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Washington State Ferry Vessel Procurement

The 2015 Washington State Legislature directed the Washington State Institute for Public Policy (WSIPP) to conduct a benefit-cost analysis of the state's ferry vessel procurement practices.[1] The legislature also directed WSIPP to:

- Compare in-state construction to construction at shipyards across the United States,
- Identify barriers to receiving three or more in-state bids to a request for proposals, and
- Recommend policies to encourage three or more in-state bidders to respond to a request for proposals.

This report presents the results of our analysis, which is organized into four parts.

I. Background on study methods, recent Washington State Ferries (WSF) vessel purchasing history, and major state purchasing requirements.

II. Comparison of major public ferry systems' fleet size, route length, and purchasing patterns; shipbuilding employment and pay; ferry construction cost dicussion; and case studies.

III. Identification of barriers to increasing number of in-state bids.

IV. Analysis of constructing ferries out-of-state using benefit-cost and economic impact approaches.

Summary

Washington State Ferries (WSF) operates the largest ferry system in the U.S., maintaining 22 ships in its fleet, with over 1,800 employees. Washington State law requires new ferries be constructed in state and at shipyards with state-sponsored apprenticeship programs. The state has received only one to two bids on all new ferries constructed in the last 30 years. This report identifies barriers to increasing the number of in-state bidders but makes no policy recommendations to increase this number due to data limitations.

This report presents the results of a benefit-cost analysis (BCA) and economic impact analysis (EIA) of a change in policy that shifts construction of ferries out of state. Neither analysis predicts a significant impact on Washington's economy (either positively or negatively) from building ferries out of state.

In a policy scenario in which a single ferry is built out-of-state, the BCA showed, on average, a positive net benefit of $3.25 million or about 2.5% of the total ferry purchase price. However, there was a great deal of uncertainty in our analysis. The EIA predicted an average yearly loss of about 650 jobs and about $68 million to the state gross domestic product over a two-year period. The EIA suggested that building a ferry out-of-state would have only a short-term impact on the shipbuilding industry.

Suggested citation: Barch, M., & Bania, N. (2016). *Washington State ferry vessel procurement.* (Document Number 16-12-4102). Olympia: Washington State Institute for Public Policy

[1] Second Engrossed Substitute Senate Bill 5992, Chapter 14, Laws of 2015.

This report uses a variety of methods, including the following:

1) data analysis of the shipbuilding industry using a variety of labor data sources;
2) verification and expansion of a dataset of ferry procurers, shipyards, and ferries built since 1980;[2]
3) extensive literature search on ferry cost estimation and the state of the shipbuilding industry;
4) interviews with experts (shipyards, ferry purchasers, federal regulators, and industry);[3] and
5) benefit-cost and economic impact analyses.

[2] WSIPP expanded and verified the dataset developed for the following report: State Auditor's Office. (2013). *Washington State Ferries: Vessel construction costs.* (Report No. 1008884). Olympia, WA. This was completed through searching news articles and the public records of a variety of public ferry purchasers.

[3] These semi-structured interviews were conducted via telephone. Contacts were identified from three sources: the maritime literature; the dataset of public ship purchasers and shipyards; and via a snowball sampling method.

I. Background

Washington State Ferries (WSF) is the largest ferry system[4] in the U.S., maintaining 22 ships[5] in its fleet, with over 1,800 employees.[6] The ferries carry 23 million passengers annually[7] to 20 different ports of call.[8] Administered as part of the state highway system, WSF connects island communities to the state's mainland and links the state transportation system across the Puget Sound. Over the last ten years, WSF has retired 11 ships from service[9] and added another five[10] to its fleet. Four of the 144-car ferries are reaching the end of their 60-year service life, and WSF predicts replacements are needed by 2027 to maintain the current level of service.[11]

[4] According to the National Census of Ferry Operators, ferries are defined as providing itinerant, fixed route, common carrier passenger, and/or vehicle ferry service. This excludes railroad car float operations and excursion services (e.g., whale watches, casino boats, day cruises, dinner cruises, etc.), passenger only water taxi services not operating on a fixed route, LoLo (Lift-on/Lift-off) freight/auto carrier services, or long distance passenger only cruise ship services. For details, see: https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject_areas/ncfo/ncfo_methods.html.

[5] WSF recently put two of its retired vessels up for auction.

[6] http://www.wsdot.wa.gov/Ferries/yourwsf/ourfleet/

[7] http://www.wsdot.wa.gov/ferries/traffic_stats/annualpdf/2015.pdf

[8] http://www.wsdot.wa.gov/Ferries/yourwsf/ourfleet/

[9] Four of these were passenger-only ferries, which WSF has discontinued, and four were the Steel Electric class. The remaining three (the MV (Motorized Vessel) Rhododendron, MV Evergreen State, and MV Hiyu) operated primarily as back-up ferries for the fleet but were used more regularly after the Steel Electric class ferries were retired. Both the MV Evergreen State and the MV Hiyu have recently been put up for auction (see http://www.kitsapsun.com/news/local/old-state-ferries-put-up-for-auction-3e21953d-ad14-72ff-e053-0100007f3529-396066561.html).

[10] The MV Samish, MV Tokitae, MV Salish, MV Kennewick, and MV Chetzemoka.

[11] M. von Ruden, WSF Director of Vessels (personal communication, July 12, 2016).

Recent History of WSF Vessel Procurement

The state's 22 ships were built between 1958 and 2016 and range in capacity from 750 to 2,500 passengers and 64 to 202 cars. Thirteen of the 22 ships were rebuilt subsequent to their initial launch, most recently in 2005 (see Exhibit 1). All but five ships were built in Seattle. Over the last 20 years, new WSF ferry construction has been led by the Seattle-based Todd Pacific Shipyards, acquired in 2011 by Vigor Industrial (see Exhibit 2, next page).[12] [13] While other shipyards have served as subcontractors, Vigor Industrial has been the lead shipyard in the construction of the last eight ships and three classes of ferries, starting with the Jumbo Mark II class ferries constructed in the 1990s.

