Congressional Budget Office
Nonpartisan Analysis for the U.S. Congress

The Shipbuilding Composite Index and Its Rates of Change Compared With Economywide Inflation Rates

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Summary

In most years, the Department of Defense provides a 30-year shipbuilding plan to the Congress. The plan details the ships that the Navy expects to procure, along with an estimate of the costs of procuring those ships. The Congressional Budget Office is directed by law to provide an independent assessment of the costs of the Navy's plan.[1]

CBO's estimate of the costs of the Navy's shipbuilding plan typically exceeds the Navy's estimate. One reason is that when the Navy estimates the cost to build a ship in the future that is identical to one already built, it assumes that construction costs—in constant dollars—do not change. But the costs of labor and materials used in building naval ships have tended to grow faster than the costs of other goods and services in the economy. CBO accounts for that difference by comparing past increases in costs of building naval ships (that is, shipbuilding inflation)—using the Navy's shipbuilding composite index (SCI), which has existed in its current form since 1980—with increases in costs of other goods and services in the economy (that is, economywide inflation), as measured by the gross domestic product (GDP) deflator. The agency regards the difference between shipbuilding inflation and economywide inflation as growth in the constant-dollar cost of building naval ships.[2]

The SCI is divided into numerous categories and subcategories. Those individual components can have different annual rates of change. In this report, CBO describes how the differences between the largest categories of the SCI and the GDP deflator have changed over time. On average, all the major components have grown more quickly than the GDP deflator has. All told, between 1980 and 2022, the SCI grew an average of 1.2 percentage points faster per year than the GDP deflator did, although the average difference between 2015 and 2022 was 0.4 percentage points. Looking ahead, a gap between the SCI and the GDP deflator of roughly 1 percentage point would be consistent with historical experience, in CBO's assessment.

Measuring Economywide Inflation

In theory, measuring inflation is straightforward. A representative bundle of goods is defined, and then the prices of those goods are compared at two or more points in time. A five-pound bag of flour is the same product in 2022 as it was in 2021 (or 2011 or 1981), so calculating the percentage change from the 2021 price to the 2022 price provides a measure of inflation over that period.

In practice, however, measuring economywide inflation is more challenging, in large part because many products are not identical from year to year. For instance, although the average price of cars sold in the United States has increased considerably, some of that price increase reflects the fact that newer cars have enhanced capabilities, such as backup cameras, that were not previously available. The Bureau of Labor Statistics (BLS) attempts to account for

1. 10 U.S.C. § 231.

2. Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2024 Shipbuilding Plan* (October 2023), www.cbo.gov/publication/59508. CBO's assumption that the costs of shipbuilding will continue to grow at the historically observed real rates implies that a ship that costs $2.5 billion to build in 2023 would cost $3.2 billion (in 2023 dollars) in 2045.

Notes: All years referred to in this document are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end. Numbers in the text, tables, and figures may not add up to totals because of rounding. The gross domestic product deflator can be found at Bureau of Economic Analysis, "Table 1.1.4. Price Indexes for Gross Domestic Product" (March 28, 2024), https://tinyurl.com/52edp86b.

Table 1.

Computing the 2022 Shipbuilding Composite Index Using CBO's Categories

Percent

CBO's category	Weight	Rate	Weight times rate
Shipbuilder labor	44.50	3.57	1.59
Nonnuclear industrial machinery	26.27	13.73	3.61
Nuclear material	18.16	5.10	0.93
Nonnuclear aeronautical instruments	9.05	7.16	0.65
Other nonnuclear material	2.01	19.66	0.40
2022 SCI	**100**	**n.a.**	**7.17**

Data source: Congressional Budget Office, using data from the Department of the Navy. See www.cbo.gov/publication/59026#data.

SCI = shipbuilding composite index; n.a. = not applicable.

such improvements when it measures inflation.[3] Because products are often improved over time, inflation rates are typically lower when a quality adjustment is undertaken.

