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An Economic Analysis of Investment in the United States Shipbuilding Industry

31 May 2010

by

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Abstract

Amidst the global economic recession and sizeable injections of federal stimulus packages, the U.S. Navy's budget for ship construction has experienced only modest real growth. While the 2010 Quadrennial Defense Review has reaffirmed a fleet size goal of 313 ships, some suggest that $20 billion or more per year is needed to attain this level of strategic resources. This research has analyzed the United States' shipbuilding industry as a potential source of economic stimulus using measures applied in the United Kingdom by economists at Oxford Economics. First, monetary impacts from the "ship building and repairing" sector were analyzed using U.S. Bureau of Economic Analysis (BEA) input/output data and the "Leontief inversion process" modeled at Carnegie Mellon University. This sector was compared with five alternative investments. Second, the benefits of the shipyard-related labor market were analyzed using data from the BEA and Naval Sea Systems Command. Measures of capital intensity and capacity were then applied to companies representing five industries. The results suggest that U.S. shipbuilding generates monetary benefits comparable to alternatives, while supporting more labor than other sectors. Finally, excess capacity shows a clear ability to absorb an increase in demand, providing prompt and positive impact on sustainable economic recovery.

Keywords: Shipbuilding, economics, multiplier, investment, economic return, funding of alternative investments, use of taxpayer dollars, economic analysis, ships, lifecycle, manufacturing economic return, economic stimulus, stimulus, recession, Navy

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Acknowledgments

My father died suddenly of a heart attack in my final week of writing this thesis. I dedicate this humble product to the 30 cherished years I shared with him—in honor of his passionate energy, selfless devotion to his children, and his benevolent heart. Thank you to my surviving mother, Diana, and to my late father, Steve, for teaching me so much about how to live for God and for family.

Absolutely essential to all of my endeavors, my successes, and life as I know it, is the compassionate love and support of my wonderful wife, Sarah. We have enjoyed the precious gift of a baby boy (Benjamin Aaron Meyers) born February 20, amidst the demands of this thesis effort. We also have a most joyful 2-year-old daughter named Maren Beth, who always makes me smile and laugh. Also as I conclude this thesis, my wife and I are celebrating our 5th anniversary of wonderful marriage. Lastly, my mother-and father-in-law are two of the most kindhearted and generous people I've ever known, and I appreciate their encouragement and backing. To my blessed family, I do so ardently value all of your support and sacrifice—past, present, and future, in support of my naval career and professional ambitions.

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Lastly, a sincere “Thank You” to Andrew Tessler at Oxford Economics for all of the e-mail responses and the personal meeting, Jonathan Wright and Morris Fields at Naval Sea Systems Command, RADM Hilarides, the Carnegie Mellon Green Design Institute, and others who contributed supporting knowledge and data.

About the Authors

Lieutenant Nicholas Meyers was born in Cumberland, Maryland. In December of 2002 he graduated from Virginia Tech's Corps of Cadets with a B.S. in Computer Engineering, cum laude, and was commissioned as a submarine officer in the United States Navy. During the summer of 2002 he completed George Washington University's "Semester in Washington" program through their Graduate School of Political Management.

Following Naval Nuclear Power School and prototype training, Lieutenant Meyers reported to USS COLUMBIA (SSN-771), home-ported in Pearl Harbor, Hawaii. During this Junior Officer's tour, Lieutenant Meyers served as "Chemistry and Radiological Controls Assistant" during a Western Pacific Deployment, as well as "Communications Officer" during numerous exercises and Submarine Command Course Operations. He also completed Naval Reactors qualifications and Department of Energy certification as a "Nuclear Engineer Officer."

In April of 2007, he reported to COMMANDER, SUBMARINE FORCES, in Norfolk, Virginia, where he served as a Submarine Watch Officer and as a Regional Employment Officer in the Operations department.

Lieutenant Meyers will graduate in June from the Naval Postgraduate School in Monterey, California, with a Masters in Business Administration (MBA) in Financial Management. He will report to the Submarine Officer's Advanced Course in Groton, Connecticut, for follow-on service as a Department Head.

His personal decorations include the Navy and Marine Corps Commendation Medal, and the Navy and Marine Corps Achievement Medal with one Gold Star.

Nicholas Meyers is married to the former Sarah Jo Mickiewicz of Sarasota, Florida. The family of four includes a joyful two-year old daughter named Maren Beth and a new 4-month old son, Benjamin Aaron!

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List of Acronyms and Abbreviations

ARRA	*American Recovery and Reinvestment Act*
ASA	American Shipbuilding Association
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
CBO	Congressional Budget Office
CNO	Chief of Naval Operations
CSBA	Center for Strategic and Budgetary Assessments
DoN	Department of the Navy
EB	Electric Boat
GD	General Dynamics
GDP	Gross Domestic Product
LECG	Law and Economics Consulting Group
NAVSEA	Naval Sea Systems Command
NG	Northrop Grumman
OPNAV	Office of the Chief of Naval Operations
PAT	Portfolio Assessment Team
PEO	Program Executive Officer
TARP	Troubled Asset Relief Program

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I. Introduction

A. Purpose of Study

In 2008 and 2009, the United States' economy struggled with what has widely been described as "the worst economic crisis since the Great Depression." Specifically, the national economic data show a reduction of 1.7% in real gross domestic product (GDP), measured in constant 2005 dollars, since the beginning of calendar year 2008 (BEA, 2009). Although this contraction may seem slight, this is the first six-quarter period since 1982 that the national GDP growth has been negative. Now, with the nationwide unemployment rate near 10%, the United States has lost over 7.3 million jobs since the start of the damaging recession (Homan, 2009). Some economists are predicting recovery in 2010, but national leaders and decision makers continue to look to spending by the federal government as a means of stimulating job growth, injecting stability, and sustaining recovery.

In a series of efforts to mitigate drastic economic decline, the U.S. Congress passed a $700 billion Troubled Asset Relief Program (TARP) package in October 2008, followed by the $787 billion *American Recovery and Reinvestment Act (ARRA)* on February 13, 2009 (Recovery Accountability and Transparency Board, 2009). Of the initial TARP package, about $550 billion has been committed to various financial firms, banks, and institutions throughout the country; so far, $70.1 billion has been returned to the Treasury (Ericson, He & Schoenfield, 2009). The Federal Reserve and the White House continue to seek proper locations for depositing large sums of federal dollars as a means of ensuring continued, consistent recovery of our national economic forecasts. As recently as December 8, 2009, the *New York Times* featured a front-page article in which White House economist Jared Bernstein suggested that the administration is considering an additional $150 billion in stimulus spending, of which $50 billion could be invested "in infrastructure projects alone such as roads, bridges, and water projects" (Pace, Taylor & Elliott, 2009). Additionally, the Office of Management and Budget (OMB) has stated that President Obama believes "we need to rebuild and retrofit America for the demands of the twenty-first century 21st Century" (Orszag, 2009). Furthermore, in a letter to the Senate Majority Leader dated February 2009, the Director of the OMB stated that this rebuilding and retrofitting will "entail repairing and modernizing roads and mass transit options across the country" (Orszag, 2009). Clearly, national leaders are convinced that boosting federal spending is one of the best tools for ensuring that America's $14.3 trillion[1] economy remains healthy and growing at a stable, sustainable pace. The questions now being discussed in various offices and conference rooms throughout Washington, DC, and the country as a whole include robust debates about where to invest these funds. What effects will a $1 trillion health care package have on our weakened economy? Where are the benefits of the *American Recovery and Reinvestment Act;* where have they been manifested? The executive branch claims to track every dollar spent under this $787 billion umbrella, but how is that spending really benefiting the economy? Other, perhaps equally important, questions exist for industries and sectors yet to benefit from federal spending packages and stimulus measures—what *could* investments in those sectors be doing to improve the economy?

One important industry that has not received direct funding from government intervention in the current recession has been the U.S. shipbuilding sector. A search for "shipbuilding" at the federal government's Web site, which is designed to provide transparency to American citizens, reveals that a mere $132,000 of the $787 billion package has been allocated to a company called Horizon Shipbuilding in Alabama (Recovery, 2009).[2] This $132,000 payment from the Department of Transportation is the only evidence of *ARRA* funding for shipbuilding; thus, not even 1/10 of 1% of

[1] Based on gross domestic product (GDP), the seasonally adjusted, annualized amount for the 3rd quarter of 2009 (BEA, 2009).

[2] Search was conducted at www.recovery.gov, a Web site with a mission statement to "provide easy access to data related to Recovery Act spending and allow(s) for the reporting of potential waste, fraud, and abuse" (Recovery, 2009).

the *American Recovery and Reinvestment Act* has been invested in shipbuilding companies.

Those with an interest in the U.S. shipbuilding industry believe that their particular sector of manufacturing has a special ability to provide economic stimulus for national decision makers and taxpayers alike. The purpose of this thesis is to determine the return or benefit to the U.S. national economy for federal expenditures in the shipbuilding sector. Applying commonly used economic models, discussed in detail in the pages that follow, to pertinent macroeconomic data will help to make this determination. As politicians seek to stimulate and sustain U.S. economic growth, they hope to create or maintain jobs, expand national gross domestic product, and provide a lasting resource for future economic potential; investments in shipbuilding may accomplish all three goals, as this study will seek to demonstrate.

B. Problem

1. Problem 1: U.S. Navy Fleet Size: An Uncharted Goal

The Chief of Naval Operations (CNO) has repeatedly affirmed a commitment to maintain a United States naval fleet of at least 313 warships (McIntire, 2009). However, the *30-year Shipbuilding Plan* for fiscal year 2011 does not include 313 ships for the U.S. naval fleet until the year 2020 (Director, 2010). There is apparently a sharp discrepancy between these CNO estimates of national needs for our naval fleet and the projected fleet decline, if funding for ship construction remains constant in real dollars. An estimate from the American Shipbuilding Association suggests that our fleet could drop to a mere 180 ships if additional funding for ship construction is not received (see Figure 1). Another study by the Center for Strategic and Budgetary Assessments (CSBA) suggests that the congressional appropriation for Shipbuilding and Conversion, Navy (SCN) would have to be funded to levels of about $20.4 billion in order to achieve the Navy's desired force structure in future years (Work, 2009). The same CSBA study references recent Congressional Budget Office estimates that a total of $22.4 billion per year would be required to reach a fleet size of 313 ships by 2013. Finally, the

Congressional Budget Office (CBO) has estimated that by 2020, $25 billion will be needed annually for ships. In stark contrast to these projected levels for achievement of the CNO's fleet size goal, $12.7 billion was the total funding of the fiscal year 2009 SCN account. Based on CSBA estimates, the effort was underfunded by about 35% (DoN, 2008). Additionally, the *30-year Shipbuilding Plan* for fiscal year 2011 states that through 2040, "to be consistent with expected future defense budgets, the Department of the Navy's annual shipbuilding construction (SCN) budget must average no more than $15.9 billion per year in FY2010 dollars" (Director, 2010).

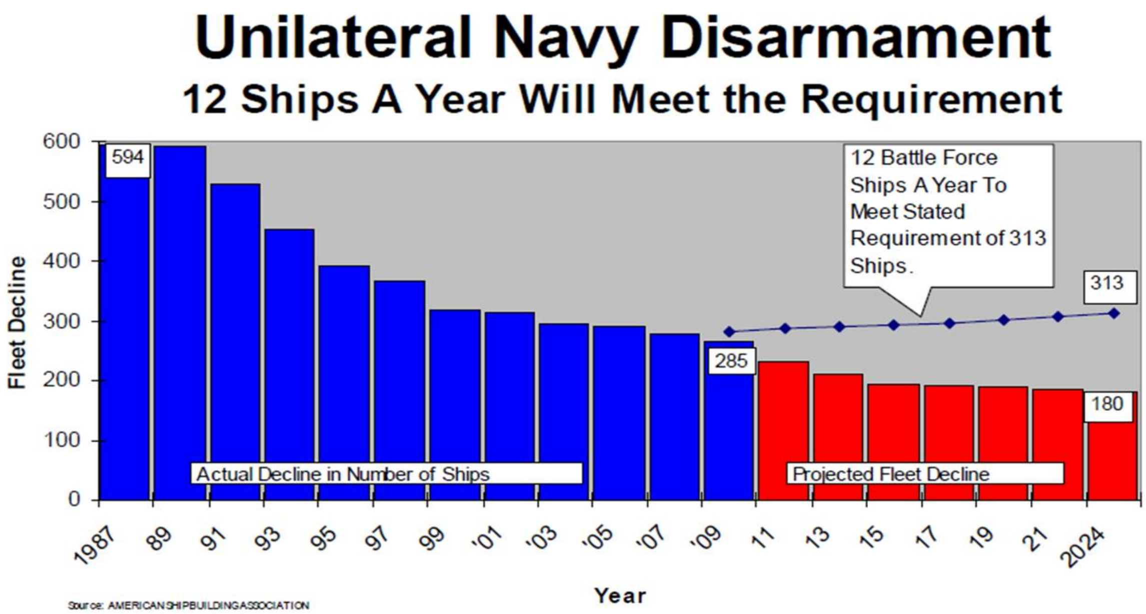

Figure 1. Unilateral Navy Trends Graph (From ASA, 2009)

The ostensible likelihood is that barring any geopolitical events that may punctuate the national security equilibrium, the United States Navy is not likely to reach a fleet of 313 ships before the year 2040. In addition, the academic and practical arenas of shipbuilding cost growth and projected-fleet-size funding estimates have been thoroughly explored by talented minds with reliable experience. For these reasons, primarily, this thesis study will not explore issues of (1) appropriate fleet size to meet national security needs, or (2) the rising costs of ship construction as it impacts efforts to reach projected needs. Although both of these issues are considered important, thorough and credible studies by congressional experts such as Mr. Ronald O'Rourke of the Congressional Research Service, RAND, and others have been and currently are being conducted within these arenas; this thesis will focus elsewhere.

2. Problem 2: What Does Shipbuilding Do for the Economy? How?

A second important problem exists within the topics of U.S. naval fleet size, national economic woes, and ship construction—a more obscure, but perhaps more solvable problem. That issue is: what are the economic benefits of building ships? When comparing the alternative options for investing federal taxpayer dollars—for example, building highways versus bailing out banks—several important questions are at the forefront of consideration. First, what is the health and capacity of the industry being considered for receipt of billions of dollars? Could the sector accept the billions of dollars of additional funding and apply them to an economic benefit for others? Does the industry have the necessary capital and labor in place? Are there resources or vendors whose financial health depends upon the sector considered? For instance, building highways requires not only large pools of available labor, but also purchases from blacktop/concrete producers, perhaps equipment rentals for steamrollers and forklifts, and other suppliers who would benefit from increased demand of their products. Are there similar supply-chain benefits for the builders of ships? Investments of federal tax dollars should be allocated to the sectors in which they would economically benefit the most people, or provide the most activity for the U.S. economy.

When evaluating a particular industry for its ability to enhance national economic recovery and growth, one should consider the channels through which the benefits will be manifest. In determining channels of impact, quantitative multipliers should be calculated. Once a trusted and scrutinized economic multiplier is available for each investment option, public-sector decision makers could be as well informed as private-sector investment bankers or venture capitalists who seek to deposit their wealth where it will multiply the greatest, earn the most rewards, and pay dividends to their stakeholders for future periods. Political leaders seeking to stabilize and grow the U.S. economy could evaluate the economic return for various investment options using a similar framework; their stakeholders are all U.S. citizens, and their wealth is the measure of national GDP. Here, the public-sector problem of where to invest the billions of available dollars for “recovery and reinvestment” could be considered in the context of economy activity generated and jobs created or supported.

C. Scope of Thesis Study

1. What’s Not Included, and Why?

From both a quantitative and qualitative perspective, this study will primarily consider the U.S. shipbuilding and repairing industry.[3] Thus, issues of rising construction and procurement costs of Navy ships will not be a focus of this study. Rather, **benefit to the regional and national economy** will be explored, quantified where possible, and analyzed through specific measures of economic analysis.

Although required by Title 10 of the *United States Code*, the Navy’s *30-year Shipbuilding Plan* for fiscal year 2010 was not submitted to Congress in 2009; it was deferred pending the completion of the *Quadrennial Defense Review (QDR)*, which was concluded in February 2010 (O'Rourke, 2009). The mix of vessels to be procured has been planned, and the evaluation of shipbuilding costs is being thoroughly scrutinized by national authorities on the subject such as Ronald O’Rourke, who is with the Congressional Research Service.[4] With the latest publication of the *Nuclear Posture Review*, the *QDR*, the *30-year Shipbuilding Plan*, and the *President’s Fiscal Year 2011 Budget*, much light has been shed on the path

[3] As classified by North American Industrial Classification System’s (NAICS) 6-digit sector code #336611.