The first vessel in the Kwa-di Tabil class experienced cost overruns and delays (see Exhibit 3, next page). Vigor Industrial has delivered the later ferries in both the Kwa-di Tabil class and in the Olympic class of vessels (the 144-car) on-time and closer to or under budget, especially after allowing for the contingency that WSF adds to the awarded contract.[14] WSF reserves a contingency fund set aside to cover unexpected costs not covered in the budget. For a more in-depth discussion of recent WSF procurement including the events surrounding the construction of the Kwa-di Tabil ferries (see Appendix IX).

Exhibit 1

WSF Fleet Details

Class	# of vessels	Car capacity	Passenger capacity	Years built (rebuilt)
Evergreen State*	2	87	792	1958-59 (1994-95)
Issaquah	6	90-124	1,076-1,200	1980-82 (1989-2005)***
Jumbo	2	188	2,000	1972-1973 (2003-2004)
Jumbo Mark II	3	202	2,500	1997-1999
Kwa-di Tabil	3	64	750	2010-2011
Olympic	2**	144	1,500	2014-2016
Super	4	144	1,069-2,000	1967 (1991, 2005)***

Source: http://www.wsdot.wa.gov/ferries/vesselwatch/Vessels.aspx

Notes:

* One of the Evergreen State class ferries is a backup vessel for the fleet and is not in regular service.

** Two additional Olympic class ferries are under construction with anticipated delivery dates of 2017 and 2018.

*** One of the Issaquah class vessels, the Sealth, and one of the Super class vessels, the Hyak, have not been rebuilt.

[12] http://www.bizjournals.com/seattle/news/2011/02/15/vigor-completes-130m-purchase-of-todd.html

[13] Vigor Industrial consists of several subsidiary companies. Vigor Fab is the subsidiary responsible for building the 144-car ferries. http://vigor.net/projects/project/144_car_ferries

[14] According to the Washington State Auditor's Office (2013) Performance Audit, WSF sets an additional 10-20% of the awarded shipyard contract as contingency funding (p. 44) with the higher amount reserved for the first vessel in a new class.

Exhibit 2

Recent WSF Vessel Construction

1997-1999: Three Jumbo Mark II class ferries were built (202-car)

- Two qualified bidders
- Todd Pacific Shipyards won the bid

2009-2012: Three Kwa-di Tabil class ferries were built (64-car)

- Todd Pacific Shipyards submitted the only winning bid, as the lead shipyard in a winning consortium of other shipyards in state

2012-2018 (in progress): Four Olympic class ferries were built (144-car)

- One bid by Vigor Industrial (formerly Todd Shipyards) as lead contractor of a consortium of in-state shipyards
- Two of four are already in service (Tokitae and Samish)
- Chimacum is due in 2017, and Suquamish is due in 2018

Exhibit 3

Construction Contract Award and Total Spent on Recent WSF Ferry Construction (unadjusted dollars in millions)

	Kwa-di Tabil Class (64-car)			Olympic Class (144-car)			
	Chetzemoka	**Salish**	**Kennewick**	**Tokitae**	**Samish**	**Chimacum**	**Suquamish**
Year built	*2010*	*2011*	*2012*	*2014*	*2015*	*2017 (in progress)*	*2018 (in progress)*
Contract award	$65.48	$60.00	$54.11	$115.35	$109.42	$112.65	$111.56
Estimated final shipyard cost	$76.37	$63.63	$55.55	$116.60	$110.37	$112.66	$111.56
Difference	($10.89)	($3.63)	($1.44)	($1.26)	($0.95)	($0.01)	$0.00

Source: Data on Kwa-di Tabil Class ferries is from: SAO (2013) pg. 39. Data on Olympic class ferries is from: R. Wohlfrom, WSF Vessel Project Engineer (personal communication, November 21, 2016).

Note:

Numbers may not add due to rounding.

Major In-State Shipyard Requirements

Two state laws include major provisions regarding which shipyards are qualified to bid on Washington State ferries:

1) Build in Washington; and
2) The Apprenticeship Act.

Build in Washington. The Washington State Legislature requires state ferries, including the Jumbo Mark II, the Kwa-di Tabil, and the current Olympic class of ferries, be built in state.[15] The last WSF ferry built outside of Washington was in 1967. The law makes exceptions for owner-furnished equipment as well as manufactured components and systems. Many of the components of the ferries are built out-of-state or outside of the U.S. For example, the rudders on the Kwa-di Tabil class ferries were built in Germany.[16]

The 2015 Legislature modified the requirement that ferries are built in state. The change will go into effect after July 1, 2017.[17] After that point, if all bids on a new ferry are 5% more than the engineer's estimate, WSF must reject all proposals and re-issue a request for proposals not subject to this in-state construction requirement.[18]

The Apprenticeship Act. Washington State requires shipyards that bid on new ferry construction to have an apprenticeship program approved by the State Regulatory Apprenticeship Council.[19] This requirement applies to all Washington State Department of Transportation (WSDOT) public works projects worth more than $3 million. The apprenticeship law requires 15% of work be performed by workers enrolled in state-approved apprenticeship programs. Shipyards bidding on state ferry projects can either have a pre-existing training program approved by the council or start a new program.

Federal requirements. Shipyards and ferry purchasers are also subject to federal requirements. The Merchant Marine Act of 1920 (Jones Act) and the Passenger Vessel Services Act (PVSA) of 1886[20] require that hulls of ferries are constructed in the U.S. Additionally, shipyard construction is subject to labor, safety, health, and environmental regulations. Coast Guard standards and the Americans with Disabilities Act also regulate the safety and configuration of ferries.

