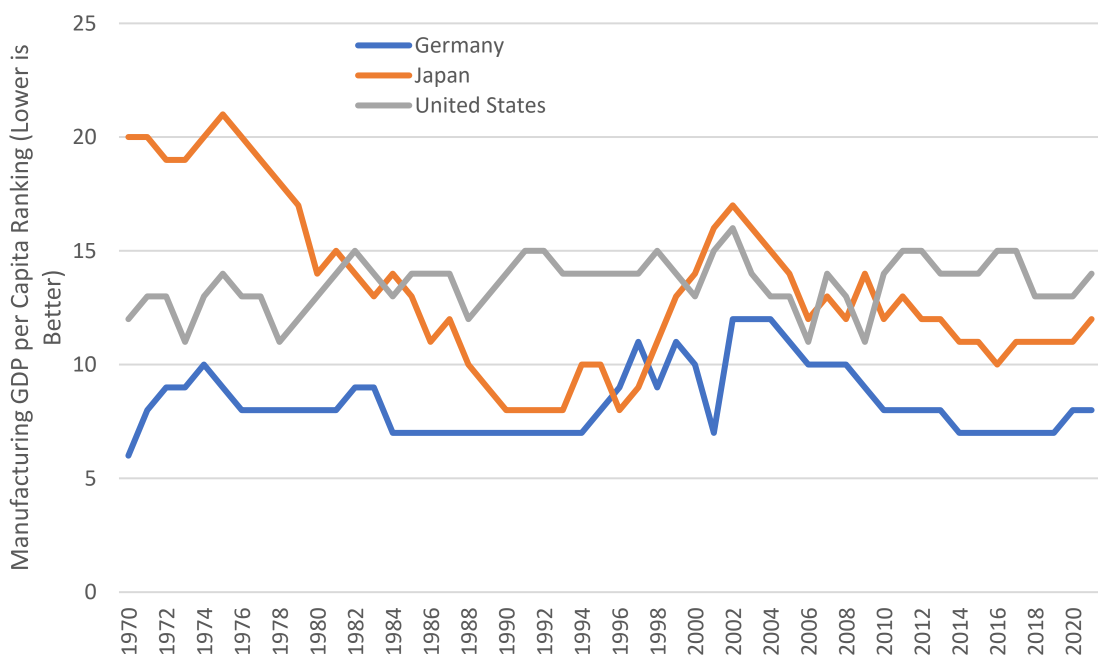


Figure 2.6: Manufacturing Per Capita Ranking, 1970-2021: Lower is Better

Data Source: United Nations Statistics Division. (2023). “National Accounts Main Aggregates Database.” http://unstats.un.org/unsd/snaama/Introduction.asp

[11] 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
[12] Ibid.

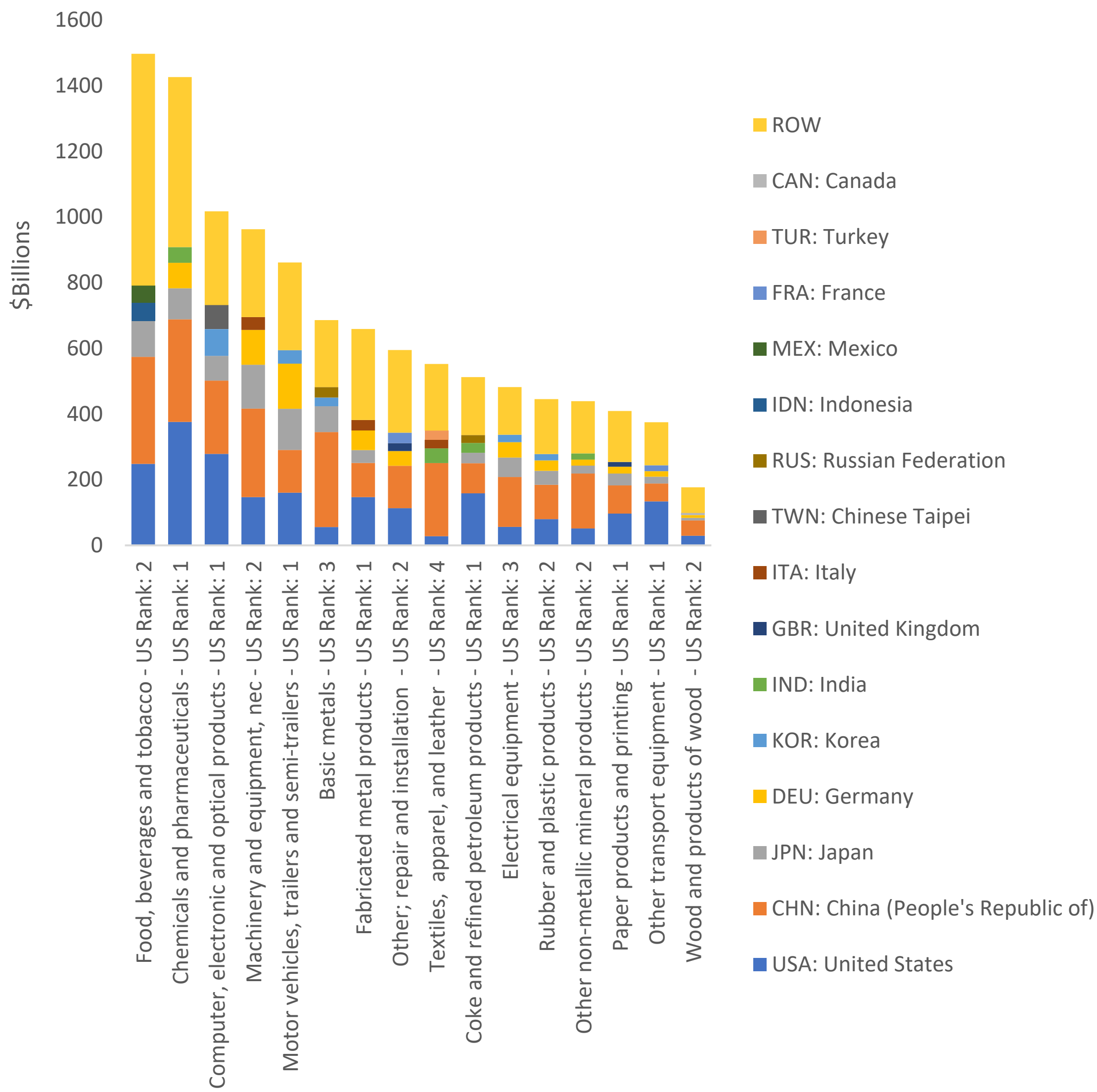


Figure 2.7: Global Manufacturing Value Added by Industry, Top Five Producers and Rest of World (ROW) (2015) – 64 Countries

Source: OECD. (2020) STAN Input-Output Tables. https://stats.oecd.org/

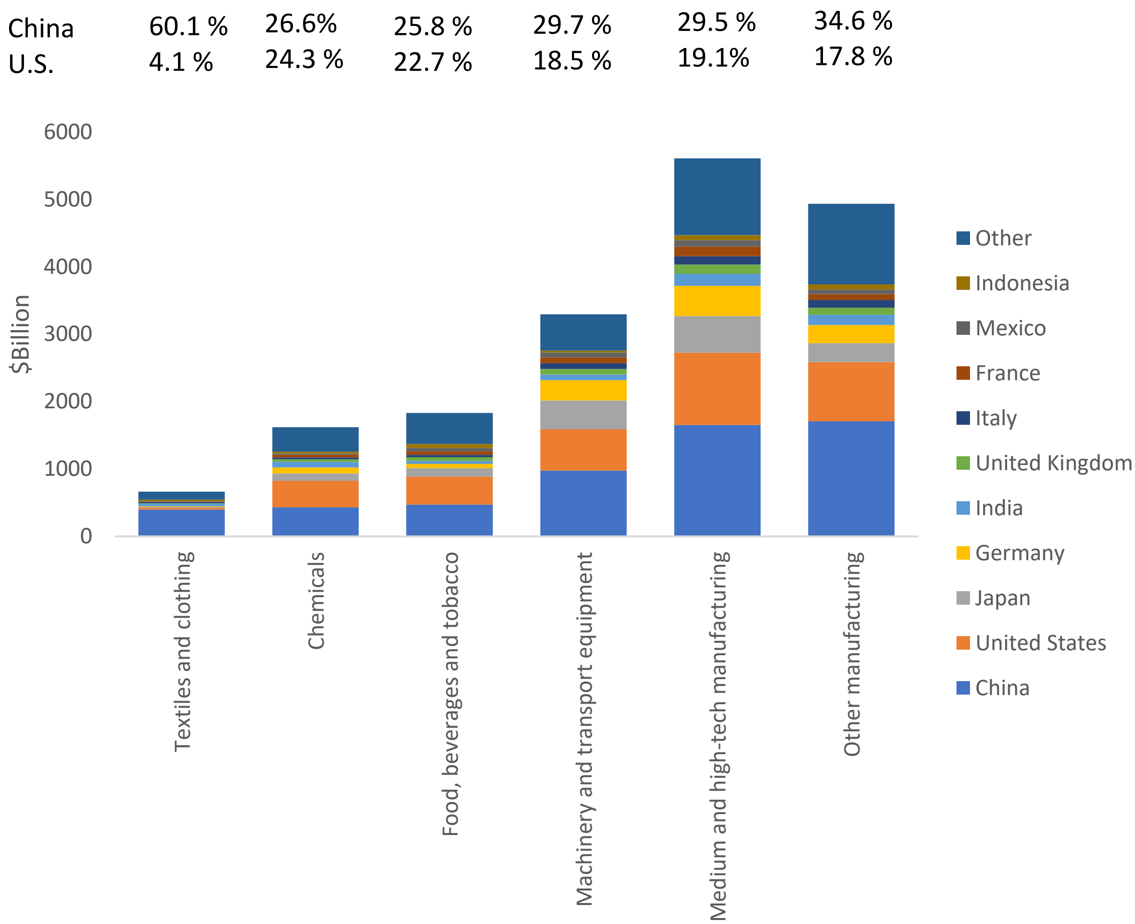


Figure 2.8: Value Added by Major Sectors, Top 10 Largest Manufacturing Countries, 2020

Note: These values were estimated using the total manufacturing valued added from the United Nations Statistics Division multiplied by the percent of manufacturing value added that each sector represents from the World Bank.
Note: Data for all six categories were available for 76 countries; thus, the estimates do not reflect total global production. The countries with all six categories available represent 91.3 % of global manufacturing.
Note: China and U.S. percentages are the percent of the total of the countries with data available.
Sources: World Bank. 2023. World Development Indicators. https://data.worldbank.org/products/wdi.
United Nations Statistics Division. (2023). "National Accounts Main Aggregates Database."
http://unstats.un.org/unsd/snaama/Introduction.asp

2.2. Domestic Details

There are two primary methods for adjusting value added for inflation. The first is using chained dollars, which uses a changing selection of goods to adjust for inflation. The second uses an unchanging selection of goods to adjust for inflation. [13] There has been some dispute about the accuracy of each for some goods. This report presents value added in chained dollars. Previous reports included both; however, the differences are often minor.

[13] Dornbusch, Rudiger, Stanley Fischer, and Richard Startz. (2000). Macroeconomics. 8th ed. London, UK: McGraw-Hill. 32.

Figure 2.9 shows the cumulative change in manufacturing, durable goods, and nondurable goods manufacturing from 2005 forward. From the pre-recession peak in the 4th quarter of 2007 to the 1st quarter of 2009 manufacturing declined 17 percentage points. Manufacturing didn't return to its pre-recession level until 2017. During the recent pandemic, manufacturing value added declined 17 percentage points between the third quarter of 2019 and second quarter of 2020, but returned to similar levels within a year.

Manufacturing value added in the U.S. in 2022 was $2.3 trillion in chained 2012 dollars or 11.4 % of GDP.[14] Using chained dollars from the BEA shows that manufacturing increased by 0.2 % between 2021 and 2022. Figure 2.10 and Figure 2.11 provide more detailed data on durable and nondurable goods within the manufacturing industry. As seen in Figure 2.10, long term 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, as of 2015, the U.S. was also the largest producer of computer and electronic products. As seen in Figure 2.11, in 2022 only two of eight non-durable sectors were above their 2008 value. The largest manufacturing subsector in the U.S. is computer and electronic products followed by chemical manufacturing; food, beverage, and tobacco products; and motor vehicles, trailers, and parts, as seen in Figure 2.12. Note that this is based on chained dollars. Adjustments using other methods or the nominal value can have slightly different results.

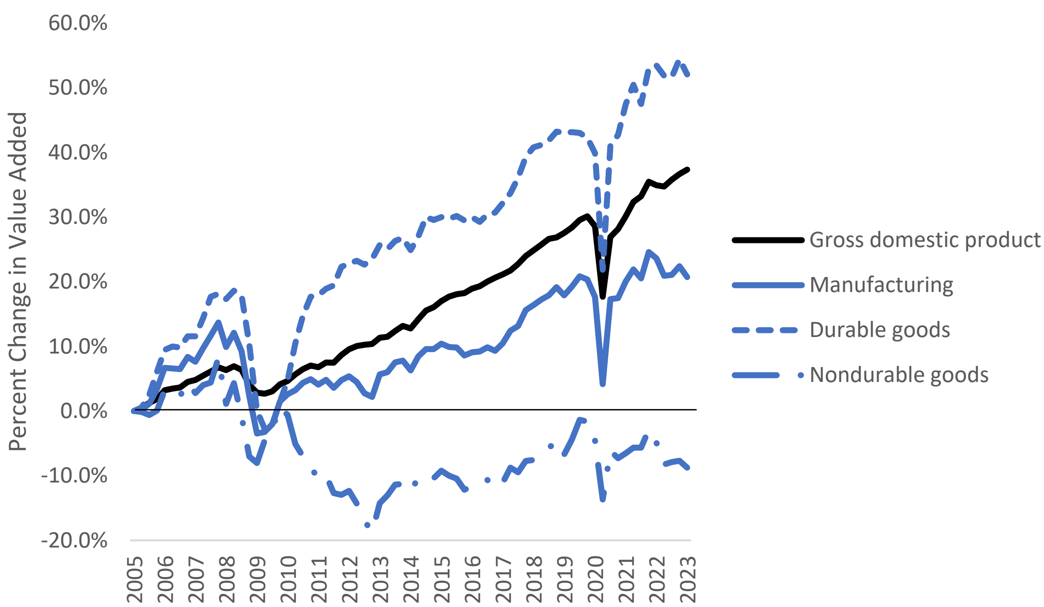
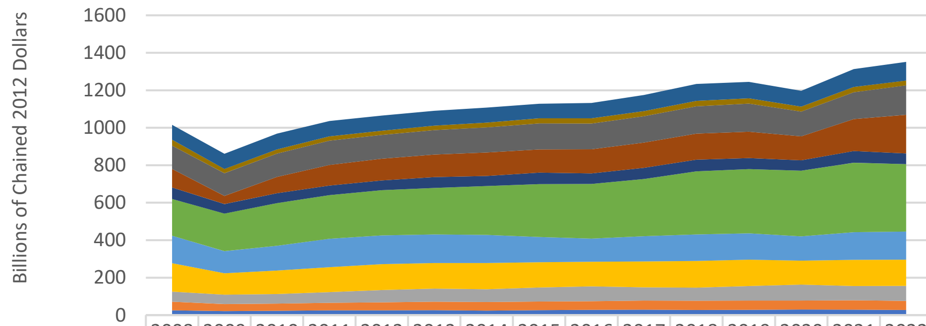


Figure 2.9: Cumulative Percent Change in Value Added (2012 Chained Dollars)

Bureau of Economic Analysis. (2023a). "Industry Economic Accounts Data." http://www.bea.gov/iTable/index_industry_gdpIndy.cfm

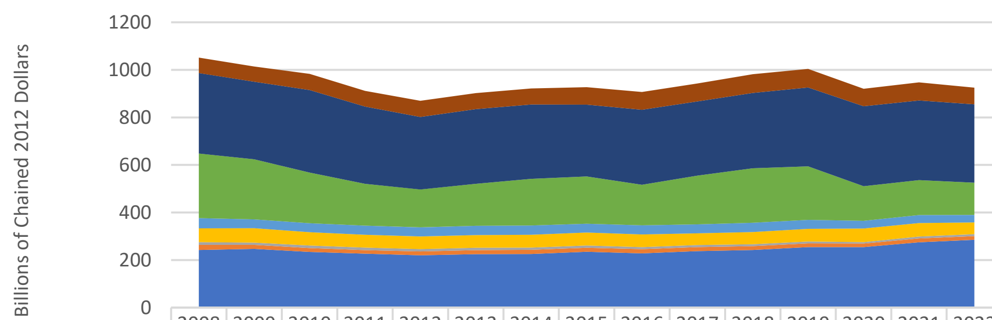
[14] Bureau of Economic Analysis. (2021) "Industry Economic Accounts Data." http://www.bea.gov/iTable/index_industry_gdpIndy.cfm