[4] Mr Ronald O’Rourke is a specialist in naval affairs with the Congressional Research Service, and has published numerous studies regarding the rising costs of Navy ships for the U.S. Navy, as well as analysis of other nations’ ship-procurement programs; most are available at www.crs.gov.

ahead for U.S. shipbuilding and naval fleet size. This thesis will not attempt to make a contribution to the analysis of rising ship costs, proper mix and type of vessels to be procured, or consideration of the national funds available for ship construction. Rather, the study will focus on exploring (1) through what means, and (2) how much the shipbuilding industry benefits regional economies and the national economic health.

2. How Shipbuilding Is Unique

Through decades of active service, a United States warship provides much more than just security to the nation, forward presence abroad, and support of free trade on the high seas. Although all of these contributions are certainly of profound economic and national interest, the geopolitical nature of each contribution will not be further explored in this particular study. Here, though, as the shipbuilding industry is compared and contrasted with alternative investment options, a few important and unique qualities of a ship must be highlighted upfront.

Each ship class has an approved maintenance plan that sets future dates for overhauls and refit periods through its end-of-life. Additionally, during the decades of service, technological upgrades and modernization installs require equipment purchases from vendors in dozens of states. Nuclear refueling or conventional ship overhauls employ hundreds of workers in highly paid positions of delicately skilled labor at shipyards throughout the country. One recent study by Naval Sea Systems Command's Portfolio Assessment Team (NAVSEA PAT) suggests that the average shipyard employee's contribution to state GDP is six to nine times higher than the average state worker (Wright & Fields, 2009). Not only are these shipyard jobs dependable and high paying, but also the induced effects of skilled labor's contribution to local and state GDP are **more economically influential** than alternative sectors, as this study will demonstrate. For each ship that is constructed, 30 or 40 years of maintenance and support is provided from shipyards and repair facilities, each time with additional economic activity generated. The economic impacts of shipbuilding throughout the supply chain and the U.S. economy will only grow and compound as more ships are built. As compared to an automobile or a tank, which doesn't exist for as long and doesn't require as much maintenance or as many upgrades, technology insertions, or manning, ships repeatedly contribute their multipliers of economic benefit, providing stimulus and jobs to their regions and to the nation.

II. Background

In any credible study or analysis, the lessons of history should not be ignored. The U.S. shipbuilding industry has a particularly fascinating history, filled with many "highs and lows." An overview of the industry's current status is imperative to analyzing its potential for national economic benefit now and in the future. For instance, pertinent questions may include the following: how utilized are our shipyard facilities? Have they "withered on the vine" amidst recent years of declining demand, or have they managed to continue necessary investments in capital facilities and infrastructure to remain competitive? Ultimately, the integrity of the final argument will be contingent upon a thorough exploration of why ships are unique as a product that can be manufactured. A central focus of this study will be to demonstrate how these unique economic attributes of ship construction and operation translate into national stimulus and impact. Thus, this section includes a history of U.S. shipbuilding, a brief description of the shipbuilding industry today, and a fundamental depiction of how and why ships are unique from satellites, tanks, highways, and other procurement or manufacturing opportunities.

A. History

The United States shipbuilding industry is one of the oldest in the country, and one with a dramatic and notable history. According to Mr. William Walters in his 2000 article in the *Geographic Review*, the American Navy at the end of the nineteenth century had atrophied to the point of mere "international insignificance" (p. 2). Starting in 1885, the U.S. Congress began a transformational initiative to fund the "new Navy," with a key component being a legal requirement for almost all American ships to be built in domestic shipyards with domestic purchases for supplies and equipment (Meyers, 2009). Following decades of fairly uneventful naval construction, the United States successfully mounted, during the years of 1930 to 1949, "the largest naval shipbuilding effort by any nation in the history of the world" (Walters, 2000). In this time period, over 1.5 million American workers were employed by the shipbuilding industry, and over 550 full-sized destroyers and over 1,051 newly designed tank-landing ships were produced. In more recent times, shipbuilding has faced modern challenges and difficulties from various sources.

As a direct result of commercial shipbuilding alone in the United States, the nation's 2001 measure of gross domestic product (GDP) was increased by $11 billion, while more than 147,000 total jobs were created[5] (LECG, 2002). However, the years that followed reflect a tumultuous journey for domestic shipbuilders, one in which uncertainty prevailed and the future looked repeatedly bleak. As congressional priorities shifted to deficit reduction, overcapacity was rampant in shipyards. Even time-tested companies lacked the demand stability to govern investment decisions in skilled labor-manning, infrastructure, and vendor-bases throughout the country (Barnard, 2005). By early 2006, the Navy released its intentions to cut its 2006 shipbuilding plan by 1/3 of the estimate, eliminating two of the six ships that the industry had expected to build in that upcoming year. The result was not only high unit costs per vessel, but also instability throughout the industry and the supply chain, which permeated the corporate culture and created an atmosphere of volatility.

B. Today

As recently as 2001, the Navy had 318 battle-force warships, while today the fleet size is 286 (Navy.mil, 2010). Even more disturbing are the projected trends for future ship numbers—perhaps as low as 180 ship in the U.S. fleet by 2024, if funding for ship construction is not increased in real dollars (ASA, 2009). The American Shipbuilding Association makes the following assessment:

> Years of underinvestment in shipbuilding has resulted in a major contraction of the industry. Thousands of jobs have been lost and scores of companies have exited the shipbuilding business. As a result, for many of the critical

[5] All measures are in 2001 dollars (LECG, 2002).

> systems and components that make a ship, there is only one remaining U.S. manufacturer left in the business. (2009, p. 2)

The existence of only one U.S. manufacturer for a critical part presents ostensible concerns for cost management and Department of Defense acquisition program managers.

1. The Navy's Unique Role—Sea Control

Over 70% of our planet is covered by oceans in a global political and trade climate that seems to shrink almost daily; the United States' ability to project presence abroad is dependent upon access to all corners of the globe. George Friedman comments in his book *The Next 100 Years*:

> [T]he single most important geopolitical fact in the world [is] the United States controls all of the world's oceans. No other power in history has been able to do this. And that control is not only the foundation of America's security but also the foundation of its ability to shape the international system. ... At the end of the day, maintaining its control of the world's oceans is the single most important goal for the United States geopolitically. (2009, pp. 42–45)

In support of the goal of ensuring continued sea control, Admiral Mullen, Chairman of the Joint Chiefs, and others have suggested that, along with our allies, we strive ultimately towards a 1,000-ship Navy, while diligently persisting with maritime security and cooperative engagement (McGuire, 2009). However, as discussed in Problem 1 of the Introduction, the current and projected funding levels for ship construction do not support the current goals of 313 vessels in the fleet. Still, the naval service remains the only national asset with the ability to project U.S. presence abroad, protect vital trade routes, and police the world's vast ocean resources.

2. Today's United States Shipbuilding Industry

The 2009 U.S. shipbuilding industry itself employed over 300,000 people in 49 states (ASA, 2009).[6] Although there are more than 4,000 companies throughout these 49 states that manufacture ship systems and components, the core defense-industrial-shipbuilding base consists of six shipyards owned by just two companies—General Dynamics and Northrop Grumman. The Newport News, Virginia, site of Northrop Grumman (NG) is the sole builder of nuclear-powered aircraft carriers; Newport News and General Dynamic's (GD) Electric Boat in Groton, Connecticut, are the only two locations where nuclear submarines are built. The other members of the so-called "big six" shipyards are Bath Iron Works (GD), Ingalls (NG), Avondale (NG), National Steel and Shipbuilding Company (NASSCO)(GD). Conventional surface combatants are built at Bath Iron Works and Ingalls, while Avondale and NASSCO construct naval auxiliary ships; Avondale and Ingalls build amphibious assault ships. In Mississippi, with over 10,900 employees, Ingalls Shipbuilding is the state's largest private employer (NG, 2009).

Government-run, public shipyards play an important role in the industry as well. In Hawaii, "Pearl Harbor Naval Shipyard (PHNSY) and Intermediate Maintenance Facility (IMF)" is "the largest industrial employer in the state of Hawaii, with a combined civilian and military workforce of over 4,700" people and an operating budget of $687 million, which includes $426 million in payroll (Honolulu Advertiser, 2010).

C. Other Nations' Ship Procurement

Several countries have economies now growing at a faster rate than our own. The *QDR* itself points out that India is now the world's fastest growing democracy, while China is the world's most populous nation (DoD, 2010). In fact, China's economy grew by 8.7% in 2009, while the U.S. economy contracted by 2.4% (NBS,

[6] Wyoming is the only state not represented in the ASA's "nationwide distribution of shipyards and suppliers."

2009; BEA, 2010). Today, more than 90% of U.S. imports and exports are transported by ships, and nearly 40% of the world's oil supply is shipped through the Straits of Hormuz (U.S. Energy, 2008). Additionally, the last decade has seen the resurgence of the real threat of pirates and sea-based terrorists entering the oceans, particularly off the coast of Somalia. Developing as well as many developed nations are realizing the strategic importance of building and maintaining robust, healthy navies with the latest technologies and with the ability to protect national interests.

In countries in which economic growth has allowed for newfound resources to be allocated, several governments have chosen to build vessels as an appropriate investment for government spending. Mr. O'Rourke summarizes the following in the background section of his November 23, 2009, Congressional Research Service report regarding China's naval modernization:

> China's naval modernization effort encompasses a broad array of weapon acquisition programs, including programs for anti-ship ballistic missiles (ASBMs), anti-ship cruise missiles (ASCMs), land-attack cruise missiles (LACMs), surface-to-air missiles, mines, manned aircraft, unmanned aircraft, submarines, destroyers and frigates, patrol craft, amphibious ships and craft, mine countermeasures (MCM) ships, and supporting C4ISR6 systems. In addition, observers believe that China may soon begin (or already has begun) an indigenous aircraft carrier construction program. (p. 2)

Between 1995 and 2007 China placed into service a total of 38 submarines, which averages a rate of 2.9 per year. In Russia, the government recently approved a $60 billion naval-shipbuilding rearmament plan (ASA, 2009). In addition, the Indian government has prioritized manufacturing as a way of pulling the country out of poverty, and the Indian Ministry of Shipping has announced a $1.8 billion investment plan in four shipyards by 2017. India's annual GDP is $1.22 trillion, less than 10% of the annual U.S. GDP (World Bank, 2009).[7]

[7] Based on 2008 levels, as measured in U.S. dollars by the World Bank. India ranks 12th in the world in GDP, and the U.S. ranks 1st (World Bank, 2009).

D. How Ships Are Economically Unique

Ultimately, any analysis of the benefits of investing in shipbuilding and a larger fleet size must directly highlight how ships distinguish themselves from other defense and non-defense investment alternatives. There are at least four main ways that ships are distinguishable from other options such as tanks, bridges, and highways. First and foremost, a ship offers a recurring economic benefit as it is updated, maintained, and modernized during its 30- 40-year life cycle. Unlike a tank or bridge, a ship receives millions of dollars of commercial-off-the-shelf (COTS) technology insertions as well as scheduled engineering overhauls, new equipment installs, and refueling availabilities. Each of these evolutions provides a specially trained and highly skilled group of laborers with employment opportunities. Secondly, the value of the jobs created by the shipbuilding industry are clearly far above the economic value (measured as a factor of state GDP per capita) of the average job, as presented in chapter 4 in the NAVSEA Portfolio Assessment Team's study. Thirdly, the capital intensity of the shipbuilding industry is substantially high, regardless of the measurement technique used (Lim, 2007).

One aspect in which shipbuilding is not necessarily unique, but certainly threatened, is the recent (twenty-first century) atrophy of skills throughout its supporting industrial and supplier base. American leaders have become aware of the importance of keeping an industrial base capable and qualified to meet the defense security needs of the future. In May 2009, Congress passed the *Weapon Systems Acquisition Reform Act of 2009*, in which Title 10 of the *United States Code* is amended by adding the following new paragraph (6) at the end of section 2501(a):

> **SEC. 303. EXPANSION OF NATIONAL SECURITY OBJECTIVES OF THE NATIONAL TECHNOLOGY AND INDUSTRIAL BASE.**
>
> (a) Maintaining critical design skills to ensure that the armed forces are provided with systems capable of ensuring technological superiority over potential adversaries.

In short, this amendment emphasizes the importance of considering the "critical design skills" of engineers, contractors, and others who research and develop the weapons systems of America's military forces for both today and tomorrow. Other sections of the act require that the decision to terminate major-weapons-systems acquisition programs will include consideration of the effect of the program's termination on the industrial base itself. Rather than a step towards consolidation of industrial support, as some critics may argue, the act is a necessary and important measure to ensure that our competitive industrial and defense design base remains healthily engaged and does not atrophy.

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III. Methodology

A. General Approach

In a September 2009 study entitled *The Economic Case for Investment in the UK Defence Industry*, researchers and economists at Oxford Economics in London used a detailed framework for analyzing the economic contribution of various industries (Oxford Economics, 2009). This thesis will apply much of the Oxford Economics' framework as it analyzes the economic returns of the U.S. shipbuilding and repairing sector, as defined by North American Industrial Classification System (NAICS) code 336611, through at least four lenses:

(1). *Monetary impact*—using input/output analysis to analyze the direct, indirect, and induced channels of the shipbuilding sector on the U.S. economy.

(2). *Labor market impact*—how many jobs are supported by U.S. shipbuilding; what are the relative skill levels of those jobs compared to average; what is the regional distribution of those jobs throughout the country?

(3). *Capital intensity*—"sectors that invest the most in capital and labor present the largest potential for losses if they fail" (Oxford Economics, 2009).

(4). *Capacity measures and a rapid return?*—"in order for an increase in Government procurement to have an immediate impact on the economy, a sector must have sufficient spare capacity to absorb the additional demand" (Oxford Economics, 2009).

In order to best understand the methodology used by Oxford Economics, the researcher travelled to the group's London Office in December 2009 to meet with the two economists who were mainly responsible for the study's content—Mr. Andrew Tessler and Mr. Pete Collings. Additionally, this thesis research included interviews with professors, shipbuilding industry leaders, and several distinguished economists both inside and outside of the U.S. Department of Defense. A list of standardized interview questions is included in Appendix A. In all, interviews were conducted with economists, professionals, and industry experts affiliated with the following organizations:

- Oxford Economics, London;
- General Dynamics' Electric Boat Division (GD/EB), Groton, CT;
- Naval Reactors (NAVSEA 08), Washington, DC;
- Naval Sea Systems Command Cost Engineering and Industrial Analysis (NAVSEA 05C), Washington, DC;
- Strategic Systems Programs (SSP), Arlington, VA;
- Program Executive Office (PEO) for Submarines, Washington, DC;
- Naval Postgraduate School, Monterey, CA;
- General Dynamics' National Steel and Shipbuilding Company (GD/NASSCO), San Diego, CA;
- Office of the Assistant Secretary of the Navy (Financial Management and Comptroller), Washington, DC;
- Program Executive Office (PEO) for Integrated Warfare Systems, Washington, DC; and
- Defense Resources Management Institute (DRMI), Monterey, CA.

B. Free Market Concerns

Several months of research and interviews with various economists revealed that some of them have a fundamental ideological concern regarding the use of government spending as a means of stimulating the economy. The idea that government spending creates a multiplier effect for economic benefit is based on the economic theory of John Maynard Keynes, and the formal concept of a multiplier was published by Richard Kahn in 1931 (Samuelson, 1994). Much academic debate and theory about the multipliers applicability continues to permeate economic literature. In today's environment, a prominent professor of economics at Harvard University, Dr. Robert Barro, has conducted research demonstrating that there is "no evidence of a Keynesian multiplier effect" for stimulus spending, and he has published his view that "defense-spending multipliers exceeding one likely apply only at very high unemployment rates, and nondefense multipliers are probably smaller" (Redlick, 2009). Still, prominent economists disagree about the beneficial effects of Keynesian government spending. The *Journal of Post Keynesian Economics* is a forum in which scholars can publish research based on the theories of Keynesian multipliers and Keynes' ideas of stimulus.

One distinguished economist with Stanford University's Hoover Institute and others with the Naval Postgraduate School have suggested that the United States government could acquire ships more efficiently (at a lower cost) by allowing them to be produced overseas, where there may be a comparative advantage for ship construction. Although perhaps economically sound, national decision makers widely agree that U.S. national security requires maintaining the ability to build warships on American soil. Once agreed that the capability to produce U.S. warships on American soil is vital to U.S. national security interests, the benefits, or economic returns of doing so ought to be well known. In the *Journal of Post Keynesian Economics*, findings published in 2005/2006 reveal that "a rise in defense spending had a favorable impact on GDP and employment, but led to larger trade and budget deficits" (Atesoglu, 2005–6). Although there is much political and economic debate on the economic merits of government spending and investment, this research will build upon the work of credible, established Nobel-laureate economists[8] and closely follow the methodology employed by researchers at Oxford Economics.

