

# The U.S. Semiconductor Industry: A Key Contributor to U.S. Economic Growth

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The U.S. semiconductor industry is a uniquely important contributor to the U.S. economy. Thanks to rapid technological development, the industry's contribution to the U.S. economy grew 265 percent from 1987 to 2011, **more than that of any other major U.S. manufacturing industry**. According to the U.S. government, the U.S. semiconductor industry **contributes more than \$65 billion** to the U.S. economy, more than all other U.S. manufacturing industries but two.<sup>2</sup>

## Key Takeaways

- 1) The U.S. semiconductor industry doubled its share of gross domestic product (GDP) between 1987 and 2011. During this period, the industry's real contribution to U.S. GDP has grown annually by 5.5 percent, more than two times faster than GDP.
- 2) The U.S. semiconductor industry continued to grow rapidly during 2007-2011, despite a decreasing overall U.S. economic performance. U.S. semiconductor industry's real contribution grew 5.2 percent annually during this period – nearly twenty times faster than GDP, as its annual real growth slowed down to 0.3 percent. This disparity suggests the U.S. semiconductor industry is becoming ever more important to U.S. economic growth.
- 3) In absolute terms, the U.S. semiconductor industry's share of U.S. GDP is the third largest of all U.S. manufacturing industries, behind only the petroleum refinery and pharmaceutical preparations industries.

## Introduction

In 1998, the Semiconductor Industry Association published a report by Nathan Associates Inc. confirming, based on government-collected data, that the U.S. semiconductor industry was first among U.S. manufacturing industries in terms of its economic contribution to the U.S. economy.<sup>3</sup> For decades, the U.S. semiconductor industry has perennially contributed more value to U.S. economic growth than most if not all other U.S. manufacturing industries.

The world is increasingly dependent on semiconductors: your phone, watch, car, and even your refrigerator have more computing power than early computers. We are traveling fast towards an even more connected world, a world of the internet of things – where our appliances are able to communicate with each other – ensuring more efficient usage of energy and other resources and getting more value with less cost.

This development would be unimaginable without the U.S. semiconductor industry's sustained investment in research and development (R&D). Almost no other U.S. industry invests as heavily in R&D – in 2013, the industry invested \$34 billion in R&D, the highest percent of total sales of any industry.<sup>4</sup>

Investing in R&D pays off for Americans. Gordon Moore, one of the founders of Intel Corporation, predicted in the mid-1960s that the number of transistors on an integrated circuit, or chip, would double every 18-24 months. So far, the industry has been able to keep up with this prediction known as “Moore’s Law” astonishingly well: the modern day commercial chip carries nearly 2 million times more transistors than its predecessor in the 1970s.<sup>5</sup> Today’s chips can perform more and more complicated tasks while becoming smaller at the same time, thus enabling their use in countless devices that improve our lives in multiple ways.


## Industry Value Added – the Contribution to GDP

There are several different ways to evaluate an industry’s input into the economy. Some often used key metrics include total revenues, employment, exports, capital investment, and R&D spending. The U.S. semiconductor industry performs very well using these criteria: in 2013, U.S. semiconductor industry revenue was approximately \$155 billion,<sup>6</sup> it directly employed roughly 250,000 workers, and it indirectly supported an additional million jobs.

An industry’s economic value can also be measured by its *value added* – or contribution – to the economy. In the language of business, the concept of value added can be explained as revenues from total sales less the purchases of components, materials, and services from other companies. In economic terms, value added is explained as the total sum of compensation to labor (returns on labor), gross operating surplus (returns on capital), and taxes paid to government, less government subsidies. Calculated either way, the end result is the same. Adding the results of all industries together equals total GDP – when one industry’s contribution grows, the total economy grows. Finally, it is important to note that capital expenses are not deducted from gross operating surplus – this means that investments grow GDP as well. For a simple example of value added, see Box 1.

**Box 1. What is value added?**

Imagine John, who wants to bake and sell cookies. He drives to the nearby grocery store to buy flour, eggs, milk, chocolate and other ingredients. At home, he uses some water and electricity to make the dough, heat the oven and transform the ingredients into delicious cookies. As he sells the cookies on the market, the difference in revenue he generates and the total cost he spent on the ingredients, transportation and energy is the value added to the economy. Similarly, using different commodities to transform silicon and other materials into highly productive microchips and other semiconductor products adds value to our economy.



The diagram illustrates the calculation of value added for the semiconductor industry. It consists of three blue rectangular boxes connected by mathematical symbols. The first box on the left contains the text "Industry's Output: Shipments, Wages, Investments, R & D". A minus sign is positioned between this box and the second box in the middle, which contains "Prices of Purchased Intermediate Products, Raw Materials, Services". An equals sign is positioned between the second box and the third box on the right, which contains "Semiconductors' Value Added to GDP = \$65 billion".