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Miscellaneous manufacturing	79	81	84	82	81	79	81	78	83	86	90	89	84	95	100
Furniture and related products	31	23	23	23	22	24	26	27	28	28	29	28	26	28	26
Other transportation equipment	124	121	124	130	127	130	133	139	137	141	146	151	132	143	157
Motor vehicles, trailers, and parts	100	43	87	110	116	121	125	123	129	134	140	141	128	170	206
Elect. Equip., appliances, components	61	51	53	51	52	57	54	61	57	60	62	58	55	63	57
Computer and electronic products	196	200	227	233	241	248	261	282	291	306	337	343	350	371	360
Machinery	147	118	132	151	153	152	150	135	124	134	142	141	130	148	150
Fabricated metal products	151	114	126	134	138	137	140	135	131	138	142	141	127	139	140
Primary metals	54	50	51	57	66	70	68	75	79	70	70	77	85	76	80
Nonmetallic mineral products	47	38	39	41	43	45	46	46	46	49	49	49	48	50	48
Wood products	25	22	23	25	26	27	24	27	28	29	28	29	30	30	28

Figure 2.10: Value Added for Durable Goods by Type (billions of chained dollars), 2008-2022

Data Source: Bureau of Economic Analysis. (2023a) "Industry Economic Accounts Data." http://www.bea.gov/iTable/index_industry_gdpIndy.cfm



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Plastics and rubber products	65	64	68	66	68	67	67	74	75	76	79	78	74	77	70
Chemical products	338	326	348	325	305	314	313	302	315	312	317	331	336	335	329
Petroleum and coal products	272	253	213	176	159	177	196	199	171	205	229	226	146	147	136
Printing and related activities	43	37	38	39	38	39	39	38	38	38	39	38	32	34	32
Paper products	58	61	56	54	53	54	54	55	53	49	52	53	57	57	49
Apparel and leather products	12	10	11	11	10	10	10	9	9	9	8	8	6	8	8
Textile mills, textile product mills	22	17	17	15	16	17	18	17	18	17	16	16	15	16	16
Food, beverage, tobacco products	242	247	234	227	220	225	225	235	228	238	242	254	254	275	285

Figure 2.11: Value Added for Nondurable Goods by Type (billions of chained dollars), 2008-2022: Higher is Better

Data Source: Bureau of Economic Analysis. (2023a) "Industry Economic Accounts Data." http://www.bea.gov/iTable/index_industry_gdpIndy.cfm

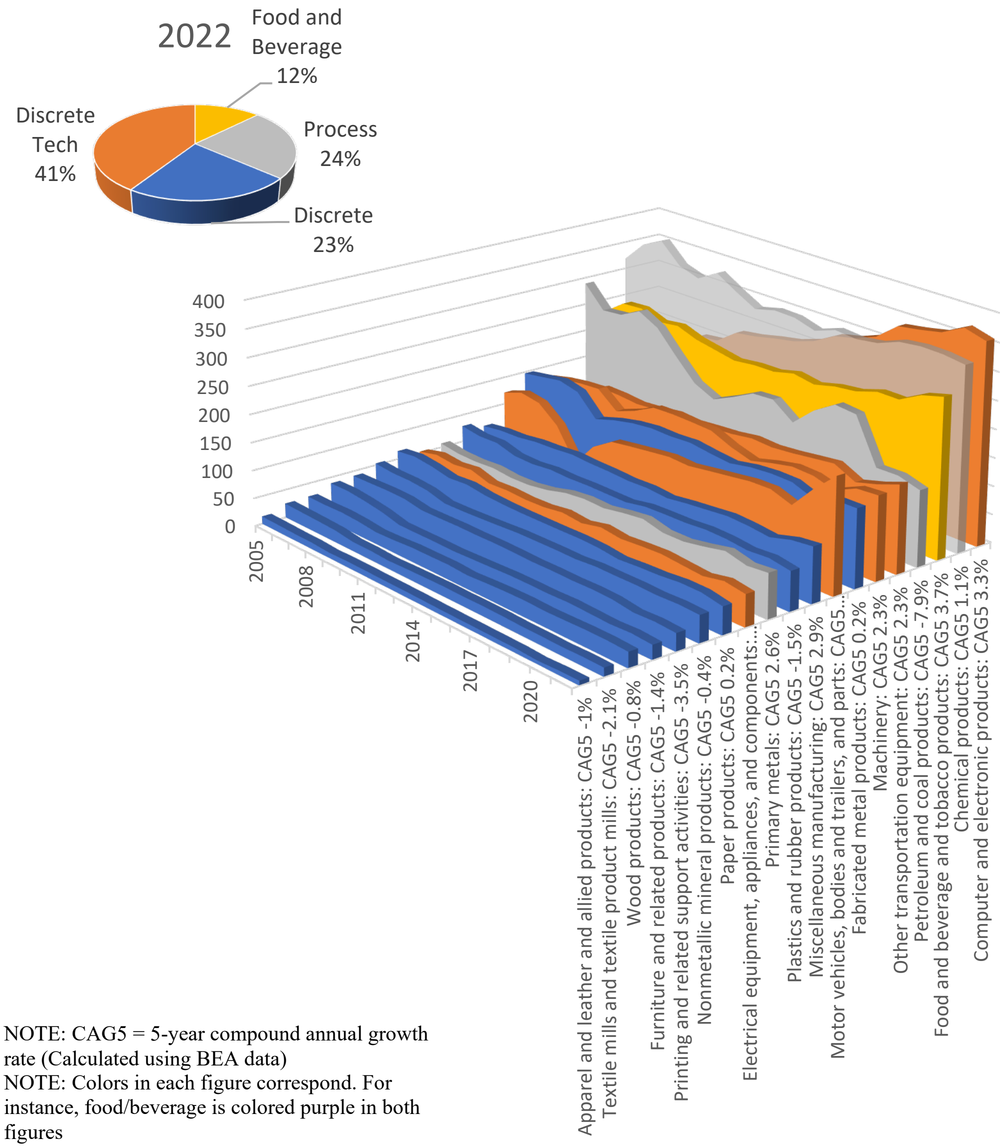


Figure 2.12: Manufacturing Value Added by Subsector (billions of chained dollars), 2005-2022

Data Source: Bureau of Economic Analysis. (2023a) "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 investment in machinery, buildings, and intellectual property in the industry (see Figure 2.13, Figure 2.14, Figure 2.15, and Figure 2.16). Discrete technology manufacturing (i.e., computer manufacturing, transportation equipment manufacturing, machinery manufacturing, and electronics manufacturing) accounts for 30 % of all manufacturing equipment and 33 % of structures. The 5-year compound annual growth in computer and electronic manufacturing equipment is negative; however, structures is growing at a rate of 2.4 %. Recall that in 2015, the U.S. was the largest producer of these goods and, as of 2022, it is the largest subsector of U.S. manufacturing.

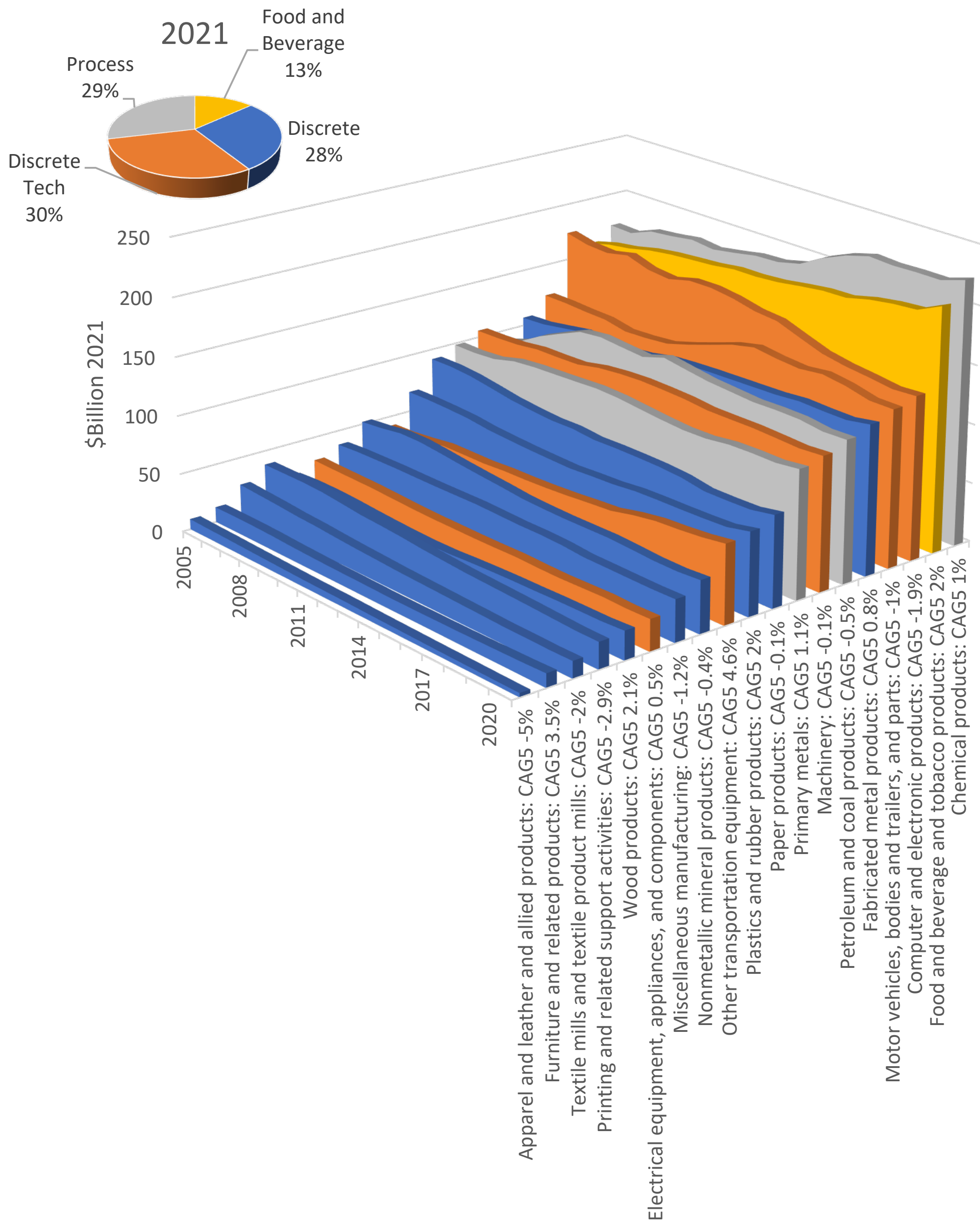


Figure 2.13: Current-Cost Net Stock: Private Equipment, Manufacturing (2005-2021)

NOTE: CAG5 = 5-year compound annual growth rate (Calculated using BEA data)
NOTE: Colors in each figure correspond. For instance, food/beverage is colored purple in both figures
Adjusted using the Consumer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. (2023b) “Fixed Assets Accounts Tables.” https://apps.bea.gov/iTable/iTable.cfm?ReqID=10&step=2

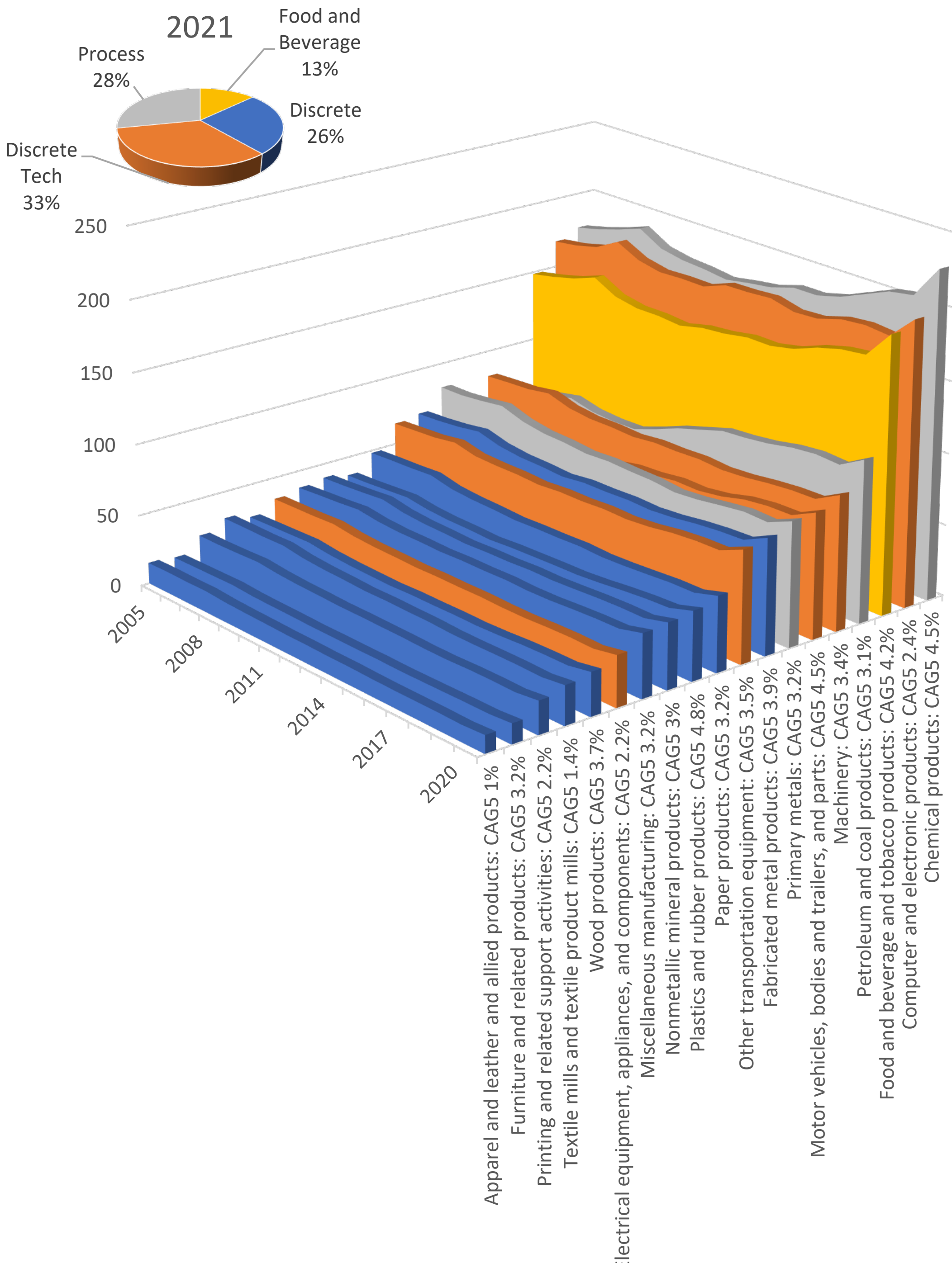


Figure 2.14: Current-Cost Net Stock: Private Structures, Manufacturing (2005-2021)

NOTE: CAG5 = 5-year compound annual growth rate (Calculated using BEA data)
NOTE: Colors in each figure correspond. For instance, food/beverage is colored purple in both figures
Adjusted using the Consumer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. (2023b) “Fixed Assets Accounts Tables.” https://apps.bea.gov/iTable/iTable.cfm?ReqID=10&step=2

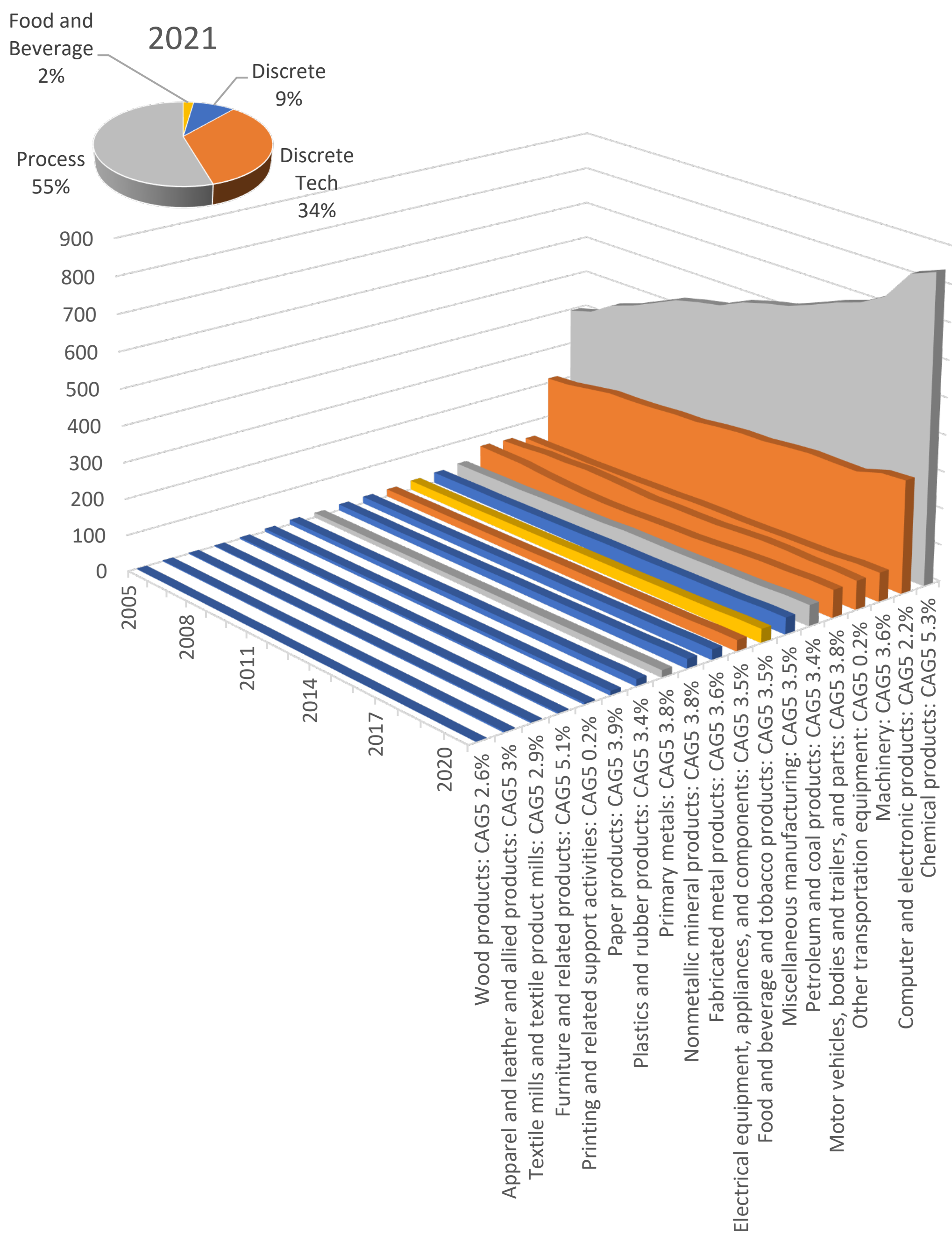


Figure 2.15: Current-Cost Net Stock: Intellectual Property Products, Manufacturing (2005-2021)