C. Monetary Impact: Direct, Indirect, Induced

1. Input/Output Analysis and Leontief Inversion

Input/output economic analysis is a Nobel Prize-winning analytical framework developed by Professor Wassily Leontief in the late 1930s (Miller & Blair, 1985). All

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[8] Wassily Leontief received "The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1973"; Paul Krugman, who widely agrees with Keynes' theories, received the prize in 2008 (Krugman, 2009).

economic activity within a country is divided into sectors or industries. In the United States, those sectors are identified using the North American Industrial Classification System (NAICS) codes.[9] Inter-industry transactions are then measured for a specific time period (one year) in constant monetary terms (the U.S. dollar). The results, known as benchmark data, are represented in a matrix consisting of outputs listed in rows, and inputs listed in columns. The format allows analysis of how one industry's outputs are dependent upon inputs from all other sectors of the economy. The United States' Bureau of Economic Analysis (BEA) last collected such economy-wide benchmark data for the U.S. economy in 2002; a revised version of that data was published in April 2008 (BEA, 2008).

Once in possession of benchmark economic data for the economy as a whole, a series of specific steps may be performed in order to identify a specific sector's impact on the economy. First, the flow from sector *i* to sector *j* is defined as z_{ij}. Next, the variable X_j is chosen as the total gross output of the individual sector *j* in the given year. From these variables, a technical coefficient, a_{ij}, is calculated as:

Equation 1

$$a_{ij} = \frac{z_{ij}}{X_j}$$

The resulting coefficient then represents the dollar value of inputs from sector *i* required for every dollar of output from sector *j*. The system is designed to provide constant returns to scale. In other words, a_{ij} is a fixed relationship; when output from sector *j* is doubled, it is assumed that the inputs required from sector *i* would also be doubled. Economies of scale in production are thus ignored; the Leontief system is strictly a linear model. Furthermore, the inter-industry flows from *i* to *j* for a

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[9] NAICS is the "standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy" (U.S. Census Bureau, 2010).

given year depend entirely and exclusively on the total output of sector *j* for that specific year (Miller & Blair, 1985).

Rather than manually performing the matrix algebra required to analyze the impacts of a certain sector, a software model developed by researchers at Carnegie Mellon University performs a Leontief inverse on the portion of the larger matrix pertinent to the sector chosen. The model, originally created in 1995, is called Economic Input-Output Life Cycle Assessment (EIO-LCA) and is "comprised of national economic input-output models and publicly available resource use and emissions data" (Carnegie, n.d.). Only the economic results will be used in this study; the environmental impact will not be considered.

With a credible reputation based on the Nobel Prize-winning theory of Wassily Leontief and reliable data from the BEA, Carnegie Mellon University proclaims that "the EIO-LCA method has been applied to economic models of the United States for several different years, as well as Canada, Germany, Spain, and select U.S. states. The on-line tool has been accessed over 1 million times by researchers, LCA practitioners, business users, students, and others." Additionally, the input/output analysis method has been "used extensively for planning throughout the world" (Carnegie, n.d.).

a. Direct, Indirect, and Induced Impacts

By considering various channels of impact, economic multipliers may be calculated for three distinct areas of the shipbuilding industry's overall economic impact: direct effects, indirect effects, and induced effects. Direct impacts are employment and activity in the sector itself—the shipbuilding industry. Indirect impacts are defined as "employment and activity supported down the supply chain, as a result of a sector's companies purchasing goods and services from" suppliers (Oxford Economics, 2009, p. 14). For example, when a shipyard is building a new Littoral Combat Ship (LCS), it may order a fire-control system to be installed that was designed in California. That same system may have been built with components from Washington state. The purchase of various equipment and supplies from vendors, as well as jobs and sales at those vendors' offices, may be quantified as indirect impacts for investment in the shipbuilding industry. Finally, induced impacts are of pivotal economic importance to the study of ship construction. Oxford Economics defines induced impacts as "employment and activity supported by the consumer spending of those employed in the sector or in its supply chain" (2009, p. 14). For instance, the manufacturer of a component ordered by the shipyard for construction of a new vessel has additional revenue from the sale of that component; that revenue is spent in the local economy buying everyday goods and services, which benefits local economic growth. The BEA states that induced multipliers, which "include the economic impact of industries and household expenditures […] are […] the most commonly used" (1997, p. 23). Induced analysis considers a wide variety of industries and activities throughout the United States and relies on creation of an economic multiplier for its quantification.

2. Other Sectors Considered

The "shipbuilding and repairing" sector will henceforth be referred to simply as the "shipbuilding" industry. Per NAICS labeling, shipbuilding is a sub-sector of the (336xxx) group labeled "vehicles and other transportation equipment." Comparisons of Leontief model output will be analyzed and contrasted with five other sectors of the U.S. economy:

- Automobile manufacturing (336111),
- Aircraft manufacturing (336411),
- Military-armored-vehicles and tank-parts manufacturing (336992),
- Nonresidential manufacturing structures (230102), and
- Health care: offices of physicians, dentists, health care practitioners (621A00).

These five sectors were chosen by the sponsor to include three other subcategories of manufacturing transportation vehicles, a more general manufacturing alternative, and also a service-based industry for comparison.

3. Estimation of Induced Multipliers

In addition to the direct and indirect economic effects to be calculated using the Carnegie Mellon model, *induced* effects should also be considered and quantified. The induced impacts of activity within a sector are "employment and activity supported by the consumer spending of those employed in the sector or in its supply chain. This helps to support jobs in [U.S.] industries that supply these purchases and includes jobs in retail outlets, companies producing consumer goods and in a range of service industries" (Oxford Economics, 2009). Since the induced effects are the most difficult to quantify, data from previous studies of U.S. and U.K. shipbuilding industries will be reviewed. Based on the recommendation of economist Andrew Tesller at Oxford Economics (www.oef.com), the induced multiplier for U.S. shipbuilding will be estimated as a fraction of the indirect multiplier. Induced multipliers may be calculated from direct/indirect multipliers by estimating the household consumption multiplier and making some general assumptions (Katz, 1980).

4. Regional Distribution of Impacts and Employment

Based on the work of Garnick and Drake in the 1970s, the Bureau of Economic Analysis (BEA) has published a handbook for users of its Regional Input-Output Multipliers System (LECG, 2002).[10] The process of using the BEA's system to derive regional multipliers is summarized concisely in the 2002 LECG report for the American Shipbuilders Council:

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[10] Regional Input-Output Multipliers System (RIMS II) is explained in Appendix C of the 2002 LECG report.

> The RIMS II method for estimating regional Input-Output multipliers can be viewed as a three-step process. In the first step, the producer portion of the national Input-Output table is made region-specific by using four-digit SIC location quotients (LQ's). The LQ's estimate the extent to which input requirements are supplied by firms within the region. RIMS II uses LQ's based on two types of data: BEA's personal income data (by place of residence) are used to calculate LQ's in the service industries; and BEA's wage-and-salary data (by place of work) are used to calculate LQ's in the nonservice industries.
>
> In the second step, the household row and the household column from the national Input-Output table are made region-specific. The household row coefficients, which are derived from the value-added row of the national Input-Output table, are adjusted to reflect regional earnings leakages resulting from individuals working in the region but residing outside the region. The household column coefficients, which are based on the personal consumption expenditure column of the national Input-Output table, are adjusted to account for regional consumption leakages stemming from personal taxes and savings.
>
> In the last step, the Leontief inversion approach is used to estimate multipliers. This inversion approach produces output, earnings, and employment multipliers, which can be used to trace the impacts of changes in final demand on directly and indirectly affected industries. (p. C-9)

Rather than manually performing the matrix algebra and Leontief inversion, the results of the Carnegie Mellon Economic Input-Output Life Cycle Assessment model will once again be utilized. RIMS II models will also be obtained from the BEA so that employment and multiplier data will be available from at least two sources: Carnegie Mellon’s model and the RIMS II model.

D. Labor Market Impact

1. Highly Skilled Jobs

Many of the workers involved in ship construction and modernization have been training for years to earn the specific qualifications necessary to perform those tasks. To be a nuclear plant welder in the United States, for example, “one must be cleared by the FBI, undergo drug and alcohol testing, and pass a psychological screening. These criteria are above and beyond welding certification, diving certification, and special training required of all nuclear plant personnel" (Hancock, 2003). The nuclear welders and construction personnel who build our aircraft carriers and submarines are not an immediately renewable resource. In other words, if they are eliminated from the workforce due to drastic drops in demand for their services at the "big six" shipyards, then there are at least two formidable and unfavorable results. First, if the U.S. military suddenly has an increased demand for specialized labor in nuclear or conventional ship construction (war), then we will not have that capacity available to be utilized. We may have to actually outsource those jobs to other countries, which is particularly dangerous and difficult in terms of national security and weapons systems construction. Secondly, the atrophy of the workers' skills in industry combined with the graying of the workforce may actually lead to a regression of the "knowledge economy" of this sector of the U.S. defense and shipbuilding industries, leading to a larger-scale contraction (RAND, 2006). The principle of a knowledge economy is, in brevity, an explanation of the use of knowledge itself as a product or tool producing an economic benefit (Drucker, 1992). For instance, the training, experience, and skill level of an individual welder or shipyard worker has some inherent economic value, which can be quantified in calculating the sum of the industry or activity's economic worth.

2. Labor Trends

Data collected from Naval Sea Systems Command (NAVSEA) shows labor force levels at the nation's six private shipyards since 1985. The data has been tabulated, presented, and correlated with a specific case of demand for one shipyard.

E. Capital Intensity, and Excess Capacity—"What If"?

In researching the unique aspects of the U.S. shipbuilding industry as it compares to other defense activities, Dr. Nayantara Hensel, a former professor at the Naval Postgraduate School and current Chief Economist in the Assistant Secretary of the Navy (Financial Management & Comptroller) Office highlighted the high capital intensity and sunk investments of infrastructure existing within the shipbuilding sector.

The facilities and infrastructure themselves become economic "waste" if the existing capacity is not utilized by providing an appropriate demand signal (Hensel, 2009). The same principle is summarized nicely in the Oxford Economics report on investment in the U.K. defense industry: "sectors that invest the most in capital and labour present the largest potential for losses, if they fail" (p. 26). In summary, unlike shopping malls and retail centers, shipyards (as they are both highly capital and labor intensive) are unable to be readily converted to some other economic activity, if they fail. Rather, they become "waste." There is, therefore, an inherent opportunity cost of failing to utilize the existing capacity—the current market values of the facilities and technology themselves. Acceptance of this principle that irrevocable waste results from failure to utilize sectors with high capital intensity, combined with the clear evidence of the shipbuilding industry's investment in capital plants and equipment, supports the claim that basic funding levels to sustain the industry's existence at current levels is economically viable and preferable (Booth, Colomb & Williams, 2008).

Using public data from the released "10k" financial statements of various companies, capital intensity will be calculated as:

Equation 2

$$\frac{net\ capital\ stock}{revenue\ for\ 2009}$$

This ratio provides "a measure of a firm's efficiency in deployment of its assets, computed as a ratio of the total value of assets to sales revenue generated over a given period. Capital intensity indicates how much money is invested to produce one dollar of sales revenue" (BusinessDictionary.com, n.d.). Moreover, "a decline in a capital intensive industry may mean a permanent loss of productive capacity" (Oxford Economics, 2009).

The reciprocal of “capital intensity” as defined above, is a ratio known as Total Assets Turnover Ratio (TATR). The ratio measures the ability of a company (or business group within a company) to use its assets to generate sales. Expressed as “number of turns,” the higher the TATR, the more efficiently a group is using its assets in order to generate sales revenue.

Data has been isolated from General Dynamic’s 2009 published annual report. Specifically, from General Dynamics Marine Systems division, which “designs, builds and supports submarines and a variety of surface ships for the U.S. Navy and commercial customers. Among the sophisticated platforms the group delivers are nuclear-powered attack submarines, surface combatants, auxiliary and combat-logistics ships, and commercial product carriers. The group also provides world-class engineering design support and overhaul, repair and lifecycle support” (General Dynamics, 2009). Both ratios will consider all current and noncurrent assets, including fixed assets, such as plants and equipment, as well as inventory, accounts receivable, and cash.

In addition, published financial statements from corporate leaders representing the five sectors contrasted with shipbuilding will each be analyzed using the same measure of capital intensity:

- Automobile manufacturing—Ford Motor Company, Toyota
- Aircraft manufacturing—Boeing, General Dynamics Aerospace
- Military Armored Vehicles and tank parts manufacturing—GD Combat Systems
- Health care—Bayer

F. Capacity Measures & A Rapid Return?

> In order for an increase in Government procurement to have an immediate impact on the economy, a sector must have sufficient spare capacity to absorb the additional demand
>
> —Oxford Economics, 2009

Data regarding the capacity and capacity utilization of the shipbuilding sector has been collected from the Federal Reserve Board. The United States Federal Reserve Board regularly constructs estimates of capacity and capacity utilization for industries in manufacturing, mining, electric, and gas utilities. For a given industry, the capacity utilization rate is equal to an output index (seasonally adjusted) divided by a capacity index. The Federal Reserve Board's capacity indices "attempt to capture the concept of sustainable maximum output—the greatest level of output a plant can maintain within the framework of a realistic work schedule, after factoring in normal downtime and assuming sufficient availability of inputs to operate the capital in place"(Federal Reserve Board, 2009). The details of the six-step procedure used by the Federal Reserve to calculate capacity utilization are included in Appendix B.

The available macroeconomic data from the Federal Reserve were analyzed for trends in capacity utilization and compared to the median capacity-utilization rate for the fourth quarter of 2009 for the manufacturing sectors.

IV. Results

A. Input/Output Multiplier Analysis

Carnegie Mellon University's Economic Input-Output Life Cycle Assessment (EIO-LCA) model was used to perform a Leontief inverse solution based on U.S. Benchmark data with the following results. First, it should be noted that the latest United States benchmark data from the Bureau of Economic Analysis is data from 2002 that was last updated in 2008. The model's software calculates a coefficients matrix based on the input-output data for the U.S. economy. By isolating a single sector of the economy, and choosing a given level of output or production from that sector, direct and indirect economic activity estimates are generated. The shipbuilding and repairing sector (NAICS code 336611) was selected for analysis, with an increased production from that sector of $1 billion. In other words, an injection of $1 billion was entered into the model in the form of additional, final demand from the shipbuilding sector.

One possible source of an additional ship production demand of $1 billion would be government orders for U.S. Navy vessels. However, this particular model makes no distinction between military and civilian contracts, nor between Navy and commercial shipbuilding. If the private market were to demand an additional $1 billion in commercial ship construction, then the economic activity estimates would be the same as those created from Navy demand. Since the Leontief function is a linear model, output results will vary proportionally with those generated in Table 1. For instance, entering $2 billion increased output demand into the model will yield results that are double those in Table 1, while inputting $500 million will yield results that are half of those in Table 1.

Table 1. Total & Direct Economic Effects of $1 Billion Output from Shipbuilding Sector

NAICS code	Sector Description	Total Economic ($ mil)	Direct Economic ($ mil)
	Total for all sectors	*2,090*	*1,570*
336611	Shipbuilding and repairing	999	999
420000	Wholesale trade	67.0	36.1
550000	Management of companies and enterprises	64.8	33.8
333618	Other engine equipment manufacturing	55.7	49.3
331110	Iron and steel mills	32.8	16.8
533000	Lessors of nonfinancial intangible assets	31.3	23.5
541610	Management consulting services	25.0	17.8
52A000	Monetary authorities and depository credit intermediation	24.2	11.6
523000	Securities, commodity contracts, investments	21.8	13.3
531000	Real estate	21.5	4.07

1. Direct Economic Effects

In the first row of Table 1, labeled "total for all sectors," direct economic effects of $1.57 billion represent the dollar amounts of purchases made by the shipbuilding and repairing sector in order to manufacture its final product (a ship). This $1.57 billion includes the produced value of $1 billion increased economic activity for the shipbuilding and repairing sector, which is shown (minus rounding error of 1) in the second row of Table 1. So, the sector purchases $570 million worth of products (goods and services) from other sectors in order to make $1 billion worth of output.

The shipbuilding and repair sector ranks fourth of the six sectors considered, when ranked by direct economic effects, as shown in Table 2.

