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# U.S. Manufacturing in International Perspective

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## Summary

The health of the U.S. manufacturing sector has long been of great concern to Congress. The decline in manufacturing employment since the start of the 21<sup>st</sup> century has stimulated particular congressional interest. The Obama Administration has undertaken a variety of related initiatives, and Members have introduced hundreds of bills intended to support domestic manufacturing activity in various ways. The proponents of such measures frequently contend that the United States is by various measures falling behind other countries in manufacturing, and they argue that this relative decline can be mitigated or reversed by government policy.

This report is designed to inform the debate over the health of U.S. manufacturing through a series of charts and tables that depict the position of the United States relative to other countries according to various metrics. Understanding which trends in manufacturing reflect factors that may be unique to the United States and which are related to broader changes in technology or consumer preferences may be helpful in formulating policies intended to aid firms or workers engaged in manufacturing activity. This report does not describe or discuss specific policy options.

The main findings are the following:

- China displaced the United States as the largest manufacturing country in 2010, as the United States' share of global manufacturing activity declined from 30% in 2002 to 17.4% in 2012.
- Manufacturing output has grown more rapidly in the United States over the past decade than in most European countries and Japan, although it has lagged China, Korea, and other countries in Asia.
- Employment in manufacturing has fallen in most major manufacturing countries over the past two decades. The United States saw a disproportionately large drop between 2000 and 2010, but its decline in manufacturing employment since 1990 is in line with the changes in several European countries and Japan.
- U.S. manufacturers spend far more on research and development (R&D) than those in any other country, but manufacturers' R&D spending is rising more rapidly in China, Korea, and Taiwan.
- Manufacturers in all major manufacturing countries appear to be spending increasing amounts on R&D, relative to their value added. U.S. manufacturers spend approximately 11% of value added on R&D, an increase of approximately three percentage points since the 2000-2002 period. A very large proportion of U.S. manufacturers' R&D takes place in high-technology sectors, particularly pharmaceutical, electronics, and aircraft manufacturing, whereas in most other countries a far greater proportion of manufacturers' R&D outlays occur in medium-technology sectors such as motor vehicle and machinery manufacturing.

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## **Introduction**

The health of the U.S. manufacturing sector has long been of great concern to Congress. The large decline in manufacturing employment since the start of the 21<sup>st</sup> century has stimulated particular congressional interest. Members have introduced hundreds of bills intended to support domestic manufacturing activity in various ways. The proponents of such measures frequently contend that the United States is in some way falling behind other countries in manufacturing, and argue that this relative decline can be mitigated by government policy.

Examining U.S. manufacturing in isolation sheds little light on the causes of changes in the manufacturing sector. While some of those changes may be a result of factors specific to the United States, others may be attributable to technological advances, shifting consumer preferences, or macroeconomic forces such as exchange-rate movements. This report is designed to inform the debate over manufacturing policy by examining changes in the manufacturing sector in comparative perspective. It does not describe or discuss specific policy options.

The charts and tables on the pages that follow depict the position of the United States relative to other major manufacturing countries according to various metrics. Not all countries compile information on each subject, so it is not possible to show data for the same set of countries in each instance. This report draws on data from a number of sources, and has certain unavoidable statistical problems of which the reader should be aware.

Despite meaningful progress in standardization, countries define “manufacturing” in different ways. Some associate manufacturing with factory production, while others may label a self-employed artisan as a manufacturing worker. Some countries have sophisticated sampling systems to collect data about production and employment from firms and households, whereas others rely heavily on estimates drawn from macroeconomic models or collect data only from a non-random subset of enterprises, such as those located in major cities. International comparisons of compensation data are especially difficult because of national differences in taxation and employee benefits. Complicating matters further, the organizations that compile statistics obtained from national governments may adjust the raw data in different ways to improve compatibility, such that certain figures used to prepare this report may not be identical to those published by national statistical services.

Additionally, analysis of trends in manufacturing is complicated by often arbitrary distinctions between manufacturing and non-manufacturing activity. If, for example, a manufacturing firm owns the trucks that deliver its goods to customers, statisticians will count the truck drivers as manufacturing-sector workers, and their wages will be included in the manufacturing sector’s value added. If, however, the manufacturer instead contracts with a separate trucking company to deliver its goods, statisticians will consider the truck drivers to be transport-sector workers and their wages will be included in transport-sector value added, making the manufacturing sector appear smaller—even though there has been no change in the total amount of labor or the tasks performed.

All of these factors argue for caution in the use of these data, and warn against unwarranted assumptions of precision.

## How the U.S. Manufacturing Sector Ranks

The standard measure of the size of a nation's manufacturing sector is not manufacturers' sales, but rather their value added. Value added attempts to capture the economic contribution of manufacturers in designing, processing, and marketing the products they sell.

At the level of an individual firm, value added can be calculated as total sales less the total cost of purchased inputs, such as raw materials and electricity. The intuition behind this calculation is that a firm that purchases raw materials and processes them only slightly may have substantial sales, but its manufacturing efforts will not have transformed the materials in ways that significantly increase their value. Alternatively, a firm's value added can be measured as the sum of its employee compensation, business taxes (less subsidies), and profits.

The size of a country's manufacturing sector cannot be determined simply by adding up the value added of its manufacturers. If a domestic manufacturer uses inputs from its plants abroad, those inputs contain value added by the firm, but not domestically. Calculating total value added in manufacturing thus requires adjustments for imported parts and components incorporated into the output of domestic factories, and also for domestic products that were exported and used in a foreign plant to make products that were subsequently imported.<sup>1</sup>

According to United Nations estimates, China displaced the United States as the largest manufacturing nation in 2010. In 2013, according to the U.N. figures, China's value added in manufacturing reached \$2.7 trillion, compared to \$2.0 trillion for the United States. These estimates are calculated in U.S. dollars, and China's rise relative to the United States is partially due to the fact that its currency, the yuan, strengthened 25% against the dollar between 2003 and 2013.<sup>2</sup> Japan ranked third in manufacturing value added at \$917 billion in 2013 (see **Figure 1**). Germany is the only other country whose manufacturing sector is more than one-sixth the size of that in the United States.<sup>3</sup> Data from the U.S. Bureau of Economic Analysis indicate that U.S. manufacturing value added rose 1.1% in 2013 after adjustment for inflation.

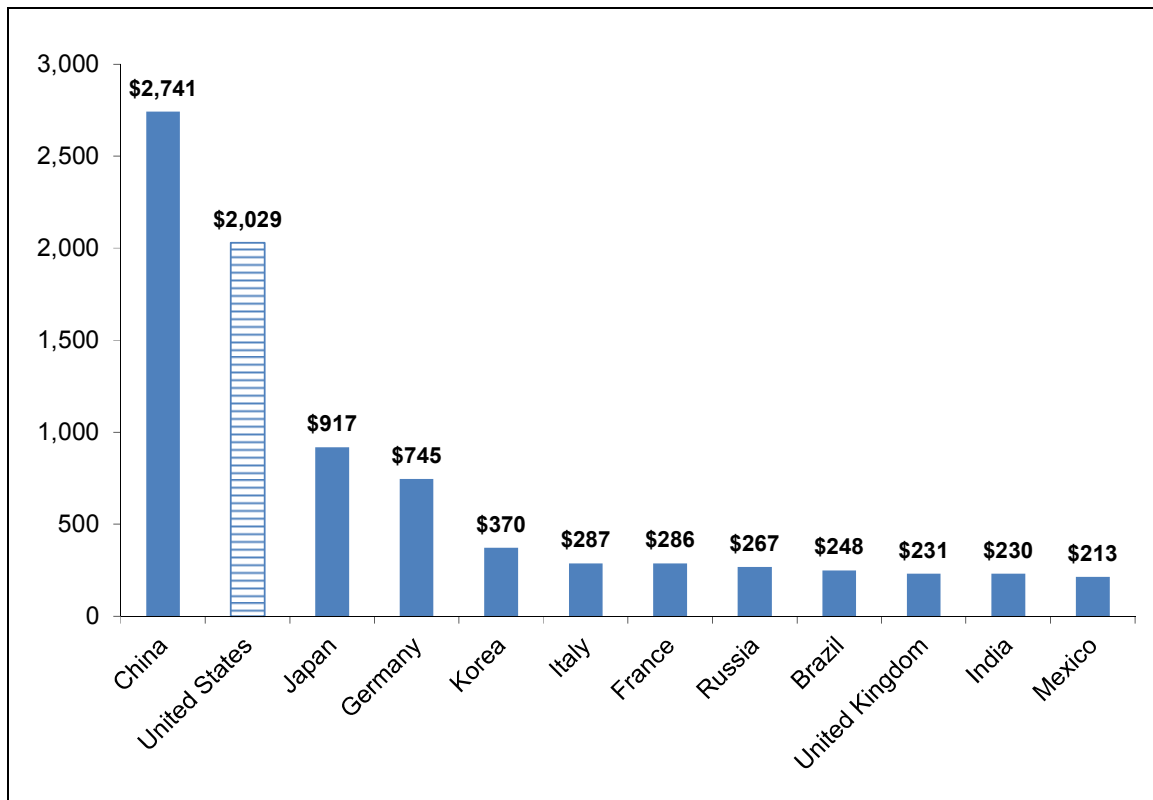
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<sup>1</sup> For more on the changing nature of value added in manufacturing, see CRS Report R41712, "*Hollowing Out*" in U.S. Manufacturing: Analysis and Issues for Congress, by (name redacted).