[15] These requirements have been tied to legislation related specifically to vessel class or bidding approach. For example, in 2008, the legislature required that any new ferry designed to carry less than 100 motor vehicles must be constructed within the boundaries of the state of Washington (RCW 47.56.780). This requirement applied to the Kwa-di Tabil class ferries, or, as relevant for the Olympic class ferries, the legislature passed requirements in 2001 that if WSF takes a design-bid approach to contracting for projects worth over $10 million, it must include a build in Washington requirement (RCW 47.60.814).

[16] http://www.ptleader.com/news/update-ferry-chetzemoka-to-enter-service-monday-on-port-townsend/article_a195809e-334d-11e6-aa83-b7920b394bcd.html

[17] RCW 47.60.815.

[18] This RCW specifically addresses initial requests for proposals, which indicates that it applies to new contracts rather than the construction of additional ferries under an existing contract.

[19] RCW 39.04.320 (1)(b)(iv).

[20] The PVSA regulates interstate coastal passenger transportation, while the Jones Act regulates interstate coastal trade. Ferries are subject to both of these acts. D. Singer, Associate Professor, Naval Architecture and Marine Engineering, University of Michigan (personal communication, July 12, 2016).

II. Comparing WSF to Other Major U.S. Public Ferry Systems

Ferries are unusual ships to produce. Most non-recreational shipbuilding in the U.S. is for the navy or for oil and gas exploration and production.[21] Generally, shipyards are concentrated in Virginia and Florida because of their large naval facilities as well as other southeastern states because of their proximity to oil and gas production.[22] WSIPP identified 21 shipyards in the U.S. that have experience building ferry ships since 1980 (see Exhibit 4).[23] These include mid-sized to large shipyards (or groups of shipyards), building high-complexity, mid-sized vessels and medium or small shipyards with some experience building ferries—predominantly passenger ferries. The majority of these shipyards are located in the southeastern U.S. in the Gulf States.

Exhibit 4

U.S. Shipyards with Experience in Ferry Construction since 1980

Region	Count of shipyards
Southeast (Alabama, Florida, Louisiana, Mississippi, and Texas)	11
Midwest (Wisconsin)	2
New England (Maine, Massachusetts, and Rhode Island)	3
West (California, Oregon, and Washington)	5

[21] Eisenhower School for National Security and Resource Strategy (2015). *Industry study: Final report shipbuilding*, Washington, D.C. Available at: http://es.ndu.edu/Portals/75/Documents/industry-study/reports/2015/es-is-report-shipbuilding-2015.pdf, p. 2.
[22] Ibid, pp. 2-3.
[23] www.shipbuildinghistory.com

Comparing Ferry Systems

Exhibit 5 (next page) provides an overview of other major ferry systems in the U.S.[24] The ferry purchasers addressed in this section, and throughout the report, represent public or public-private ferry services provided by states, counties, and cities. Washington serves by far the largest number of passengers and cars—about 16 million more passengers and 8 million more cars annually than any other state.

[24] These data are an aggregation of all public or public-private ferry services provided in each state from the 2014 National Census of Ferry Operators (NCFO). The data include county, city, and state ferries. We did not include Maine in Exhibit 5 (even though it is a top ferry system) because the NCFO had to aggregate its data with Virginia due to data disclosure rules.

Exhibit 5

Route Characteristics of Major U.S. Ferry Systems, 2013

State	# of annual passengers (millions)	# of annual cars (millions)	Route miles
Alaska	8.47	3.34	13,386
California	10.13	0.34	1,170
Florida	0.65	0.22	6
Illinois	3.09	0.74	12
Massachusetts	4.86	0.68	433
New Jersey	4.40	0.13	372
New York	13.38	1.50	612
North Carolina	4.15	0.85	165
South Carolina	0.92	0.00	40
Texas	6.12	2.14	7
Washington *(Includes non-WSF ferries)*	26.00	10.73	2,443

Source: 2013 NCFO Survey. https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject_areas/ncfo/ncfo_methods.html
Note:
Includes city, county, and state ferries.

Ferry fleets in the U.S. differ on a number of features including:

- *Route length.* The length of ferry routes can have significant implications for vessel construction. For example, the Alaska Marine Highway System (AMHS) serves far-flung communities linked together by some overnight ferries. As a result, some vessels have quarters to accommodate two crews and are designed to operate in relatively unprotected water.
- *Cars/passengers served.* With its system part of the state highway system, WSF purchases only car ferries. However, this is not universal across fleets. For example, in New York, a primarily passenger-only fleet runs via public-private partnership around Manhattan.[25]
- *Operating environment.* The nature of the waterway also affects the types of vessels purchased by ferry systems. Some Washington routes need ferries capable of operating in less protected areas of the Puget Sound. Alternatively, North Carolina has ferries for the relatively protected areas of the Outer Banks.
- *Number of routes.* The number of routes can increase the variety of vessels needed in a fleet, especially when the routes are in different operating environments. For example, Texas has only two short routes in the Gulf of Texas, which makes streamlining its fleet easier.

[25] The public agencies engaged in these partnerships include agencies such as the Port Authority of New York and New Jersey, New Jersey Transit, New York City Department of Transportation, and the Metropolitan Transportation Authority.

Public ferry systems also differ in where they purchase their ferries. For this report, WSIPP collected data on the historical purchasing patterns of ferry operators in the U.S. since 1980.[26] Exhibit 6 shows that Washington State is one of only two states that purchase over 90% of its ferries from in state since 1980. More recently, Alaska has developed a policy of geographic preference (which is discussed in Exhibit 7 on the next page).

Comparing Ferry Costs

A number of factors influence vessel costs, including the following:

- functional requirements (e.g., size, amenities, operating environments);
- shipyard capacity, productivity, and construction timeline;
- contract structure;
- cost of materials (e.g. steel, engines, electronics); and
- cost of labor.