Measuring Changes in the Costs of Building Navy Ships

The challenges in measuring rates of change in the prices of Navy ships are even greater. Though adjusting for the increase in the quality of modern cars is difficult, it is even harder to adjust for, say, the enhanced capability of a Ford class nuclear aircraft carrier relative to a Nimitz class nuclear aircraft carrier. Navy ships are more complex than cars, and new ships could be enhanced in many more ways. In addition, the Navy does not procure each type of ship every year, which further complicates estimating annual rates of change in prices.

Rather than measuring the prices the Navy pays for ships, the SCI tracks the costs of building ships. The SCI has no direct relationship with shipbuilders' productivity; that is, it measures the costs that shipbuilders incur, not what or how much the shipbuilders produce. It does not adjust for changes in ships' capabilities over time.

Estimates of the annual rate of change of the SCI are derived from an aggregation of annual rates of change in several categories associated with ship construction. CBO breaks the SCI into five categories. (The Navy breaks it into more granular subcategories; those are described later in this report.) CBO's categories are as follows:

- **Shipbuilder labor.** The hourly costs of labor at the seven shipbuilders with which the Navy contracts.[4]
- **Nonnuclear industrial machinery.** The costs of materials used in the construction of conventionally propelled ships for which, according to the Navy, BLS's general industrial machinery and equipment producer price index provides a reasonable proxy.
- **Nuclear material.** The costs of materials used in the construction of nuclear-propelled ships, as well as subcontractor labor purchased by shipbuilders that build them.
- **Nonnuclear aeronautical instruments.** The costs of materials used in the construction of conventionally propelled ships for which, according to the Navy, BLS's aeronautical, nautical, and navigational instruments producer price index provides a reasonable proxy.
- **Other nonnuclear material.** The costs of all other material used in the construction of conventionally propelled ships.

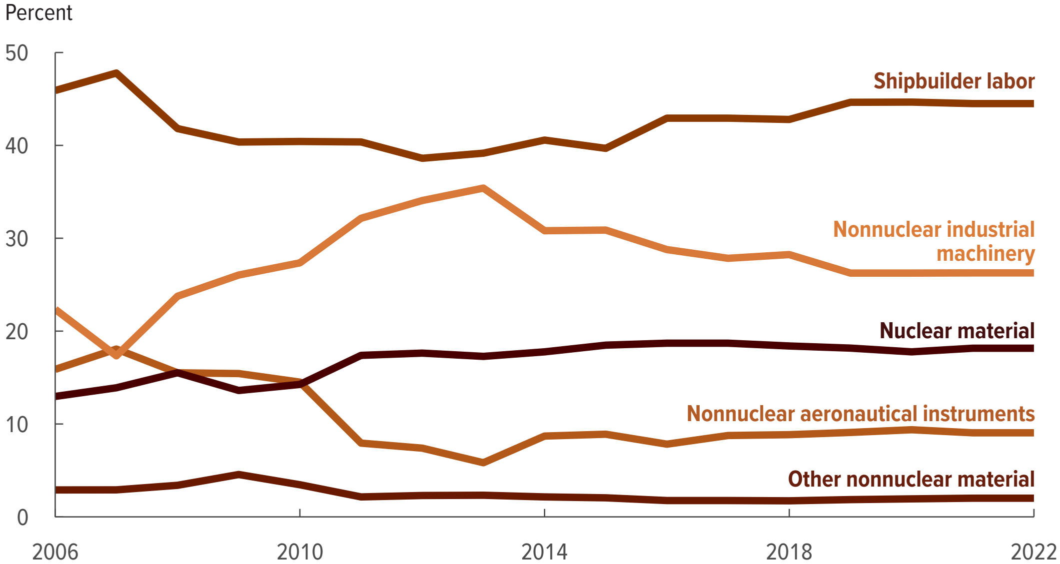
For each fiscal year, each SCI category has both a weight and a rate of change (see Table 1). A category's *weight* is its share of the total annual costs of shipbuilding. The combined weight of the five categories equals 100 percent each year, even though the weights of individual categories may