Table 2. Direct Economic Impact of an Additional $1 Billion Output by Sector

Sector #	Sector Description	Direct Economic Impact ($ billion)
336111	automobile manufacturing	$1,740
336411	aircraft manufacturing	$1,650
336992	military armored vehicles & tank parts manufacturing	$1,600
336611	shipbuilding and repairing	$1,570
230102	nonresidential manufacturing structures	$1,410
621A00	offices of physicians, dentists, health care practitioners	$1,350

2. Value Added

The difference between the $1 billion output from shipbuilding and the $570 million of inputs it requires is the value added by the shipbuilding and repairing sector itself. The value added amount represents "compensation of employees, taxes on production and imports less subsidies, and gross operating surplus. Value added equals the difference between an industry's gross output ($1 billion) minus the cost of its intermediate goods that are purchased (such as energy & raw materials)" (Carnegie, n.p.). For instance, once the raw materials and services are purchased from other sectors, the value of the skilled labor and contribution from the shipyards themselves totals $430 million. Stated differently, the $430 million in value added is one (direct) component of an increase in GDP as a result of the additional $1 billion of output.

Table 3 and Figure 2 show the value added (contribution to GDP) by sector to the U.S. economy for a $1 billion increased output from that sector. The shipbuilding sector ranks third out of the six sectors considered, when ranked by economic value added.

Table 3. Purchases and Value Added Amounts for Various Sectors, with $1 Billion Increased Production

Sector #	Sector Description	Increased Production Output ($ million)	Amount of Direct Purchases ($ million)	Value Added (difference) ($ million)
336111	automobile manufacturing	$1,000	$740	$260
336411	aircraft manufacturing	$1,000	$650	$350
336992	military armored vehicles & tank parts manufacturing	$1,000	600	$400
336611	shipbuilding and repairing	$1,000	$570	$430
230102	Nonresidential manufacturing structures	$1,000	$410	$590
621A00	offices of physicians, dentists, health care practitioners	$1,000	$350	$650

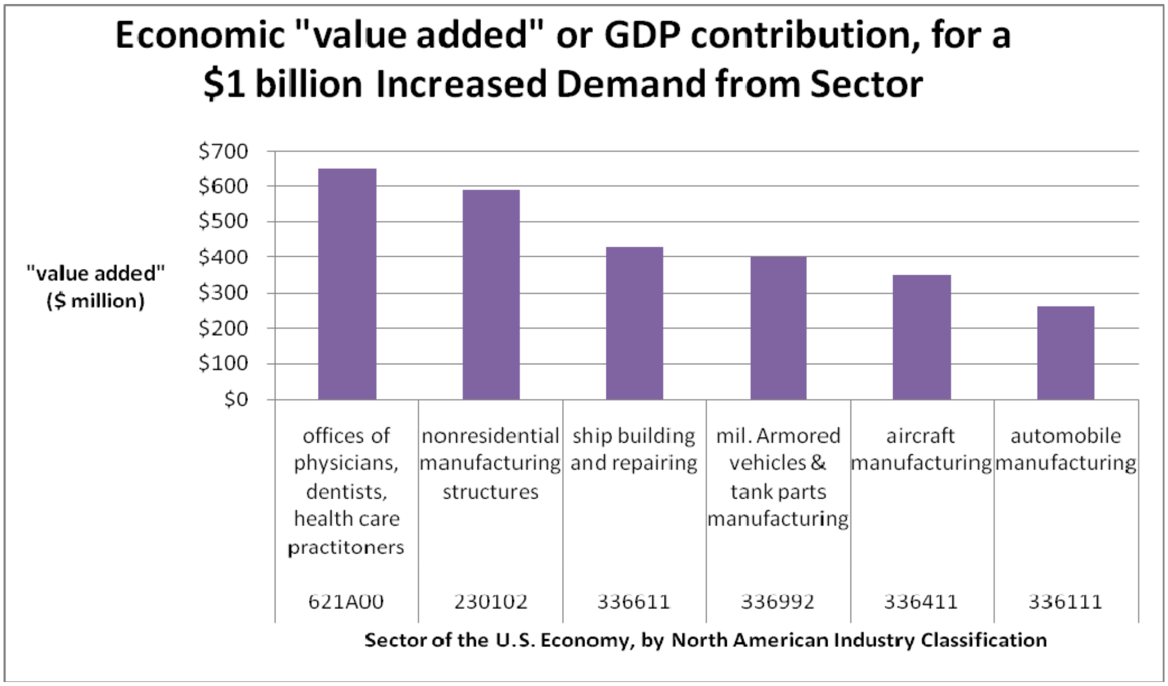

Figure 2. Economic "Value Added" for $1 Billion Increase in Demand from Sectors

Shipbuilding and repairing is a sector that is nearly split between the two main factors of production needed to generate additional output—materials and labor (purchases and value added). Whereas automobile and aircraft manufacturing are ranked number one and number two, respectively, in terms of direct economic effects, this ranking reflects a high degree of automation in their manufacturing processes. Most of the direct activity generated is due to purchases of materials these industries must make in order to manufacture their finished goods.

When the results are analyzed in terms of value added by the industry itself, the ranking of the six sectors considered is nearly inverted. In other words, "offices of physicians, dentists, and health care practitioners" (health care services), which were first when ranked by value added, were last in total direct effects. Shipbuilding remains in the middle of the group when ranked by value added, since, as a sector, it requires about 57% of materials ($570 million/$1,000 million), and 43% labor as components of the additional $1 billion output. One may conclude that shipbuilding represents a “healthy balance” between these two contributing factors of production, providing stimulation of the economy through both purchases of materials and wages to workers. The data reflect that shipbuilding is both capital and labor intensive, presenting two avenues for economic stimulus.

3. Total Economic Effects

For shipbuilding and repair, a total economic impact of $2.09 billion, as presented in the first row of Table 1, represents the total purchases by all sectors of the economy resulting from an additional $1 billion output from shipbuilding and repairing. The $2.09 billion includes the direct purchases made by the shipbuilding and repair sector itself, and also the indirect purchases further up the supply chain—the materials and services needed to produce the goods sold to the shipbuilding and repairing sector. Included within the $2.09 billion of activity is the $1 billion of increased final output from shipbuilding. Figure 3 shows how the total $2.09 billion is divided.

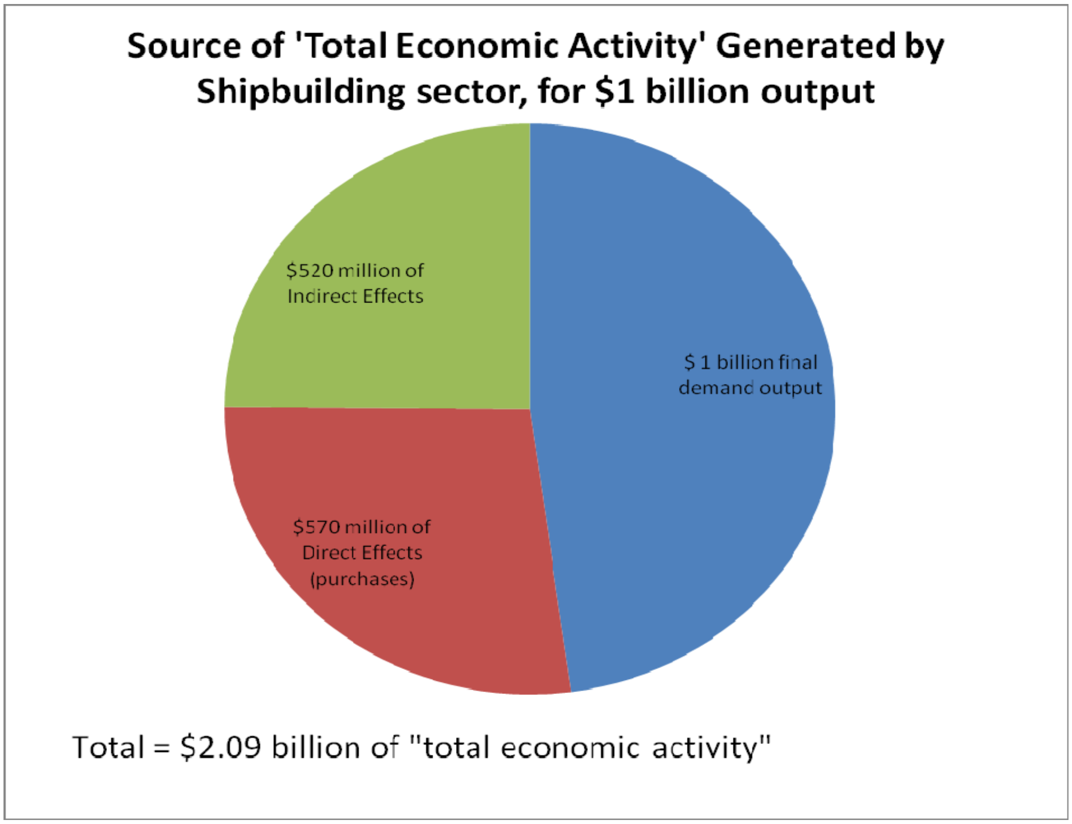

Figure 3. Sources of Total Economic Activity Generated by Shipbuilding

Figure 4 shows a graphical representation of the total and direct economic effects generated by an additional $1 billion output from six different sectors of the U.S. economy.

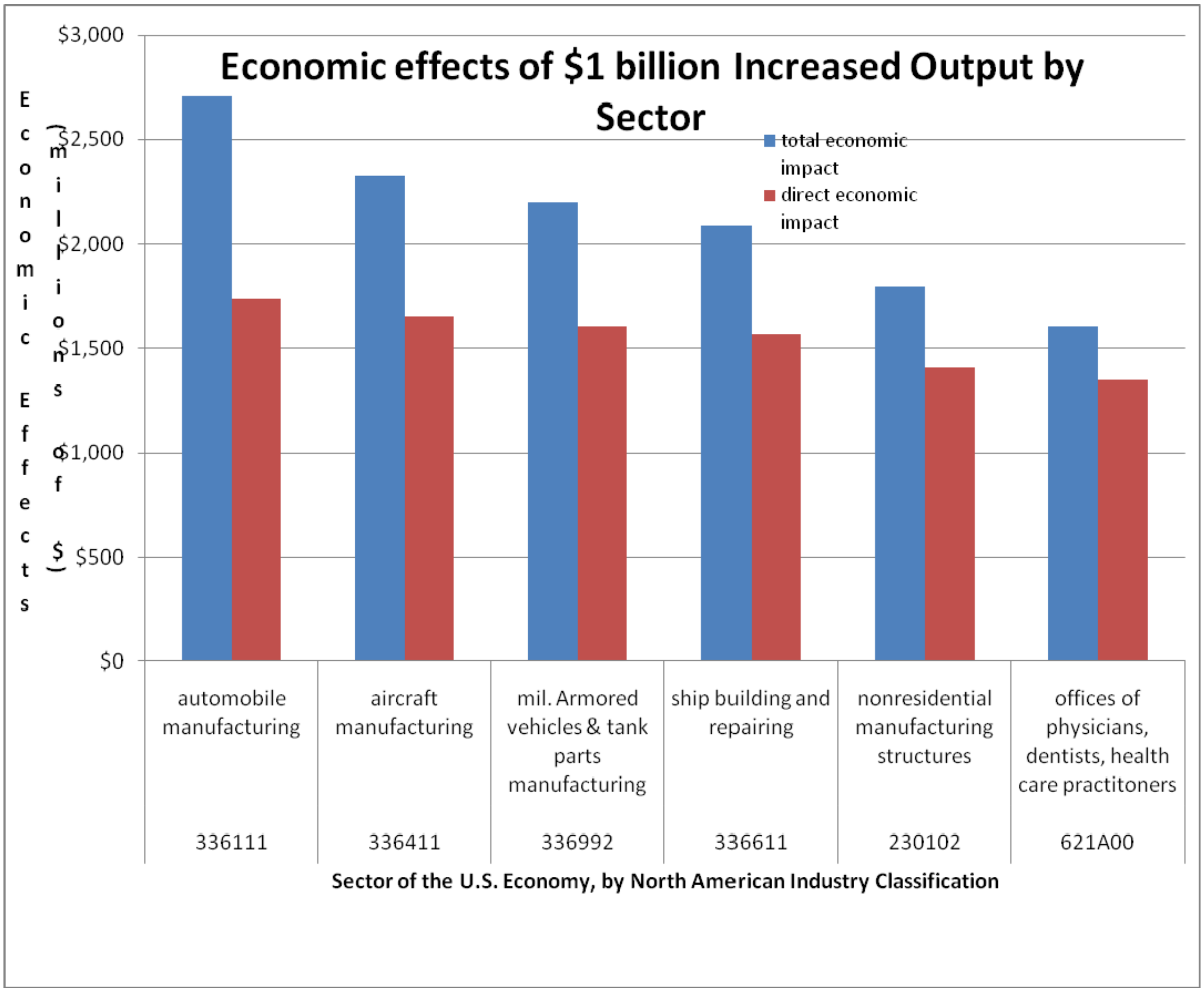

Figure 4. Economic Effects of Additional $1 Billion of Output from Sectors

The shipbuilding sector ranks fourth out of the six sectors considered, when ranked by total economic effects, with a multiplier of 2.09 ($2,090 million/$1,000 million). Regional economic multipliers for each of the "big six" shipyards may actually be much higher, as suggested by the results of the BEA's Regional Input-Output Modeling System (RIMS) results presented in Table 9 and described below.

4. Induced Economic Effects

Since $2.09 billion of total economic activity occurs for every $1 billion increased output from shipbuilding, the output multiplier, when considering only the impacts within the sector (direct) and the supply chain (indirect), is 2.09. Economists refer to this as a "Type I multiplier" (Tessler & Collings, 2009). For every $1 of increased output from shipbuilding, about $2.09 of direct and indirect activity occurs.

An additional impact in this analysis is the induced effects from the $2.09 billion of activity throughout the economy. The induced impacts are "employment and activity supported by the consumer spending of those employed in the sector or in its supply chain. This helps to support jobs in [U.S.] industries that supply these purchases and includes jobs in retail outlets, companies producing consumer goods and in a range of service industries" (Oxford Economics, 2009). The induced multiplier is the most difficult to calculate or estimate, and the least defendable for any industry or sector. Economists call multipliers that include induced effects "Type II multipliers" (Tessler & Collings, 2009). The U.S. Bureau of Economic Analysis describes Type II multipliers as a "measure [of] the economic impact of industries and household expenditures. These multipliers include the impacts associated with the spending of earnings by labor within the region. Therefore, endogenous multipliers can be used to estimate the sum of direct, indirect, and induced impacts. These are the most commonly used multipliers" (BEA, 1997).

Since the Carnegie Mellon software does not include induced effects in generating the economic activity results, a Type II multiplier is not explicitly calculated using the Leontief inversion process within that model. However, the constant that relates the "Type I and Type II multipliers in an input-output model [has been] proven to be exactly the consumption multiplier for the household sector" (Katz, 1980). The basic consumption multiplier is based on the Marginal Propensity to Consume (MPC) and the tax rate (*t*), and may be calculated as shown in Equation 3.

Equation 3

$$\frac{1}{1 - MPC\,(1 - t)}$$

An average tax rate of 29% was used, including federal income tax, social security, medicare, and possible state taxes (Steuerle, 2004). Assuming a national, average marginal propensity to save (savings rate) of 5%, then MPC = 1 – MPS = 95% (OMB, 2010). The result shows as follows:

Equation 3 Applied

$$\frac{1}{1 - 0.95\,(1 - 0.29)} = 3.07$$

The result of using this consumption-multiplier estimate to produce Type II multipliers is included in Table 4.

Table 4. Calculation of Type II Multipliers for Various Sectors

Sector #	**Sector**	(Type I multiplier	minus increased output)	* consumption multiplier	result – estimated Type II multiplier
336111	automobile manufacturing	2.71	1	3.07	5.25
336411	aircraft manufacturing	2.33	1	3.07	4.08
336992	Military armored vehicles & tank parts manufacturing	2.2	1	3.07	3.68
336611	shipbuilding and repairing	2.09	1	3.07	3.35
230102	nonresidential manufacturing structures	1.8	1	3.07	2.46
621A00	offices of physicians, dentists, health care practitioners	1.6	1	3.07	1.84

In reality, differences exist in consumption multipliers between various sectors, but a realistic range is between 3.0 and 3.5, based on tax rates varying by region and MPC varying by profession or trade.

An alternative means of calculating Type II multipliers was conducted using the Regional Input-Output Modeling System (RIMS II) through the U.S. Bureau of Economic Analysis. The results from this method are presented by specific state—showing 51 various output multipliers (including the District of Columbia), accounting for the induced factor of consumers' spending wages. The resulting output from the RIMS model is presented in Table 9.

5. Multipliers: The "Bottom Line" for the Navy SCN Account

Applying the induced multiplier, as calculated, to the Navy's expenditures on ship construction, allow an estimate of that account's economic impact on the U.S. economy. The FY2010 budget included $13.8 billion ($13,776,867,000) for the "Shipbuilding and Conversion, Navy," or SCN account (DoN, 2009). Starting at that $13.8 billion level, Table 5 shows the estimate of total economic impact to the U.S. economy. At current funding, the Navy's SCN account provides about $46.2 billion of economic activity nationwide.