Exhibit 6

Fleet Size and Purchasing Pattern for Major U.S. Ferry Systems 1980-2015

State	Count of publicly owned ferries	% built in-state
Alaska	10	30%
California	16	0%
Florida	12	92%
Illinois	5	0%
Maine	10	50%
Massachusetts	5	40%
New Jersey	12	0%
New York	19	0%
North Carolina	13	0%
South Carolina	5	0%
Texas	6	67%
Washington *(Includes non-WSF ferries)*	27	96%*

Notes:
Includes city, county, and state ferries.
* The out-of-state ferry is the Eastern Washington Sanpoil, which was purchased from Foss Shipyard in Oregon. http://www.seattletimes.com/seattle-news/a-name-for-the-states-newest-smallest-ferry-sanpoil/

[26] WSIPP expanded and verified the dataset developed for State Auditor's Office (2013). This was completed through searching news articles and the public records of a variety of public ferry purchasers.

Exhibit 7

Case Studies

Below are two case studies on the procurement practices of British Columbia Ferry Services Inc. (BC Ferries) and Alaska Marine Highway System (AMHS). Full case studies and citations can be found in Appendix VIII.

BC Ferries

BC Ferries operates ferry services in British Columbia, Canada. It is the largest ferry operator in the world, with a fleet of 34 vessels that serves 47 terminals. In 2003, the ferry system was restructured as a private corporation, with the provincial government as the single shareholder. This restructuring came on the heels of an unsuccessful enterprise to locally construct three ferries, designed to meet local transportation needs and bolster the local shipbuilding industry. The cost for the ferries stretched from a projected $210 million to $463 million, and the schedule fell over two years behind. The ferries experienced many problems and were sold at a loss shortly after entering service.

After 2003, BC Ferries opened its bidding process for ferry construction. Unlike U.S. ferry operators, BC Ferries can purchase internationally constructed ships, but with a 25% import duty. In 2004, BC Ferries awarded a three-ship contract worth $325 million ($267 million U.S.) to a German shipyard. BC Ferries estimated that even with the import duty, construction in Germany would save almost $80 million. In 2014, BC Ferries again awarded another three-ship contract to a European shipyard, this time in Poland.

Alaska Marine Highway System

While BC Ferries moved toward an open bidding process, AMHS began using a contract process that involves working more closely with a single in-state shipyard. AMHS serves the longest routes of any ferry system in the U.S. and has specific construction needs because of overnight routes and rough sea conditions.

In 2006, AMHS began a design process for a day shuttle ferry that was originally estimated to cost between $25 million and $30 million. Many design changes resulted in the estimate climbing to $120 million. In 2010, AMHS returned $68 million in federal funds the state received for the ferry and scrapped the designs developed so far. AMHS instead is in the process of constructing two small ships for the same $120 million budget. By returning federal grant funds, AMHS had more control over the bidding process, and was able to limit bidding to in-state shipyards.

To negotiate the price of the new ferries, AMHS used a "construction manager/general contractor" (CMGC) process. Unlike a traditional “low-bid” process, the shipyard is involved early in the design process. When the shipyard is familiar with the design, the shipyard negotiates a guaranteed maximum price. Because of its early involvement, the shipyard can assist in developing a design that aims to reduce construction costs. The only shipyard to participate in the CMGC bidding process was Vigor Alaska, which leases the Ketchikan shipyard owned by the state. AMHS was able to negotiate with Vigor Alaska to construct the two day ferries for the $120 million maximum agreed upon price.

Functional requirements. A wide variety of ship design decisions affect construction costs. This includes a single- or double-ended design; the amount of steel necessary for the vessel's projected lifespan; designing the ferry to operate in the appropriate waterways; compatibility with terminals; and the provision of food or other amenities for passengers.

For example, WSF use a double-ended configuration that increases the speed of on- and off-loading passengers and cars but may also add to construction costs. WSF staff report trying to maintain a high degree of uniformity among its ferries. Standardization may reduce the costs and complexity of operation, maintenance, and crew training but may also raise costs by making it difficult for shipyards to negotiate for best prices.

Shipyard capacity, productivity, and timeline. The capacity of the shipyard can also impact ferry construction costs. As discussed previously, ferries are a small part of the shipbuilding industry, with larger contacts for ships generated by oil and natural gas exploration or the navy. When oil prices are high, shipyards are less likely to bid on ferry construction, and the ferry construction prices are likely higher.

When shipyards have slack capacity, they may decide to bid competitively on ferry projects in order to maintain their work force. For example, the AMHS negotiated with Vigor Alaska to construct its ferries during the summer months when the shipyard is less busy.[27]

[27] https://www.adn.com/business/article/new-ferry-contract-part-effort-create-shipbuilding-industry-alaska/2014/10/06/

The efficiency with which a shipyard can build a vessel can also affect construction costs. Many variables could affect efficiency, including skill of the labor force, extent of pre-outfitting of the vessel, technological sophistication of the shipyard, etc. There are standard metrics for the number of labor hours it takes a shipyard to produce a ship, after adjusting for the complexity of the vessel; however, information on shipyard efficiency is proprietary.[28]

Timelines can also impact cost. WSF cites the compressed timeline as an important factor in cost overruns for Washington's Chetzemoka ferry.[29] The Chetzemoka was built after the Steel Electric class ferries were unexpectedly retired. The final cost of the ferry exceeded the initial contract due in part to the large number of change orders used to correct and change the design after construction had already begun. For a full discussion, see Appendix IX.

The U.S. Coast Guard must inspect and provide passenger ferries with a certificate of inspection prior to operation. WSF has involved the Coast Guard early in the design phase to prevent delays or changes.[30] When the design phase overlaps with the building phase of the ships, the result can be costly change orders and delays as well as limiting the degree of pre-outfitting of the ships, which reduces building efficiency.[31] Research

[28] For example, Compensated Gross Tonnage (CGT) is a standard method for comparing shipyard output, both nationally and internationally. It is calculated by multiplying the tonnage of a ship by a coefficient that captures the complexity of the vessel.

[29] State Auditor's Office (2013), p. 26.

[30] https://www.uscg.mil/proceedings/archive/2005/Vol62_No4_Wint2005-06.pdf, p. 6-8.