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
Adjusted using the Consumer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. (2023b) "Fixed Assets Accounts Tables." https://apps.bea.gov/iTable/iTable.cfm?ReqID=10&step=2

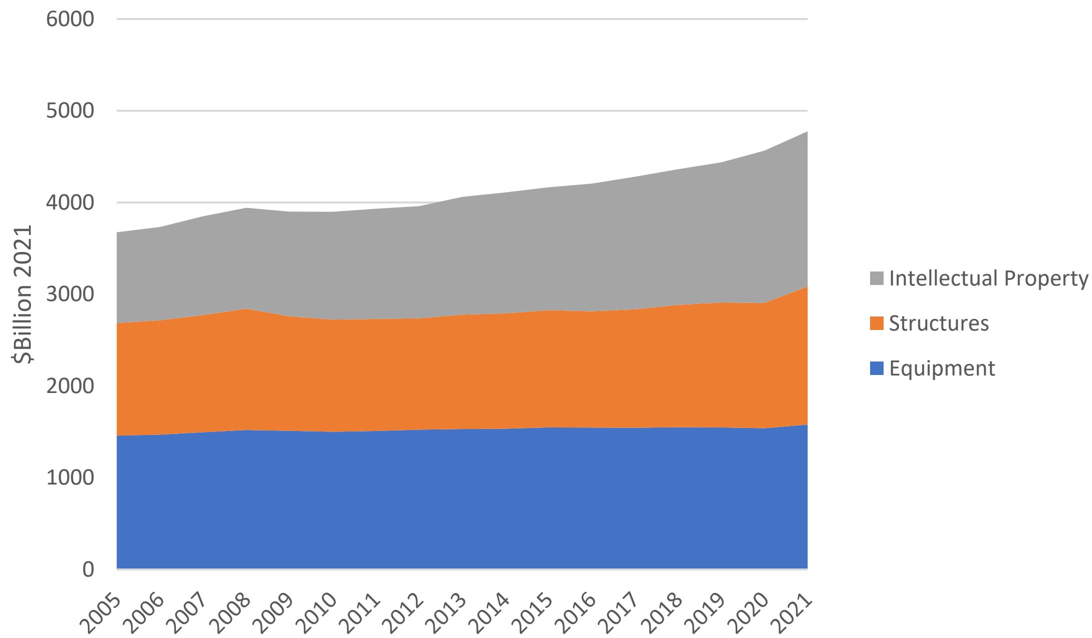


Figure 2.16: Current-Cost Net Stock in Manufacturing, by Type (2005-2021)

Adjusted using the Consumer Price Index from the Bureau of Labor Statistics
Data Source: Bureau of Economic Analysis. (2023b) "Fixed Assets Accounts Tables."
https://apps.bea.gov/iTable/iTable.cfm?ReqID=10&step=2

3. US Manufacturing Supply Chain

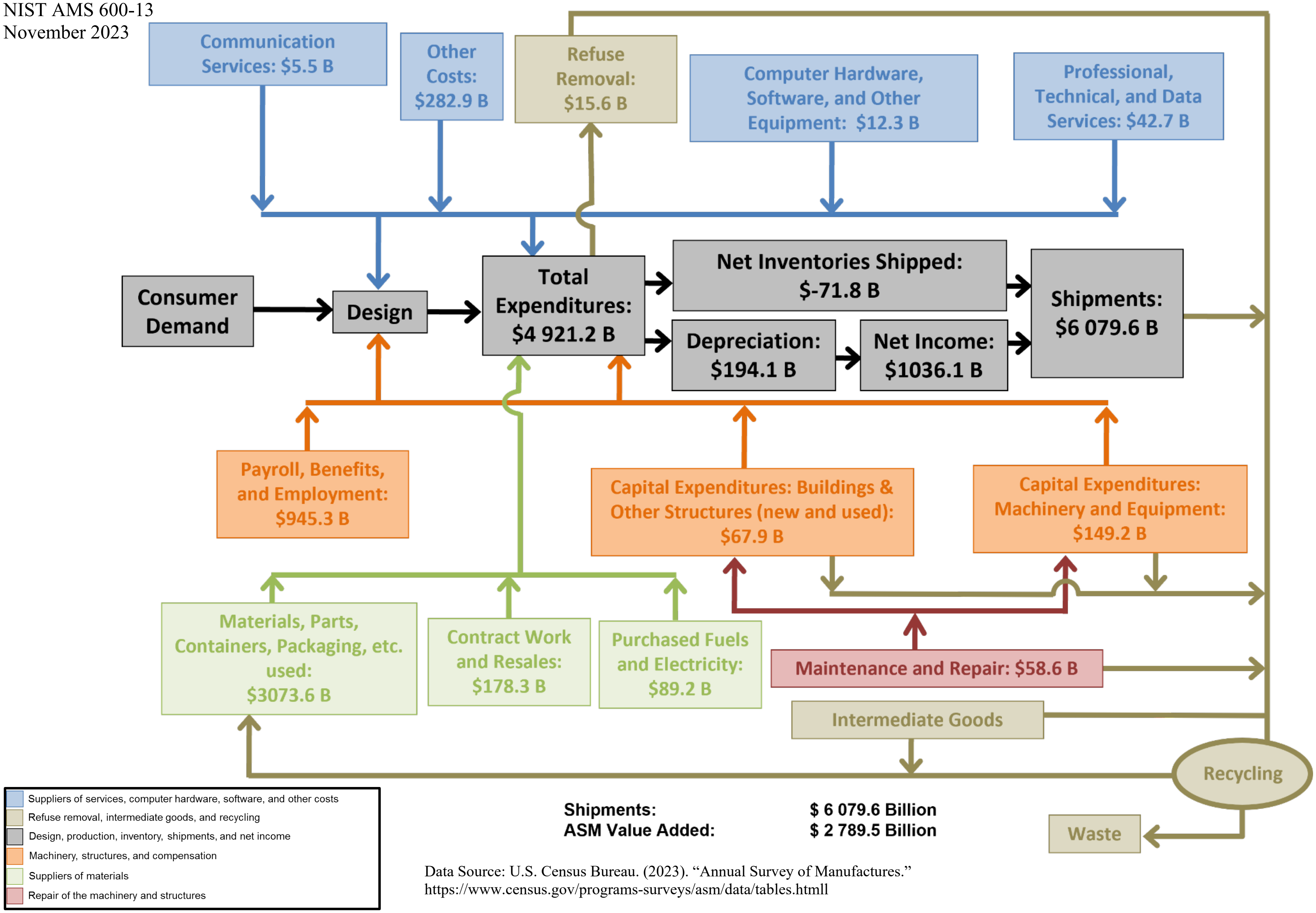
There are many suppliers of goods and services that have a stake in manufacturing; these include resellers, providers of transportation and warehousing, raw material suppliers, suppliers of intermediate goods, and suppliers of professional services. Using data from the Annual Survey of Manufactures,[15] Table 3.1 presents and Figure 3.1 maps the purchases that the manufacturing industry made for production, which is disaggregated into five

Table 3.1: Supply Chain Entities and Contributions, Annual Survey of Manufactures, 2021

	2021 ($Billions 2021)
I. Services, Computer Hardware, Software, and Other Expenditures	
a. Communication Services	5.5
b. Computer Hardware, Software, and Other Equipment	12.3
c. Professional, Technical, and Data Services	42.7
d. Other Expenditures	282.9
e. TOTAL	**343.4**
II. Refuse Removal Expenditures	**15.6**
III. Machinery, Structures, and Compensation Expenditures	
a. Payroll, Benefits, and Employment	945.3
b. Capital Expenditures: Structures (including rental)	67.9
c. Capital Expenditures: Machinery/Equipment (including rental)	149.2
d. TOTAL	**1162.4**
IV. Suppliers of Materials Expenditures	
a. Materials, Parts, Containers, Packaging, etc… Used	3073.6
b. Contract Work and Resales	178.3
c. Purchased Fuels and Electricity	89.2
d. TOTAL	**3341.2**
V. Maintenance and Repair Expenditures	**58.6**
VI. Shipments	
a. Expenditures	4921.2
b. Net Inventories Shipped	-71.8
c. Depreciation	194.1
d. Net Income	1036.1
E. TOTAL	**6079.6**
VII. Value Added estimates	
a. Value added calculated VI.E-VI.b-VI.A+III.a	2175.6
b. ASM Value added	2789.5
c. BEA value added	2496.8

Note: Colors correspond with those in Figure 3.1
Source: U.S. Census Bureau. (2023).

[15] U.S. Census Bureau. (2022). "Annual Survey of Manufactures." https://www.census.gov/programs-surveys/asm/data/tables.html



Data Source: U.S. Census Bureau. (2023). "Annual Survey of Manufactures." https://www.census.gov/programs-surveys/asm/data/tables.htmll

Figure 3.1: Manufacturing Supply Chain, 2021

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.

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." [16] As seen in Table 3.2, there is an estimated $1939 billion in manufacturing value added with an additional $2339 billion in indirect value added from other industries for manufacturing, as calculated using input-output analysis.[17] Direct and indirect manufacturing accounts for 24.1 % of total GDP.

In 2021, the U.S. imported approximately 20.4 % 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 12.4 %. As can be seen in Table 3.3, these proportions 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 U.S. 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

Table 3.2: Direct and Indirect Manufacturing Value Added

		Value Added ($ Billion 2019)		
NAICS	Description	Direct	Indirect	Total
	TOTAL U.S. GDP			17 775
31-33	Total Manufacturing*	1 939	2 339	4 278
333-336	Discrete Technology Products	676	680	1 356
313-323, 327-332, 337-339	Discrete Products	489	581	1 070
324-326	Process Products	534	1 077	1 611
311-312	Food, Beverage, and Tabaco	240	629	869

* The sum of the 3 digit NAICS does not equal total manufacturing due to overlap in supply chains.

Source: Thomas, Douglas. (2020). Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide
Note: These values are calculated by taking 2012 data and adjusting it to 2019; thus, they may not match other estimates in this report.

[16] Tassey Gregory. (2010) "Rationales and Mechanisms for Revitalizing U.S. Manufacturing R&D Strategies." *Journal of Technology Transfer*. 35. 283-333.
[17] This analysis uses the 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	3 299 062	697 789	5 073 606	21.2%	13.8%
2007	3 557 606	729 968	5 384 729	20.5%	13.6%
2008	3 690 928	841 311	5 473 777	22.8%	15.4%
2009	2 809 726	538 090	4 484 832	19.2%	12.0%
2010	3 219 052	673 484	4 991 727	20.9%	13.5%
2011	3 721 021	841 681	5 564 423	22.6%	15.1%
2012	3 838 013	839 127	5 742 330	21.9%	14.6%
2013	3 942 929	818 937	5 906 561	20.8%	13.9%
2014	3 972 514	827 537	5 992 760	20.8%	13.8%
2015	3 572 474	694 664	5 670 789	19.4%	12.2%
2016	3 440 157	641 801	5 513 136	18.7%	11.6%
2017	3 533 815	681 409	5 701 973	19.3%	12.0%
2018	3 782 706	748 939	6 086 825	19.8%	12.3%
2019	3 686 526	695 876	6 025 842	18.9%	11.5%
2020	3 259 481	593 649	5 473 588	18.2%	10.8%
2021	3 821 920	778 621	6 289 922	20.4%	12.4%

Source Data: Bureau of Economic Analysis. (2023c). Input-Output Accounts Data. https://www.bea.gov/industry/input-output-accounts-data
* Commodities used by industries
** From the import matrix

U.S. national trends. Tabikh estimates from survey data in Sweden that the percent of planned production time that is downtime amounts to 13.3 %.[18] According to NIST's Manufacturing Cost Guide, downtime amounts to 8.3 % of planned production time and amounts to $245 billion for discrete manufacturing (i.e., NAICS 321-339 excluding NAICS 324 and 325).[19] In addition to downtime, defects result in additional losses. The Manufacturing Cost Guide estimates that defects amount to between $32.0 billion and $58.6 billion for discrete manufacturing (i.e., NAICS 321-339 excluding NAICS 324 and 325), depending on the method used for estimation.[20]

The USGS estimates that 15 % of steel mill products end up as scrap in the manufacturing process.[21] 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

[18] Tabikh, Mohamad. (2014). "Downtime Cost and Reduction Analysis: Survey Results." Master Thesis. KPP321. Mälardalen University. http://www.diva-portal.org/smash/get/diva2:757534/FULLTEXT01.pdf
[19] Thomas, Douglas. (2020). Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide
[20] Thomas, Douglas. (2020). Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide
[21] Fenton, M. D. (2001) "Iron and Steel Recycling in the United States in 1998." Report 01-224. U.S. Geological Survey: 3. https://pubs.usgs.gov/of/2001/of01-224/

Table 3.4: Percent of U.S. 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

Source: Thomas, Douglas. (2020). Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide

(25 % of steel loss and 40 % of aluminum loss), the shape produced[22] (10 % to 15 % of loss), and defects in the manufacturing processes (5 % of loss).[23] 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.

Another source of losses can be found in cybercrime where criminals can disrupt production and/or steal intellectual property. The Manufacturing Cost Guide estimates that manufacturers lost between $8.9 billion and $38.6 billion due to cybercrime.

Manufacturing costs also accumulate in assets such as buildings, machinery, and inventory. In addition to the estimates provided in Figure 2.13, Figure 2.14, Figure 2.15, and Figure 2.16, data on assets is published periodically in the Economic Census. As seen in Table 3.5, total depreciable assets amount to $3.4 trillion with $2.7 trillion being machinery and equipment.

[22] 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.
[23] Allwood, J. M. & Cullen, J. M. (2012). Sustainable Materials with Both Eyes Open. Cambridge Ltd. 185. http://www.withbotheyesopen.com/

Table 3.5: Depreciable Assets and the Rate of Change, 2017 ($million 2017)

	Buildings and Structures	Machinery and Equipment	Total
Gross value of depreciable assets (acquisition costs), beginning of year	661 841*	2 645 636*	3 307 476
Capital Expenditures (added to assets)	33 705	134 733	168 438
Retirements (subtracted from assets)	11 597*	46 358*	57 955
Gross value of depreciable assets (acquisition costs, end of year)	683 949	2 734 011	3 417 960
Percent of depreciable assets that are new (end of year)			4.9%

* Assumes that the proportions of buildings and structures or machinery and equipment are the same as that for capital expenditures.

Source: U.S. Census Bureau. (2020) 2017 Economic Census. https://www.census.gov/data/tables/2017/econ/economic-census/naics-sector-31-33.html

A frequently invoked axiom suggests that roughly 80 % of a problem is due to 20 % of the cause, a phenomenon referred to as the Pareto principle. [24] That is, a small portion of the cause accounts for a large portion of the problem. Joseph Juran proposed that the Pareto principle could be applied to an organization's operations.[25] For instance, 80 % of defects would be the result of 20 % of the causes. Identifying that small portion of the cause (i.e., the 20 %) can facilitate making large efficiency improvements in operations. Manufacturing industry NAICS codes are categories of production activities. A larger industry (i.e., one in the top 20 %) suggests that there is more of a particular type of activity and/or the activities are more costly; thus, an increase in productivity in a larger industry would either reduce a costly activity or reduce an activity that occurs at high frequency. The result is a greater impact than might otherwise be achieved. 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.[26] Table 3.6 provides a list of the top 20 % of domestic supply chain industries for U.S. manufacturing by value added. 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.