Similar to Nathan Associates’ earlier report, the value added figures presented in this paper are based on U.S. government data, calculated as the U.S. semiconductor industry’s receipts from sales of its products (value of industry shipments) less the industry’s expenditure on intermediate products and services. When calculating the value added of the U.S. semiconductor industry, double-counting has been avoided by deducting the value of raw materials such as silicon, partly finished products such as chemicals, and services of other industries, such as utilities, from the value of the end products such as microprocessors and LEDs.

## The U.S. Semiconductor Industry’s Value Added

Government data indicates that the U.S. semiconductor industry is one of the most important manufacturing industries to the U.S. economy.<sup>7</sup> While Moore’s Law guides the semiconductor industry to continually improve and innovate, the global economy teeters and wavers. Many have predicted that Western countries are lacking growth capacity and therefore are approaching an era of slowed growth, even as low as an annual rate of 1-2 percent.<sup>8</sup> This view suggests these countries have reached a stable phase of development and modernization, their population is aging, and there are no new economy-wide sources of rapid growth in sight. Since growth is still occurring in the high-tech sector, its direct and indirect contributions to economic growth are becoming increasingly more important.

Indeed, if we look at the U.S. economy during 1987-2011, the average annual growth rate was only 2.6 percent (Figure 1). During the same period, the U.S. semiconductor industry’s contribution to GDP grew at a much greater pace, 5.5 percent annually. In fact, the contribution of the U.S. semiconductor industry has grown faster than that of any other major manufacturing industry: the industry’s value added in 2011 is 3.6 times higher than in 1987 (Figure 3).<sup>9</sup> And whereas the growth of the overall U.S. economy has been very low in recent years, the U.S. semiconductor industry shows no signs of slowing down: during 2007-2011, its contribution increased by 5.2 percent annually.

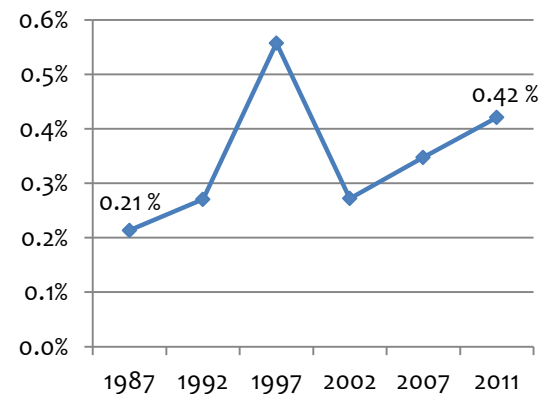
Altogether, the U.S. semiconductor industry’s contribution to the U.S. economy was estimated to be as high as \$65 billion dollars in 2011 (Table 1), and the industry has doubled its share of GDP since 1987 (Figure 2). If the 5.5 percent real annual growth trend continues from 2011, the industry’s contribution to the economy will double by 2024.

**Figure 1. Annualized Real Growth of U.S. Semiconductor Industry vs. U.S. GDP, 1987-2011 and 2007-2011**



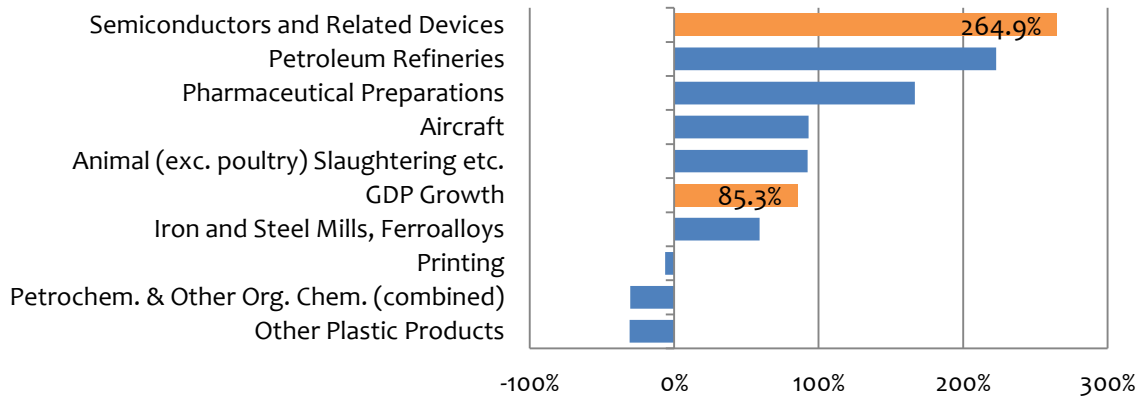
Source: BEA 2007, ASM 2011, Author's calculations.

**Figure 2. U.S. Semiconductor Industry’s Share of GDP Has Doubled from 1987 to 2011**



Source: BEA 2007, ASM 2011.

**Figure 3. Growth in Real Value Added to U.S. GDP (1987-2011)**  
 Top 10 Manufacturing Industries Measured by Value Added in 2011



Source: BEA 2007, ASM 2011, author's calculations.