[31] Moyst, H., & Das, B. (2005). Factors affecting ship design and construction lead time and cost. *Journal of ship production, 21*(3), 186-194.

shows that pre-outfitting the components of the ship is less expensive than adding systems later in the construction process.[32] However, pre-fitting requires clear design plans from the beginning.

Contract structure. The way contracts structure payment schedules, responsibility for change orders and risk for delays and overruns can also impact final costs to ferry purchasers.[33] The number of ships in a contract can also affect construction costs. Multi-ship contracts can reduce the per-vessel ship cost. With the greater predictability that comes with multi-ship agreements, shipyards have greater incentive to bid, which can increase competition. According to maritime experts, this predictability and scale can also incentivize shipyards to provide up-front capital investment in their yards for these specific ships.[34] This greater predictability allows shipyards to plan to utilize the capacity of their yards and maintain their workforce. Multi-ship contracts also provide an incentive for shipbuilders to invest in the engineering and planning functions, leading to more efficient construction processes and lower costs.

Materials. The cost of materials also can significantly affect vessel cost. Most material costs are the same regardless of shipyard location. For example, U.S. steel prices are the same nationwide, although transportation costs for steel to the shipyard may vary. Similarly, shipyards often purchase the components for their vessels (propulsion systems, electronics, etc.) from the same providers, so there is little geographic difference in cost, according to experts interviewed for this study.

Labor. In interviews, maritime experts, shipyard representatives, and ferry operators pointed to regional differences in labor costs as a potentially significant driver in ferry construction costs. To compare shipbuilding labor costs in Washington State to costs throughout the U.S., we examined several national data sources. The full methodology and results are provided in Appendix VI.

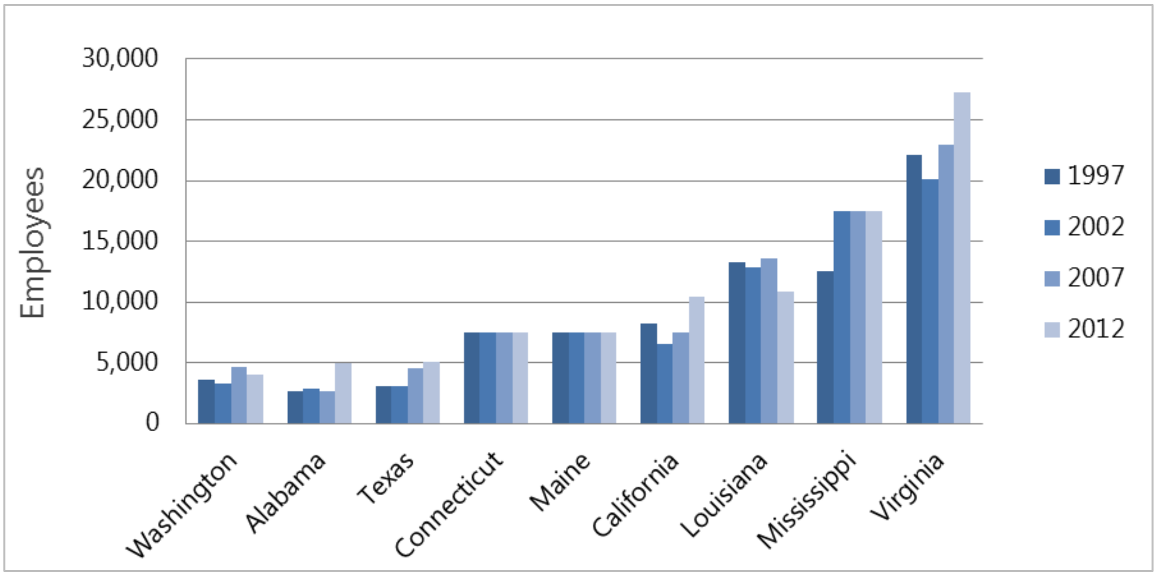
We focused on the nine states with the largest number of shipbuilding employees—Alabama, California, Connecticut, Louisiana, Maine, Mississippi, Texas, Virginia, and Washington. In 2012, average pay in Washington State shipyards was slightly above the other eight states.[35] Shipbuilding labor costs in Washington were between 3% to 13% higher than the comparison states.

Regional labor cost differences as measured here can result from a number of factors. They can reflect differences in worker skill and productivity levels, competitive conditions in regional labor markets, different state-by-state sub-industry mixes within the aggregate ship and boat building industry. In 2012, Washington employed 3.8% of the U.S. ship building and repair workforce with about 4,000 workers.[36] The number of establishments has been relatively stable from 2000 to 2012—160 in 2007 and 150 in 2012.[37] Exhibit 8 (next page) illustrates the size of Washington's industry compared to the other eight major shipbuilding states.

[32] http://www.marineinsight.com/naval-architecture/advanced-outfitting-in-shipbuilding/
[33] D. Singer, Associate Professor, Naval Architecture and Marine Engineering, University of Michigan (personal communication, May 3, 2016).
[34] Miroyannis, A. (2006). *Estimation of ship construction costs*. Master's thesis, Massachusetts Institute of Technology (MIT).
[35] Average pay is calculated using the total payroll divided by number of employees. See Appendix VI for details.
[36] This includes only civilian employees.
[37] Mefford, C. (2013). *Washington State maritime cluster: Economic impact study*. Seattle, WA: Community Attributes Inc. Available online at: http://www.psrc.org/assets/10304/Maritime-Impact.pdf.

Exhibit 8

Employment in the Ship Building and Repair Industry,
Nine Largest Ship Building States



Source: 1997, 2002, 2007, and 2012 Economic Census.
Note:
Some data is imputed at the midpoint of reported range due to data suppression.

III. Identification of Barriers to More In-State Bids

As part of the legislative assignment, WSIPP was asked to identify barriers to receiving three or more in-state bids on WSF ferry construction. WSF ferry contracts for the last three classes of ferries have had one to two bids on new construction contracts (see Exhibit 2 on page 4).