[24] Hopp, Wallace J. and Mark L. Spearman. (2008). Factory Physics. Third Edition. (Waveland Press, Long Grove, IL.
[25] Six Sigma Daily. "Remembering Joseph Juran And His Lasting Impact on Quality Improvement." https://www.sixsigmadaily.com/remembering-joseph-juran-quality-improvement/
[26] 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

Table 3.6: Top 20 % of Domestic Supply Chain Entities, Value Added

Code	Industry Description	$Billion 2019	Code	Industry Description	$Billion 2019
324110	Petroleum refineries	596.1	482000	Rail transportation	26.6
211000	Oil and gas extraction	516.1	325180	Other Basic Inorganic Chemical Manufacturing	26.0
550000	Management of companies and enterprises	128.5	112A00	Animal production, except cattle and poultry and eggs	26.0
325412	Pharmaceutical preparation manufacturing	83.0	336390	Other Motor Vehicle Parts Manufacturing	25.8
336112	Light truck and utility vehicle manufacturing	78.5	339112	Surgical and medical instrument manufacturing	25.7
424A00	Other nondurable goods merchant wholesalers	77.5	533000	Lessors of nonfinancial intangible assets	25.3
336411	Aircraft manufacturing	76.6	334510	Electromedical and electrotherapeutic apparatus manufacturing	24.7
423A00	Other durable goods merchant wholesalers	68.9	522A00	Nondepository credit intermediation and related activities	24.7
221100	Electric power generation, transmission, and distribution	63.4	322120	Paper mills	24.6
331110	Iron and steel mills and ferroalloy manufacturing	59.8	3259A0	All other chemical product and preparation manufacturing	24.4
325110	Petrochemical manufacturing	57.2	5241XX	Insurance carriers, except direct life	24.1
484000	Truck transportation	56.7	1111A0	Oilseed farming	24.0
531ORE	Other real estate	55.3	486000	Pipeline transportation	23.9
325190	Other basic organic chemical manufacturing	54.9	541200	Accounting, tax preparation, bookkeeping, and payroll services	23.7
312200	Tobacco product manufacturing	48.7	21311A	Other support activities for mining	23.3
336412	Aircraft engine and engine parts manufacturing	48.6	311810	Bread and bakery product manufacturing	22.5
334413	Semiconductor and related device manufacturing	48.1	333120	Construction machinery manufacturing	22.4
334511	Search, detection, and navigation instruments manufacturing	42.7	561700	Services to buildings and dwellings	22.1
326190	Other plastics product manufacturing	42.6	230301	Nonresidential maintenance and repair	21.4
323110	Printing	41.8	322210	Paperboard container manufacturing	21.4
52A000	Monetary authorities and depository credit intermediation	38.7	339113	Surgical appliance and supplies manufacturing	21.3
424700	Petroleum and petroleum products	37.5	332310	Plate work and fabricated structural product manufacturing	21.2
325211	Plastics material and resin manufacturing	36.9	33291A	Valve and fittings other than plumbing	20.8
1111B0	Grain farming	36.3	423600	Household appliances and electrical and electronic goods	20.3
1121A0	Cattle ranching and farming	34.4	333415	Air conditioning, refrigeration, and warm air heating equipment	20.1
423800	Machinery, equipment, and supplies	33.1	331200	Steel product manufacturing from purchased steel	19.6
334220	Broadcast and wireless communications equipment	31.1	325620	Toilet preparation manufacturing	19.6
561300	Employment services	31.0	333130	Mining and oil and gas field machinery manufacturing	19.4
336111	Automobile manufacturing	30.1	524200	Insurance agencies, brokerages, and related activities	19.2
541300	Architectural, engineering, and related services	29.4	332320	Ornamental and architectural metal products manufacturing	19.1
325610	Soap and cleaning compound manufacturing	29.0	333111	Farm machinery and equipment manufacturing	19.1
424400	Grocery and related product wholesalers	28.6	33441A	Other electronic component manufacturing	19.0
336413	Other aircraft parts and auxiliary equipment manufacturing	28.5	326110	Plastics packaging materials and unlaminated film and sheet manufacturing	18.9
325310	Fertilizer manufacturing	28.5	332800	Coating, engraving, heat treating and allied activities	18.5
325414	Biological product (except diagnostic) manufacturing	28.4	331490	Nonferrous metal (except copper and aluminum)	18.1
541100	Legal services	28.4	423100	Motor vehicle and motor vehicle parts and supplies	18.1
332710	Machine shops	28.1	541610	Management consulting services	17.8
31161A	Animal (except poultry) slaughtering, rendering, and processing	28.1	5419A0	All other miscellaneous professional, scientific, and technical services	17.7

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	$2019 Billion
000000	All Occupations	1822.7
510000	Production Occupations	433.2
110000	Management Occupations	277.2
430000	Office and Administrative Support Occupations	180.7
530000	Transportation and Material Moving Occupations	144.9
130000	Business and Financial Operations Occupations	144.3
170000	Architecture and Engineering Occupations	141.8
410000	Sales and Related Occupations	117.9
150000	Computer and Mathematical Occupations	103.7
490000	Installation, Maintenance, and Repair Occupations	101.3
470000	Construction and Extraction Occupations	43.6
190000	Life, Physical, and Social Science Occupations	24.9
270000	Arts, Design, Entertainment, Sports, and Media Occupations	18.9
230000	Legal Occupations	18.7
450000	Farming, Fishing, and Forestry Occupations	16.6
370000	Building and Grounds Cleaning and Maintenance Occupations	16.2
290000	Healthcare Practitioners and Technical Occupations	11.3
350000	Food Preparation and Serving Related Occupations	11.1
330000	Protective Service Occupations	6.8
390000	Personal Care and Service Occupations	2.5
250000	Education, Training, and Library Occupations	1.6
310000	Healthcare Support Occupations	1.3
210000	Community and Social Service Occupations	1
	TOTAL	3642.3

Source: Thomas, Douglas. (2020). Manufacturing Cost Guide. https://www.nist.gov/services-resources/software/manufacturing-cost-guide

4. Employment, Compensation, Profits, and Productivity

The Annual Survey of Manufactures estimates that there were 11.2 million employees in the manufacturing industry in 2021, which is the most recent data available (see Table 4.1). The Current Population Survey estimates that there were 15.2 million manufacturing employees in 2022 and the Current Employment Statistics estimates 12.8 million employees in 2022, the most recent data available (see Table 4.2 and Table 4.3). According to data in Table 4.2, manufacturing accounted for 9.6 % of total employment. 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

Table 4.1: Employment, Annual Survey of Manufactures

NAICS	Description	2020	2021
311	Food manufacturing	1 509 076	1 509 329
312	Beverage and tobacco product manufacturing	214 712	224 136
313	Textile mills	78 736	77 854
314	Textile product mills	97 569	96 965
315	Apparel manufacturing	65 696	62 491
316	Leather and allied product manufacturing	25 213	25 055
321	Wood product manufacturing	395 339	398 867
322	Paper manufacturing	328 945	330 425
323	Printing and related support activities	372 745	351 849
324	Petroleum and coal products manufacturing	105 383	100 428
325	Chemical manufacturing	758 902	778 136
326	Plastics and rubber products manufacturing	768 225	773 438
327	Nonmetallic mineral product manufacturing	386 482	384 716
331	Primary metal manufacturing	346 423	317 946
332	Fabricated metal product manufacturing	1 339 334	1 296 417
333	Machinery manufacturing	1 008 247	996 694
334	Computer and electronic product manufacturing	776 220	758 833
335	Electrical equipment, appliance, and component manufacturing	334 391	341 237
336	Transportation equipment manufacturing	1 535 704	1 534 161
337	Furniture and related product manufacturing	347 017	333 078
339	Miscellaneous manufacturing	510 868	513 924
TOTAL		11 305 227	11 205 979

Data Source: U.S. Census Bureau. (2023). “Annual Survey of Manufactures.” https://www.census.gov/programs-surveys/asm/data/tables.html

Table 4.2: Employment by Industry (Thousands): Current Population Survey

	Total Employed		
	2021	2022	Percent Change
Agriculture and related	2 291	2 290	0.0%
Mining, quarrying, and oil and gas extraction	603	601	-0.3%
Construction	11 271	11 790	4.6%
Manufacturing	14 718	15 231	3.5%
Wholesale and retail trade	19 623	19 462	-0.8%
Transportation and utilities	9 377	10 079	7.5%
Information	2 721	2 867	5.4%
Financial activities	10 725	11 033	2.9%
Professional and business services	19 295	20 628	6.9%
Education and health services	34 725	35 377	1.9%
Leisure and hospitality	12 635	13 728	8.7%
Other services	7 186	7 530	4.8%
Public administration	7 410	7 674	3.6%
Total*	152 580	158 290	3.7%

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

Source: Bureau of Labor Statistics. (2023a) Current Population Survey. "Table 17: Employed Persons by Industry, Sex, Race, and Occupation." <http://www.bls.gov/cps>

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

	2021	2022
Total Private	124 311	130 404
Manufacturing	12 354	12 825
Durable Goods	7 681	7 975
Nondurable Goods	4 673	4 850

Source: Bureau of Labor Statistics. (2023b) Current Employment Statistics. http://www.bls.gov/ces/home.htm

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.

Between January 2005 and January 2010, manufacturing employment declined by 19.6 %, as seen in Figure 4.1. As of July 2023, employment was still 8.9 % below its 2005 level. In times of financial difficulty, large purchases are often delayed or determined to be unnecessary. Thus, as would be expected, during the late 2000's recession durable goods declined more than nondurable goods. The other major decline in manufacturing employment was during the pandemic. Between January 2019 and April of 2020, manufacturing employment declined 10 percentage points to be 19.9 % below its 2005 level. By September 2021, manufacturing employment had risen to 12.8 % below its 2005 level. However, at that time there were a substantial number of job openings in manufacturing as seen in Figure 4.1.

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 increased 12.6 % between 2020 and 2021 (see Table 4.4). Nonfatal injuries increased as did the injury rate (see Table 4.5). The incident rate for nonfatal injuries in manufacturing remains higher than that for all private industry. As illustrated in Figure 4.2, fatalities, injuries, and the injury rate have a five-year compound growth rate of -3.8 %, -3.1 %, and -1.7 % respectively.

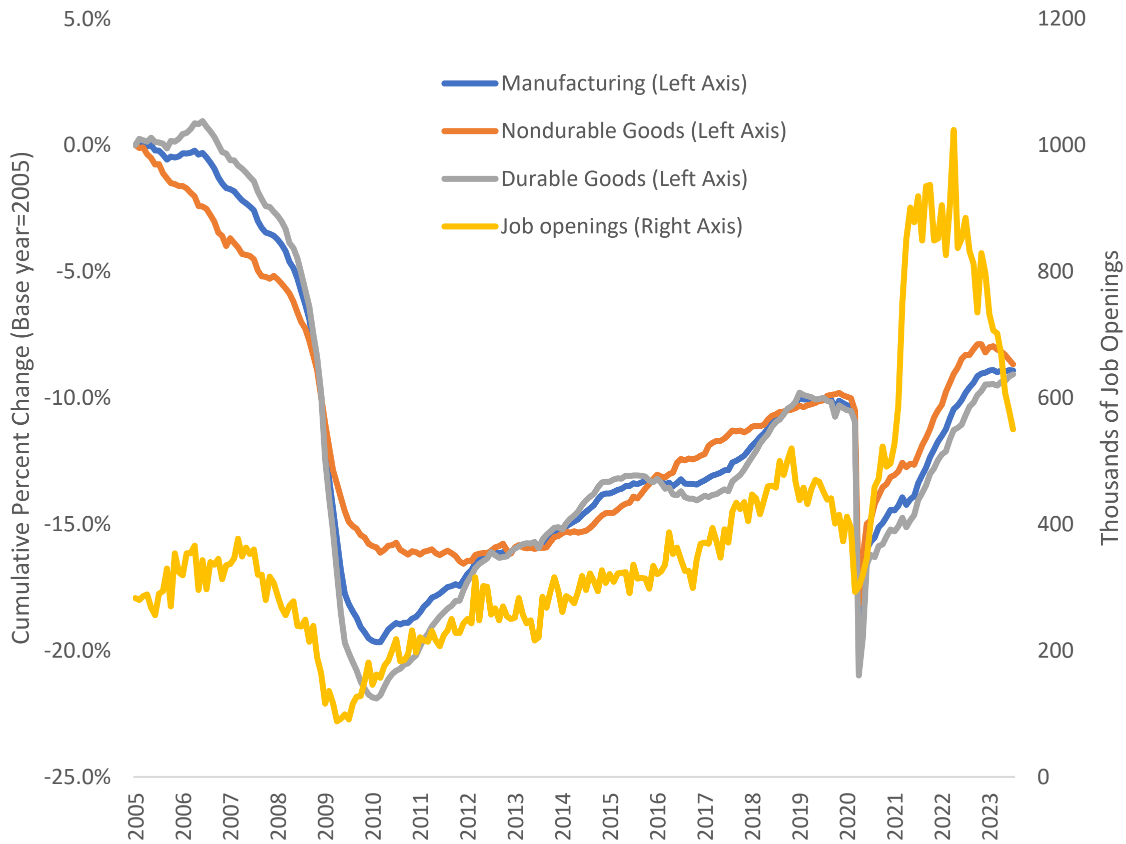


Figure 4.1: Cumulative Change in Percent in Manufacturing Employment (Seasonally Adjusted) and Number of Job Openings (seasonally Adjusted), 2005-2023

Source: Bureau of Labor Statistics. (2023b) Current Employment Statistics. http://www.bls.gov/ces/ and Bureau of Labor Statistics. (2023c) Job Openings and Labor Turnover Survey. https://www.bls.gov/jlt/
Source: Bureau of Labor Statistics. (2023c). Job Openings and Labor Turnover Survey. https://www.bls.gov/jlt/

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 substances or environments	Contact with objects and equipment
2020	Total	4764	705	1778	71	805	672	716
	Manufacturing	340	42	76	10	55	50	106
2021	Total	5190	761	1982	76	850	798	705
	Manufacturing	383	36	84	10	55	82	115
Percent Change	Total	8.9%	7.9%	11.5%	7.0%	5.6%	18.8%	-1.5%
	Manufacturing	12.6%	-14.3%	10.5%	0.0%	0.0%	64.0%	8.5%

Source: Bureau of Labor Statistics. (2022a) 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

		2020	2021	Percent Change
Manufacturing	Incident Rate per 100 full time workers*	3.1	3.3	6.5%
	Total Recordable Cases (thousands)	373.3	385.1	3.2%
Private Industry	Incident Rate per 100 full time workers	2.7	2.7	0.0%
	Total Recordable Cases (thousands)	2654.7	2607.9	-1.8%

Source: Bureau of Labor Statistics (2022b). Injuries, Illness, and Fatalities Program. 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)

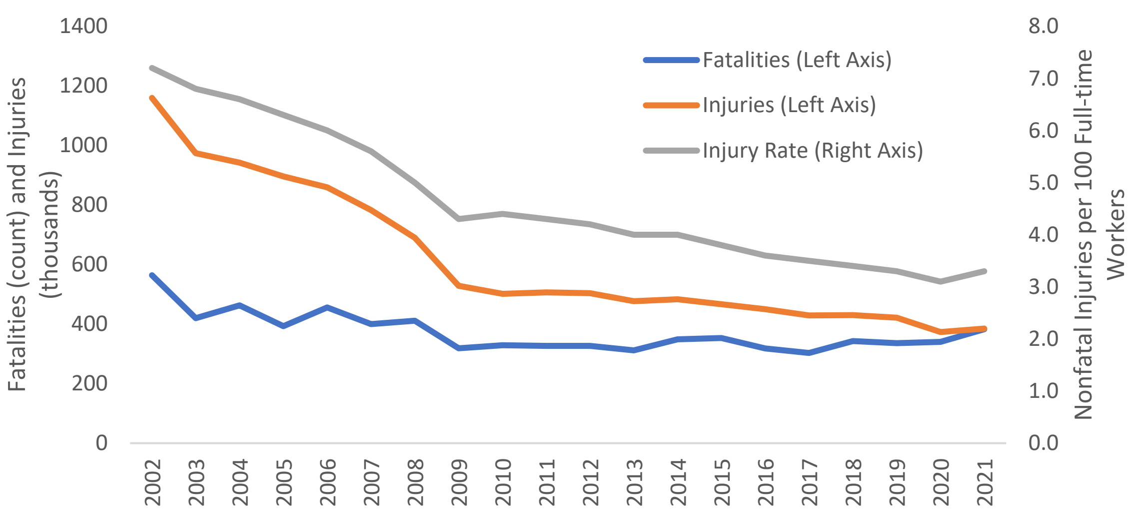


Figure 4.2: Manufacturing Fatalities and Injuries

Source: Bureau of Labor Statistics. (2022b). Injuries, Illness, and Fatalities Program. http://www.bls.gov/iif/
Source: Bureau of Labor Statistics. (2022a) Census of Fatal Occupational Injuries. "Industry by Event or Exposure." <http://stats.bls.gov/iif/oshcfoi1.htm>

During the late 2000s recession, the average 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 late 2000's recession and 2020 decline of GDP, as can be seen in Figure 4.4. This is likely because low wage earners are disproportionately impacted by employment reductions, which suggests that high wage earners not only receive more pay, but also have more job security. Average hours also dropped during the pandemic
and has largely returned to pre-recession levels. Like the late 2000's recession, during the pandemic wages increased while hours and employment decreased.