3. Discussion is ongoing about how to best make quality adjustments to cost and price indexes. See, for instance, Daniel E. Sichel, "Productivity Measurement: Racing to Keep Up," *Annual Review of Economics*, vol. 11 (August 2019), pp. 591–614, https://doi.org/10.1146/annurev-economics-080218-030439; Brent R. Moulton, *The Measurement of Output Prices, and Productivity*, Hutchins Center on Fiscal & Monetary Policy (Brookings, July 2018), https://tinyurl.com/vy9taet7; and Brent R. Moulton and Karin E. Moses, "Addressing the Quality Change Issue in the Consumer Price Index," no. 1, *Brookings Papers on Economic Activity* (1997), https://tinyurl.com/2ajdwyes. For how BLS adjusts quoted prices of new vehicles to account for changes in quality, see Bureau of Labor Statistics, Office of Prices and Living Conditions, *Guidelines for Quality Adjustment of New Vehicle Prices* (May 2014), www.bls.gov/cpi/quality-adjustment/new-vehicles.pdf.

4. Those shipbuilders are Austal USA in Mobile, Alabama; Bath Iron Works in Bath, Maine; Electric Boat Corporation in Groton, Connecticut, and Quonset Point, Rhode Island; Fincantieri Marinette Marine in Marinette, Wisconsin; Ingalls Shipbuilding in Pascagoula, Mississippi; National Steel and Shipbuilding Company in San Diego, California; and Newport News Shipbuilding in Newport News, Virginia. General Dynamics owns Bath Iron Works, Electric Boat, and National Steel and Shipbuilding. Huntington Ingalls Industries owns Ingalls Shipbuilding and Newport News Shipbuilding. See Government Accountability Office, *Navy Shipbuilding: Increasing Supervisors of Shipbuilding Responsibility Could Help Improve Program Outcomes*, GAO-22-104655 (April 2022), www.gao.gov/products/gao-22-104655.

Figure 1.

Category Weights in the Shipbuilding Composite Index, 2006 to 2022



Shipbuilder labor represented almost half of the costs in the shipbuilding composite index between 2006 and 2022.

Data source: Congressional Budget Office, using data from the Department of the Navy. See www.cbo.gov/publication/59026#data.

change from year to year. That is, an increase in the percentage share of one or more categories must be offset by a decrease in one or more of the remaining categories. A category's *rate of change* measures how much costs within a category have increased or decreased from the previous year. The annual SCI is a weighted average of all the composite categories: First, the weight and rate of change for each category are multiplied, and then those products are summed. The SCI increased by 7.17 percent in 2022 from the previous year, though the rates of increase in the costs associated with the other nonnuclear material and nonnuclear industrial machinery categories were much greater.

The weights of the five categories have varied from year to year, reflecting changes in the types of costs incurred in shipbuilding (see Figure 1). The relative weight of nonnuclear industrial machinery roughly doubled, from 17 percent to 35 percent, between 2007 and 2013. That increase came at the expense of shipbuilder labor, which declined from 48 percent to 39 percent, and nonnuclear aeronautical instruments, which decreased from 18 percent to 6 percent. Since 2013, the weight of the nonnuclear machinery category has declined to 26 percent, whereas the weights of shipbuilder labor and nonnuclear aeronautical instruments have increased, to 44 percent and 9 percent, respectively. The evolution of those weights reflects the Navy's estimates of the proportional importance of each category in the total costs shipbuilders incur.

The nuclear material weight fluctuated in a fairly narrow range between 13 percent and 19 percent over the 2006–2022 period, even though about half of appropriations for new-ship construction went to purchase nuclear-propelled vessels over that period. In the SCI's structure, any government-furnished material (GFM) is tied to a nonnuclear price index, even if it is used on a nuclear-propelled ship. Nuclear material weights correspond solely to material directly purchased by the two shipbuilders that build nuclear-propelled vessels—Electric Boat Corporation and Newport News Shipbuilding.