<sup>2</sup> Currency appreciation calculated from Federal Reserve Board, G.5 release, annual average data.

<sup>3</sup> United Nations National Accounts Main Aggregates Database, value added by economic activity at current prices—U.S. dollars, <http://unstats.un.org/unsd/snaama/resQuery.asp> (accessed January 6, 2014). The data used here are standardized and hence may differ from those reported by national statistical services. For example, the United Nations estimates U.S. manufacturing value added of \$1.994 trillion in 2014, whereas the U.S. Bureau of Economic Analysis estimates \$1.867 trillion (as of January 6, 2014).

**Figure 1. Leading Countries, Value Added in Manufacturing**  
Billion dollars, 2013



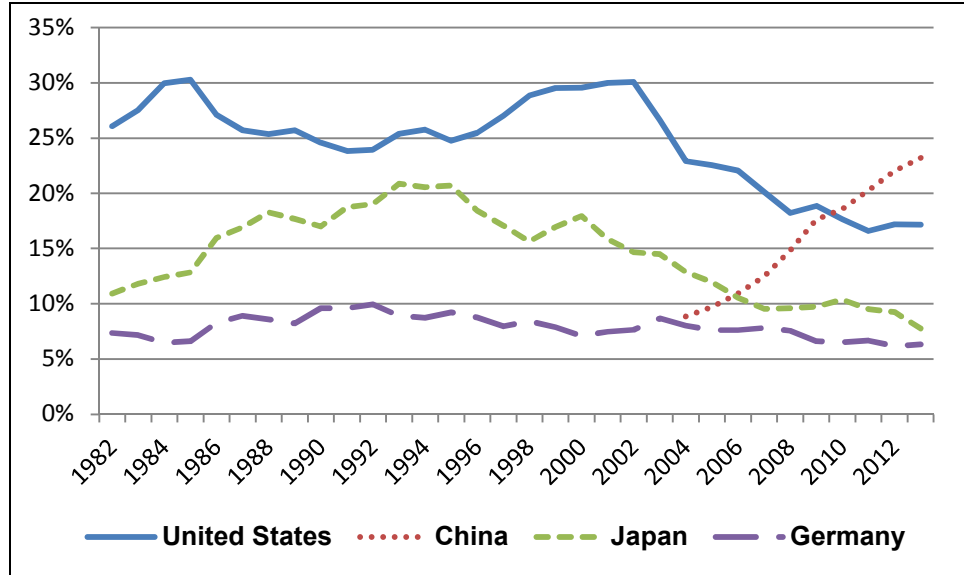
**Source:** United Nations National Accounts Main Aggregates Database, value added by economic activity, at current prices—U.S. dollars.

The U.S. share of global manufacturing value added has declined over time, from 30% in the early 1980s to 17%-18% today (see **Figure 2**). Similarly, Japan's share of global manufacturing value added has contracted from 21% in 1993 to around 8% now, and Germany's has fallen from 10% (in 1990, just after reunification) to 6%. It is important to note that global shares are measured in U.S. dollars, so each country's share in a given year is greatly affected by the strength of its currency against the dollar.

The declining shares of the wealthy economies are a consequence of the very rapid increase in manufacturing activity in emerging economies, notably China, and do not necessarily indicate absolute declines in manufacturing value added. Manufacturing value added in the United States, as measured by the Bureau of Economic Analysis in inflation-adjusted 2009 dollars, rose 40% from 1997 to 2014, although not until the second quarter of 2014 did manufacturing activity exceed the level at the onset of the most recent recession in 2007.<sup>4</sup>

<sup>4</sup> Bureau of Economic Analysis, real value added by industry, seasonally adjusted at annual rates through Q3.2014, as released on January 22, 2015.

**Figure 2. Selected Countries' Shares of Manufacturing Value Added**  
 Calculated in current U.S. dollars

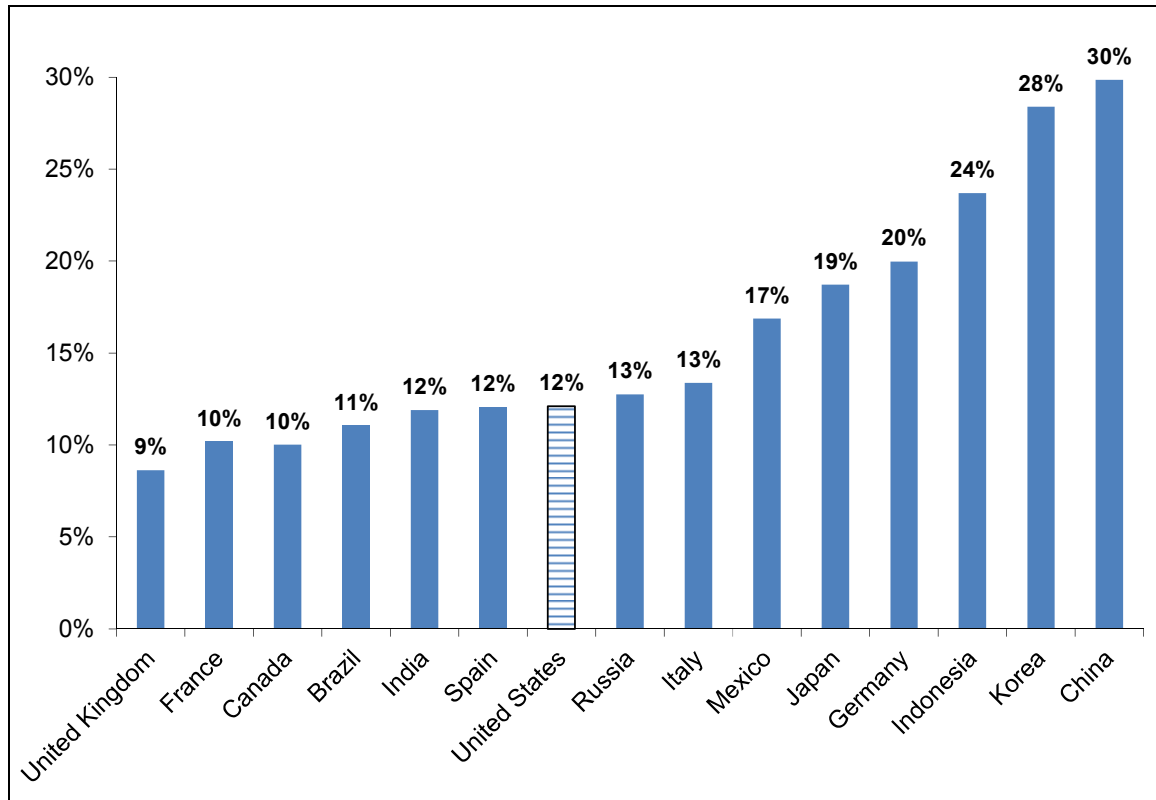


**Source:** United Nations National Accounts Main Aggregates Database, value added by economic activity, at current prices—U.S. dollars.