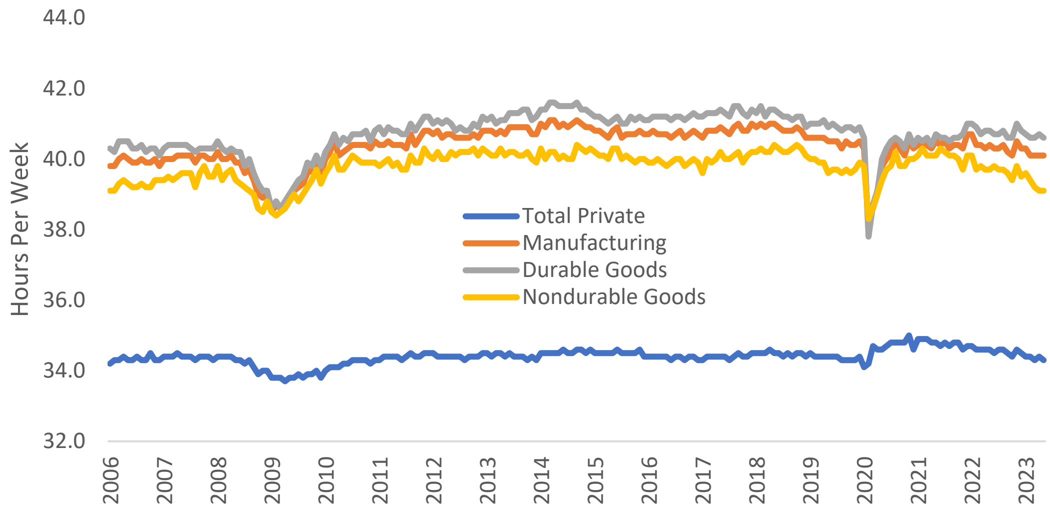


Figure 4.3: Average Weekly Hours for All Employees (Seasonally Adjusted)

Source: Bureau of Labor Statistics. (2023b) Current Employment Statistics. http://www.bls.gov/ces/home.htm

The compound annual growth rate in real dollars for private sector wages was 0.6 % between July 2018 and July 2023 and compensation was -0.1 % for manufacturing. As illustrated in Figure 4.5, employee compensation in manufacturing, which includes benefits, has had a five-year compound annual growth of -1.0 %, but remains 6.3 % above total private industry compensation. In May of 2018 the average hourly wages for the total private sector exceeded that of manufacturing, which was not the case before that time. Hourly compensation in manufacturing, which includes benefits, still exceeds that of the total private industry; however, the difference has narrowed significantly. In the first quarter of 2007, hourly compensation in manufacturing was 17.2 % higher than the private sector. By the first quarter of 2023, this difference narrowed to 6.3 %. As illustrated in Figure 4.6, the prices received by producers for all manufacturing between July 2020 and July 2022 has increased 33.4 % while in the fifteen years prior to that (i.e., June 2005 to June 2020) it only increased 27.1 % total. For those that invest in manufacturing, corporate profits have had a five-year compound annual growth of 10.4 %, as illustrated Figure 4.7, and nonfarm proprietors' income for manufacturing has had a five-year compound annual growth rate of -8.4 %, as illustrated in Figure 4.8.

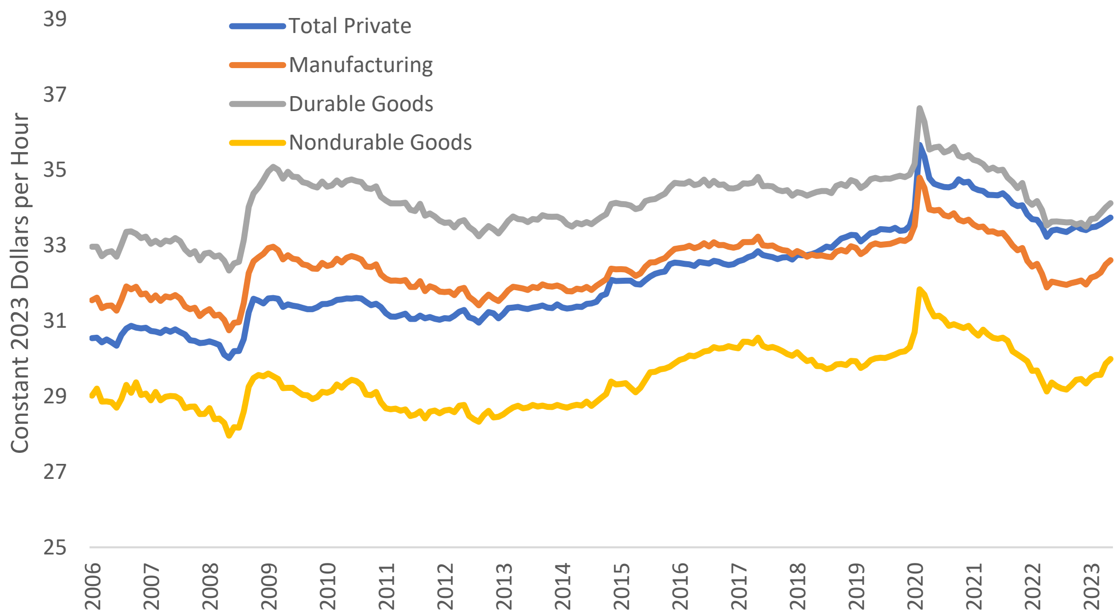


Figure 4.4: Average Hourly Wages for Manufacturing and Private Industry (Seasonally Adjusted)

Source: Bureau of Labor Statistics. (2023b) Current Employment Statistics. http://www.bls.gov/ces/home.htm
Adjusted using the CPI for all consumers. Bureau of Labor Statistics. (2022d). Consumer Price Index. https://www.bls.gov/cpi/data.htm

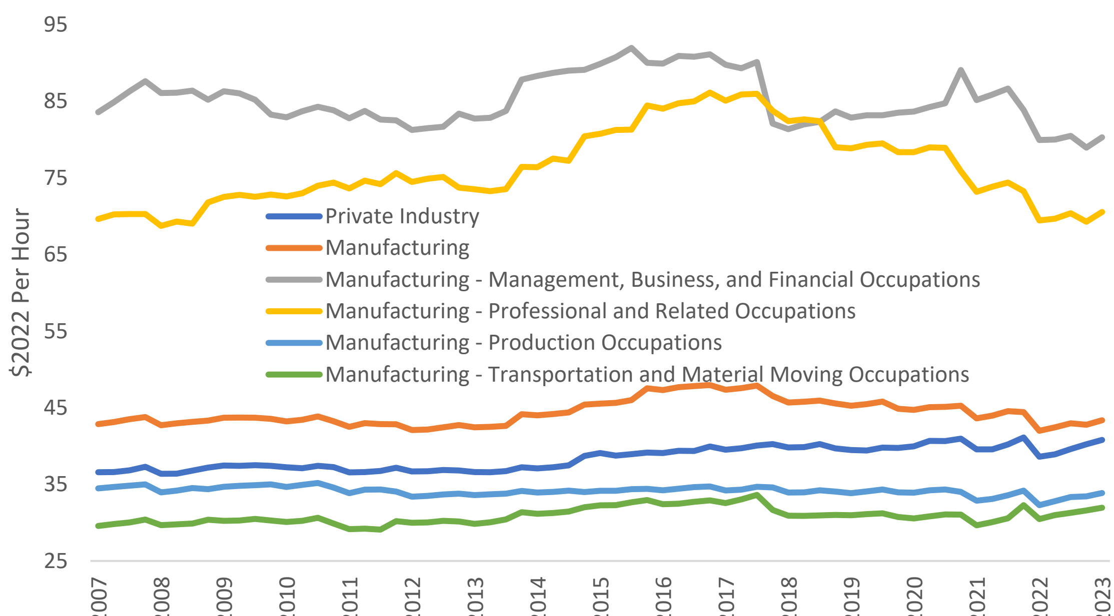


Figure 4.5: Employee Compensation (Hourly)

Source: Bureau of Labor Statistics. (2023e) National Compensation Survey. http://www.bls.gov/ncs/
Adjusted using the Consumer Price Index for all consumers from the Bureau of Labor Statistics.

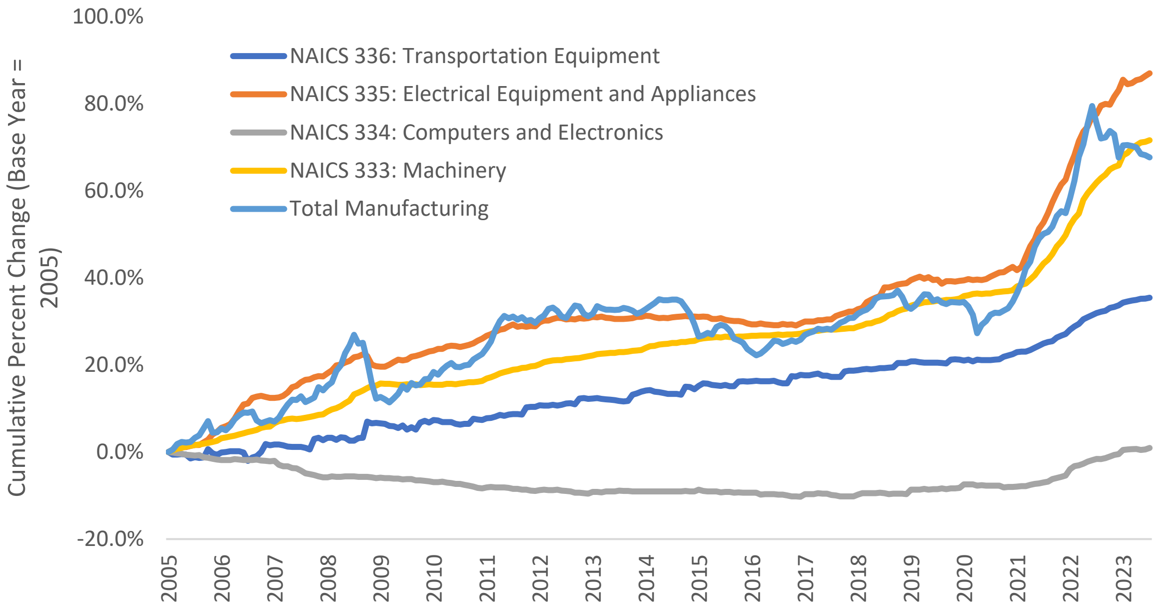


Figure 4.6: Inflation - Cumulative Percent Change in the Producer Price Index (Selling Price Received), 2005-2023

Source: Bureau of Labor Statistics. (2023). Producer Price Index. https://stats.bls.gov/ppi/databases/

An important aspect of manufacturing is the efficiency and productivity with which resources are used. The Bureau of Labor Statistics provides an index of labor productivity and total factor productivity. Labor productivity for manufacturing decreased by 1.0 % between the second quarter of 2022 and the second quarter of 2023, as illustrated in Figure 4.9. The five-year compound annual growth is -0.6 %. The Bureau of Labor Statistics total factor productivity measures "the efficiency at which combined inputs are used to produce output of goods and services" (Bureau of Labor Statistics 2023g). For U.S. manufacturing, total factor productivity increased 3.6 % from 2020 to 2021 and has a 5-year compound annual growth rate of 0.7 %, as illustrated in Figure 4.10. Productivity in the U.S. is relatively high compared to other countries. As illustrated in Figure 4.11, the U.S. is ranked ninth in output per hour among 142 countries using data from the Conference Board.[27]

[27] Conference Board. (2022) Total Economy Database: Output, Labor and Labor Productivity. https://www.conference-board.org/data/economydatabase/index.cfm?id=27762

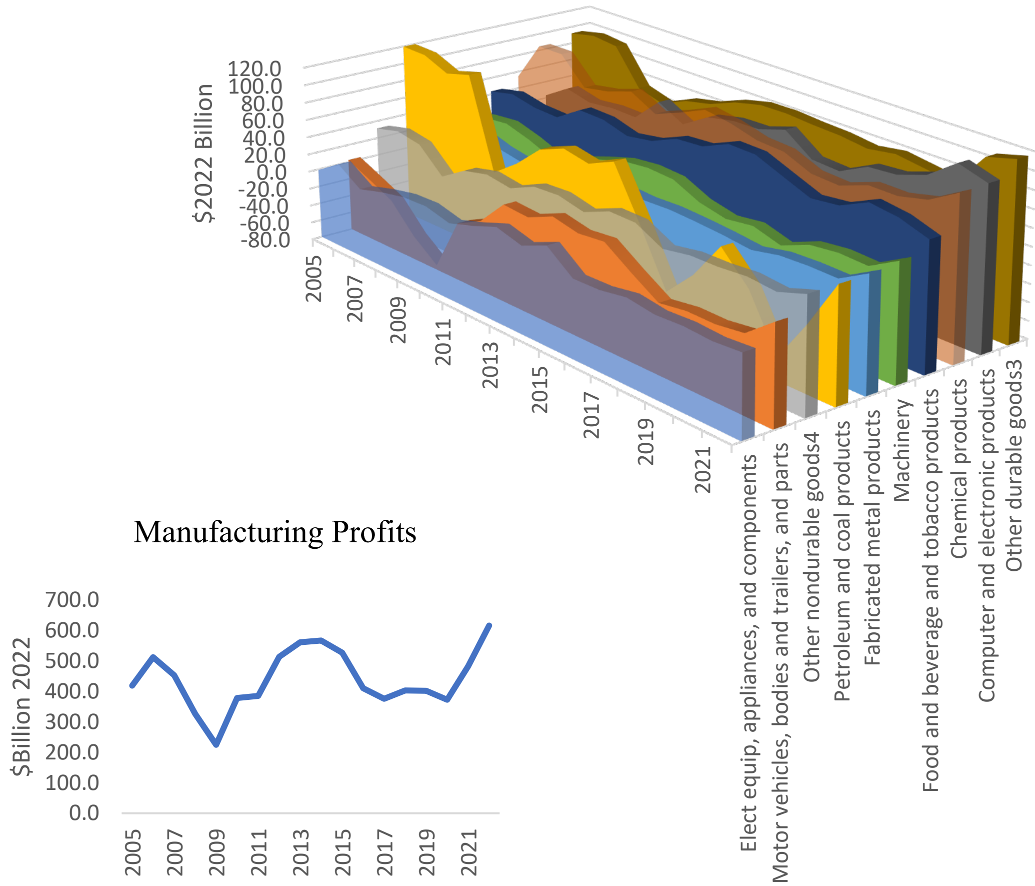


Figure 4.7: Profits for Corporations

Source: Bureau of Economic Analysis. (2023d) Income and Employment by Industry. Table 6.16D. Corporate Profits by Industry. https://apps.bea.gov/iTable/index_nipa.cfm.

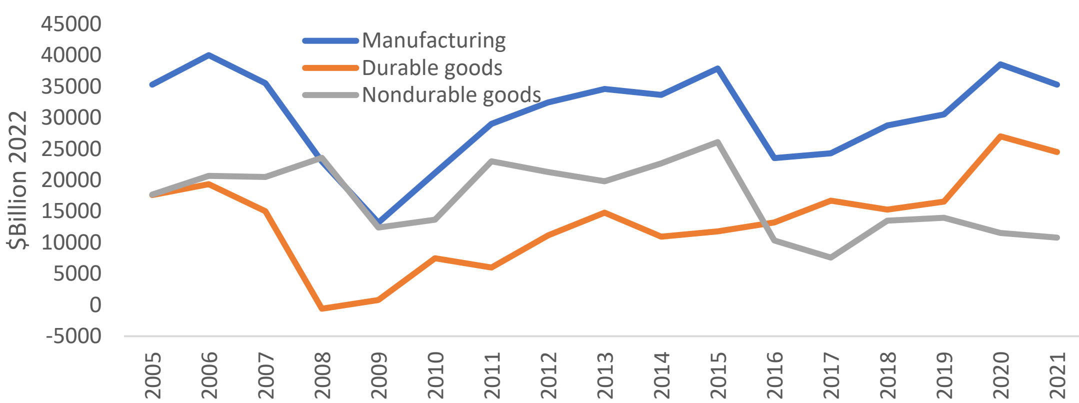


Figure 4.8: Nonfarm Proprietor's Income

Source: Bureau of Economic Analysis. (2023d) Income and Employment by Industry. Table 6.12D. Nonfarm Proprietors' Income. https://apps.bea.gov/iTable/index_nipa.cfm.