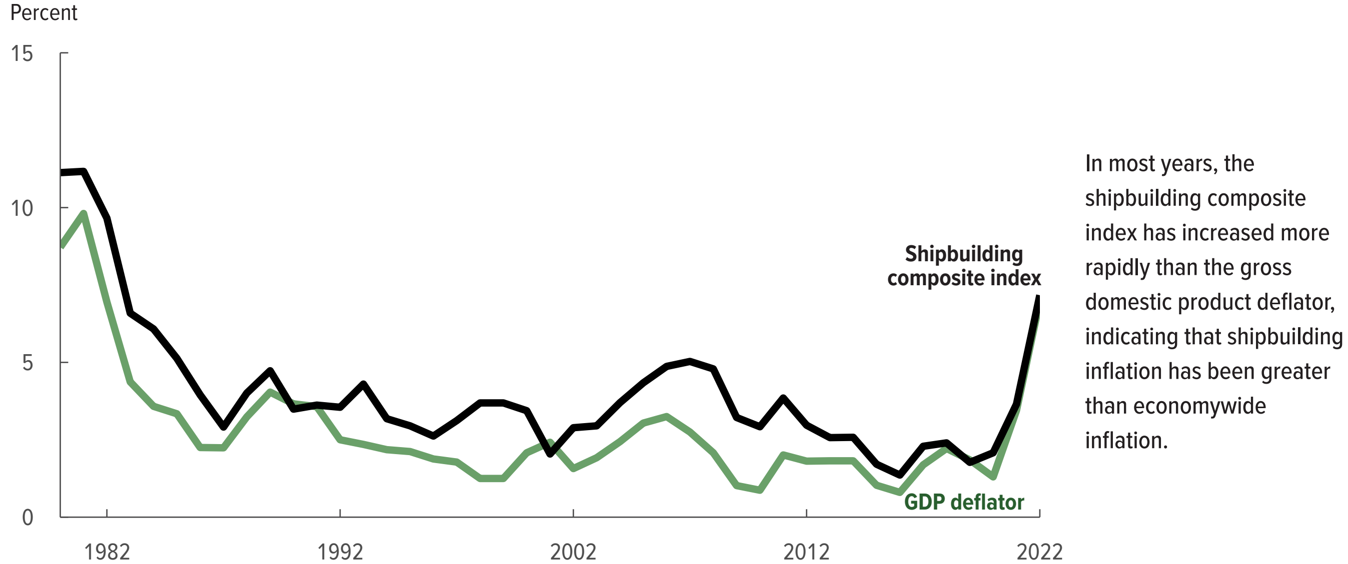
The Difference Between the SCI and the GDP Deflator

Between 1980 and 2022, the SCI increased an average of 1.2 percentage points faster than the GDP deflator did; the SCI's rate of change was lower than that of the GDP deflator in only three years over that period (see Figure 2). The difference has shrunk in recent years, however: Between 2015 and 2022, the SCI increased an average of 0.4 percentage points per year faster than the GDP deflator did.

The compounded effect of the difference between the SCI and the GDP deflator is sizable. For example, $100 at the beginning of 1980 growing at the rate of the GDP deflator would be $328 at the end of 2022. The same $100 growing at the rate of the SCI would be $546 at the end of 2022, or 66 percent more.

Figure 2.

Rates of Change in the Shipbuilding Composite Index and the Gross Domestic Product Deflator, 1980 to 2022



Data source: Congressional Budget Office, using data from the Bureau of Economic Analysis and the Department of the Navy. See www.cbo.gov/publication/59026#data.

GDP = gross domestic product.

CBO obtained category-level weights and rates for the SCI for 2006 through 2022 and therefore focused its analysis on that period. During those years, the SCI increased, on average, 1.1 percentage points faster than the GDP deflator—very similar to the average for 1980 through 2022. During the 2006–2022 period, each of the CBO-defined categories of the SCI, on average, grew more quickly than the GDP deflator (see Table 2).

- The hourly costs of shipbuilder labor increased 1.0 percentage points faster than the GDP deflator, on average.
- Costs of nonnuclear aeronautical instruments increased, on average, 0.9 percentage points faster than the GDP deflator, the lowest average rate of increase across the five categories.
- Other nonnuclear material had the greatest difference, increasing 1.5 percentage points faster than the GDP deflator, on average.
- Each of the five categories had at least one year with slower growth than the GDP deflator. The category with the highest variance, other nonnuclear material, had six years in which its rate of change was below that of the GDP deflator.