Manufacturing value added amounted to 12.1% of total U.S. gross domestic product (GDP) in 2013, according to United Nations calculations. Manufacturing is more significant in the United States, relative to the size of the economy, than in the United Kingdom, France, and Canada, but much less important than in Japan, Germany, Indonesia, Korea, and China (see **Figure 3**). Chinese manufacturing value added accounted for 29.9% of its economy’s total output in 2013, according to the U.N. The manufacturing share in China has declined in recent years, while the share in the United States has remained relatively stable.

In this respect, it is important to note that a high ratio of manufacturing value added to GDP is not necessarily a sign of economic vibrancy. To the contrary, a high ratio may indicate that various policies or practices, such as labor regulations, credit subsidies, or protection from imports, are standing in the way of a reallocation of capital and labor from manufacturing to other sectors in which they might contribute more to economic growth.

**Figure 3. Share of Manufacturing in National Economies**  
 Manufacturing value added as percentage of Gross Domestic Product, 2013



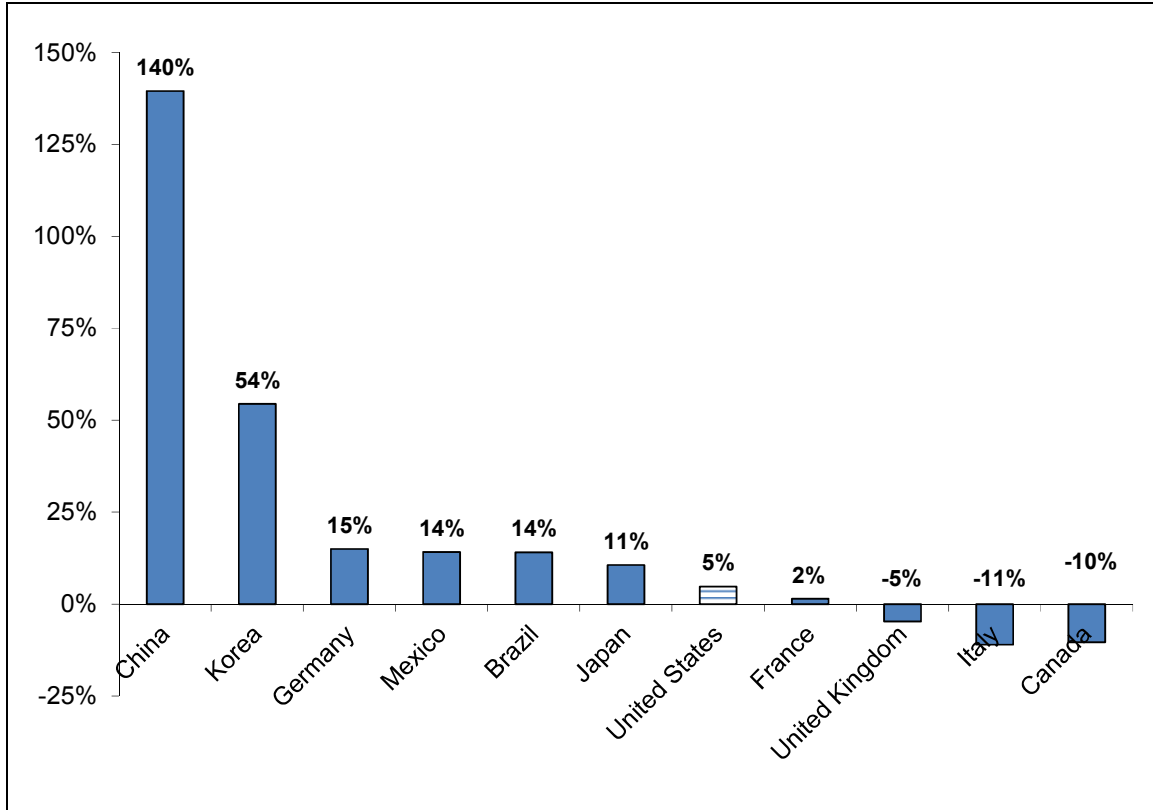
**Source:** United Nations National Accounts Main Aggregates Database, value added by economic activity and Gross Domestic Product, at current prices—national currency.

Despite its relatively low rank in manufacturing as a share of GDP, the United States appears to have outperformed most other wealthy countries in the growth of manufacturing value added in recent years. U.S. value added in manufacturing, adjusted for inflation, rose 5% between 2005 and 2013, according to U.N. data. Japan had 11% growth in manufacturing value added during that period, while the United Kingdom, Italy, and Canada saw declines in value added. China and Korea had much faster growth in manufacturing value added than the United States over the same period, after adjusting for inflation (see **Figure 4**). These data are expressed in terms of each country's currency, adjusted for its domestic inflation, so exchange-rate changes play no role.<sup>5</sup>

<sup>5</sup> United Nations National Accounts Main Aggregates Database, Value Added by Economic Activity at constant 2005 prices, national currency, <http://unstats.un.org/unsd/snaama/selbasicFast.asp>.



**Figure 4. Change in Value Added in Manufacturing, 2005-2013**  
Adjusted for inflation in each respective country



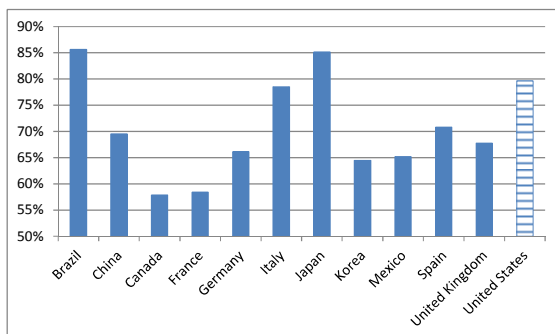
Source: <http://unstats.un.org/unsd/snaama/selbasicFast.asp>.

Data from the Organisation for Economic Co-operation and Development (OECD), a group of 34 nations, most with relatively high per-capita incomes, show that domestic value added accounts for a comparatively high proportion of the value of U.S. manufactured exports. In other words, U.S. manufacturers use a low proportion of imported inputs and a high proportion of domestically produced inputs, compared to manufacturers in other countries. For example, nearly 80% of the value of U.S. exports of transport equipment in 2009 was added in the United States, while most other countries' exports of such equipment contained far less domestic value added (see **Figure 5**). With respect to exports of electrical and optical equipment, the share of value added domestically is far greater for the United States (89%) than for Japan (82%), Germany (75%), China (58%), or Korea (53%), according to the OECD.<sup>6</sup>

<sup>6</sup> Calculated from OECD-WTO Trade in Value Added database, Value Added embodied in Gross Exports by Source, [http://stats.oecd.org/Index.aspx?DataSetCode=TIVA\\_OECD\\_WTO#](http://stats.oecd.org/Index.aspx?DataSetCode=TIVA_OECD_WTO#) (accessed March 11, 2015).

**Figure 5. Domestic Value in Exports of Transport Equipment**

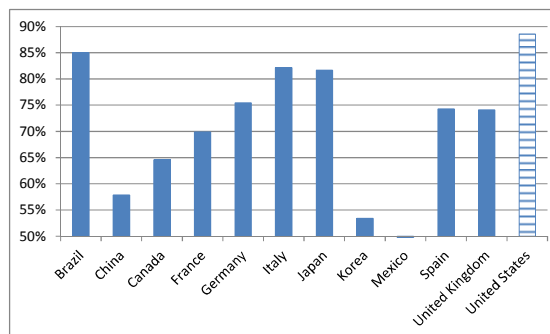
2009



**Source:** OECD-WTO Trade in Value Added, Value Added in Gross Exports by Source.

**Figure 6. Domestic Value in Exports of Electrical and Optical Equipment**

2009



**Source:** OECD-WTO Trade in Value Added, Value Added in Gross Exports by Source.

The United States has performed well in manufacturing, compared to other high-income economies, when viewed over a longer time period. From 1990 through 2013, the only high-income countries with faster growth in manufacturing value added were a handful of smaller economies including Finland, Israel, and Sweden, as well as Korea.