With an increase of $2 billion to the SCN account, and applying a calculated Type II multiplier of 3.35, the economic activity generated will be approximately $52.9 billion nationwide. For the purposes of generating Tables 5 and 6, an increase in SCN funding is assumed to be equal to an increase in final demand output from the shipbuilding and repair industry (NAICS code 336611).

Table 5. Impact of Various SCN Funding Levels on U.S. Economy (Using Type II Multipliers)

Increase in SCN Funding ($ billion)	Total SCN Budget Level ($ billion)	Total Economic Impact ($ billion)
0	$13.8	$46.2
$0.1	$13.9	$46.6
$1	$14.8	$49.6
$2	$15.8	$52.9
$5	$18.8	$63.0
$6	$19.8	$66.3
$7	$20.8	$69.7
$8	$21.8	$73.0
$9	$22.8	$76.4
$10	$23.8	$79.7

When considering the effect on U.S. Gross Domestic Product of potential changes to the Navy's SCN funding, one must isolate the "value added" portion of the economic activity generated. Carnegie Mellon's Green Design Institute explains the value added definition in its handbook for users of the EIO-LCA model:

> The value added represents compensation of employees, taxes on production and imports less subsides, and gross operating surplus. Value added equals the difference between an industry's gross output (income, taxes, and inventory change) and the cost of its intermediate inputs (energy, raw materials, semi-finished goods, and services that are purchased). Another way to think about Value Added is that once the [shipbuilding and repairing] sector purchases all the materials that it needs to make its product, it is still just a pile of parts and services. The amount

paid to workers, the taxes, etc., also contribute to the economy and create a useful product that has additional value to a consumer beyond the original pile of parts and services. (2008, n.p.)

The Carnegie Mellon University model shows that about $430 million of "value added" is created for an increase in final demand of $1 billion. Since all Leontief models are linear, the projected increase in U.S. GDP for various increases in SCN funding levels are predictable.

Table 6. Effect on U.S. GDP for Various SCN Funding Levels

Increase in SCN Funding ($ billion)	**Increase in GDP ($ million)**	**Total SCN Budget Level ($ billion)**	**Total SCN Account Contribution to GDP (Value Added) ($ million)**
(from FY10 level)	**(delta - value added)**	**(based on $13.8B for FY2010)**	**($43 mil per $100 mil)**
0	$0	$13.8	$5,934
$0.1	$43	$13.9	$5,977
$1	$430	$14.8	$6,364
$2	$860	$15.8	$6,794
$5	$2,150	$18.8	$8,084
$6	$2,580	$19.8	$8,514
$7	$3,010	$20.8	$8,944
$8	$3,440	$21.8	$9,374
$9	$3,870	$22.8	$9,804
$10	$4,300	$23.8	$10,234

The United Kingdom Office of National Statistics states that Gross Value Added (GVA) is "used in the estimation of Gross Domestic Product (GDP)." Furthermore, the "production approach to estimating GDP looks at the contribution of each economic unit by estimating the value of an output (goods or services) less the value of inputs used in that output's production process" (UK Office of National Statistics, 2002). In this research, analysis of U.S. benchmark I/O tables suggests that the shipbuilding industry requires $570 million of purchases or inputs in order to produce $1 billion worth of output (ships). Therefore, the data show that raising the Navy's funding for shipbuilding and repair by $1 billion will also boost U.S. GDP by an additional $430 million. Additionally, current SCN funding of $13.8 billion (FY2010) generates about $5.9 billion of Gross Domestic Product for the U.S. economy.

B. Labor Market Impact

1. Using the Carnegie Mellon EIO-LCA Model

Using the Carnegie Mellon EIO-LCA model, the numbers in Table 7 represent the complete number of employees needed across the supply chain of purchases in order to produce the level of output of $1 billion.

Table 7. Number of Employees Needed to Generate $1 Billion of Output in Six Sectors

Sector #	Sector	# of Employees
336611	shipbuilding and repairing	16,700
336992	military armored vehicles & tank parts manufacturing	15,300
336411	aircraft manufacturing	14,300
336111	automobile manufacturing	13,800
621A00	offices of physicians, dentists, health care practitioners	13,800
230102	nonresidential manufacturing structures	11,200

The U.S. economy-wide benchmark data used for this section is the 1997 benchmark data, since the 2002 EIO-LCA model did not include the labor output functionality. Here, the shipbuilding and repair sector ranks first out of the six considered, with 16,700 additional employees needed throughout the supply chain in order to increase shipbuilding output by $1 billion. The model used is a linear model, so an increased output of $100 million would require 1,670 employees. The next most labor-intensive sector of the six considered is military armored vehicles manufacturing, which would utilize 15,300 additional employees. In other words, of the six specific sectors considered here for possible investments of federal government dollars (to increase that sector's output), shipbuilding and repairing will create or support the highest number of jobs. The results are also shown in Figure 5.

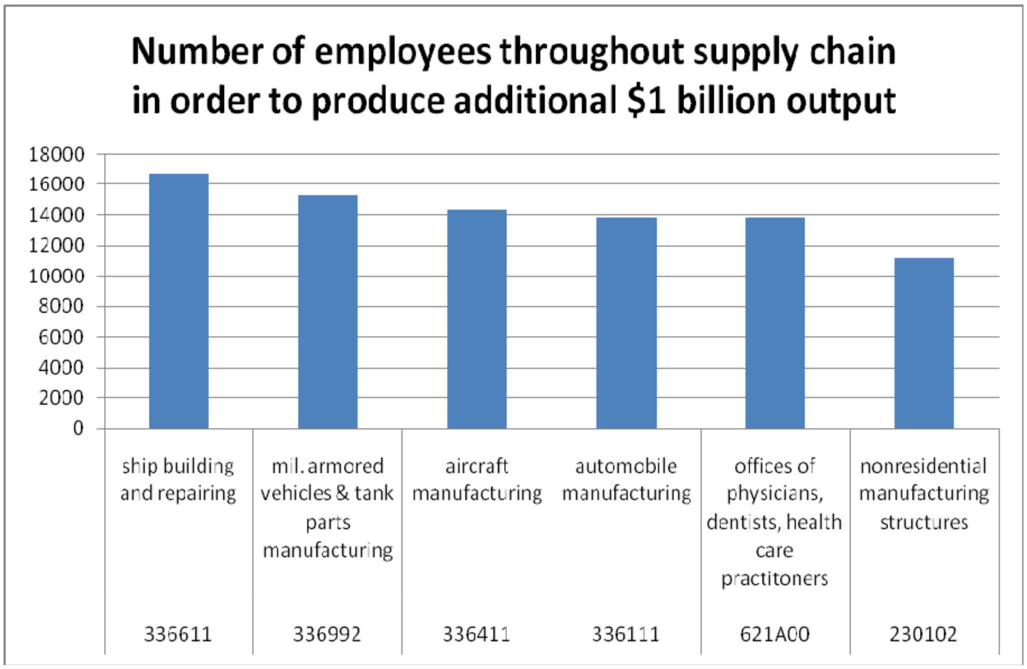

Figure 5. Number of Employees to Produce $1 Billion of Output

Of the 16,700 jobs created or supported by the shipbuilding and repairing sector in order to create an additional $1 billion of output, the EIO-LCA model suggests that 9,180 of those jobs would be within the shipbuilding sector itself, while the remaining 7,520 would be throughout the supply chain (part of the indirect benefit). In addition, Figure 6 shows the estimated distribution of the direct and indirect labor throughout the country. The graphical results are presented as a percentage of total sector employment (direct and indirect) employed. The states that include the nation's "big 6" private shipyards, as described in Chapter II, all show substantial percentages of the increased labor.

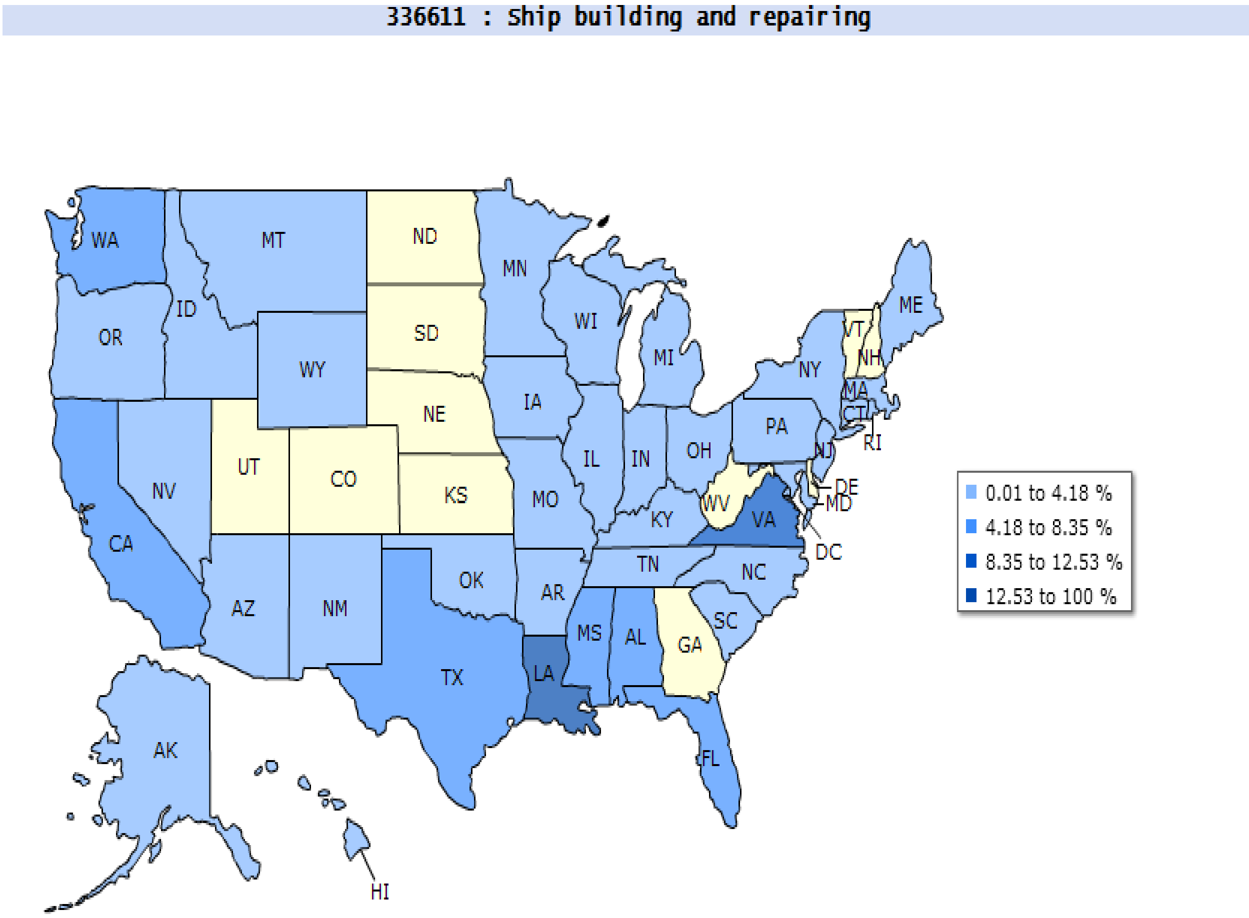

Figure 6. Nationwide Distribution of Labor for the Shipbuilding Industry
(Carnegie Mellon, 2008)

Several assumptions and limitations are associated with the use of the EIO-LCA model to estimate increased employment based on a larger output demand. First, the data is old (1997 benchmark). However, the industries selected are mature industries. Use of the model for information technology or telecommunications estimates would be much less reliable because these sectors have experienced more widespread growth than shipbuilding, auto/aircraft manufacturing, or health care services. Secondly, the Bureau of Economic Analysis compiles benchmark data through surveys and forms submitted by U.S. corporations to the federal government. Uncertainty in sampling, response rate, and errors in form completion are just a few of the potential sources of discrepancy between the data input and reality.

In addition, the EIO-LCA is a producer price model—"the price a producer receives for goods and services (plus taxes, minus subsidies), or the cost of buying all the materials, running facilities, paying workers, etc." (Carnegie, 2008, n.p.). The alternative pricing method, "purchaser price," would include the producer price plus the transportation costs of shipping the product to the point of sale and the wholesale and retail trade margins (the profit these industries take for marketing and selling the product). For many goods, the producer prices can be far less than what a final consumer would pay (e.g., the producer price for leather goods in the U.S. is approximately 35% of the final purchaser price) (Carnegie, 2008, n.p.).

2. Shipyard Direct Labor Trends

The Naval Sea Systems Command (NAVSEA 05C) provided data for the employment of workers at six U.S. private shipyards for the past several decades. The data are presented in Table 8 and Figure 7, which shows variation in the labor force levels at the "big 6" shipyards. The six shipyards are all owned by one of just two companies—Northrop Grumman (NG) or General Dynamics (GD). As of the beginning of 2009, these shipyards employed over 56,000 workers in 7 states:

- Northrop Grumman—VA
- Northrop Grumman—MS
- Northrop Grumman—LA
- General Dynamics Electric Boat—RI & CT
- General Dynamics Bath Iron Works—ME
- General Dynamics National Steel and Shipbuilding Company (NASSCO)—CA

Table 8. Shipyard Employment as of January 1:

	1985	1990	1995	2000	2005	2009
(NG) Newport News	28,502	25,517	19,878	16,971	18,769	18,720
(NG) Ingalls	10,805	11,516	13,952	10,500	12,470	11,385
(NG) Avondale	4,656	7,013	5,904	7,581	7,631	5,486
(GD) Electric Boat	24,797	21,572	15,347	8,646	11,775	10,546
(GD) Bath Iron Works	7,534	11,494	9,125	7,516	5,918	5,439
(GD) NASSCO	4,055	3,236	4,076	2,695	4,213	4,772
TOTAL	***80,349***	***80,348***	***68,282***	***53,909***	***60,776***	***56,348***

As seen in Table 8, individual shipyard workforce levels varied from 1985 to 2009. Ingalls, Avondale, and NASSCO were relatively stable, but Electric Boat and Newport News suffered significant workforce losses. These losses may be correlated to declines in demand. For instance, only one U.S. submarine was constructed[11] from 1998 to 2003, when Electric Boat's workforce levels reached its lowest point in several decades (Doehring & Jenning, 2009).

Twenty years ago, in January 1990, over 80,000 workers were employed. In 2000, shipyard labor force levels were even lower than today, reaching about 67% of the 1990 levels. Today, 70% of the 1990 employment levels are working throughout the six shipyards represented in Figure 7.

[11] Identified by Commissioning Data (http://www.gdeb.com/programs/ and http://www.navysite.de/submarine.htm). USS Connecticut was commissioned December 11, 1998.

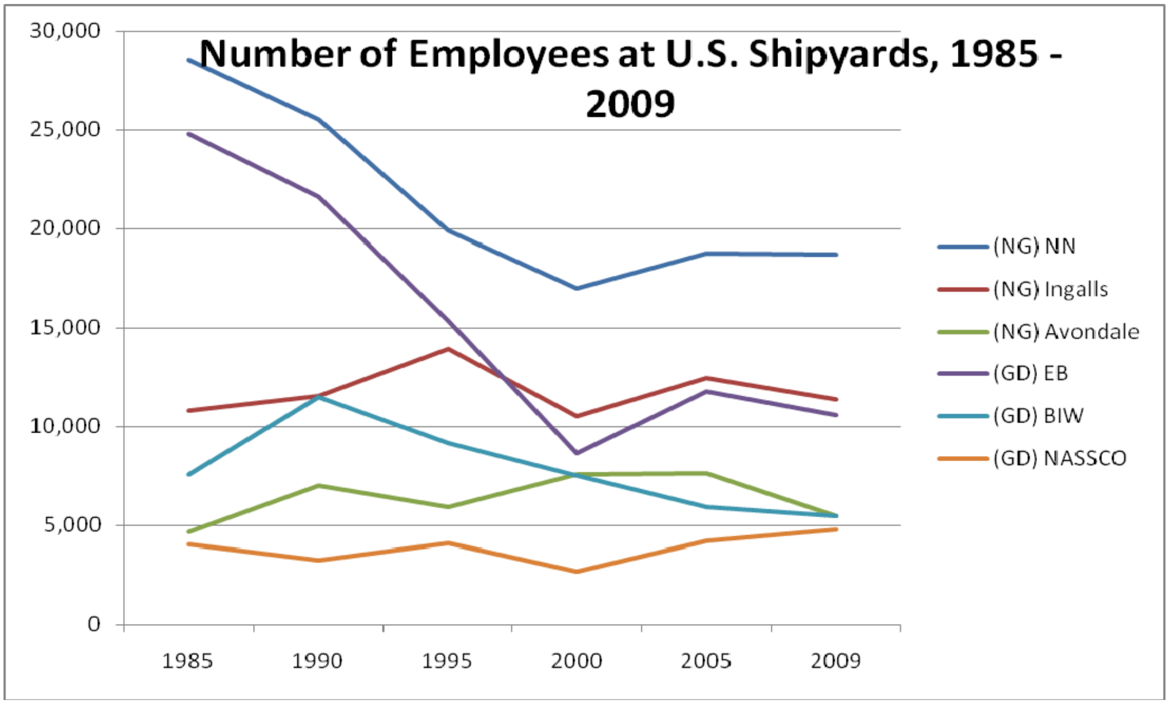

Figure 7. U.S. Shipyard Labor Trends
(After NAVSEA 05C data file, last updated for all shipyards in January 2009)

Figure 8 was produced by NAVSEA 05C's Portfolio Assessment Team and shows the contribution to state GDP per shipyard worker compared to the average worker in the state. The results show that in Maine, where Bath Iron Works employs over 5,400 workers, shipyard workers contribute, on average, more than nine times the income of an average Maine worker.[12]

[12] The source of average state-wage data is the respective state's Bureau of Labor Statistics.