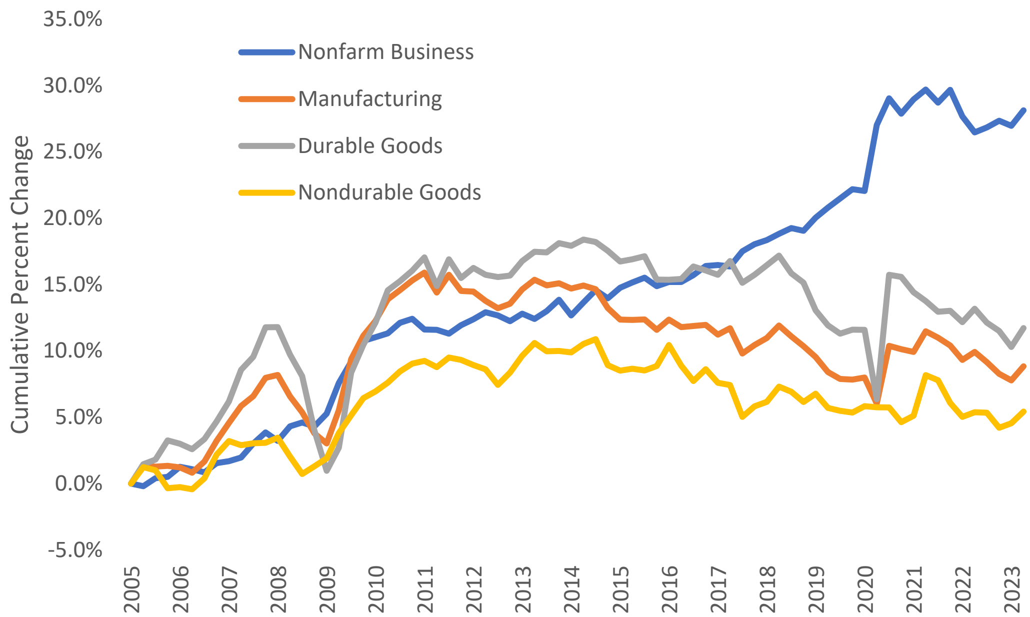


Figure 4.9: Manufacturing Labor Productivity Index (2012 Base Year = 100)

Source: Bureau of Labor Statistics. (2023f) Productivity. https://www.bls.gov/mfp/

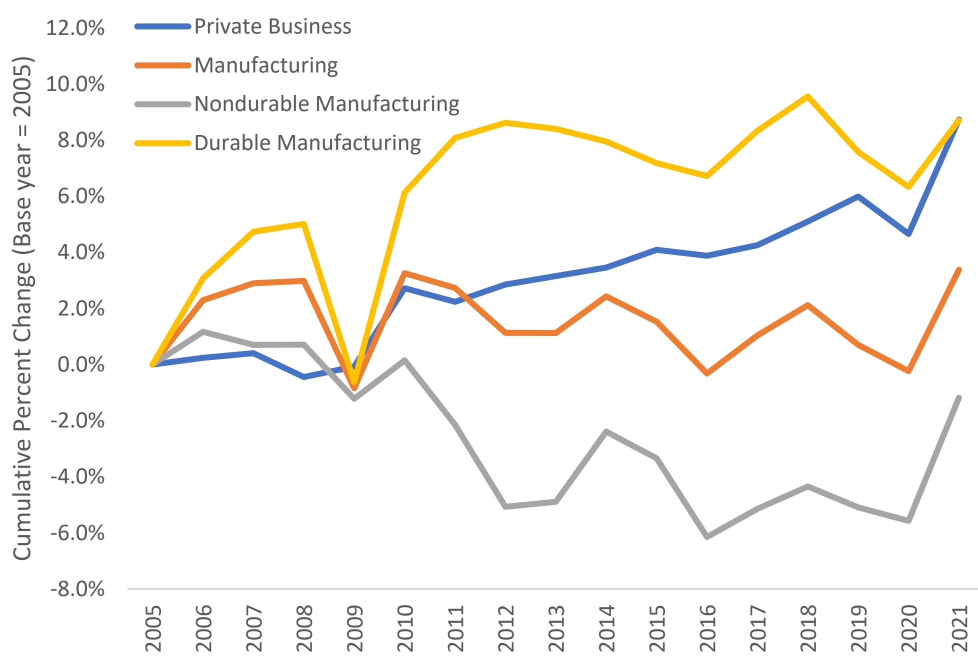


Figure 4.10: Manufacturing Total Factor Productivity Index

Source: Bureau of Labor Statistics. (2023f) Productivity. https://www.bls.gov/mfp/

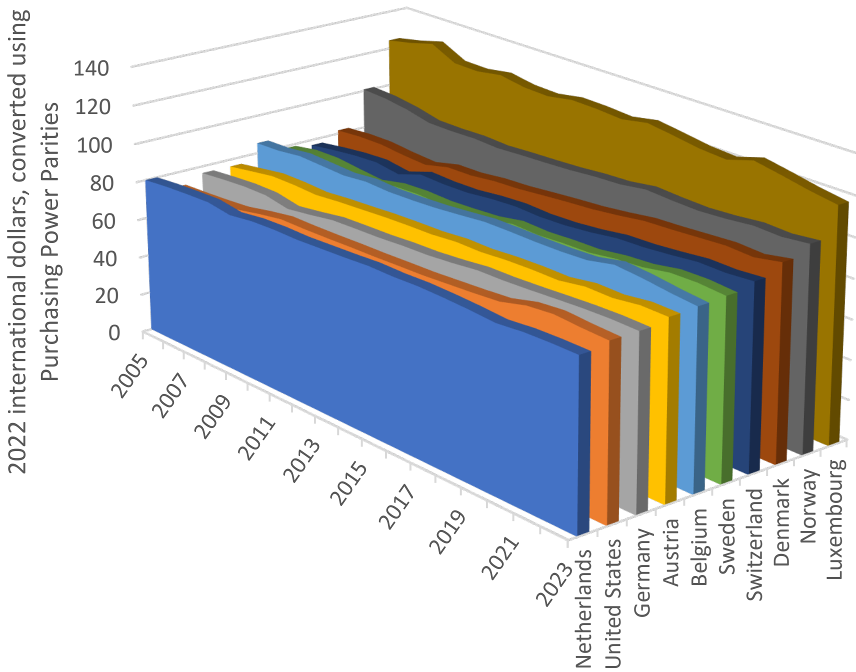


Figure 4.11: Output per Labor Hour (Top Ten Countries Out of 133)

Source: Conference Board. (2023) Total Economy Database: Output, Labor and Labor Productivity. https://www.conference-board.org/data/economydatabase/index.cfm?id=27762

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 U.S. ranked 4th in 2020 in resident patent applications per million people, which puts it above the 95th percentile among 138 countries. Using patent applications as a metric can be problematic though, as not all innovations are patented and some patents might not be considered innovation. The U.S. ranked 5th in research and development expenditures as a percent of GDP in 2020, which puts it above the 90th percentile (see Figure 5.2) among 84 nations. As seen in Figure 5.3, U.S. enterprise research and development expenditures in manufacturing increased 1.8 % between 2018 and 2019 and has a 5-year compound annual growth rate of 2.9 % (not shown). In terms of researchers per million people, the U.S. ranked 17th in 2019, putting it just above the 80th percentile (see Figure 5.4). In journal articles per million people it ranked 24th in 2020, and China had more articles than the U.S. (see Figure 5.5).[28] Exports are also frequently seen as a measure of competitiveness. The U.S. was the second largest exporter in 2022, as seen in Figure 5.6.

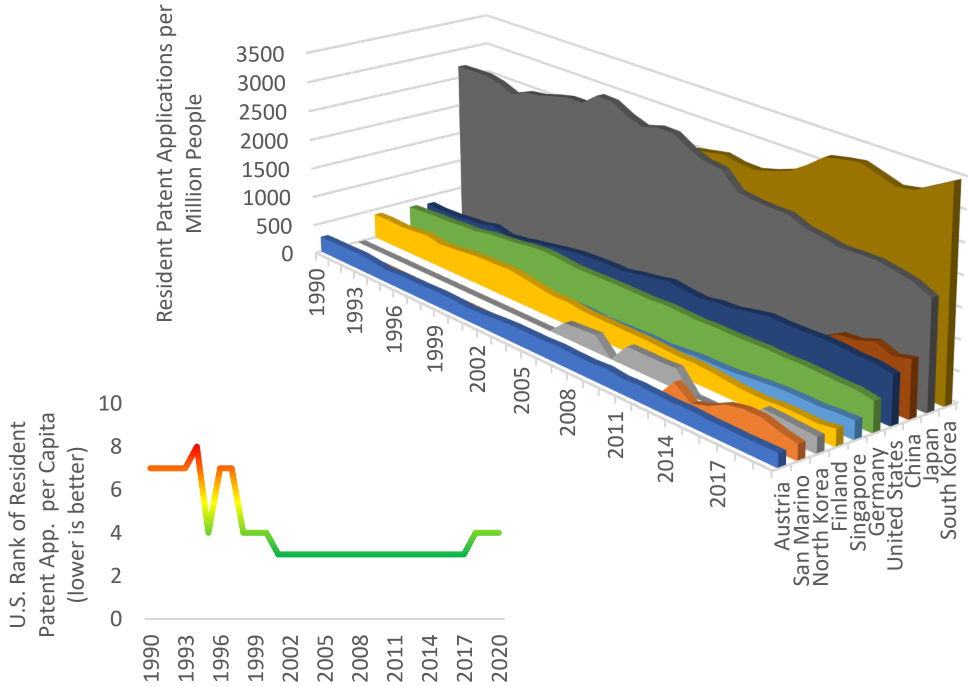


Figure 5.1: Patent Applications (Residents) per Million People, Top Ten (1990-2020)

World Bank. 2023. World Development Indicators. https://data.worldbank.org/products/wdi

[28] World Bank. 2022. World Development Indicators. http://data.worldbank.org/data-catalog/world-development-indicators

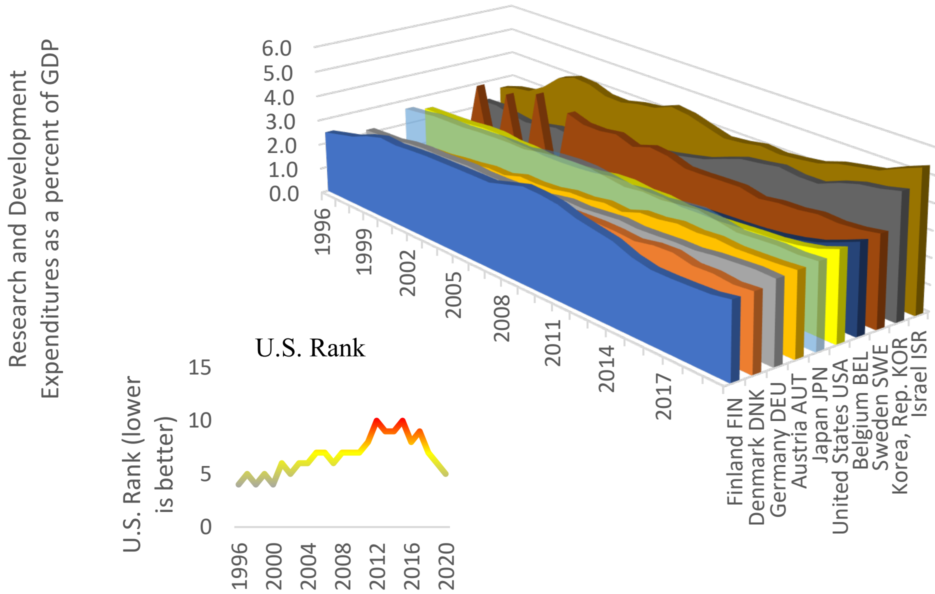


Figure 5.2: Research and Development Expenditures as a Percent of GDP, Top Ten

Source: World Bank. 2023. World Development Indicators. https://data.worldbank.org/products/wdi
* Missing data was interpolated

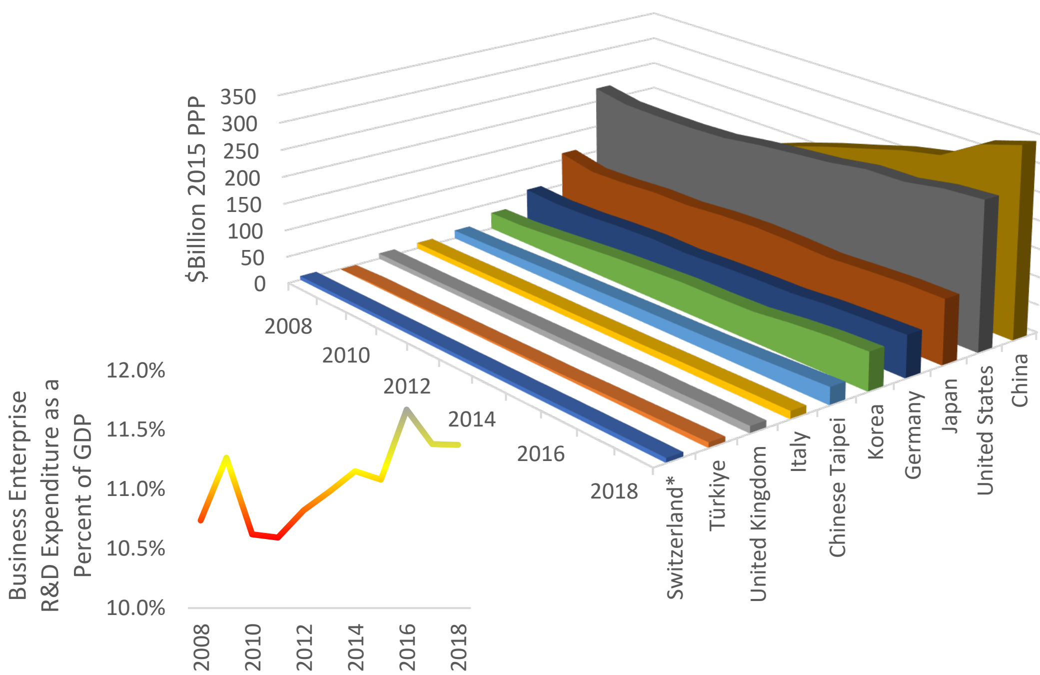


Figure 5.3: Manufacturing Enterprise Research and Development Expenditures

Source: OECD. (2022) Business Enterprise R-D Expenditure by Industry (ISIC 4). http://stats.oecd.org/#
United Nations Statistics Division. (2023). "National Accounts Main Aggregates Database." http://unstats.un.org/unsd/snaama/Introduction.asp
*Missing values were interpolated

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 U.S. innovation landscape. Figure 5.7 provides the U.S. ranking for 20 measures of competitiveness. This provides some indicators to identify opportunities for improvement in U.S. economic activity. In 2023, the U.S. ranked low in prices, public finance, societal framework, and international trade among other things. Overall, the U.S. ranked 9th in competitiveness for conducting business.[29]

The 2016 Deloitte Global Manufacturing Competitiveness Index uses a survey of CEOs to rank countries based on their perception. The U.S. was ranked 2nd out 40 nations with China being ranked 1st. High-cost labor, high corporate tax rates, and increasing investments outside of the U.S. were identified as challenges to the U.S. industry. Manufacturers indicated that companies were building high-tech factories in the U.S. due to rising labor costs in China, shipping costs, and low-cost shale gas.[30] According to

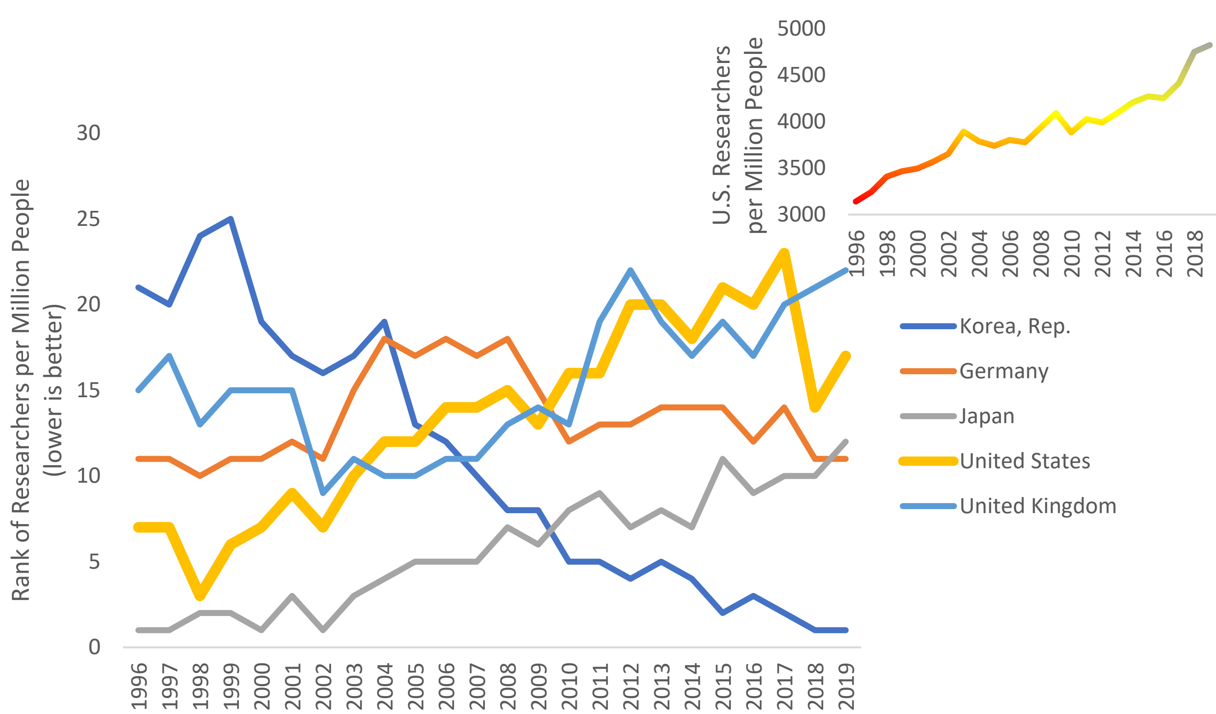


Figure 5.4: Researchers per Million People, Ranking

World Bank. 2023. World Development Indicators. https://data.worldbank.org/products/wdi