Additionally, data on inflows of foreign investment suggest that the United States has been an attractive manufacturing location relative to other high-income countries in recent years.<sup>7</sup> Over the 2007-2012 period, 39% of foreign direct investment coming into the United States went into the manufacturing sector, a far higher percentage than in any other large, wealthy economy.<sup>8</sup> Comparative data are not available regarding the extent to which that foreign investment financed construction of new manufacturing facilities as opposed to acquisition of existing facilities.

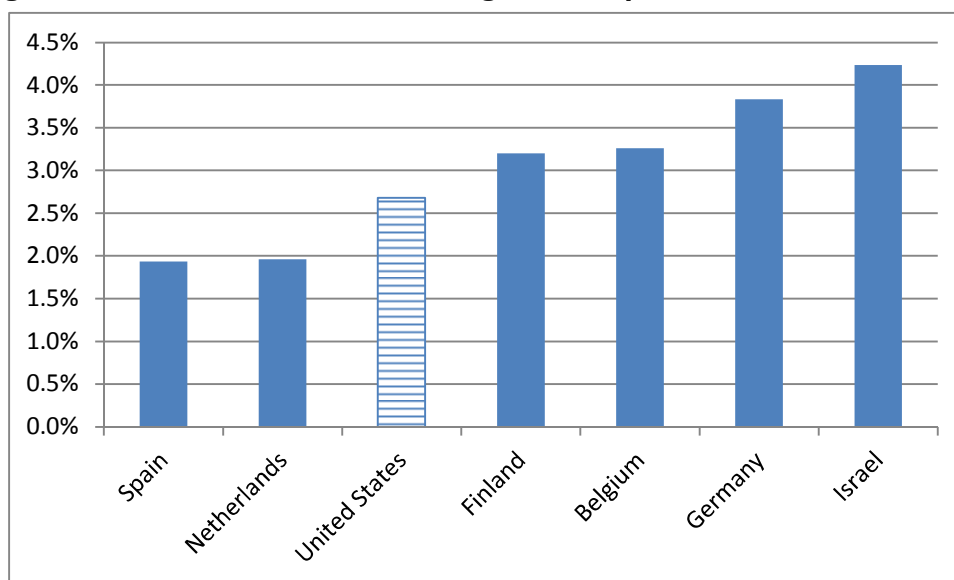
Data permitting international comparisons of capital investment in manufacturing are available for only a few countries. These indicate that gross investment in fixed manufacturing capital, such as factories and equipment, is significantly lower than in Germany and Israel, but higher than in other advanced economies such as Spain and the Netherlands (see **Figure 7**). Gross fixed capital formation in general is comparatively low in the United States,<sup>9</sup> but the United States also devotes a smaller proportion of fixed capital investment to the manufacturing sector than most of the other countries for which recent data are available.<sup>10</sup>

<sup>7</sup> For analysis of the role of international differences in corporate taxation in location decisions, see CRS Report R42927, *An Analysis of Where American Companies Report Profits: Indications of Profit Shifting*, by (name redacted), and CRS Report R41743, *International Corporate Tax Rate Comparisons and Policy Implications*, by (name redacted).

<sup>8</sup> OECD International Direct Investment Statistics, "Foreign direct investment: flows by industry," [http://www.oecd-ilibrary.org/finance-and-investment/data/oecd-international-direct-investment-statistics\\_idi-data-en](http://www.oecd-ilibrary.org/finance-and-investment/data/oecd-international-direct-investment-statistics_idi-data-en).

<sup>9</sup> <http://stats.oecd.org>, "National Accounts at a Glance: 6. Capital," indicator K1S: Consumption of fixed capital, percentage of GDP.

<sup>10</sup> Some 10% of U.S. fixed-capital formation in 2009 occurred in the manufacturing sector, compared to 8.7% in France. The highest proportion among the countries for which data are available was 25.4% in Korea. See OECD, National Accounts Statistics, "Detailed National Accounts: Capital formation by activity," [http://www.oecd-ilibrary.org/economics/data/detailed-national-accounts/capital-formation-by-activity\\_data-00008-en?isPartOf=/content/](http://www.oecd-ilibrary.org/economics/data/detailed-national-accounts/capital-formation-by-activity_data-00008-en?isPartOf=/content/) (continued...)

**Figure 7. Investment in Manufacturing Fixed Capital as Share of GDP, 2013**

**Source:** OECD, National Accounts Statistics, “Detailed National Accounts: Capital formation by activity” and “Gross Domestic Product.”

**Note:** Data for Spain and Israel pertain to 2012.

Interpreting these data on investment in manufacturing is problematic. A high ratio of gross fixed capital formation to output is not necessarily positive from an economic point of view; if such investment is generating a low return, then high capital investment could indicate inefficient use of capital. The relatively low level of gross investment in the United States might therefore indicate that U.S. manufacturers pay greater attention to return on capital than their counterparts in other countries. Another explanation might be that U.S. manufacturers face comparatively few obstacles to contracting fabrication or assembly work to manufacturers abroad, whereas other nations may have policies in place to promote domestic fabrication and assembly or to discourage foreign sourcing. Also, it is important to note that the definition of gross fixed capital used by the OECD appears to exclude software, which may represent a greater share of investment by U.S. manufacturers than by those in other countries.<sup>11</sup>

## The Role of Services in Manufacturing

Measuring manufacturing activity is not without problems, largely because of the imperfect line between manufacturing and services. U.S. statistical agencies, for example, consider work performed at establishments whose principal business is manufacturing to be manufacturing,

(...continued)

datacollection/na-dna-data-en (accessed February 6, 2014).

<sup>11</sup> OECD uses the definition established by the United Nations Statistics Division, which reads: “Gross fixed capital formation is measured by the total value of a producer’s acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non-produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realised by the productive activity of institutional units.” <http://unstats.un.org/unsd/snaama/glossresults.asp?gID=34>.

regardless of the specific tasks involved. Similarly, all activities occurring at establishments whose principal business is services are considered service activities.

The following three examples will illustrate the statistical confusion that can result.

- If a manufacturing facility designs and then fabricates a product, the design activities generally count as value added in manufacturing and the workers engaged will be tabulated as manufacturing employees.
- If the design is created within the manufacturing firm but at a location where no physical production occurs, it could conceivably count as either a manufactured product or a service-sector product.
- If the manufacturer purchases the design from a specialist design firm, the value added in the design process will be credited to the service sector, and the workers involved will be considered service-sector employees.

In all three cases, total employment and total value added are identical; all that differs is the economic sector to which the employment and value added are attributed.

Identifying manufacturing work has become even more difficult in recent years as distribution centers, which formerly were engaged almost entirely in warehousing, have increasingly assumed tasks that traditionally were performed in factories. For example, workers in a distribution center may receive imported products in bulk, customize them before shipment to retailers or end users, and package them for individual sale. As of May 2013, more than 28,000 workers at U.S. warehousing and storage facilities were engaged in manufacturing production activities such as assembly, food processing, and packaging. Their output is unlikely to have been captured as value added in manufacturing.<sup>12</sup>

Moreover, determining the location at which value is added to a service that is used in a manufactured product can be all but impossible. Manufacturers frequently procure components from many suppliers in lengthy international supply chains, and each of those suppliers is likely to purchase service inputs to at least a limited extent. The service providers themselves may be international firms, and their involvement in a given production process may involve workers on several continents.