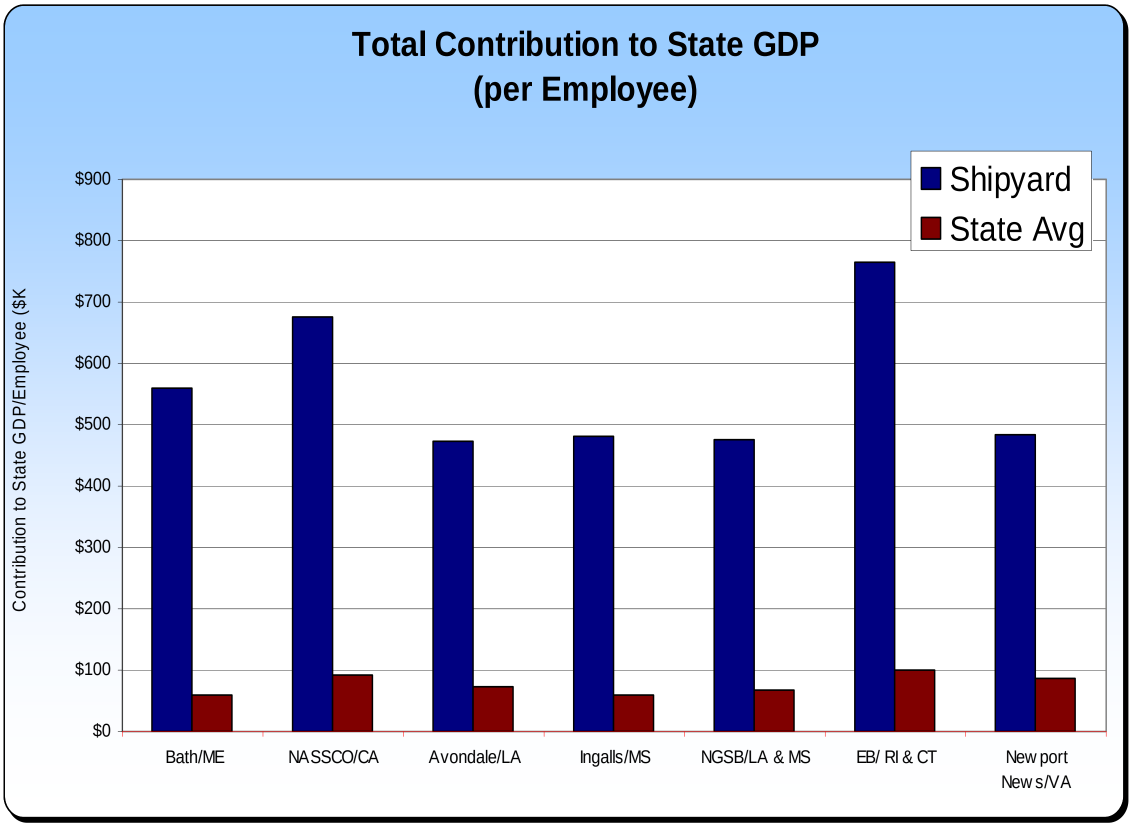

Figure 8. Shipyard Worker and Average Worker Contribution to State GDP
(From NAVSEA 05C Portfolio Assessment Team Economic Impact Study; Wright & Fields, 2009)

The results of the NAVSEA team's study suggest that shipyard workers contribute between six to nine times more, on average, per employee, than the average state worker.

3. RIMS Model's Employment Multipliers by State

Table 9 shows the result of the BEA's RIMS model for the U.S. shipbuilding industry, listed by state. Each entry in the first column, Type I output multiplier, shows the "total dollar change in output that occurs in all industries for each additional dollar of output delivered to final demand by the [shipbuilding and repairing] industry" (BEA, 1997). The RIMS multipliers were generated using 1997 benchmark data and 2006 regional data, which may explain the slight discrepancy from the Carnegie Mellon model. The calculated arithmetic mean of

Type I output multipliers in states (only those states whose output multiplier is greater than one) is 2.099, which is remarkably similar to the Carnegie-Mellon "total economic activity" multiplier of 2.09.

The second column shows the "total dollar change in earnings of households employed by all industries for each additional dollar of output delivered to final demand" by the shipbuilding industry (RIMS, 1997). This earnings data show the link between the direct and indirect multiplier of column 1 and the Type II multipliers in column 3. When considering the additional earnings generated, the total (output + earnings) Type II multiplier is presented in column 3. Since the BEA explicitly states that the RIMS II model cannot be used to predict nationwide impacts, the Carnegie Mellon model's output and consumption multiplier conversion was used to estimate induced effects.

The RIMS-generated multipliers are only valid within the defined regions (states, in this case). They cannot be used to approximate nationwide economic impact, but they are pertinent for determining which states and regions would most benefit from an increased investment in shipbuilding. In addition, RIMS multipliers have been found to be quite accurate:

> Empirical tests indicate that RIMS II yields multipliers that are not substantially different in magnitude from those generated by regional I-O models based on relatively expensive surveys. For example, a comparison of 224 industry-specific multipliers from survey-based tables for Texas, Washington, and West Virginia indicates that RIMS II average multipliers overstate the average multipliers from the survey-based tables by approximately 5 percent. For the majority of individual industry-specific multipliers, the difference between RIMS II and survey-based multipliers is less than 10 percent. (Lynch, 2000)

The employment data presented in the fourth column represent the "total change in number of jobs that occurs in all industries for each additional 1 million dollars of output delivered to final demand by the industry" (BEA, 1997). For instance, if an increased final demand from the nation's shipbuilding industry was $1 billion, and $10 million of that demand included supply-chain purchases from the state of Illinois, then this activity would generate over 160 new jobs within that one state.

In the final column, the value-added multiplier shows the “total dollar change in value added that occurs in all industries for each additional dollar of output delivered to final demand.”

Table 9. Multipliers Generated by RIMS for the Shipbuilding and Repairing Industry

	Final Demand				
State	Output ($) (Type I)	Earnings ($)	Output + Earnings ($) (calculated; Type II)	Employment (jobs)	Value Added ($)
Illinois	2.60	0.74	3.34	16.18	1.32
Pennsylvania	2.54	0.72	3.26	15.34	1.28
Ohio	2.50	0.73	3.23	17.37	1.26
Texas	2.43	0.73	3.16	16.13	1.25
Tennessee	2.37	0.69	3.07	16.34	1.20
Michigan	2.36	0.72	3.09	16.59	1.20
California	2.33	0.72	3.05	14.67	1.21
Wisconsin	2.31	0.69	3.00	16.87	1.16
Indiana	2.31	0.67	2.97	15.26	1.15
North Carolina	2.30	0.69	2.99	17.17	1.17
Minnesota	2.28	0.68	2.96	17.14	1.17
South Carolina	2.26	0.66	2.92	15.67	1.13
Georgia	2.26	0.68	2.93	17.01	1.17
Missouri	2.25	0.63	2.88	16.02	1.15
Kentucky	2.25	0.63	2.88	16.86	1.11
Alabama	2.23	0.67	2.90	15.73	1.12
New Jersey	2.18	0.61	2.78	11.14	1.12
Massachusetts	2.12	0.62	2.74	12.34	1.10
Oregon	2.08	0.59	2.67	12.64	1.07
Connecticut	2.07	0.61	2.68	10.83	1.06
Virginia	2.06	0.60	2.66	12.58	1.05
Washington	2.04	0.64	2.68	12.52	1.06
Arkansas	2.02	0.61	2.63	16.57	1.01
Mississippi	1.95	0.56	2.51	13.51	0.96
Maryland	1.94	0.55	2.49	11.63	1.00
Louisiana	1.94	0.59	2.52	14.03	0.99
New York	1.93	0.57	2.50	10.29	1.00
Florida	1.90	0.61	2.51	13.58	1.00
Rhode Island	1.87	0.49	2.36	10.63	0.96
Maine	1.84	0.56	2.39	12.88	0.94
Idaho	1.82	0.57	2.39	12.40	0.94
Hawaii	1.73	0.56	2.29	12.34	0.90
Delaware	1.68	0.40	2.08	7.26	0.85

Alaska	1.60	0.50	2.10	12.20	0.82
DC	1.14	0.03	1.18	0.53	0.54
Arizona	1.00	0.00	1.00	0.00	0.00
Colorado	1.00	0.00	1.00	0.00	0.00
Iowa	1.00	0.00	1.00	0.00	0.00
Kansas	1.00	0.00	1.00	0.00	0.00
Montana	1.00	0.00	1.00	0.00	0.00
Nebraska	1.00	0.00	1.00	0.00	0.00
Nevada	1.00	0.00	1.00	0.00	0.00
New Hampshire	1.00	0.00	1.00	0.00	0.00
New Mexico	1.00	0.00	1.00	0.00	0.00
North Dakota	1.00	0.00	1.00	0.00	0.00
Oklahoma	1.00	0.00	1.00	0.00	0.00
South Dakota	1.00	0.00	1.00	0.00	0.00
Utah	1.00	0.00	1.00	0.00	0.00
Vermont	1.00	0.00	1.00	0.00	0.00
West Virginia	1.00	0.00	1.00	0.00	0.00
Wyoming	1.00	0.00	1.00	0.00	0.00

C. Capital Intensity

Data collected from the 2009 annual reports of the companies listed in Table 10 show mixed results for the ratio of capital intensity, defined here as:

Equation 4

$$\frac{\text{net capital stock (or current assets) as reported at end of period}}{\text{revenue for period}}.$$

According to Oxford Economics (2009), "any decline in a capital intensive industry may mean a permanent loss of productive capacity for the [U.S.] economy." Prior to collecting the data, the expectation was that shipbuilding would be found to "stand out" as one of the most highly capital intensive. Ostensibly, several millions of dollars of property, plant, and equipment (PP&E) are required to operate a shipyard, with a considerable amount of land also necessary. These assets would be recorded on the balance sheet and included in the numerator of the equation to calculate capital intensity. However, the balance sheet data collected show that the two shipbuilding groups, General Dynamics Marine Systems and Northrop Grumman's Shipbuilding, actually are the two lowest capital intensities, calculated at 38.4% and 72%, respectively. However, two important observations must be highlighted from the data. First, the PP&E included in the reported total assets are recorded at current (depreciated) value. Since many of the nation's private shipyards have been operating for several decades, it is reasonable to assume that several long-lived assets are mostly or fully depreciated. For instance, the NASSCO shipyard in California, now owned by General Dynamics Marine Systems, has been in operation since 1959. In Connecticut, General Dynamics now owns and operates Electric Boat, which has been in existence since the beginnings of submarine construction in 1899. Much of Electric Boat's key infrastructure, clearly valuable capital today to the shipbuilding industry, is likely fully depreciated. Thus, it would be reported on the balance sheet as an asset valued at zero. One solution to this issue of asset valuation would be to collect historical cost data. If all assets for the companies in Table 10 could be valued at original, inflation-adjusted historical cost, then the comparisons of capital intensity ratios would be more valid and meaningful.

Secondly, the low capital-intensity ratios for the shipbuilding business shown in Table 10 necessarily reflect a high Total Assets Turnover Ratio (TATR), since TATR is the reciprocal of capital intensity, as defined here. Companies with a higher TATR are using their existing assets to generate revenue more efficiently. Here, General Dynamics Marine Systems TATR of 2.61 turns indicates that for every $1 of asset value on the books at the end of 2009, the business group generated $2.61 of revenue during the 2009 fiscal year. This high ratio stands out amongst those reported in Table 10 and supports the old belief that shipbuilding is a stable "cash cow" (Shulman, 2008).

Table 10. The Capital Intensity and Total Assets Turnover Ratios for Various Companies/Business Groups, Listed by Sector

Sector/Business	Total Assets, or "Net Capital Stock" (millions of $)	Revenue (millions of $)	Capital Intensity (total assets/revenue)	Total Asset Turnover Ratio (TATR) (revenue/total assets)
Shipbuilding				
General Dynamics Marine Systems	2,441	6,363	38.4%	2.61
*Northrop Grumman Shipbuilding	4,427	6,145	72.0%	1.39
Aircraft Manufacturing				
General Dynamics Aerospace	6,957	5,171	134.5%	0.74
Boeing	62,053	68,281	90.9%	1.10
Automobile Manufacturing				
Ford Motor Company	82,002	105,893	77.4%	1.29
Toyota Motor Company	29,062	20,530	141.6%	0.71
Military Armored Vehicle Manufacturing				
General Dynamics Combat Systems	9,342	9,645	96.9%	1.03
Health Care				
Bayer	51,042	31,168	163.8%	0.61
*Northrop Grumman Data is from 2008 Annual Report				

(Note: Generated from 2009 Annual Reports)

D. Capacity Measures

1. Industrial Production by Industry

A crucial question in determining the best place for government investment dollars is whether a sector will be able to deliver the items procured (and, thus, the economic impact) in a timely manner. "In order for an increase in government procurement to have an immediate impact on the economy, a sector must have sufficient spare capacity to absorb the additional demand" (Oxford Economics, 2009). The capacity of a specific sector is, therefore, a measurement reflecting the ability of that sector to provide a timely return. The U.S. Federal Reserve Board calculates quarterly industrial production measures and capacity utilization rates for various manufacturing, mining, and electric and gas utilities sectors. Quarterly production output is compared to a 2002 baseline output and reported by sector group according to NAICS classification code. The full procedure used by the U.S. Federal Reserve Board is included in Appendix B.

The Industrial Production Index reported measures "the real output of the manufacturing, mining, and electric and gas utilities industries; the reference period for the index is 2002" (U.S. Federal Reserve Board [FRB], 2009). Data is collected from two main sources: (1) output measured in physical units, and (2) data on inputs to the production process, from which output is inferred. Details of the Federal Reserve Board's procedure are included in Appendix B.

Ship and boatbuilding (3366xx) is an aggregate group that includes shipbuilding and repairing (336611) as well as boatbuilding (336612) (U.S. Census, 2010). According to the FRB, the proportion of ship and boatbuilding that is classified as the shipbuilding and repairing sector is about 66% (FRB, 2010). The 66% proportion is calculated by using value added in 2006, which the Board estimates as $9.337 million for shipbuilding and repairing, compared to $14.072 million for the ship and boatbuilding group.

Furthermore, based on value added levels in 2006, the shipbuilding and repair sector is further divided into military and civilian production. Of the sector's $9.337 million, $7.067 million is due to military orders, while $2.271 is due to civilian demand (the numbers do not add perfectly due to rounding). Therefore, 76% of the value added from NAICS sector code 336611 is due to military shipbuilding and repair.

Table 11 shows that as of the fourth quarter of 2009, the ship and boatbuilding sector is producing 73.7% of its output at the baseline 2002 level. Some sectors analyzed in previous sections of this thesis (nonresidential manufacturing construction and health care) could not be included here since the Federal Reserve does not publish production data for these sectors. However, a direct comparison of current (fourth quarter 2009) ship and boat production with aircraft manufacturing, automobile manufacturing, total U.S. manufacturing, and miscellaneous manufacturing categories is insightful.

Of the industrial production data considered and reported in Table 11, only the automobile manufacturing sector is lower than shipbuilding, at 66.24%. The automobile manufacturing production declined sharply in the first quarter of 2009, presumably due to the recession. The table also shows that while overall U.S. manufacturing production has remained relatively constant since the second quarter of 2008, at 145%–147% of 2002 levels, the ship and boatbuilding sectors have fallen from about 98% to about 74% of its 2002 baseline over the past six quarters. Since shipbuilding and repairing is responsible for about 66% of the ship and boatbuilding group, one may reasonably conclude that shipbuilding and repairing is also operating at about 73.7% of its 2002 production levels.