[29] IMD. (2021). IMD World Competitiveness Country Profile: U.S. https://worldcompetitiveness.imd.org/countryprofile/US
[30] Deloitte. (2016). 2016 Global Manufacturing Competitiveness Index.
http://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-gmci.pdf

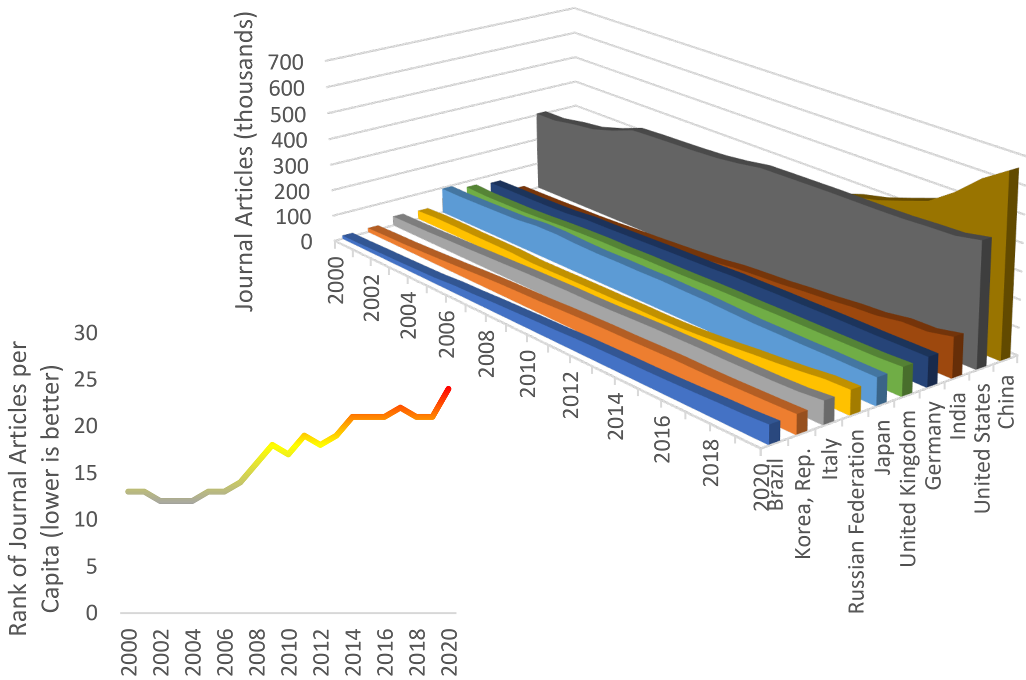


Figure 5.5: Journal Articles, Top 10 Countries

World Bank. 2023. World Development Indicators. https://data.worldbank.org/products/wdi

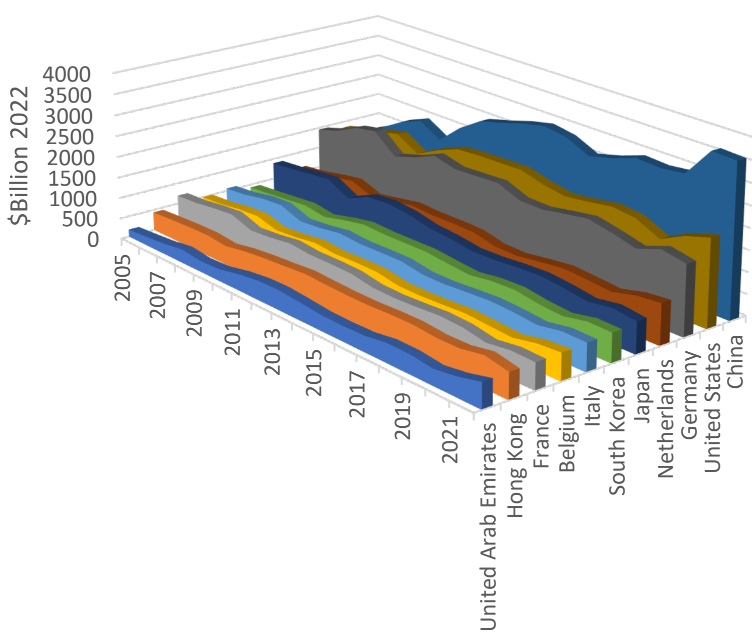


Figure 5.6: Merchandise Exports, Top Ten Exporters

World Bank. 2023. World Development Indicators. https://data.worldbank.org/products/wdi
NOTE: Adjusted using the Consumer Price Index for all consumers from the Bureau of Labor Statistics.

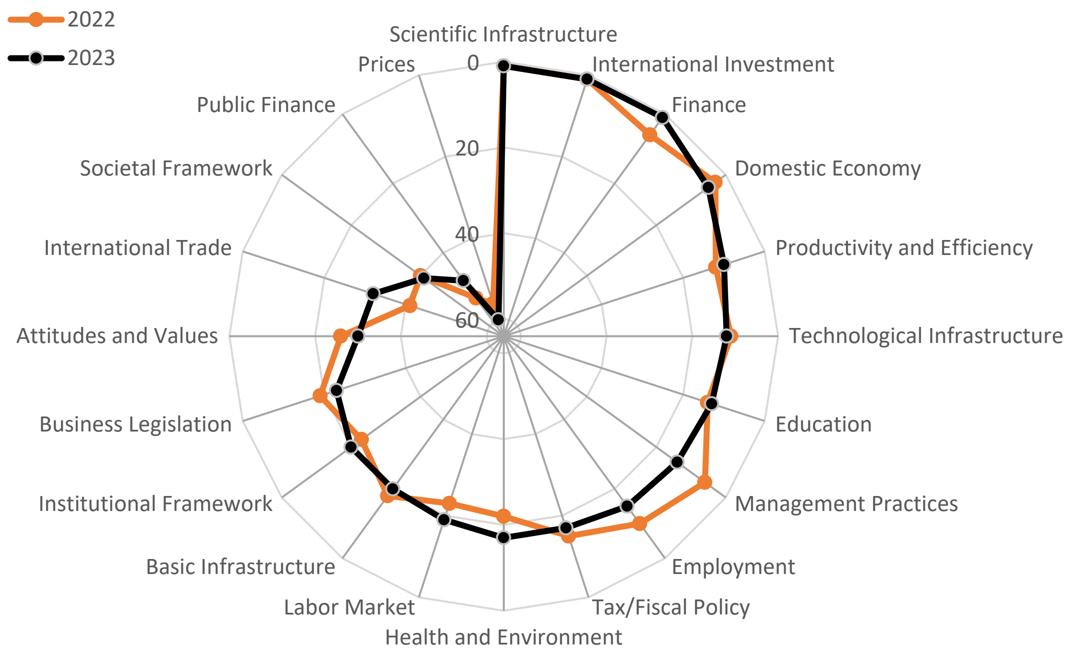


Figure 5.7: IMD World Competitiveness Rankings for the US: Lower is Better (i.e., a Rank of 1 is Better than a Rank of 64) – 64 countries ranked

Source: IMD. (2023). IMD World Competitiveness Country Profile: U.S. https://worldcompetitiveness.imd.org/countryprofile/US

the Deloitte Global Manufacturing Competitiveness Index, advantages to U.S. 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 2019 Global Competitiveness Report uses 12 items to assess the competitiveness of 141 economies, which includes the set of "institutions, policies and factors that determine a country's level of productivity." The U.S. was ranked 2nd overall with various rankings in the 12 "pillars" that underly the ranking, as illustrated in Figure 5.8. Within the 12 "pillars," there were lower rankings in health, macroeconomic stability, and information/communication technology adoption.[31] The index uses a set of 90 factors to produce the 12 items in Figure 5.8. A selection of those that are relevant to standards, technology, and information dissemination are presented in Table 5.1. Those that have poorer rankings might be opportunities for improvement.

[31] World Economic Forum. (2019). The Global Competitiveness Report 2019. http://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

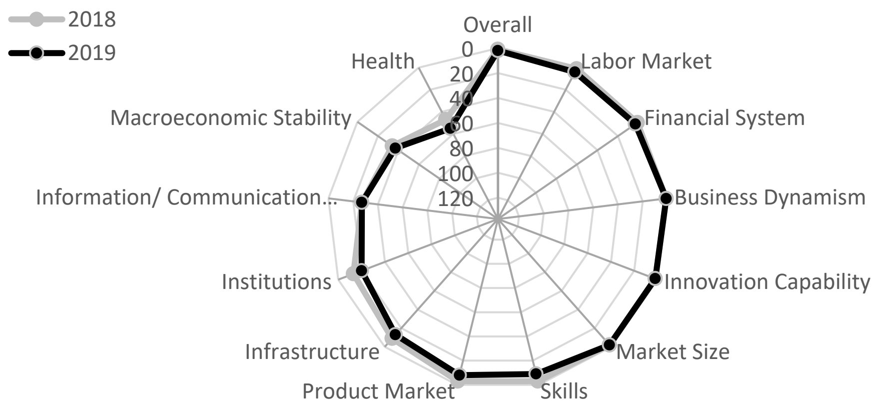


Figure 5.8: World Economic Forum 2019 Global Competitiveness Index: U.S. Pillar Rankings: Lower is Better

Source: World Economic Forum. (2019). The Global Competitiveness Report 2018. http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf

Among those selected in Table 5.1, the U.S. ranks below the 90th percentile in both of the *crime* items, 2 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.

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.[32] The U.S. ranked 5th overall, as seen in Table 5.2.

The Annual Survey of Entrepreneurs makes inquiries on U.S. 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

[32] United Nations Industrial Development Organization. (2020). Competitive Industrial Performance Report 2020. https://stat.unido.org/content/publications/competitive-industrial-performance-report-2020

Table 5.1: World Economic Forum Competitiveness Index Indicators – Selection of those Relevant to Standards, Technology, and Information Dissemination Solutions, Rankings Out of 141 Countries (Lower is Better)

Pillar	Component	US Rank	Application
1	Organized crime	69	Crime
1	Terrorism incidence	83.3	Crime
1	Intellectual property protection	12	IP Protection
2	Road connectivity index	1	Transport
2	Quality of roads	17	Transport
2	Railroad density (km of roads/square km)	48	Transport
2	Efficiency of train service	12	Transport
2	Airport connectivity	1	Transport
2	Efficiency of air transport services	10	Transport
2	Liner shipping connectivity index	8	Transport
2	Efficiency of seaport services	10	Transport
2	Electrification rate (% of population)	2	Utilities
2	Electric power transmission and distribution losses (% output)	23	Utilities
2	Exposure to unsafe drinking water (% of population)	14	Utilities
2	Reliability of water supply	30	Utilities
3	Mobile-cellular telephone subscriptions (per 100 people)	54	Utilities
3	Mobile-broadband subscriptions (per 100 people)	7	Utilities
3	Fixed-broadband internet subscriptions (per 100 people)	18	Utilities
3	Fibre internet subscriptions (per 100 people)	45	Utilities
3	Internet users (% of population)	26	Utilities
5	Healthy life expectancy	54	Labor - Health
6	Mean years of schooling	7	Human Capital
6	Extent of staff training	6	Human Capital
6	Quality of vocational training	8	Human Capital
6	Skillset of graduates	5	Human Capital
6	Digital skills among population	12	Human Capital
6	Ease of finding skilled employees	1	Human Capital
6	School life expectancy (expected years of schooling)	30	Human Capital
6	Critical thinking in teaching	9	Human Capital
6	Pupil-to-teacher ratio in primary education	45	Human Capital
11	Cost of starting a business (% GNI per capita)	24	Barriers to Entry
11	Time to start a business (days)	31	Barriers to Entry
11	Companies embracing disruptive ideas	2	Innovation
12	State of cluster development	2	Innovation
12	International co-inventions (applications/million people)	19	Innovation
12	Multi-stakeholder collaboration	2	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	4	Innovation
12	Trademark applications (per million people)	32	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

As seen in Figure 5.9, there are five items where more than a third of the firms indicated negative impacts, including taxes, slow business or lost sales, unpredictability of business conditions, finding qualified labor, and government regulations. [33]

Countries are sometimes compared to or alluded to as brands. According to a survey on country reputation of products published by Statista (see Figure 5.10), the U.S. ranks 10th among 49 total countries. Another ranking from Ipsos (see Figure 5.11), the U.S. ranks 8th. The high ranking of the U.S. supports the idea that manufacturers in the U.S. tend to compete based on differentiation rather than cost competition.

Table 5.2: Rankings from the Competitive Industrial Performance Index 2021, 150 Total Countries

Country	Rank
Germany	1
China	2
Ireland	3
South Korea	4
United States	5

Source: United Nations Industrial Development Organization. (2021). Competitive Industrial Performance Report 2021. https://stat.unido.org/

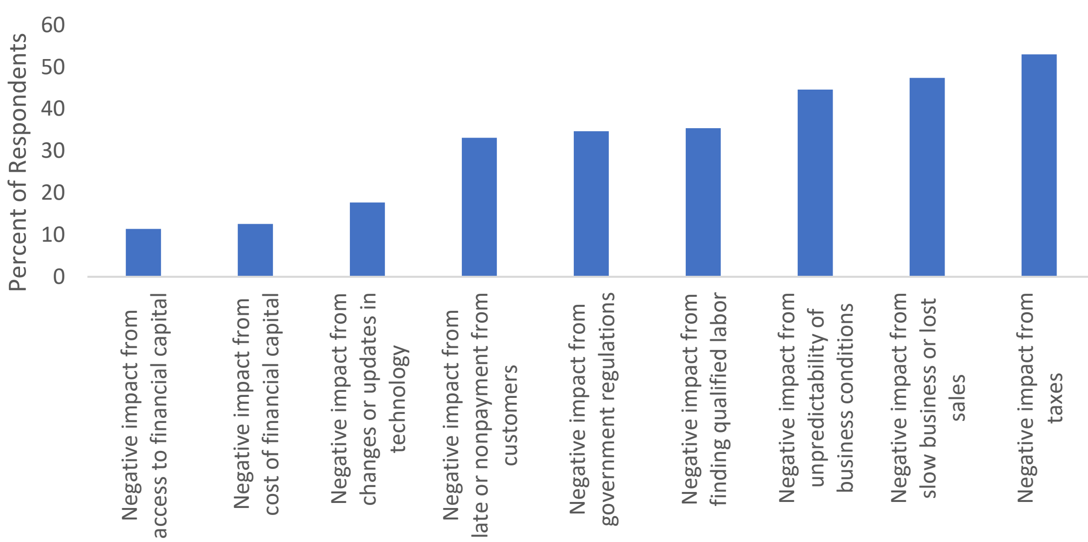


Figure 5.9: Factors Impacting U.S. Business (Annual Survey of Entrepreneurs), 2016

Source: U.S. Census Bureau. (2019). Annual Survey of Entrepreneurs. https://www.census.gov/programs-surveys/ase.html

[33] U.S. Census Bureau. (2019) Annual Survey of Entrepreneurs. https://www.census.gov/programs-surveys/ase.html