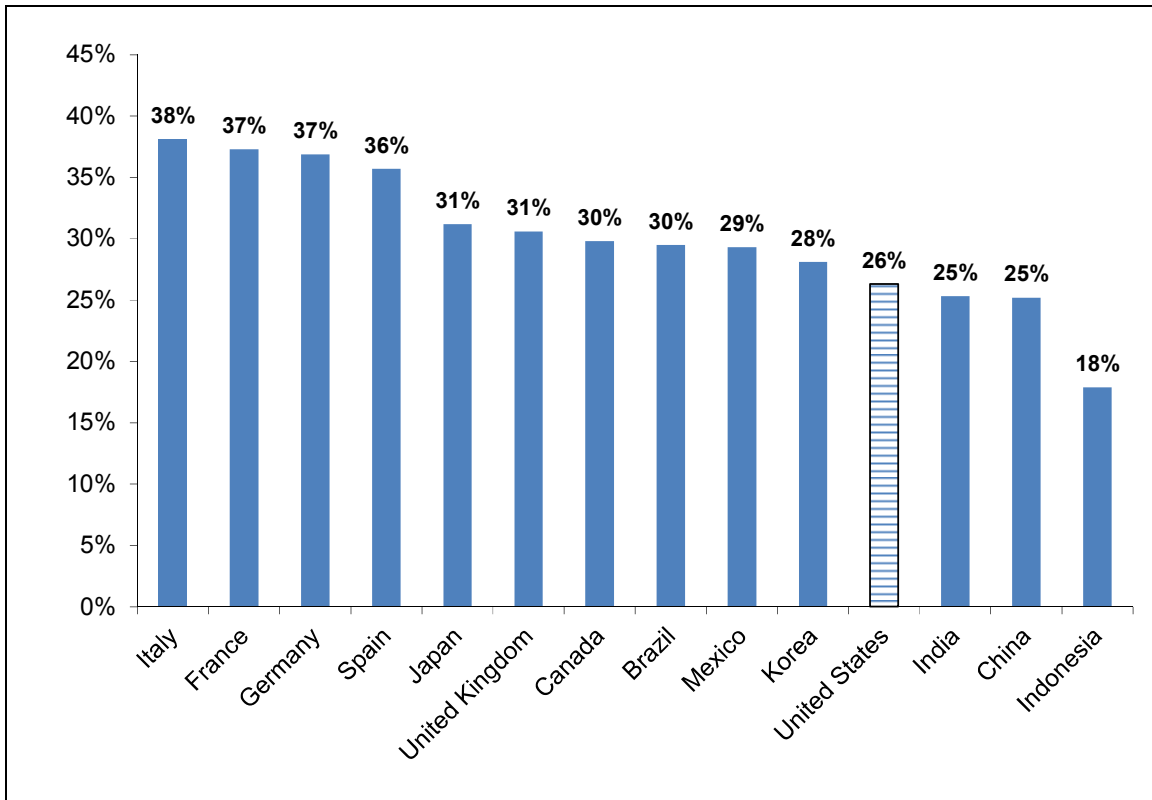
Efforts to measure the value of manufacturing-related services more accurately are still in their infancy. According to 2009 data, U.S. exports of manufactured products include a lesser proportion of services content than exports of most other advanced economies (see **Figure 8**). However, U.S. manufacturers made very little use of imported services content in exports compared to exporters in other countries. For example, 12.2% of the value of Chinese manufactured exports and 13.4% of the value of Korean manufactured exports in 2009 comprised imported services, compared with 4.4% of the value of U.S. manufactured exports.

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<sup>12</sup> Bureau of Labor Statistics, Occupational Employment Statistics for Warehousing and Storage, <http://data.bls.gov/oes>.

**Figure 8. Service-Sector Inputs into Manufacturing Exports**

Service-sector value added as percentage of total value added in of manufactured exports, 2009



**Source:** Organisation for Economic Co-operation and Development (OECD), STAN Input-Output Database, May 2011, <http://dx.doi.org/10.1787/888932487628>.

The figures illustrated in **Figure 8** show only the importance of services purchased by manufacturers from outside firms. One possible interpretation of these data is that U.S. manufacturers are more vertically integrated than those in other countries. A partial explanation is that a comparatively efficient transportation system requires U.S. exporters to spend less on purchasing transportation than their competitors in other countries: the cost of transportation and communications services came to only 3.5% of the value of U.S. manufactured exports in 2009, compared with 5.4% in Germany and 6.9% in Japan.<sup>13</sup>

## Manufacturing Work

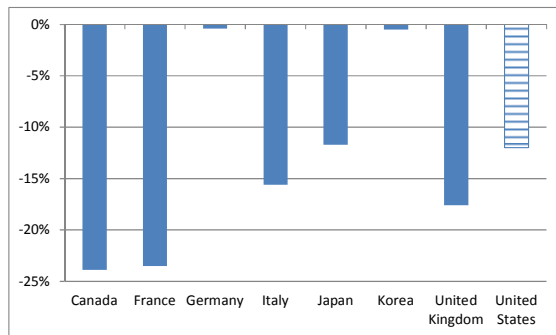
International comparisons of manufacturing employment trends are hampered by inadequate data, particularly for emerging economies. Among the top-ranking manufacturing countries, China, Brazil, and India do not report complete information on manufacturing employment at the

<sup>13</sup> OECD, services content of manufactured exports by type of service, 2009, [http://www.oecd-ilibrary.org/sites/sti\\_scoreboard-2013-en/07/02/index.html?contentType=&itemId=/content/chapter/sti\\_scoreboard-2013-61-en&containerItemId=/content/serial/20725345&accessItemIds=/content/book/sti\\_scoreboard-2013-en&mimeType=text/html](http://www.oecd-ilibrary.org/sites/sti_scoreboard-2013-en/07/02/index.html?contentType=&itemId=/content/chapter/sti_scoreboard-2013-61-en&containerItemId=/content/serial/20725345&accessItemIds=/content/book/sti_scoreboard-2013-en&mimeType=text/html) (accessed March 12, 2015).

national level. Mexico has a nationwide statistical sampling program, but due to definitional and methodological changes a consistent time series is available only since 2005.

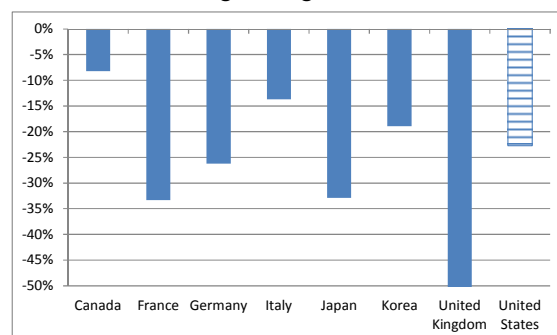
All of the advanced economies for which data are available have experienced long-term declines in manufacturing employment. Manufacturing employment in the United States, as measured by surveys of workers (rather than surveys of establishments), fell by 12% from 2003 through 2013. France, Spain, Sweden, and the United Kingdom saw much greater declines over that period, while the employment declines in Canada, Italy, and Japan were similar to that in the United States (see **Figure 9** for data on selected countries). Over the 22-year period since 1991, manufacturing employment fell by a much lower percentage in the United States than in France, Japan, and the United Kingdom (see **Figure 10**). These figures indicate that the diminished importance of manufacturing as a source of jobs is not limited to the United States.<sup>14</sup>

**Figure 9. Manufacturing Employment**  
Percentage change, 2003-2013



**Source:** The Conference Board, “International Comparisons of Annual Labor Force Statistics,” 2014, Table I-18.

**Figure 10. Manufacturing Employment**  
Percentage change, 1991-2013



**Source:** The Conference Board, “International Comparisons of Annual Labor Force Statistics,” 2014, Table I-18.

The international comparison of manufacturing employment is somewhat different if viewed in terms of hours worked rather than by the number of workers. By this metric, Germany experienced a similar decline in manufacturing work to that of the United States over the 1990-2012 period, while the declines in France, Japan, and the United Kingdom were larger. The timing differed among countries, with manufacturing work hours falling faster in other countries during the 1990s and the United States experiencing a comparatively steep drop from 2002 to 2012. Corresponding data for 2013 have not yet been released.<sup>15</sup>