**Table 1. Top 10 Manufacturing Industries Ranked by their Value Added to the U.S. Economy, 2011 and 2007**  
 (million, current dollars, before redefinitions<sup>10</sup>).

2011			
Rank	Industry	NAICS code <sup>11</sup>	Value Added
1	Petroleum refineries	324110	111,666
2	Pharmaceutical preparation manufacturing	325412	101,777
<b>3</b>	<b>Semiconductor and related device manufacturing</b>	<b>334413</b>	<b>65,362</b>
4	Aircraft manufacturing	336411	52,237
5	Printing	32311M	45,322
6	Other plastics product manufacturing	32619M	39,703
7	Petrochemical manufacturing	325110	36,256
8	Iron and steel mills and ferroalloy manufacturing	33111M	35,295
9	Other basic organic chemical manufacturing	32519M	34,915
10	Animal (except poultry) slaughtering and processing	31161N	34,576
2007			
Rank	Industry	NAICS code	Value Added
1	Petroleum refineries	324110	139,068
2	Pharmaceutical preparation manufacturing	325412	95,259
<b>3</b>	<b>Semiconductor and related device manufacturing</b>	<b>334413</b>	<b>50,326</b>
4	Aircraft manufacturing	336411	45,948
5	Printing	323110	44,423
6	Tobacco product manufacturing	312200	37,094
7	Light truck and utility vehicle manufacturing	336112	30,580
8	Search, detection, and navigation instruments manufacturing	334511	26,689
9	Other plastics product manufacturing	326190	25,341
10	Electronic computer manufacturing	334111	25,082

Source: Bureau of Economic Analysis, 2007 benchmark input-output accounts of the U.S. economy; 2011 Annual Survey of Manufactures.



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## ENDNOTES

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<sup>2</sup> All figures presented in this paper are based on the U.S. Bureau of Economic Analysis' (BEA) Benchmark Input-Output Tables for years 1987, 1992, 1997, 2002, 2007, and on U.S. Bureau of Census's Annual Survey of Manufactures 2011 (refreshed). Note that all dollar amounts are presented in current dollars, but inflation has been eliminated in the year-to-year comparisons expressed in percentages (Figures 1, 3). 1987 is used as base year in order to keep the results comparable to those presented in the 1998 report. The two larger manufacturing industries are petroleum refineries and pharmaceutical preparations manufacturing.

<sup>3</sup> Nathan Associates Inc. (1998). *America's Semiconductor Industry: Turbocharging the U.S. Economy*. Arlington, VA: Semiconductor Industry Association.

<sup>4</sup> IC Insights, Inc. – The McClean Report 2014.

<sup>5</sup> For example, in 1971, Intel's 4004 chip had 2,300 transistors. In 2014, Intel's 15-Core Xeon Ivy Bridge-EX chip has 4,310,000,000 transistors.

<sup>6</sup> Total sales of U.S. headquartered semiconductor companies in 2013. Data provided by World Semiconductor Trade Statistics (WSTS) and SIA.

<sup>7</sup> BEA conducts every five years a thorough analysis of the cross-relations and interdependencies of the American economy using a quantitative modeling technique called the input-output model. The Annual Survey of Manufactures, done by the U.S. Census, collects firms' annual figures which are plugged into the most recent BEA model to reach an estimate of the contribution of different industries.

<sup>8</sup> See e.g. Jorgenson, D. W.; Ho, M. S.; Samuels, J. D. (2014): What Will Revive U.S. Economic Growth? Lessons from a prototype industry-level production account for the United States. *Journal of Policy Modeling*(36), 674-691.

<sup>9</sup> While some of the industries that were very small in 1987 may have had even higher contributions to growth over this period, the top 10 industries presented in the table account for 24.6 percent, nearly a quarter of the total for the manufacturing industry's contribution, and thus changes in their contribution carry a much higher weight in the overall economic development.

<sup>10</sup> For the sake of comparability, and given the limitations of the Annual Survey of Manufactures data, all figures here are presented "before redefinitions", that is, without attributing the industries' potential secondary outputs to their primary industries (as specified by BEA). In the redefinition process, for example, the output of a restaurant located inside a hotel would be partially classified under the food industry. The difference, however, between the figures before and after redefinitions is minor: for 2009, the total value of secondary output was only 3.1 percent of total output.

<sup>11</sup> Note that there are minor differences between the NAICS coding in the Annual Survey of Manufactures (2011 data) and BEA data (2007): the codes ending in a letter include more than one subcategory, so that for example Printing (32311M) includes all printing industries within the range 323110-323119. In short, some industries in the 2011 table may have slightly higher values than they actually have.

## BIBLIOGRAPHY

Jorgenson, D. W., Ho, M. S., & Samuels, J. D. (2014). What Will Revive U.S. Economic Growth? Lessons from a prototype industry-level production account for the United States. *Journal of Policy Modeling*(36), 674-691.

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