Notably, the SCI increased less than the GDP deflator did in 2019, driven by a decline in shipbuilders' average labor costs per hour. (That labor rate is fully burdened, meaning that it includes shipbuilders' overhead costs.) The change in labor costs refers to the rate of change in cost per worker, not the rate of change in total labor costs. That rate could decline for a variety of reasons, even as total spending on labor increased. For example, if a shipbuilder had a larger workload requiring more workers, fixed overhead costs would be spread over more employees, leading to a decline in average labor rates. If that shipbuilder hired additional junior employees who were paid less than more senior workers, the average labor rate would also be lower. In both cases, the labor weight would increase because total spending on labor would rise.

By scaling the differences for each category relative to the GDP deflator by the relative weight of each category in each year, CBO found that the shipbuilder labor category accounted for about 40 percent of the overall 1.1 percentage point average difference between the SCI and the GDP deflator observed between 2006 and 2022. Nonnuclear industrial machinery accounted for about 30 percent of the difference, nuclear material accounted for about 20 percent, and nonnuclear aeronautical

Table 2.

Trends in the Shipbuilding Composite Index Relative to the Gross Domestic Product Deflator, by Category

Percent

	Average weight, 2006 to 2022	Average difference, 2006 to 2022	Average difference, 1980 to 2022	Statistically significant trend
Shipbuilder labor	42	1.0	1.6	Downward
Nonnuclear industrial machinery	28	1.3	0.7	None
Nuclear material	17	1.4	1.1	None
Nonnuclear aeronautical instruments	11	0.9	1.1	None
Other nonnuclear material	2	1.5	1.3	None

Data source: Congressional Budget Office, using data from the Bureau of Economic Analysis and the Department of the Navy. See www.cbo.gov/publication/59026#data.

The average difference is the observed rate of change in a category's costs minus the annual change in the gross domestic product deflator

instruments accounted for most of the rest. The other nonnuclear material category had a low average weight (about 2 percent), so its contribution to the SCI's difference relative to economywide inflation was minor, despite its volatility.

Projecting the Difference Between the SCI and the GDP Deflator

Because the difference between the SCI and the GDP deflator has been relatively small in the recent past, CBO also explored whether that trend was more likely to persist or to revert to the greater historical difference.

To gain insight into future trends, CBO analyzed how the categories of the SCI have evolved over time relative to the GDP deflator. Although CBO only had a weight-and-rate category breakdown of the SCI back to 2006, the Navy provided CBO with estimates of the categories' annual rates of change back to 1980.

Since 1980, all of the categories of the SCI have, on average, grown more quickly than the GDP deflator has. The SCI for shipbuilder labor grew more slowly than the GDP deflator in 2018, 2019, 2021, and 2022. The negative difference in 2019 was caused by a reduction in the average shipbuilder labor rate. In 2018, 2021, and 2022, average rates increased, but not as rapidly as the GDP deflator. Those differences resulted in a downward trend in the costs of shipbuilder labor relative to the GDP deflator. However, CBO anticipates that the difference will return to close to its historical average in the future, in part because of adjustments for economywide inflation in union labor contracts.

The other categories have not had statistically significant trends in their differences over time. That is, there is no evidence that their rates of change are converging to the GDP deflator's rate of growth. In CBO's assessment, therefore, it would be consistent with historical experience for a roughly 1 percentage point gap between the SCI and the GDP deflator to continue.

Components of the Shipbuilding Composite Index

The Navy breaks the SCI into 25 subcategories. Those subcategories are more granular than the categories CBO uses; for details on how they correspond, see Table 3.

This section provides further details about the Navy's subcategories. First, the SCI divides costs into two broad categories: those borne by shipbuilders and those classified as government-furnished material. GFM includes all the items the federal government provides to shipbuilders in the process of building a ship.

Shipbuilders' costs are then broken into three components: labor, nonnuclear material, and nuclear material. Labor costs are composed of direct costs, indirect costs, and a subcategory called plan costs (the costs of naval architects and other professional personnel involved in ship design). Although the labor subcategories cover different types of laborers, the SCI's annual rates of change have been the same for all three subcategories.

Material costs represent the costs of goods and services that the seven shipbuilders buy from their suppliers and subcontractors. (Material costs include the suppliers' and

Table 3.