The United States is not unique in experiencing a decline in the need for labor in the manufacturing sector. Even in Korea and Taiwan, where manufacturing output has expanded far more rapidly than in the United States, factories require fewer total hours of labor than was formerly the case. The reduced demand for labor is directly related to improved labor productivity. Manufacturing labor productivity increased much more rapidly in the United States between 2002 and 2012 than in Canada, European countries, or Japan (see **Figure 11**). Taiwan

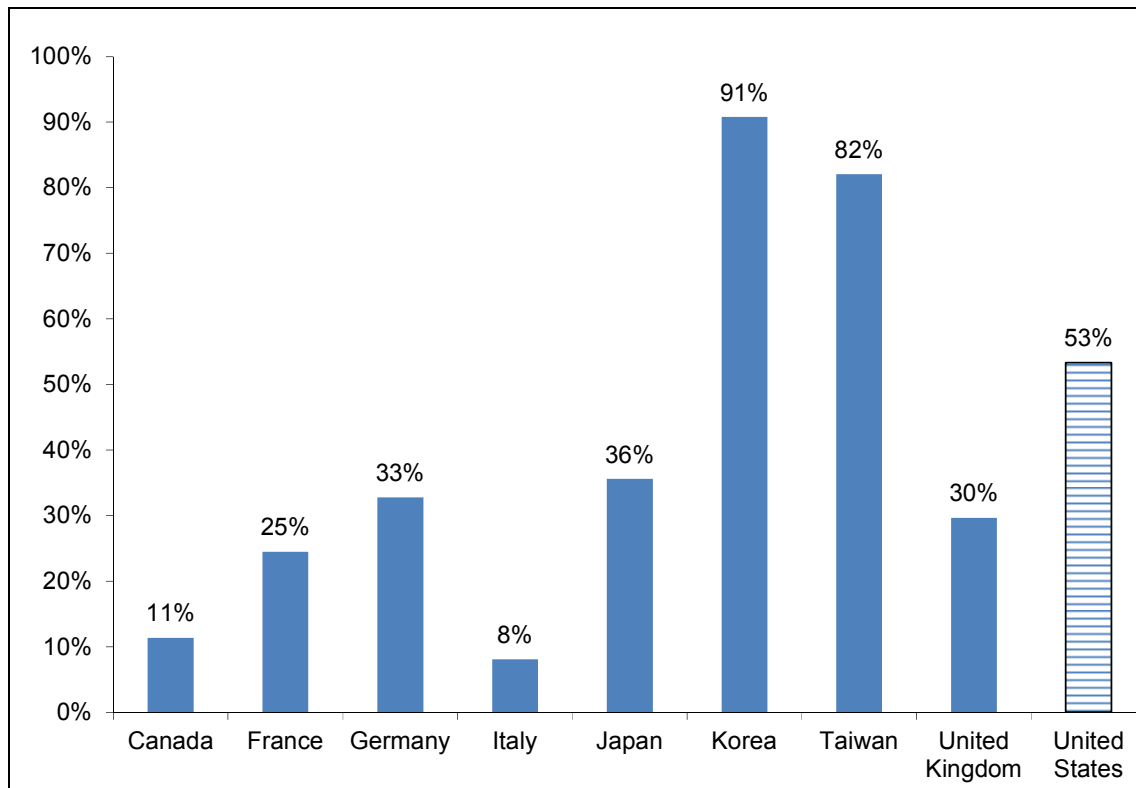
<sup>14</sup> These data were compiled by the U.S. Bureau of Labor Statistics (BLS) and adjusted for consistency.

<sup>15</sup> The Conference Board, International Labor Comparisons program, December 2013, Table 4, <http://www.conference-board.org/ilcprogram/>.

and Korea both had greater improvement in manufacturing labor productivity than the United States, probably due to declining employment in labor-intensive industries, such as apparel.

**Figure 11. Real Output per Labor Hour in Manufacturing**

Percentage change, 2002-2012



**Source:** The Conference Board, International Labor Comparisons program, “International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends, 2012,” Table 1, <http://www.conference-board.org/ilcprogram/>.

The strong improvement in U.S. labor productivity in manufacturing has several causes. One is manufacturers’ large investments in automation, which have eliminated many routine assembly jobs; fewer than 39% of the workers in U.S. manufacturing establishments are now directly engaged in production. A related factor is the rapid increase in education levels among U.S. manufacturing workers, some 29% of whom possess college degrees.<sup>16</sup> A third cause of improvement in average manufacturing productivity is the rapid growth of certain sectors in which labor productivity is extremely high. These include instrument manufacturing, in which output grew 56% from 2002 to 2012, and aerospace manufacturing, which expanded output 39% over the same period, during which total U.S. manufacturing output rose 9%.<sup>17</sup>

<sup>16</sup> On occupations and education within the manufacturing sector, see CRS Report R41898, *Job Creation in the Manufacturing Revival*, by (name redacted).

<sup>17</sup> Output changes are calculated from annual figures published in the Federal Reserve Board G.17 release, “Industrial Production and Capacity Utilization.”

In part, however, the measured improvement in labor productivity in manufacturing also reflects the rapid shrinkage of low-productivity manufacturing activities since 2000. During this period, many manufacturers moved routine assembly work abroad, either to their own factories or to those of contract suppliers. For example, the reduction of U.S. import barriers encouraged apparel imports and led to a reduction of domestic capacity in the low-productivity apparel industry. As U.S. plants with below-average productivity closed, average productivity of the remaining manufacturing plants necessarily increased even in the absence of productivity improvements.<sup>18</sup> Similarly, the very rapid increases in manufacturing labor productivity in Korea and Taiwan likely reflect the closure of low-productivity manufacturing as well as the expansion of capital-intensive manufacturing.

At the other extreme, Italy, which has seen a comparatively small drop in manufacturing employment, experienced by far the smallest increase in output per hour worked of any of the wealthy countries for which data are available, along with a decline in manufacturing value added. In combination, these figures suggest that restructuring low-productivity operations has been a challenge for Italian manufacturers.

Average compensation per employee in U.S. manufacturing was \$36.34 per hour in 2013, a 46% increase since 2000.<sup>19</sup> U.S. hourly manufacturing labor costs were lower than those in 13 of 33 countries for which the Conference Board, a private research organization, collected data. Due in part to exchange-rate changes, average compensation per hour expressed in U.S. dollar terms has been rising more slowly in the United States than in most other major manufacturing countries, with the notable exception of Japan (see **Table 1**).

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<sup>18</sup> In general, the manufacturing industries with the lowest productivity growth are those in which it has proven most difficult to automate production processes to increase output per worker hour. The apparel and footwear industries are notable in this respect. From 1973 to 2001, productivity grew at an annual rate of 0.9% for all U.S. manufacturing, but at only 0.7% for apparel and 0.3% for leather and leather products. For detailed data, see Bureau of Labor Statistics, "Multifactor Productivity in U.S. Manufacturing and in 20 Manufacturing Industries, 1949-2001," February 10, 2004, <http://www.bls.gov/mfp/tables.htm>, and "Manufacturing Sector and NIPA-level Manufacturing Industries KLEMS Multifactor Productivity Tables by Measure," August 11, 2011, <http://www.bls.gov/mfp/mprdload.htm>.

<sup>19</sup> "Compensation" includes pay for time worked, employee benefits, and labor-related taxes net of subsidies.



**Table I. Hourly Compensation Costs in Manufacturing**

U.S. dollar basis, 2013

	Direct Pay	Total Compensation Costs	Change in Compensation Costs Relative to United States, 2000-2013 (percentage points)
Brazil	\$7.29	\$10.69	18
Canada	\$29.06	\$36.33	26
France	\$29.83	\$42.85	19
Germany	\$27.90	\$48.98	16
Italy	\$26.23	\$36.92	20
Japan	\$23.86	\$29.13	-2
Korea	\$17.67	\$21.96	20
Mexico	\$4.75	\$6.62	0
Taiwan	\$8.01	\$9.37	2
United Kingdom	\$26.49	\$31.00	-3
United States	\$27.66	\$36.34	NA

**Source:** The Conference Board, "International Comparisons of Hourly Compensation Costs in Manufacturing and Submanufacturing Industries," December 17, 2014.