We identified barriers in three categories:

1) industry,
2) statutory, and
3) contractual.

Industry

Two shipyards in Washington State have capacity to build the Olympic class ferries.

WSF evaluates shipyard qualifications to bid on new ferry construction. Prospective yards are evaluated based on a number of factors, including physical assets, workforce, financial status/bonding capacity, and past performance.[38]

Exhibit 9 provides some information on major Washington shipyards. According to WSF, only Vigor Industrial and Dakota Creek are currently known to be qualified to bid on the 144-car ferries. However, Dakota Creek presently does not have a state-sponsored apprenticeship program. Nichols Brothers has a state-sponsored apprenticeship program, but it does not currently have the capacity to be the lead shipyard in constructing the 144-car ferries (see Exhibit 9 on the next page). At this time, Vigor Industrial is the sole in-state bidder that meets all state requirements.

Consolidation of the American Shipbuilding Industry

Following World War II and intensifying through the 1970s, the American shipbuilding industry has contracted. Where previously multiple firms had clustered around an advantageous geographic location, regional markets frequently have consolidated to a single firm.[*] As of August 2014, only two companies held over 50% of the domestic national shipbuilding market share.[**] Shipyards increasingly tend to specialize in specific vessel types, further reducing potential competition.

During the same time period, few new medium or large shipyards have been established. With the exception of Austal U.S.A., founded in 1999, major American shipyards are many decades old.[***] There are high barriers to entry in the form of capital requirements that deter new shipbuilding yards. Also, maritime experts we interviewed stated that there are only a limited number of viable physical locations in the U.S. generally, and in Puget Sound specifically, for new shipyards. These industrially-zoned areas are sometimes crowded out by commercial or residential zones.

* Walters, W.W. (2000). Geographic record: American naval shipbuilding, 1890-1989. *Geographical Review, 90*(3), 424-426.
** Eisenhower School for National Security and Resource Strategy (2015), p. 2.
*** Ibid. p. 20.

[38] M. von Ruden, WSF Director of Vessels (personal communication, September 2, 2016).

Exhibit 9
Major Washington State Shipyards

Name	Location	Founded	# of employees	Note
Dakota Creek	Anacortes, WA	1975	600	No state-approved apprenticeship program
Nichols Brothers	Freeland, WA	1964	265	Past partner in constructing Olympic class ferries
Vigor Industrial	Seattle, WA	Acquired Todd Shipyard in 2011	2000	Leading shipyard on the last eight WSF ferries

Source: Information on founding dates and number of employees is from Mefford (2013), p. 29.

The oil and natural gas industry can also impact the number of bids. When oil prices are high, shipyards are busy building for these industries. When oil prices fall, ferry purchasers reported to WSIPP in interviews as having greater interest from shipyards looking to use up their extra capacity.

Contractual

As discussed previously, as the number of ships in a contract increases, so does the potential for cost-savings through shipyard learning and infrastructure investment. Ship purchasers interviewed for this study also reported that interest from shipyards increased along with the number of ships in a contract.

Statutory

State law requires bidders on state ferry construction have a state-approved apprenticeship program and be located in state.

It is possible the apprenticeship program does affect the number of in-state bids. The program could potentially bolster the shipbuilding industry through training the workforce. Alternatively, the program could potentially deter shipyards without qualified apprenticeship programs from either bidding on contracts or discourage smaller yards from developing their capacity to bid on larger projects. WSIPP was unable to empirically evaluate this policy due to insufficient data about how shipyards would behave if this requirement were removed.

The build-in-Washington requirement prevents only non-Washington shipyards from bidding on new ferry construction; therefore, the requirement does not have a direct influence on the number of in-state bidders. The next section of the report will conduct a benefit-cost analysis to evaluate the net policy impact of removing that requirement and shifting ferry construction out of state.

Why We Make No Policy Recommendations Regarding Barriers to In-State Bidders

WSIPP was asked to make policy recommendations to increase the number of in-state bids to three. In Washington State, the fundamental barrier to achieving three in-state bids is the small number of capable shipyards. The number of qualified yards could potentially increase to two if Dakota Creek satisfied the Apprenticeship Act requirements or if those requirements were removed or altered.

Other policy practices we discussed, particularly increasing the number of ships in a contract, might encourage shipyards to satisfy state apprenticeship requirements and/or increase their capabilities to compete for the new contracts. However, WSIPP does not have sufficient empirical evidence to recommend those policy changes.

IV. Analysis of Constructing Ferries Out of State

The legislature directed WSIPP to perform a benefit-cost analysis (BCA) of the state's ferry procurement practices. The current policy is relatively unique among public entities in the U.S. and requires WSF to solicit and accept bids for the construction of new ferries only from shipyards located within Washington State. We examine a possible change in current procurement practice: moving construction to an out-of-state shipyard. To be clear, this analysis is about procurement policy, acquisition costs, and the location of shipbuilding activity, not about changes to the state's transportation system.

The following section describes the methodology and results of WSIPP's analysis of ferry procurement policy: detail is provided in Appendix I. In addition to a BCA, WSIPP conducted a supplementary economic impact analysis (EIA). While a BCA helps determine whether the benefits of a policy change outweigh its costs, an EIA is intended to determine how a policy affects the economic activity in a region.

For both of these analyses, WSIPP uses an identical scenario—the purchase of a single Olympic class ferry. The *Tokitae* and *Samish*, completed in 2014 and 2015, respectively, are examples of this type of ship. These ships have a displacement of 4,384 tons, are equipped with two 3,000 horsepower engines, and have a passenger capacity and a vehicle capacity of 1,500 and 144, respectively.[39] WSF's expected acquisition cost for one of these ships constructed under the current build-in-Washington policy is approximately $130 million (in 2015 dollars).[40] The purchase year is 2021, based on WSF's adjust long-range plan. We adjusted prices to future values using a shipyard inflation rate (see Appendix I).