Figure 9 best illustrates the downward trend in the industrial production measured from the ship and boatbuilding sectors. Since the second quarter of 2008, over 24% of the baseline production level in 2002 has been lost (97.95%–73.68%). This data suggest that the shipbuilding industry may be well positioned to absorb additional output demand from military or civilian orders, and thus the economic impact and return quantified in section 1 of this chapter could be timely and immediate.

Table 11. Industrial Production for Various Sectors (by Calendar Quarter) as a Percentage of 2002 Baseline
(From U.S. Federal Reserve Board)

Sector Description	**2008Q2**	**2008Q3**	**2008Q4**	**2009Q1**	**2009Q2**	**2009Q3**	**2009Q4**
Automobile NAICS=336111, sa	84.39	98.38	78.02	38.47	44.72	59.62	66.24
Ship and boatbuilding NAICS=3366, sa	97.95	90.19	84.80	78.15	80.97	84.13	73.68
Aerospace and miscellaneous transportation equipment NAICS=3364-9, sa	124.22	116.26	110.64	117.98	114.08	116.30	113.41
Aerospace product and parts NAICS=3364, sa	130.51	121.03	113.62	128.69	122.24	124.51	123.35
Manufacturing (NAICS), sa	146.92	147.31	147.45	147.30	146.90	146.33	145.71
Miscellaneous NAICS=339, sa	164.26	166.06	167.33	168.02	168.23	168.16	168.05

*sa = seasonally adjusted

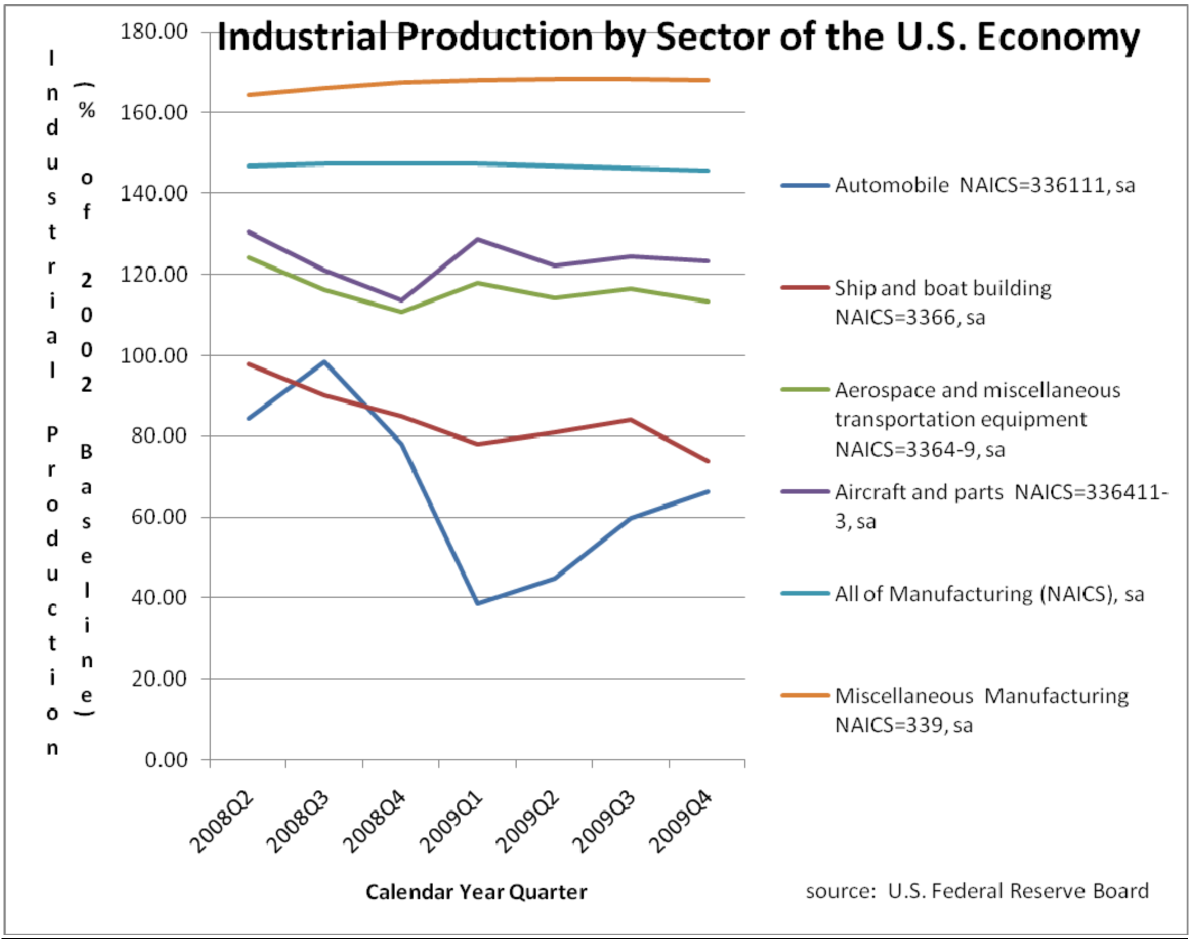

Figure 9. Industrial Production as a Percentage of Baseline Levels

2. Capacity Utilization

For a given industry, "the capacity utilization rate is equal to an output index (seasonally adjusted) divided by a capacity index" (FRB, 2009). The method used to capture an industry's maximum sustainable output, for use in the denominator of the capacity calculation, is described in Appendix B. Not all specific manufacturing industries, as classified by NAICS code, are included in the Federal Reserve's capacity utilization data. The data does not show calculated capacity utilization for shipbuilding and repairing (336611); however, data is available for the manufacturing of transportation equipment group (336xxx group). The results are presented in Table 12 and show that the United States "transportation equipment" manufacturing industries are producing at about 61% of capacity as of the first quarter of 2010.

The median capacity of the selected industries listed in Table 12 is 69.5%. According to this data, the manufacturing of wood products is the lowest utilized sector of U.S. manufacturing at a mere 50.6% utilization, while the oil and gas extraction industry is operating at about a 97.8% utilization rate. The data clearly show that the industries classified as “manufacturing of vehicles and transportation equipment,” which includes the nation’s shipyards, are operating below the median capacity utilization rate for the U.S. manufacturing, mining, and electric and gas utilities.

The Federal Reserve’s publication entitled *Industry Structure of Industrial Production* shows that ship and boatbuilding (3366xx subgroup) comprises about 5.2% of the calculation for the transportation equipment manufacturing (FRB, 2010). This proportion is calculated by considering the value added in 2006. The publication reports that ship and boatbuilding added about $14.072 million in 2006, while the transportation equipment manufacturing group added $271.111 million. Thus, the available calculations for capacity utilization rate do not show conclusively that shipbuilding is below capacity. However, Table 12 is included here to support the conclusions from the Industrial Production trends and does show an opportunity for timely return from an increased demand in manufacturing transportation equipment.

Table 12. Capacity Utilization Rates of Selected Manufacturing, Mining, and Electric/Gas Utilities in 2009 and 2010 (Percentage of Capacity)

Description	2009Q3 (%)	2009Q4 (%)	2010Q1 (%)
Wood product NAICS=321, sa	50.3	50.0	50.6
Nonmetallic mineral product NAICS=327, sa	57.1	54.7	53.9
Motor vehicles and parts NAICS=3361-3, sa	48.4	51.8	54.2
Furniture and related product NAICS=337, sa	57.6	57.6	58.0
Transportation equipment NAICS=336, sa	**58.8**	**60.1**	**61.1**
Other manufacturing, sa	62.8	63.7	61.9
Machinery NAICS=333, sa	57.0	58.8	62.1
Support activities for mining NAICS=213, sa	48.8	53.7	62.5
Semiconductors and related equipment, sa	60.0	59.2	63.1
Primary metal NAICS=331, sa	53.3	58.8	63.4
Durable manufacturing (NAICS), sa	60.7	61.8	63.5
Leather and allied product NAICS=316, sa	55.0	58.1	64.6
Textile product mills NAICS=314, sa	62.1	63.8	65.5
Fabricated metal product NAICS=332, sa	62.7	64.2	66.1
Textiles and products NAICS=313,4, sa	59.5	64.5	66.3
Beverage and tobacco product NAICS=312, sa	64.4	66.2	66.4
Computer and electronic product NAICS=334, sa	63.9	64.1	67.0
Textile mills NAICS=313, sa	57.1	65.0	67.0
Miscellaneous NAICS=339, sa	67.9	69.0	68.6
Primary & semifinished processing (capacity), sa	67.0	68.5	69.7
Manufacturing (NAICS), sa	67.2	68.4	69.9
Finished processing (capacity), sa	68.5	69.8	71.4
Aerospace and miscellaneous transportation eq. NAICS=3364-9, sa	75.6	73.7	72.3
Plastics and rubber products NAICS=326, sa	66.7	69.3	72.6
Electrical equipment, appliance, and component NAICS=335, sa	70.0	70.6	72.8
Total index, sa	70.0	71.4	73.0

Apparel and leather goods NAICS=315,6, sa	65.7	67.5	73.2
Paper NAICS=322, sa	73.6	74.2	73.8
Apparel NAICS=315, sa	68.1	69.6	74.9
Chemical NAICS=325, sa	72.0	73.4	75.1
Mining (except oil and gas) NAICS=212, sa	74.5	72.7	76.3
Nondurable manufacturing (NAICS), sa	74.2	75.5	76.7
Petroleum and coal products NAICS=324, sa	84.3	82.8	80.7
Food NAICS=311, sa	79.9	81.2	82.6
Crude processing (capacity), sa	82.4	83.9	86.4
Mining NAICS=21, sa	83.2	84.7	88.3
Oil and gas extraction NAICS=211, sa	96.6	97.9	97.8

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V. Summary, Conclusions, and Recommendations

A. Summary of Findings

1. Monetary Impact

According to the input/output analysis conducted via Carnegie Mellon's EIO-LCA, a notional increase in final demand from the shipbuilding sector of $1 billion would produce about $2.09 billion of direct and indirect economic activity. The $1 billion of final output delivered would include about $570 million of supply chain or raw materials purchases and about $430 million of value added, or GDP growth (Carnegie, n.p.). In addition to the $1 billion output, direct economic effects would be $570 million, while total indirect effects would be $520 million (totaling $2.09 billion). Throughout the U.S. economy, at least 410 different sectors, as classified by 6-digit NAICS codes, would benefit from an increased demand in shipbuilding.

Five other sectors of the U.S. economy were analyzed using the same notional increase in final demand of $1 billion: automobile manufacturing, aircraft manufacturing, military armored vehicle and tank parts manufacturing, nonresidential manufacturing structures, and the offices of physicians, dentists, and health care practitioners. Although shipbuilding's $2.09 of generated economic activity ranks fourth of the six sectors considered, shipbuilding represents the most even balance between supply-chain purchases and value added by the sector itself. Since all Leontief models are linear, results generated will be interpreted in proportion to those presented for any notional increase in final demand. The $570 million of material purchases needed to create $1 billion of output, therefore, means that the shipbuilding sector must spend about 57% of its revenue from its customers on purchases from its suppliers. Moreover, 43% of its sales or output includes value added by the shipbuilding sector itself. In contrast, the automobile-manufacturing sector, which ranks first in generating total economic activity, requires about 74% of its final output value in direct purchases used, meaning that only 26% is value added.

This shipbuilding and repairing sector, as a possible investment of government tax revenue, represents the best balance between material purchases (generating activity throughout the supply chain), and value added in the sector itself—which, since value added includes the salaries and efforts of workers within the shipbuilding sector, generates jobs.

A more accurate measure of total economic impact is a Type II multiplier, which includes the spending by labor of earnings within the industry. By calculating the consumption multiplier for the household sector, using an estimated nationwide savings rate of 5% and an average tax rate of 29%, one may approximate the conversion of a multiplier from Type I to Type II. The consumption multiplier calculated was 3.07, which implies that the ratio of all factors considered in Type II will be 3.07 times larger than only the direct and indirect impacts considered in Type I multiplier derivation. The process reveals that the sum of direct, indirect, and induced impacts represented in the Type II multiplier is about $3.35 billion of activity for every $1 billion of additional investment, or sector demand. The use of a Type II multiplier does not change the ranking of the shipbuilding sector as compared to the other five, but it does most accurately reflect the economic activity generated by increased demand from the shipbuilding industry. These Type II multipliers "are the most commonly used multipliers" (BEA, 1997).

Since almost all SCN funding results in a demand within the shipbuilding sector, the calculated multiplier may be used to estimate the nationwide economic impact of SCN funding on the U.S. economy. The results show that current SCN funding of $13.8 billion (as proposed in the President's fiscal year 2011 budget), will contribute about $46.2 billion of economy activity and over $5.9 billion to U.S. GDP. **Increasing the Navy's budget for SCN to $20 billion would result in over $67 billion of activity throughout the nation, with more than $8.6 billion contributed to GDP.**

2. Labor Market Impact

The Carnegie Mellon EIO-LCA model estimates that about 16,700 employees are needed throughout the supply chain in order to produce an additional $1 billion of product from the shipbuilding industry. **This labor-market estimate places the shipbuilding sector first of the six sectors considered**. Furthermore, the RIMS II model purchased from the BEA Web site, which produces regional results listed by state, shows an average (only considering states with employees supported greater than 1) of 14.1 job supported for every $1 million of increased final demand. Once again, since linear interpolation may be used in these models relying on input/output tables, this would suggest 14,100 jobs for an increased demand of $1 billion. The RIMS II model may have a lower estimate since its regional data is from 2006, while the Carnegie Mellon employment estimator model is using data from the 1997 benchmark. Nine years of increased automation of many processes within most industries may now result in less employment needed for manufacturing-related tasks. A comparison between industries was not conducted for the RIMS II model, but one likely conclusion is that the other manufacturing sectors considered have also experienced more growth in automation, resulting in fewer jobs supported.

NAVSEA provided data on employment levels at the nations "big 6" shipyards, which show a clearly declining trend. Since 1990, 30% of the jobs at U.S. private shipyards have been lost. As logic would suggest, employment numbers seem to be correlated with demand since Electric Boat fell from 24,797 employees in 1985 to just 8,646 in 2000, and only produced one submarine from 1998 to 2003. In addition, NAVSEA's Portfolio Assessment Team concluded that shipyard jobs contribute between six and nine times as much to state GDP per worker as an average job within the state (Wright & Fields, 2009).

The RIMS II model supports the Carnegie Mellon model's estimate of 2.09 for a direct and indirect multiplier, but differed in its estimation of the induced multiplier. Perhaps the discrepancy may be explained by varying spending habits and taxation rules across states. Since the BEA explicitly states that the RIMS II model cannot be used to predict nationwide impacts, the Carnegie Mellon model's multiplier, converted to account for household consumption, was considered a more valid approximation of induced effects.

3. Capital Intensity

Oxford Economics has published that "sectors that invest the most in capital and labor present the greatest potential for losses if they fail" (2009). The data collected for total assets of various companies, including General Dynamics Marine Systems and Northrop Grumman Shipbuilding, were scattered due to depreciation methods and asset valuation methods. If the current replacement cost of fixed assets were used, one could argue that much higher capital intensity ratios would exist for shipyards. Although such a calculation of replacement cost is beyond the scope of this research, the principle of the shipbuilding industry's highly capital-intensive structure that reflects a high potential loss for the nation's productivity is pertinent. Although the collected data did not support this notion as anticipated, the most likely reason is a heavily depreciated representation of old assets in place at shipyards, which inaccurately represents their true replacement or historical value.

4. Capacity Measures

The data from the U.S. Federal Reserve Board clearly show that the shipbuilding and repair sector includes sufficient spare capacity to absorb an increase in demand for products (ships). The sector's capacity utilization was estimated using two sources of data from the Federal Reserve Board. First, industrial production as a percentage of a baseline of measured real output in 2002 is about 74%. Secondly, the capacity utilization ratio calculated for shipbuilding's aggregate group "manufacturing of transportation equipment," show production at about 61% of capacity as of the first quarter of 2010. Since labor and capital are the two main factors of production, and NAVSEA labor data shows a growth in private shipyard employment since 2002, one may conclude that U.S. shipyards are operating well below capacity.

An evaluation of capacity utilization rates calculated by the Federal Reserve Board also supports the conclusion that the transportation equipment manufacturing sectors, which includes shipbuilding, is operating well below capacity. The industry is well positioned for the economic impacts described in earlier sections to have a timely positive impact on the U.S. economy.