**Notes:** "Direct Pay" includes vacation pay, bonus payments, and employer contributions to employees' savings funds. "Total Compensation Costs" additionally includes pensions, disability insurance, sick leave, health insurance, severance pay, other social insurance expenditures, and taxes on payrolls or employment. "Change in Compensation Costs Relative to United States" incorporates the effects of exchange-rate changes.

Accurate nationwide data on manufacturing compensation costs in China and India are not available. The Conference Board estimates that average manufacturing compensation in China was \$3.07 per hour in 2012, having risen 154%, in U.S. dollars, between 2007 and 2012. With respect to India, the Conference Board estimates average hourly compensation in formal manufacturing establishments to have been \$1.59 in 2011, but cautions that this figure overstates average compensation as it pertains to only about 20% of the country's manufacturing workers. Because data from China and India are not comparable to those from other countries, they are not included in **Table 1**.<sup>20</sup>

The data on average hourly compensation costs can be misleading, as they are not adjusted for differences in the industrial mix. In most countries, including the United States, labor costs vary greatly among industries; the average hourly wage of production workers at U.S. sawmills is around \$16 per hour, whereas the average hourly wage for production workers in aircraft manufacturing exceeds \$37.

<sup>20</sup> For information on issues related to measurement of compensation in China and India, see Judith Bannister, "China's manufacturing employment and hourly labor compensation, 2003-2009," U.S. Bureau of Labor Statistics, June 7, 2013, [http://www.bls.gov/fls/china\\_method.pdf](http://www.bls.gov/fls/china_method.pdf), and Jessica R. Sincavage, Carl Haub, and O.P. Sharma, "Labor Costs in India's organized manufacturing sector," *Monthly Labor Review*, May 2010, p. 22, <http://www.bls.gov/opub/mlr/2010/05/art1full.pdf>.

The most recent U.S. data on comparative compensation costs within individual industries show U.S. costs to be lower than those in major European countries, although well above those in emerging economies (see **Table 2**). The more detailed data that would be required to correct for national differences in the products manufactured by these industries are not available.

**Table 2. Hourly Compensation Costs in Selected Manufacturing Industries**

U.S. dollar basis, 2012

	Paper	Textiles	Chemicals	Machinery	Motor Vehicles
Brazil	\$13.30	\$6.96	\$18.64	\$14.28	\$17.01
France	\$43.63	\$34.31	\$55.39	\$45.14	\$50.42
Germany	\$43.66	\$35.83	\$61.55	\$52.35	\$62.07
Italy	\$35.25	\$33.30	\$46.06	\$40.10	\$41.70
Korea	\$17.89	\$14.45	\$25.74	\$19.80	\$26.81
Mexico	\$5.64	\$4.21	\$10.59	\$7.21	\$8.24
Taiwan	\$7.57	\$7.39	NA	NA	\$9.69
United Kingdom	\$30.06	\$25.08	\$32.36	\$33.04	\$39.07
United States	\$37.71	\$23.93	\$40.35	\$39.28	\$46.35

**Source:** The Conference Board, “International Comparisons of Hourly Compensation Costs in Manufacturing and Submanufacturing Industries,” December 17, 2014.

## Technology and Research in Manufacturing

High-technology manufacturing has been a particular focus of public-policy concern for many years. There is no standard definition of high-tech manufacturing, but commentators have long asserted that high-technology production has especially beneficial economic spillovers.<sup>21</sup> Although definitions of “high-tech industry” vary, the OECD considers that manufacturing of pharmaceuticals; office, accounting, and computing machinery; radio, television, and communications equipment; medical, precision, and optical instruments; and aircraft and spacecraft is particularly technology-intensive, based on those industries’ research and development (R&D) expenditures and on the amount of R&D embodied in their products.<sup>22</sup> It is important to note in this context that some industries that may have a considerable technological component, such as automobile and machinery manufacturing, are not considered high-technology industries by the OECD.

<sup>21</sup> For a recent statement of this view, see Gregory Tasse, “Competing in Advanced Manufacturing: The Need for Improved Growth Models and Policies,” *Journal of Economic Perspectives*, vol. 28 (2014), p. 29. Similar arguments were made in earlier decades in Stephen S. Cohen and John Zysman, *Manufacturing Matters: The Myth of the Post-Industrial Economy* (New York, 1987), p. 106, and Lester Thurow, *Head to Head: The Coming Economic Battle Among Japan, Europe, and America* (New York, 1992), pp. 45-51.

<sup>22</sup> These sectors correspond to United Nations International Standard Industrial Classifications 2423, 30, 32, 33, and 353. For details, see OECD, “ISIC Rev. 3 Technology Intensity Definition,” July 7, 2011, p. 1, <http://www.oecd.org/dataoecd/43/41/48350231.pdf>.

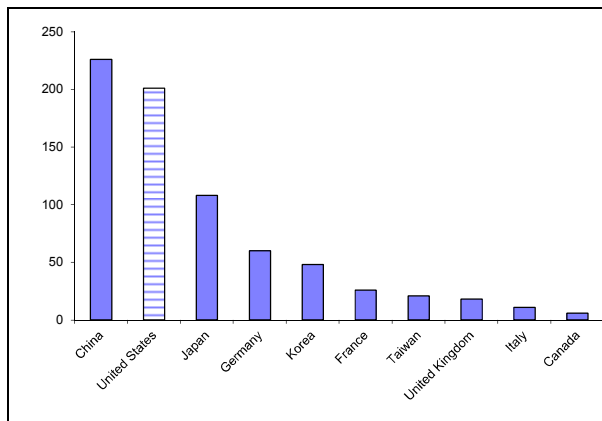
The United States derives a greater share of manufacturing value added from high-tech industries than is the case in most other OECD member countries. Moreover, the share of value added represented by high-technology sectors has been rising in the United States, whereas it has been stable or declining in many other countries.<sup>23</sup>

Manufacturers in the United States spend far more on research than those in any other major industrial country. However, OECD data indicate that, after adjusting for differences in purchasing power, manufacturers' spending on R&D in China may now exceed that in the United States. The Chinese data, available on an annual basis only since 2008, indicate that R&D spending by manufacturers is growing at double-digit annual rates. Manufacturers' R&D spending in the United States significantly exceeds that in all other countries (see **Figure 12**).<sup>24</sup>

Manufacturing R&D in the United States has been growing at a relatively modest rate, similar to that of Japan and the larger European economies. R&D spending by manufacturers has been growing much more quickly in some Asian economies, notably China, Korea, and Taiwan (see **Figure 13**). In some economies that have undergone rapid industrialization, such as Mexico and Turkey, manufacturers still devote comparatively few resources to R&D.

**Figure 12. R&D in Manufacturing, 2013**

Billions of U.S. dollars at purchasing power parity

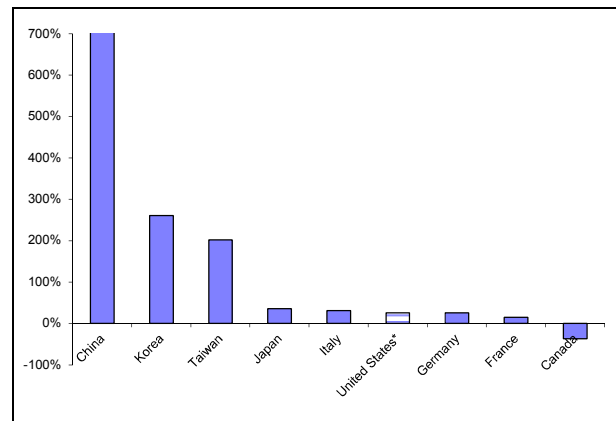


**Source:** OECD STAN database, "STAN R&D expenditures in Industry," <http://stats.oecd.org/index.aspx>.

**Note:** United States data are for 2011, France and United Kingdom data for 2012.

**Figure 13. Growth in Manufacturing R&D**

Change in real local currency, 2000-2013



**Source:** OECD STAN database, "STAN R&D expenditures in Industry," <http://stats.oecd.org/index.aspx>.

**Note:** France data are for 2000-2012, United States data for 2000-2011.

Manufacturers have been responsible for approximately 70% of all R&D conducted by businesses in the United States in recent years. This is far lower than in Germany, Japan, Korea, and China, where manufacturers account for 85%-90% of all business-financed R&D. Conversely, the service sector is relatively more important in undertaking R&D in the United States than in many