How the Navy's Subcategories Correspond to CBO's Categories

CBO's category	Navy's subcategory
Shipbuilder labor	Plan costs
	Shipbuilder direct labor
	Shipbuilder indirect labor
Nonnuclear industrial machinery	Nonnuclear 200
	Nonnuclear 300
	Nonnuclear 500
	Nonnuclear 600
	Nonnuclear 700
	Government-furnished material 200
	Government-furnished material 500
	Government-furnished material 700
Nuclear material	Nuclear 100
	Nuclear 200
	Nuclear 300
	Nuclear 400
	Nuclear 500
	Nuclear 600
	Nuclear 700
	Nuclear 800
	Nuclear 900
Nonnuclear aeronautical instruments	Nonnuclear 400
	Government-furnished material 400
Other nonnuclear material	Nonnuclear 100
	Nonnuclear 800
	Nonnuclear 900

Data source: Congressional Budget Office, using data from the Department of the Navy.

subcontractors' labor costs.) Nonnuclear materials are those used to build conventionally propelled ships, and nuclear materials are those used to build nuclear-propelled ships. The same item could be both nonnuclear and nuclear material if it was used on both conventionally and nuclear-propelled ships. For example, Electric Boat Corporation, which manufactures nuclear-propelled submarines with Newport News Shipbuilding, purchases nuclear material because it builds only nuclear-propelled ships. By contrast, Ingalls Shipbuilding builds only conventionally propelled surface ships, so even if it purchased the same material as Electric Boat Corporation, Ingalls Shipbuilding's purchases would fall into the nonnuclear material subcategories. Nonnuclear and nuclear material costs are each broken into nine ship

Table 4.

Ship Work Breakdown Structure Subcategories

Number	Subcategory
100	Hull structure
200	Propulsion plant
300	Electric plant
400	Command and surveillance
500	Auxiliary systems
600	Outfit and furnishings
700	Armament
800	Total ship integration
900	Ship assembly and support services

Data source: Department of the Navy.

work breakdown structure (SWBS) subcategories that correspond to different parts of ships (see Table 4).

The GFM category is also broken into SWBS subcategories, but only for subcategories 200, 400, 500, and 700. Taken together, the 25 subcategories aggregate to form the SCI (see Table 5). However, some rates of changes in costs typically apply to more than one subcategory:

- The plan costs, shipbuilder direct labor, and shipbuilder indirect labor subcategories shared one annual rate of cost change for each year between 2006 and 2022.
- In almost all years and subcategories, the GFM annual rate of cost change has been the same as the corresponding nonnuclear material rate of cost change. (Although GFM might be used on nuclear-propelled ships, in the calculation of the SCI, nonnuclear annual rates of change are used for all GFM.)
- Over the 2006–2019 period, the SCI incorporated the same annual rates of change from the BLS for nonnuclear materials in SWBS subcategories 200, 300, 500, 600, and 700.
- The annual rate of change for nuclear subcategory 900 (ship assembly and support services) material has generally been the same as that for nonnuclear subcategory 900 and nonnuclear subcategory 800 material.

In effect, 13 unique annual rates of change generate the SCI—1 for labor, 8 for nuclear material, and 4 for nonnuclear material (see Table 6).

Table 5.

The Navy's Subcategories and CBO's Categories of the Shipbuilding Composite Index