B. Conclusions

1. For the Shipbuilders

Although the stimulus packages of 2008 and 2009 have passed without much immediate benefit to the shipbuilding industry, decision makers continue to seek investments that provide economic benefit, strong GDP growth, and job creation. Using the Oxford methodology and this study as a "spring board," the shipbuilding industry and the American Shipbuilding Association could present a well-reasoned and similarly structured economic argument for additional shipbuilding investment from the U.S. government. The measures of monetary and labor impact, combined with an estimation of the timing of such an impact through capacity measures, are mutually supportive in presenting a sound economic case.

Although the U.S. Federal Reserve Data suggest that the shipbuilding and repair sector is only operating at about 74% of its industrial production in 2002, there are currently 3% more employees throughout the nation's "big 6" shipyards than there were in 2002.[13] Clearly, the capacity exists within the shipbuilding sector to absorb large increases in demand from commercial as well as U.S. Navy customers. The onus lies within the shipbuilding industry to communicate this opportunity to its customer base.

The data evaluated suggest steady revenues and healthy profit margins from shipbuilding businesses. Additional investments in capital infrastructure such as

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[13] As calculated from NAVSEA 05C employment data. A total of 56,496 employees as of December 1, 2002, compared to 58,357 total employees on January 1, 2009.

crane facilities and dry-docks will only strengthen the sector's average capital-intensity ratio, which will support the powerful argument that a loss in demand could lead to a permanent loss in "productive capacity" (Oxford Economics, 2004).

2. For the Navy

As described in Chapter I, the unique ability of U.S. warships to project national interests abroad, preserve free trade on the high seas, and ensure sea control is well known. Given that preservation of these capabilities is within U.S. national interest and that the capacity to produce ships within U.S. borders must be maintained, the Navy should strive to better understand the economic benefits of ship construction and repair. The multipliers applied here do not end when a ship finishes construction and begins operation. Rather, warships regularly return to yards for maintenance, upkeep, and repair. Therefore, more ships in the fleet will compound the economic benefits described herein and provide additional stimulus for sustained U.S. economic recovery.

Reaffirming a commitment to a 313-ship Navy requires serious efforts to secure funding for such a fleet. In today's fiscal environment, economic impact factors must be a serious consideration. Oxford Economics has laid the framework for making a comprehensive economic case in their U.K. Defense Industry. Four of those main argument streams have been duplicated here, but the entire Oxford study could be digested and re-created by more skillful government entities such as CRS, RAND, and Navy think-tanks.

3. For Congress and the Secretariat

America's naval fleet is at a 93-year low of 286 active warships (ASA, 2009). Since the start of the damaging recession of 2008 and 2009, political decision makers have strived to identify an appropriate means of economic stimulus. Clearly, the shipbuilding sector itself is not a comprehensive solution to the country's fiscal dilemma. **However, increased investments in shipbuilding and repairing can provide a timely and substantial return and should be part of the next effort to**

provide economic stimulus. Specifically, on April 15, Representative Rob Wittman (R-VA) introduced *The National Shipbuilding Policy Act* bill (HR 5035), which would authorize $20 billion each year from fiscal year 2011 through 2015 to rebuild America's Navy. Congress should pass this resolution, possibly providing supporting appropriation of funds from the *ARRA*, of which only $97.4 billion of the $275 billion allocated to "contracts, grants, and loans" have been paid out.[14] Congress may be confident that doing so will provide a healthy benefit in job growth throughout 49 states, as well as about $3.35 billion in increased total economic activity for each $1 billion invested.

C. Recommendations

As this research topic and scope developed, far more opportunities for pertinent analysis were discovered than time constraints allowed. Consequently, NPS thesis students and other researchers are strongly encouraged to build upon this effort in the following specific areas:

- Multiplier Analysis: more sectors of the economy, beyond the six presented here, should be analyzed and compared to shipbuilding. Furthermore, regional multipliers could be identified and linked with the spending locations of the Navy's SCN account.
- Labor market: more research should be conducted to demonstrate the true regional value of shipyard employment. Although the nationwide unemployment rate is above 9%, several shipyard states such as Mississippi (11.5%) and California (12.6%) currently have even higher rates of unemployment, combined with a larger dependence on the shipbuilding sector than the average state (BLS, 2010).
- Capital intensity: in order to accurately reflect the productivity and value of the shipbuilding industry's long-lived assets, such as property, plant, and equipment, replacement cost accounting should be used in the valuation of assets and the calculation of capital intensity ratios. When the assets of businesses representing various sectors of the economy are valued a replacement cost, the shipbuilding and repairing

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[14] As of May 2, 2010 (Recovery Accountability and Transparency Board, 2010).

sector should present a high capital-intensity ratio—reflecting a substantial and permanent loss of productivity to the U.S. economy, if it should fail.

- Capacity: the lower-capacity utilization rate of shipbuilding is fairly represented by the U.S. Federal Reserve Board Data. However, interviews could be conducted with managers from a single shipyard in order to more precisely quantify that yard's ability to increase production.

1. Life Cycle Benefit

The relatively long life cycle of 30 to 40 years, along with increased maintenance activity for ships, gives the shipbuilding sector a qualitative advantage over alternative manufacturing such as tanks and automobiles. The complete economic "lifecycle benefit" of ship construction has been only introduced in this study. A profound opportunity exists to leverage the uniquely long life cycle of a ship and apply the economic activity generated—not just in its construction but also in its operations and support (crew manning, port visits), as well as in its maintenance availabilities at public and private shipyards throughout the country. For instance, neither an armored tank nor an automobile will enter dry-dock for a one-year period, providing public or private shipyard labor with employment activity, and providing the local economy with hundreds of sailors spending their salaries. This research has provided a broad introduction to the exciting topic of the economic benefits of shipbuilding and will hopefully serve as a starting point for future research efforts.

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Appendix A: Questions List

Goal: Consultation with interested and informed parties regarding data collection, past similar studies, and expected results

(1). What do you think are the "unique" aspects of shipbuilding that allow it to provide greater benefit to the economy? Do you think investments in shipbuilding provide greater benefit to the U.S. economy than popular alternatives? Why?

(2). Do you think the economic benefit of the "life of the ship" should be considered, beyond simply the benefit of the expenditures for construction itself (what about COTS technology insertions, etc)?

(3). How can the indirect/induced benefits be quantified? (reference to Oxford Defense Study helpful)

(4). What do you think is most convincing about economic arguments for more resources in any particular industry? (jobs, GDP growth,…) ?

(5). Do you think a study of local economic effects (barber shops, restaurants opening near shipyards, for example) can be effective with national policy-makers?

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Appendix B: Federal Reserve Board Procedures

Source: U.S. Federal Reserve Board

INDUSTRIAL PRODUCTION EXPLANATORY NOTES

Coverage. The industrial production (IP) index measures the real output of the manufacturing, mining, and electric and gas utilities industries; the reference period for the index is 2002. Manufacturing consists of those industries included in the North American Industry Classification System (NAICS) definition of manufacturing plus those industries–newspaper, periodical, book, and directory publishing plus logging–that have traditionally been considered to be manufacturing. For the period since 1997, the total IP index has been constructed from 312 individual series based on the 2002 NAICS codes. These individual series are classified in two ways: (1) market groups, and (2) industry groups. Market groups consist of products and materials. Total products are the aggregate of final products, such as consumer goods and equipment, and nonindustrial supplies (which are inputs to nonindustrial sectors). Materials are inputs in the manufacture of products. Major industry groups include three-digit NAICS industries and aggregates of these industries--for example, durable and nondurable manufacturing, mining, and utilities. A complete description of the market and industry structures, including details regarding series classification, relative importance weights, and data sources, is available on the Board's web site

Source Data. On a monthly basis, the individual indexes of industrial production are constructed from two main types of source data: (1) output measured in physical units and (2) data on inputs to the production process, from which output is inferred. Data on physical products, such as tons of steel or barrels of oil, are obtained from private trade associations and from government agencies; data of this type are used to estimate monthly IP wherever possible and appropriate. Production indexes for a few industries are derived by dividing estimated nominal output (calculated using unit production and unit values or sales) by a corresponding Fisher price index; the most notable of these fall within the high-technology grouping and include computers, communications equipment, and semiconductors. When suitable direct measures of product are not available, estimates of output are based on production-worker hours by industry. Data on hours worked by production workers are collected in the monthly establishment survey conducted by the Bureau of Labor Statistics. The factors used to convert inputs into estimates of production are based on historical relationships between the inputs and the comprehensive annual data used to benchmark the IP indexes; these factors also may be influenced by technological or cyclical developments. The annual data used in benchmarking the individual IP indexes are constructed from a variety of source data, such as the quinquennial *Censuses of Manufactures* and *Mineral Industries* and the *Annual Survey of Manufactures*, prepared by the Bureau of the Census; the *Minerals Yearbook*, prepared by the United States Geological Survey of the Department of the Interior; and publications of the Department of Energy.

Aggregation Methodology and Weights. The aggregation method for the IP index is a version of the Fisher-ideal index formula. (For a detailed discussion of the aggregation method, see the *Federal Reserve Bulletins* of February 1997 and March 2001.) In the IP index, series that measure the output of an individual industry are combined using weights derived from their proportion in the total value-added output of all industries. The IP index, which extends back to 1919, is built as a chain-type index since 1972. The current formula for the growth in monthly IP (or any of the sub-aggregates) since 1972 is shown below. An output index for month m is denoted by I_m^A for aggregate A and I_m for each of its components. The monthly price measure in the formula (p_m) is interpolated from an annual series of value added divided by the average annual IP index

$$\frac{I_m^A}{I_{m-1}^A} = \sqrt{\frac{\sum I_m p_{m-1}}{\sum I_{m-1} p_{m-1}} \times \frac{\sum I_m p_m}{\sum I_{m-1} p_m}}$$

The IP proportions (typically shown in the first column of the relevant tables in the G.17 release) are estimates of the industries' relative contributions to overall growth in the following year. For example, the relative importance weight of the motor vehicles and parts industry is about 8 percent. If output in this industry increased 10 percent in a month, then this gain would boost growth in total IP by 8/10 percentage point (0.08 x 10% = 0.8%). To assist users with calculations, the Federal Reserve's web site provides supplemental monthly statistics that represent the exact proportionate contribution of a monthly change in a component index to the monthly change in the total index.

Timing. The first estimate of output for a month is published around the 15th of the following month. The estimate is preliminary (denoted by the superscript "p" in tables) and subject to revision in each of the subsequent five months as new source data become available. (Revised estimates are denoted by the superscript "r" in tables.) For the first estimate of output for a given month, about 72 percent of the source data (in value-added terms) are available; the fraction of available source data increases to 86 percent for estimates in the second month that the estimate is published, 95 percent in the third month, 98 percent in the fourth month, 99 percent in the fifth month, and 99 percent in the sixth month. Data availability by data type in late 2008 is summarized in the table below:

(Percent of value added in 2008)						
Availability of Monthly IP Data in Publication Window	**Month of estimate**					
Type of Data	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**
Physical product	30	44	54	56	57	57
Production-worker hours	42	42	42	42	42	42
IP data received	72	86	95	98	99	99
IP data estimated	28	14	5	2	1	1

NOTE: The physical product group includes series based on either monthly or quarterly data. As can be seen in the first row of the table, in the first month, a physical product indicator is available for about half of the series (in terms of value added) that ultimately are based on physical product data (30 percent out of a total of 57 percent). Of the 30 percent, about two-thirds (19 percent of total IP) include series that are derived from weekly physical product data and for which actual monthly data may lag up to several months. On average, quarterly product data are received for the fourth estimate of industrial production. Specifically, quarterly data are available for the third estimate of the last month of a quarter, the fourth estimate of the second month of a quarter, and the fifth estimate of the first month of a quarter.

Seasonal Adjustment. Individual series are seasonally adjusted using Census X-12 ARIMA. For series based on production-worker hours, the current seasonal factors were estimated with data through February 2009; for other series, the factors were estimated with data through at least September 2008. Series are pre-adjusted for the effects of holidays or business cycles when appropriate. For the data since 1972, all seasonally adjusted aggregate indexes are calculated by aggregating the seasonally adjusted indexes of the individual series.

Reliability. The average revision to the level of the total IP index, without regard to sign, between the first and the fourth estimates was 0.26 percent during the 1987-2008 period. The average revision to the *percent change* in total IP, without regard to sign, from the first to the fourth estimates was 0.21 percentage point during the 1987-2008 period. In most cases (about 85 percent), the direction of the change in output indicated by the first estimate for a given month is the same as that shown by the fourth estimate.

Rounding. The published percent changes are calculated from unrounded indexes, and may not be the same as percent changes calculated from the rounded indexes shown in the release.

UTILIZATION RATES CALCULATION METHOD

Six basic steps are involved in calculating the utilization rates published by the Federal Reserve.

Step 1. Implied end-of-year indexes of industrial capacity (*ICAP*) are constructed by dividing a production index (*IP*) by a utilization rate (*U*) obtained from a survey for an end-of-year period (*t*). [1]

(1) $ICAP_t = IP_t / U_t$.

These ratios are expressed, like industrial production, as percentages of production in a base year, currently 2002, and give the general level and trend of the capacity estimates. After an annual revision of industrial production, the capacity indexes must also be revised. The implied capacity indexes will automatically incorporate revisions to production in the estimation of capacity.

Step 2. The annual movements of the implied capacity indexes are refined to give consideration to alternative indicators of capacity changes; these alternatives include capacity data in physical units and estimates of capital input by industry. [2] The Federal Reserve's estimates of annual capacity at the most detailed level are derived from the fitted values of regressions that relate the implied capacity indexes to these alternative indicators; the regressions are designed to improve the year-to-year changes in the implied capacities but to leave their trends intact.

Specifically, for industries based on utilization rates from the QSPC, the logarithm of implied capacity is regressed on industry capital input (*K*), a deterministic trend (*t*), the age of the capital stock (*A*) (a proxy for embodied technological change), and occasional dummy variables (D_i):

For series based on physical data, an analogous regression is run in which the capital input measure is replaced with the measure of physical capacity and the age-of-capital variable is omitted. The fitted values of the regressions are used as the estimates of industrial capacity.

Extrapolations of capacity beyond the latest survey year also are based on the estimated model (2), given the trend terms and estimates of capital input and related measures or updated estimates of capacity in physical volumes.

Step 3. A monthly time series is formed by interpolating between the fourth-quarter baseline capacity indexes produced by the regression models. The interpolation procedure allows the monthly rates of increase to change smoothly over time while maintaining the same fourth-quarter to fourth-quarter rates of increase as the baseline capacity indexes.

Step 4. An adjustment may then be applied to estimates of capacity that appear to reflect short-term peak capacity rather than a sustainable level of maximum output. This adjustment is most prominent in the capacity index for electricity generation, in which the margin for summer peak loads is removed from the estimates implied by the physical data. An adjustment may also be applied when data sources are changed, to achieve continuity and consistency with historical utilization rate levels.

Step 5. The monthly capacity aggregates are constructed in three steps: (1) utilization aggregates are calculated on an annual basis through the most recent full year as capacity-weighted aggregates of individual utilization rates; (2) the resulting annual utilization rate is then divided into the corresponding IP aggregate to calculate an annual capacity index; and (3) the annual capacity index is interpolated using an annually weighted Fisher index of its constituent monthly capacity series to derive the monthly capacity aggregate.

Step 6. Utilization rates for the individual series and aggregates are calculated by dividing the pertinent monthly production index by the related capacity index.

Consistency. A major aim is that the Federal Reserve utilization rates be consistent over time so that, for example, a rate of 85 percent means about the same degree of tightness that it meant in the past. A major task for the Federal Reserve in developing reasonable and consistent time series of capacity and utilization is dealing with inconsistencies between the movements of the industrial production index and the survey-based utilization rates. The McGraw-Hill/DRI Survey, now discontinued, was the primary source of manufacturing utilization rates for many years. This was a survey of large companies that reported, on average, higher utilization rates than those reported by establishments covered by the annual *Survey of Plant Capacity* (the primary source of factory operating rates through 2006, after which it was discontinued). Adjustments have been made to keep the industry utilization rates currently reported by the Federal Reserve roughly in line with rates formerly reported by McGraw-Hill. As a consequence, the rates reported by the Federal Reserve tend to be higher than the rates reported in the Census utilization surveys.

Weights. Although each utilization rate is the result of dividing an IP series by a corresponding capacity index, aggregate utilization rates are equivalent to combinations of individual utilization rates aggregated with proportions that reflect current capacity levels of output valued in current-period value added per unit of actual output.

Perspective. Over the 1972-2008 period, the average total industry utilization rate is 80.9 percent; for manufacturing, the average factory operating rate has been 79.6 percent. Industrial plants usually operate at capacity utilization rates that are well below 100 percent: none of the broad aggregates has ever reached 100 percent. For total industry and total manufacturing, utilization rates have exceeded 90 percent only in wartime.

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