WSIPP staff also considered conducting a BCA of the apprenticeship program. WSIPP would need access to a wide variety of proprietary information in order to do so. The costs of such a program to a shipyard could include start-up costs, ongoing overhead from reporting, and presumably lowered productivity due to less experienced workers and increased supervision requirements. Benefits could include lower employee acquisition and retention costs. WSIPP attempted but were unable to obtain data on labor hours for the construction of the Olympic class vessels.

An evaluation of the apprentice program requires information on how the program affects shipyard workers. For example, tracking the career paths of shipyard worker apprentices might provide the state with better insight on the program's contribution to Washington's labor force. This type of program evaluation is beyond the scope of this study.

[39] See WSDOT Ferries Division Fleet Guide, http://www.wsdot.wa.gov/NR/rdonlyres/AB031249-16EE-4422-BBEA-8D2C50A17D9C/0/FerryFleetGuideMarch2015FinalDraft.pdf.

[40] Washington State Department of Transportation, Ferries Division. (2009). *Final long-range plan*. Available at: http://www.wsdot.wa.gov/Ferries/Planning/. Information on WSF's updated procurement plan was provided to WSIPP via email (M. von Ruden, WSF Director of Vessels (personal communication, June 28, 2016)).

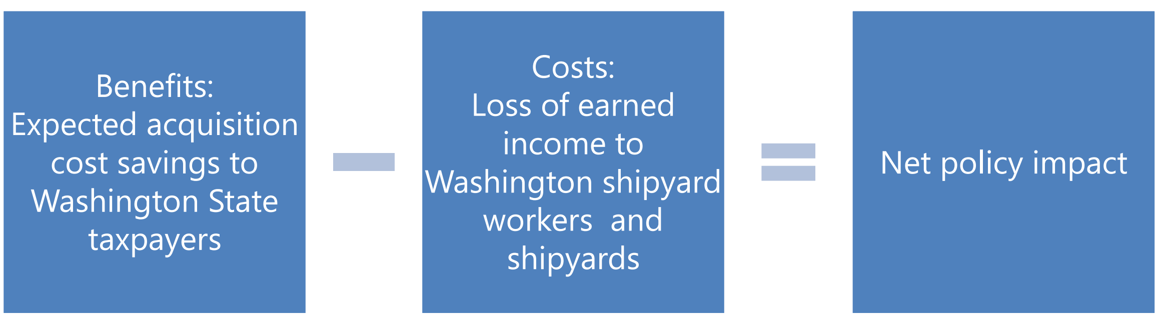
Overview of BCA

BCA is an analytical tool developed by economists to estimate the monetary value of benefits and costs resulting from a government program or policy. BCA enables a comparison of a proposed policy change relative to a "counterfactual," usually existing policy,[41] where the net benefit of each policy alternative is calculated separately as its benefits, minus its costs.

BCA has several other distinctive features, including the discounting of the future stream of benefits and costs to present value; measurement of costs in terms of foregone opportunities; exclusion of benefits and costs that represent transfers between individuals;[42] and focusing largely on primary effects to avoid the potential for double counting of benefits or costs.[43] BCA assumes that productive inputs such as capital, labor, and natural resources are fully employed, and as such, reallocating those resources to implement a new policy will typically incur an opportunity cost.[44] The conceptual framework is displayed in Exhibit 10.

Determining net benefits requires the calculation of a number of intermediate parameters, including, for example, the proportion of shipyard workers who live in Washington State. The true values of these parameters are unknown. Appendix I describes our

Exhibit 10
Conceptual Framework of the Benefit-Cost Analysis



[41] Vining, A.R., Greenberg, D.H., Boardman, A.E., & Weimer, D.L. (2011). Cost-benefit analysis: concepts and practice. Boston [etc.]: Prentice Hall points out that implicit in this comparison is the establishment of a cause-and-effect relationship between the impacts of a policy or program change and the expected benefits and costs (pp. 8-9). That is, BCA must not attribute benefits and costs to a particular policy change if these outcomes would have occurred regardless of the policy adopted.

[42] Transfers are excluded from BCA of government policies and programs. For example, taxes raised to fund an income transfer program represent a transfer from one group (taxpayers) to another group (program recipients) and as such are not counted as either a program cost or benefit. However, the administrative costs of collecting taxes and managing the income transfers would be counted as a cost. In addition, the distortionary effects of taxes on economic activity would be counted as a cost.

[43] Vining et al. (2011) explain that primary effects should always be included in BCA while the secondary effects (often referred to as second-round, spillover, side, pecuniary, or indirect effects) can and should be ignored to avoid double counting of benefits and costs (p. 115). Such secondary effects should only be included in BCA if secondary markets are distorted and prices in secondary markets change (p. 116). The focus on primary markets also means that multiplier effects are excluded from BCA (p. 20).

[44] The exception would be the case in which unemployed resources are used to implement a government program or policy. See Vining et al. (2011) for a discussion of alternative methods of evaluating the cost of using unemployed workers to implement a government program or policy (pp. 105-108).

methodology for estimating the values along with an estimate of their uncertainty. WSIPP incorporates uncertainty around these estimates by running many statistical simulations of the BCA. In each of these runs, the exact value of each of the parameters can vary within a range. This yields both an estimate of the overall net benefit based on the average of the simulation runs and a distributional measure—the percentage of cases in which the net benefit exceeds zero.

BCA focuses on measuring benefits and costs for individual persons who have "standing" in the analysis.[45] Although BCA results in a single measure of net benefits, WSIPP's approach to BCA breaks down benefits and costs from the perspectives of different groups, such as those directly affected by a policy (e.g., shipyard employees) and taxpayers. The BCA presented in this report differs from WSIPP's standard approach;[46] we developed a standalone benefit-cost model for the current analysis.[47]

Calculation of benefits. For this analysis, Washington State taxpayers have standing as potential beneficiaries affected by changes in taxes from an increase or decrease in ferry acquisition price. We estimate change in acquisition price from constructing a ferry out of state based on a historical ferry price analysis discussed in-depth in Appendix II. We compare Washington State's historical ferry purchase price to ferry purchases by other state, county, and city governments in the U.S., controlling for a variety of factors, including the following:

- passenger and vehicle capacity,
- horsepower,
- hull material,
- Washington's regulatory environment (by including ferries purchased in Washington by non-WSF ferry operators), and
- vessel tonnage.