Navy's subcategory	CBO's category	Comment
	Costs borne by shipbuilders	
Labor		
Plan costs	Shipbuilder labor	
Shipbuilder direct labor	Shipbuilder labor	The three labor subcategories always share one annual rate of change derived from a Navy-conducted survey of its shipbuilders
Shipbuilder indirect labor	Shipbuilder labor	
Shipbuilder Material		
Nonnuclear 100	Other nonnuclear material	
Nonnuclear 200	Nonnuclear industrial machinery	Same annual rate for SWBS subcategories 200, 300, 500, 600, and 700
Nonnuclear 300	Nonnuclear industrial machinery	Same annual rate for SWBS subcategories 200, 300, 500, 600, and 700
Nonnuclear 400	Nonnuclear aeronautical instruments	
Nonnuclear 500	Nonnuclear industrial machinery	Same annual rate for SWBS subcategories 200, 300, 500, 600, and 700
Nonnuclear 600	Nonnuclear industrial machinery	Same annual rate for SWBS subcategories 200, 300, 500, 600, and 700
Nonnuclear 700	Nonnuclear industrial machinery	Same annual rate for SWBS subcategories 200, 300, 500, 600, and 700
Nonnuclear 800	Other nonnuclear material	Same annual rate for SWBS subcategories 800 and 900
Nonnuclear 900	Other nonnuclear material	Same annual rate for SWBS subcategories 800 and 900
Nuclear 100	Nuclear material	
Nuclear 200	Nuclear material	
Nuclear 300	Nuclear material	
Nuclear 400	Nuclear material	
Nuclear 500	Nuclear material	
Nuclear 600	Nuclear material	
Nuclear 700	Nuclear material	
Nuclear 800	Nuclear material	
Nuclear 900	Nuclear material	This subcategory's annual rate of change was the same as the 900 subcategory for nonnuclear material except in 2014, when they differed slightly
	Government-furnished material	
200	Nonnuclear industrial machinery	This subcategory had no weight until 2013; since then, it has had the same annual rate of change as nonnuclear 200
400	Nonnuclear aeronautical instruments	This subcategory had a different rate of change than nonnuclear 400 in 2007 but was otherwise the same
500	Nonnuclear industrial machinery	Same annual rate of change as nonnuclear 500
700	Nonnuclear industrial machinery	Same annual rate of change as nonnuclear 700

Data source: Congressional Budget Office, using data from the Department of the Navy.

SWBS = ship work breakdown structure.

Table 6.

Computing the Shipbuilding Composite Index for 2022 Using the Navy's Subcategories

Percent

Navy's subcategory	Weight	Rate	Weight times rate
Costs borne by shipbuilders			
Labor			
Plan costs	7.26	3.57	0.26
Shipbuilder direct labor	16.23	3.57	0.58
Shipbuilder indirect labor	21.00	3.57	0.75
Shipbuilder material			
Nonnuclear 100	0.91	38.45	0.35
Nonnuclear 200	2.29	13.73	0.31
Nonnuclear 300	1.17	13.73	0.16
Nonnuclear 400	0.80	7.16	0.06
Nonnuclear 500	2.58	13.73	0.35
Nonnuclear 600	1.14	13.73	0.16
Nonnuclear 700	0.05	13.73	0.01
Nonnuclear 800	0.45	4.28	0.02
Nonnuclear 900	0.66	4.28	0.03
Nuclear 100	1.93	7.50	0.14
Nuclear 200	3.62	5.28	0.19
Nuclear 300	1.14	2.80	0.03
Nuclear 400	2.49	1.72	0.04
Nuclear 500	2.78	7.35	0.20
Nuclear 600	1.12	9.91	0.11
Nuclear 700	1.55	4.28	0.07
Nuclear 800	1.68	3.29	0.06
Nuclear 900	1.85	4.28	0.08
Government-furnished material			
200	9.93	13.73	1.36
400	8.25	7.16	0.59
500	1.89	13.73	0.26
700	7.22	13.73	0.99
2022 SCI	**100**	**n.a.**	**7.17**

Data source: Congressional Budget Office, using data from the Department of the Navy. See www.cbo.gov/publication/59026#data.

SCI = shipbuilding composite index; n.a. = not applicable.

This report was prepared to enhance the transparency of the work of the Congressional Budget Office. In keeping with the agency's mandate to provide objective, impartial analysis, the report makes no recommendations.

Edward G. Keating and Eric J. Labs prepared the report with guidance from David Mosher. Chandler Lester offered comments. Nikhil Bhandarkar fact-checked the report.

Philip Koenig of the University of British Columbia and Daniel Sichel of Wellesley College commented on an earlier draft. The assistance of external reviewers implies no responsibility for the final product; that responsibility rests solely with CBO.

Jeffrey Kling and Robert Sunshine reviewed the report, Caitlin Verboon edited it, and R. L. Rebach created the graphics and prepared the text for publication. The report is available at www.cbo.gov/publication/59026.

CBO seeks feedback to make its work as useful as possible. Please send comments to communications@cbo.gov.

Phillip L. Swagel
Director