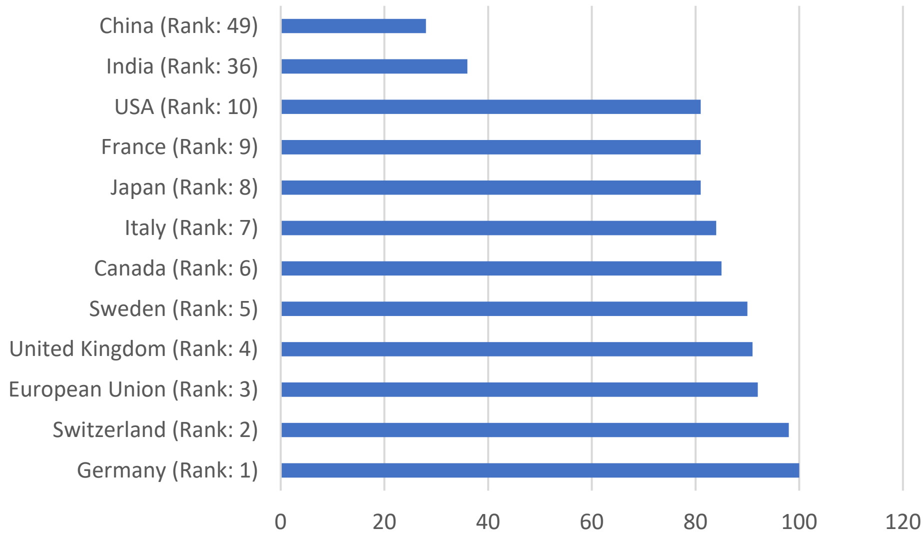


Figure 5.10: Made-in-Country Index, 2017

Source: Loose, Nicolas. (2017). "Made-in-Country Index 2017." https://www.statista.com/page/Made-In-Country-Index

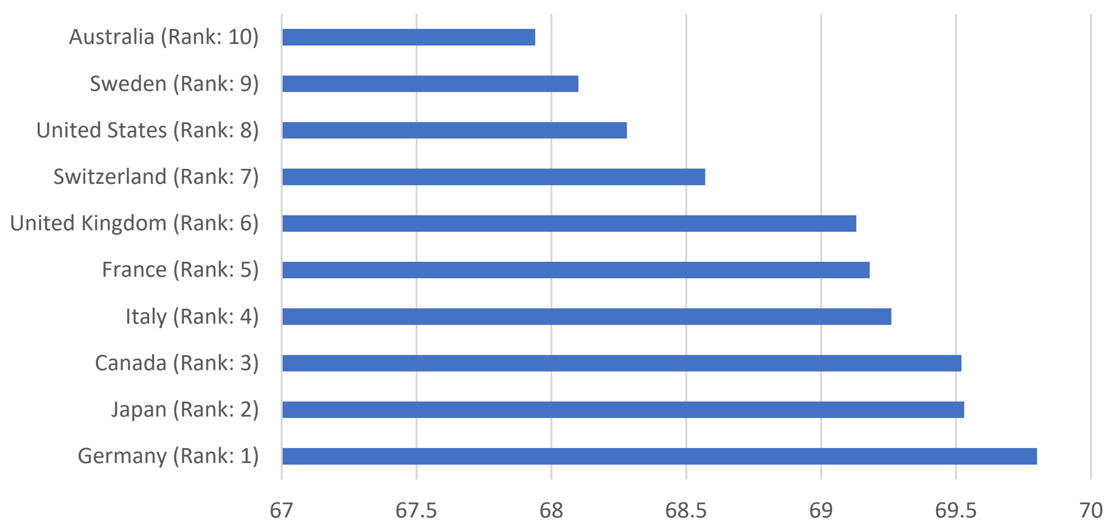


Figure 5.11: Ipsos National Brands Index, 2021

Source: Ipsos. (2022). "Nation Brands Index 2022."
https://www.ipsos.com/sites/default/files/ct/news/documents/2021-10/NBI-2021-ipsos.pdf

6. Discussion

This report provides an overview of the U.S. manufacturing industry. There are 3 aspects of U.S. manufacturing that are considered: (1) how the U.S. industry compares to other countries, (2) the trends in the domestic industry, and (3) the industry trends compared to those in other countries. The U.S. remains a major manufacturing nation; however, other countries are rising rapidly. Manufacturing in the U.S. was significantly impacted by the 2000's recession and the 2020 economy.

The U.S. accounts for 16.3 % of global manufacturing, according to the United Nations Statistics Division National Accounts Main Aggregates Database, making it the second largest. Compound real (i.e., controlling for inflation) annual growth in the U.S. between 1996 and 2021 was 2.1 %, which places the U.S. below the 50th percentile. The compound annual growth for the U.S. between 2016 and 2021 was 2.2 %. This puts the U.S. just above the 50th percentile but above Canada and Germany among others. In terms of subsectors of manufacturing, the U.S. ranks 1st in 7 industries out of 16 total while China was the largest for the other industries, as reported in OECD data.

In 2022, there was an estimated $2.3 trillion in manufacturing value added in chained 2012 dollars. Using 2012 input-output data adjusted to 2019 dollars, there is an estimated $4278 billion, including direct and indirect value added, associated with U.S. manufacturing. In 2019, the U.S. imported approximately 20.4 % of its intermediate goods, according to BEA data. Discrete technology products account for 41 % of manufacturing value added, according to BEA data.

From the pre-recession peak in the 4th quarter of 2007 to the 1st quarter of 2009 manufacturing declined 17 percentage points. Manufacturing didn't return to its pre-recession level until 2017. During the recent pandemic, manufacturing value added declined 17 percentage points between the third quarter of 2019 and second quarter of 2020, but returned to similar levels within a year. Between January 2005 and January 2010, manufacturing employment declined by 19.6 %. As of July 2023, employment was still 8.9 % below its 2005 level. Between January 2019 and April of 2020, manufacturing employment declined 10 percentage points to be 19.9 % below its 2005 level. By September 2021, manufacturing employment had risen to 12.8 % below its 2005 level.

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Appendix A. U.S. Semiconductor Manufacturing

U.S. semiconductor manufacturing value added was $30.4 billion in 2020 and was 10.6 % larger in 2020 than it was in 2008, as illustrated in Figure A 1. The industry value added has had a 5-year compound annual growth rate of 4.2 %. The U.S. has a significant presence in the semiconductor manufacturing industry with an estimated 12 % of the global production capacity (see Table A 1). As shown in both Table A 1 and Figure A 1, while U.S. semiconductor employment has been relatively flat, manufacturing value added has generally grown; however, global growth has been faster, as seen in Table A 1. The result is that the U.S. share of the industry went from 37 % in 1990 to 12 % in 2020.

As seen in Table A 2, the U.S. has 43 % of the 10 nm to 22 nm process technology market. Generally, the lower the number, the greater the performance and the more technologically advanced the technology because it represents the space for features on a chip.[34] The U.S. has little to no capacity for the most advanced technology, which is at the 10 nm or less process technology. U.S. owned firms, which own facilities around the world, have a commanding position in terms of the design of semiconductors, as seen in Table A 3. Additionally, U.S. firms held significant proportions of national markets, including 49.9 % of the Chinese market, and

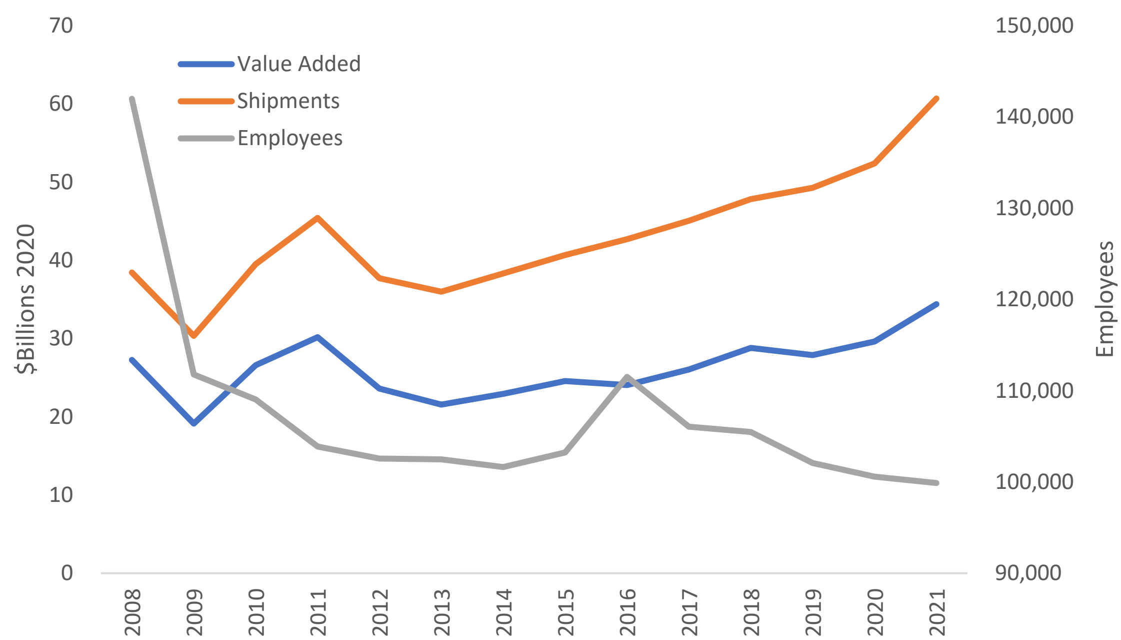

Figure A 1: Semiconductor Shipments, Value Added, and Employment, 2008-2021

Source: U.S. Census Bureau. Annual Survey of Manufactures. 2023. https://www.census.gov/programs-surveys/asm/data.html
Note: Adjusted using the PPI for "semiconductors and related device mfg" from the Bureau of Labor Statistics
Note: 2017 Value Added was interpolated

[34] Congressional Research Service. 2020. "Semiconductors: U.S. Industry, Global Competition, and Federal Policy." https://crsreports.congress.gov/product/pdf/R/R46581

48.6 % of the Asia Pacific market (see Table A 4). As illustrated in Figure A 2, U.S. productivity has grown significantly with a 3.1 % 5-year compound annual growth in total factor productivity and 2.9 % for labor productivity. Meanwhile, wages grew slightly between 2008 and 2015; however, they generally declined thereafter.

Table A 1: U.S. Share and Growth of Production Capacity

	U.S. Share of Global Capacity	CAGR	
		U.S.	World
1990	37%		
2000	19%	12.8%	20.20%
2010	13%	5.0%	9.60%
2020	12%	4.0%	4.90%
2030 (Projected)	10%	3.0%	4.60%

Source: Semiconductor Industry Association. 2020a. "Government Incentives and US Competitiveness in Semiconductor Manufacturing." https://www.semiconductors.org/wp-content/uploads/2020/09/Government-Incentives-and-US-Competitiveness-in-Semiconductor-Manufacturing-Sep-2020.pdf

Table A 2: 2019 National Share of Global Process Technology and Value of Subsidies, 2019

		U.S.	China	Taiwan	South Korea	Japan	Europe	Other	TOTAL
Process Technology (lower is more technologically advanced)	< 10 nm	0%	0%	92%	8%	0%	0%	0%	100%
	10-22 nm	43%	3%	28%	5%	0%	12%	9%	100%
	28-45 nm	6%	19%	47%	6%	5%	4%	13%	100%
	> 45 nm	9%	23%	31%	10%	13%	6%	7%	100%
Subsidies 2000-2020 (billions)*		$0	~$50	$0.5+	$7-10	$5-7+	$2.5+	-	
Tax Incentives (2000-2020)**		No	Yes	Yes	Yes	Yes	Yes		
Other Government Incentives (2000-2020)		No	Yes	Yes	Yes	Yes	Yes	-	

Source: Semiconductor Industry Association. "2021 State of the U.S. Semiconductor Industry." https://www.semiconductors.org/wp-content/uploads/2021/09/2021-SIA-State-of-the-Industry-Report.pdf
Source: Semiconductor Industry Association. 2020b. U.S. Needs Greater Semiconductor Manufacturing Incentives. https://www.semiconductors.org/wp-content/uploads/2020/07/U.S.-Needs-Greater-Semiconductor-Manufacturing-Incentives-Infographic1.pdf?utm_source=morning_brew
* Estimates based on SIA analysis of national-level direct funding to companies
** Industry-specific tax incentives

Table A 3: U.S. Company Semiconductor Value Added Occurring Globally, 2019

Category	U.S. Share of Value Added	Category Share of Value Added (Global)*
R&D Intensive		
Electronic Design Automation and Core IP	74%	3%
Logic	67%	30%
Discrete, Analog, and Other	37%	17%
Memory Semiconductors	29%	9%
Manufacturing Equipment	41%	12%
Capital Intensive		
Materials	11%	5%
Wafer Fabrication	12%	19%
Assembly, Packaging, and Testing	2%	6%
TOTAL	38%	100%

* Sum may not equal total due to rounding
Source: Semiconductor Industry Association. "2021 State of the U.S. Semiconductor Industry." https://www.semiconductors.org/wp-content/uploads/2021/09/2021-SIA-State-of-the-Industry-Report.pdf

Table A 4: U.S. Firms Share of National Semiconductor Markets

Region	Total ($2022 Billion)	U.S. Share
China	180.5	53.4%
Asia Pacific/All Other Market	150.5	47.9%
Americas	141.1	41.8%
Europe	53.8	50.0%
Japan	48.2	42.8%
TOTAL		48.0%

Source: Semiconductor Industry Association. 2023. 2023 Factbook. https://www.semiconductors.org/wp-content/uploads/2023/05/SIA-2023-Factbook_1.pdf

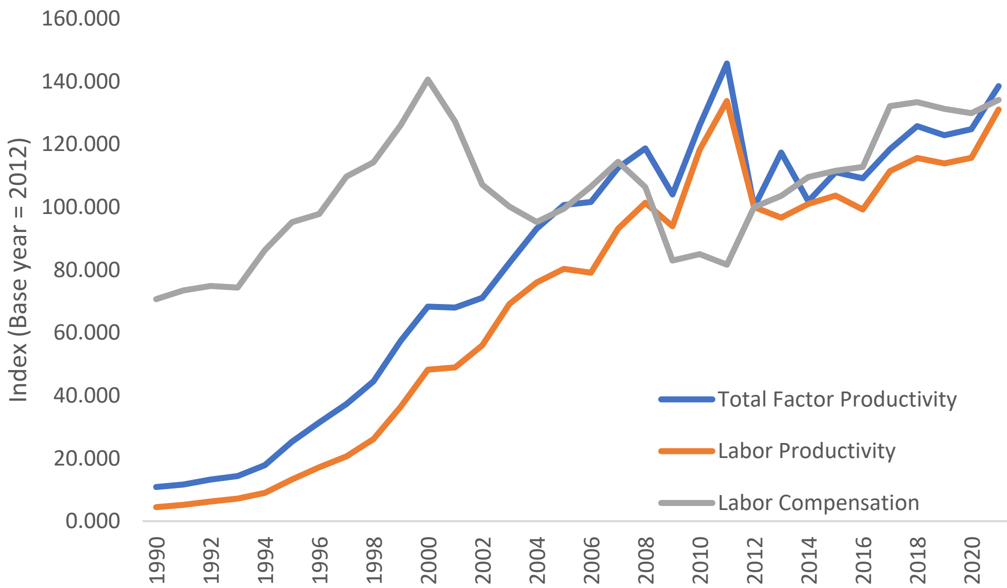

Figure A 2: Semiconductor Industry Productivity Indices, 1990-2021

Source: Bureau of Labor Statistics. 2022f. Productivity. https://www.bls.gov/productivity/data.htm

Appendix B. Additive Manufacturing

Table B.1 provides an approximation of the shipments and value added of the goods produced using additive manufacturing in the United States. For this report, this is referred to as the additive manufacturing industry. There are other associated activities such as the production of the additive manufacturing machinery and materials. These are costs/inputs of the additive manufacturing industry. The approximated shipments of goods produced using additive manufacturing in the U.S. is $2.8 billion with value added being $1.4 billion. These represent a small proportion of the manufacturing industry; however, it should not be concluded that this technology is not important or impactful, as it is often an input in the production of other goods. For instance, in 2022 utilities were only 1.4 % of GDP, but where would the economy be without electricity. Nuts and bolts are a small proportion of the value of a car, but how would be assemble an automobile without them. Additive manufacturing facilitates rapid prototyping to produce products in a shorter period of time, weight/material reduction, and lower cost production for small batches and customized products, including parts for products that are no longer produced. Moreover, the size of the industry does not represent the economic impact of the technology.

Table B.1: Approximation of U.S. Shipments and Value Added of Goods Produced using Additive Manufacturing

Category	Relevant NAICS Codes	Shipments of US Made AM Products ($millions, 2021)*	Total US Shipments ($millions, 2021)	AM Share of Industry Shipments	Total Value Added ($millions, 2021)*	AM Value Added ($millions, 2021)
Motor vehicles	NAICS 3361, 3362, 3363	433.48	620 402	0.07%	180 836	126
Aerospace	NAICS 336411, 336412, 336413	498.80	152 113	0.33%	75 339	247
Medical/dental	NAICS 3391	463.17	94 889	0.49%	62 293	304
Government/military	NAICS 336414, 336415, 336419, 336992	178.14	40 502	0.44%	14 821	65
Architectural	NAICS 3323	133.61	113 646	0.12%	58 817	69
Consumer products/electronics, academic, and other	All other within NAICS 332 through 339	1 054.01	954 970	0.11%	527 054	582
TOTAL	NAICS 332 through 339	2761.2	1 976 521	0.14%	919 160	1 394

* These values are calculated assuming that the percent of total additive manufacturing made products for each industry is the same for the US as it is globally. It is also assumed that the US share of AM systems installed is equal to the share of revenue for AM products

Note: Numbers may not add up to total due to rounding