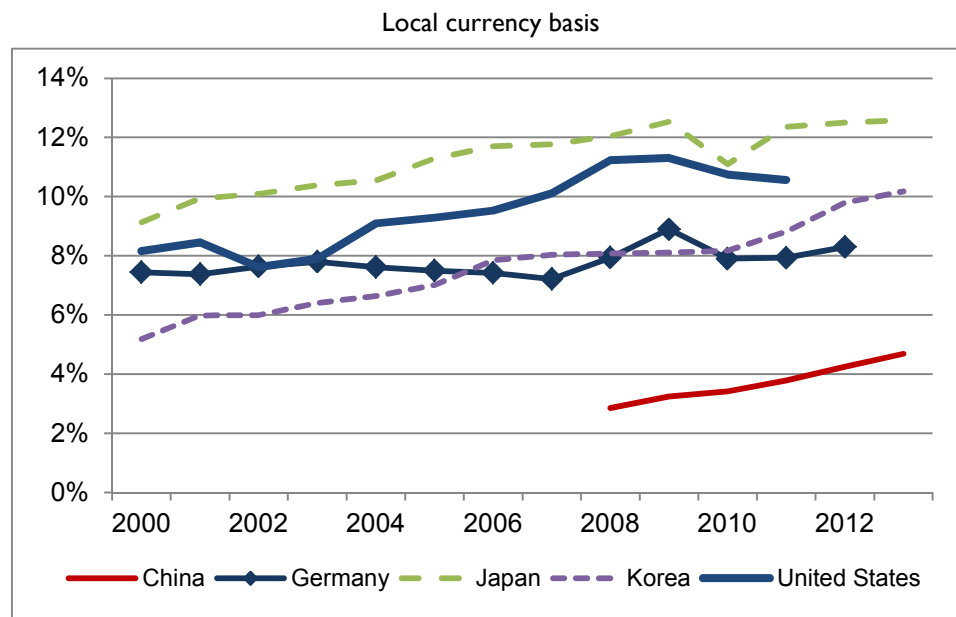
<sup>23</sup> Based on CRS analysis of OECD Structural Analysis Database.

<sup>24</sup> These figures include expenditures by manufacturers, whatever the original source of the funds.

other countries. The most notable exception is the United Kingdom, where service companies account for three-fifths of all business R&D spending.<sup>25</sup>

The research intensity of U.S. manufacturing has increased significantly in recent years, as shown by data indicating that R&D accounts for a growing share of manufacturing value added. In 2000, U.S. manufacturers spent 8% of sales on R&D, a figure that rose into the 11% range starting in 2008. A similar trend is in evidence in most other countries. However, U.S. manufacturers still spend more on R&D, relative to value added, than manufacturers in other large manufacturing countries, with the exception of Japan (see **Figure 14**).

**Figure 14. Manufacturing R&D as Share of Manufacturing Value Added**



**Source:** CRS, from OECD STAN R&D expenditures in industry, [http://stats.oecd.org/Index.aspx?DataSetCode=ANBERD\\_REV4](http://stats.oecd.org/Index.aspx?DataSetCode=ANBERD_REV4), and value-added data in United Nations National Accounts Main Aggregates Database, <http://unstats.un.org/unsd/>.

One reason for national differences in R&D intensity in manufacturing is differences in the composition of the manufacturing sector. Industries such as aircraft, spacecraft, and electronic instrument manufacturing are among the most research-intensive in every country, and, all other things equal, countries in which these sectors are relatively large may be expected to have greater R&D intensity in manufacturing than countries in which they are less important.

**Table 3** provides an alternative cross-country comparison of R&D spending by manufacturers by breaking out R&D intensity by industry for 2006. It illustrates that U.S. manufacturers are more research-intensive than those in other countries only in selected industries, such as electronic instruments. In other industries, foreign manufacturers spend comparatively more on R&D than those in the United States. For example, Japanese manufacturers of office, accounting, and computing machinery devote a greater share of sales to R&D than those in any other country, and

<sup>25</sup> OECD, Science, Technology and R&D Statistics, "Business enterprise R-D expenditure by industry," [http://stats.oecd.org/BrandedView.aspx?oeed\\_bv\\_id=strd-data-en&doi=data-00183-en](http://stats.oecd.org/BrandedView.aspx?oeed_bv_id=strd-data-en&doi=data-00183-en) (accessed February 10, 2014).

Italy, whose manufacturers generally are much less R&D-intensive than those in other countries, appears to have particularly extensive industry research related to aerospace manufacturing.

**Table 3. Comparative Research and Development Spending by Industry**

R&D outlays by manufacturers as a percentage of sales, 2006

	Canada	France	Germany	Italy	Japan	Korea	United Kingdom	United States
All manufacturing	1.4%	2.5%	2.4%	0.6%	3.7%	1.9%	2.4%	3.3%
Pharmaceuticals	11.9%	8.7%	10.4%	1.5%	15.0%	2.5%	24.9%	22.5%
Office, accounting, computing machinery	10.9%	7.9%	4.1%	1.1%	28.7%	3.9%	0.4%	11.0%
Electrical machinery	1.3%	3.5%	1.3%	0.5%	8.8%	1.4%	3.3%	2.0%
Instruments	NA	7.1%	6.6%	2.4%	14.4%	2.2%	3.6%	18.0%
Motor vehicles	0.5%	4.7%	4.4%	1.8%	4.3%	2.8%	1.9%	3.4%
Aircraft and spacecraft	6.3%	5.2%	10.4%	12.5%	4.2%	9.0%	10.7%	11.3%

**Source:** OECD, STAN indicators: R&D intensity of manufacturing sectors, [http://www.oecd-ilibrary.org/industry-and-services/data/stan-oecd-structural-analysis-statistics/stan-indicators-2009\\_data-00031-en](http://www.oecd-ilibrary.org/industry-and-services/data/stan-oecd-structural-analysis-statistics/stan-indicators-2009_data-00031-en).

**Table 4** confirms that manufacturers' R&D spending is targeted quite differently in different countries. In general, a very large proportion of U.S. manufacturers' R&D takes place in high-technology sectors, particularly pharmaceutical, electronics, and aircraft manufacturing, whereas in most other countries save Korea, a far greater proportion of manufacturers' R&D outlays occur in medium-technology sectors such as motor vehicle and machinery manufacturing.

**Table 4. Manufacturers' R&D Spending by Sector, 2011**

Percentage of total R&D spending by manufacturers

Country	Chemicals	Pharmaceuticals	Computers, Electronics, Optical	Motor Vehicles	Other Transport Equipment
China	9.3%	3.7%	18.6%	7.3%	4.4%
France	5.8%	5.8%	22.3%	13.4%	20.4%
Germany	7.5%	9.3%	15.0%	37.3%	5.9%
Italy	4.3%	7.3%	18.1%	16.3%	14.1%
Japan	6.9%	11.4%	29.1%	25.3%	0.5%
Korea	7.0%	2.6%	55.9%	13.6%	1.9%
United Kingdom	4.4%	8.2%	15.2%	20.2%	18.9%
United States	4.4%	25.1%	30.4%	5.0%	16.8%

**Source:** OECD (2013), Research and Development Statistics: Business enterprise R-D expenditure by industry- ISIC Rev. 4," OECD Science, Technology and R&D Statistics database (accessed March 17, 2015).

**Note:** U.S. data pertain to 2010. U.S. figures for motor vehicles and other transport equipment are not disclosed separately, and are estimated by CRS. Chinese figures for motor vehicles and other transport equipment are based on 2012 data, as data for 2011 are not available.

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