The analysis suggests that other ferry purchasers pay on average about 9% less than WSF for a similarly equipped vessel. However, our estimate has a large margin of error (between about -40% to +13%), which is not surprising given the small population of ferries and high level of variation. The 9% difference, when applied to the price of the $130 million ferry, results in a $12.7 million benefit, adjusted to a present discounted value of $10.5 million. The BCA incorporates the uncertainty associated with the estimate.

Washington State is very restricted in its ability to use federal funds for new ferry vessel construction due to its in-state geographic preference. Even if policy was changed to open bidding, it is unlikely that Washington could secure significant sources of funding for new ferry construction from current federal funds.[48] However, the U.S.

[45] It is important to note that BCA is concerned with the well-being of individual persons who have *standing*. Entities such as businesses, organizations, and governmental units are not persons and therefore do not have standing in BCA (however, the *owners* of businesses have standing if they are persons). In conducting studies for the Washington Legislature, WSIPP's approach is that all *current* Washington State residents have standing in the BCA.

[46] See http://www.wsipp.wa.gov/TechnicalDocumentation/WsippBenefitCostTechnicalDocumentation.pdf.

[47] Over the last 20 years, WSIPP has developed a custom benefit-cost model that addresses the benefits and costs of individually; based interventions (e.g., tutoring programs in K–12 education, programs to reduce recidivism for individuals in prison, substance abuse treatment, etc.). The policy question posed in this report is much broader than an individual intervention; rather than rely on our existing benefit-cost model for this analysis, we developed a new model specifically for the purpose of this assignment.

[48] Most federal funding for ferry systems comes from the Ferry Boat Discretionary Fund, administered by Federal Highway Administration. The fund is distributed via formula, and

Department of Transportation announced in October 2016 that it would accept applications for infrastructure grants under a new program that could potentially fund new vessel construction.[49] WSIPP had insufficient notice of this new program to incorporate it into the calculation of benefits. It is unclear whether WSF would win the competition for such a grant, and there is uncertainty over the program's future in light of the change in presidential administration.[50] However, securing federal grant funds could significantly increase the benefits from a policy change to open bidding.[51]

Calculation of costs. In-state shipyard workers and owners have standing in the calculation of costs because a policy change could directly affect their income. We estimate a number of intermediate factors to determine how shifting the construction of a $130 million ferry out-of-state would affect these two groups. For each parameter in our analysis, we include a range of possible values in order to incorporate the margin of error (see Appendix I for a full discussion). After adjusting for shipbuilding specific inflation, we expect the future cost of the ferry to be $135.72 million (in 2015 dollars). We calculate that 60% of the ferry cost would be spent on labor (rather than materials) resulting in a total of $81.47 million of foregone income earned from ferry construction. We divide that amount between workers and owners based on a proportion derived from the 2012 Economic Census. We also subtract the proportion of income likely earned by workers or owners living outside of Washington State.

Workers and owners would not lose the entirety of the $81.5 million because they would be gaining income in other ways. Our additional analyses (see Appendix IV) suggest that historically there has not been a strong and direct connection between in-state ferry construction and the size of the Washington shipbuilding labor force.

We account for the likelihood that shipyard workers would be able to get jobs in other industries (see Appendix V) and that shipyards could fill up their slack capacity (see Appendix IV). We estimate shipyard employment will fall by 1.2% when ferry construction is shifted out of state and that 14.3% of resources (both shipyard workers and the shipyard's capital resources) will not be able to shift to other activities. This results in a loss of income of $5.66 million to Washington shipyard workers and $3.09 million to Washington shipyard owners.

As is standard economic practice, we discount those numbers to represent the present value of the lost income, which gives us an estimate of $4.69 million of lost income for Washington shipyard workers and $2.56 million in lost income for Washington shipyard owners.

Washington State would not likely be able to increase its funding from this source if its geographic preference were removed. The Federal Transit Administration (FTA) also administers a smaller fund, which WSF currently has secured for preservation of its terminals and vessels. WSIPP spoke with two ferry purchasers that have qualified for FTA funding. Shipyards have to satisfy many requirements in order to be a qualified builder under that FTA funding, which discourages some bidders.

[49] https://www.transportation.gov/build-america/fastlane/fastlane-ii-notice-funding-opportunity

[50] http://www.infrainsightblog.com/2016/11/articles/financing/u-s-department-of-transportation-solicits-project-applications-for-850-million-in-fastlane-grants/

[51] Opening up bidding would not require construction to occur out-of-state, which is the policy scenario evaluated in the BCA and EIA.

Exhibit 11

Some Intermediate Variables Used in the Calculation of Costs of Building a Ferry Out of State

Expected cost of ferry in future (2015 dollars)	$135.72 million
Share of shipyard revenue spent on materials, labor	40%, 60%
Income earned during ferry construction	$81.47 million
Percentage of income earned by shipyard workers	54%
Percentage of income earned by shipyard owners	46%
Income earned by shipyard workers	$44.32 million
Income earned by shipyard owners	$37.15 million
Percentage of shipyard workers living in WA	97.8%
Percentage of shipyard owners living in WA	59.8%
Income earned by shipyard workers living in WA	$43.33 million
Income earned by shipyard owners living in WA	$22.21 million
Impact of ferry construction on shipyard employment	1.25%
Transitional unemployment share	14.3%
Income lost by shipyard workers living in WA	$5.66 million
Income lost by shipyard owners living in WA	$3.09 million
Income lost by WA shipyard workers (present discounted value)	**$4.69 million**
Income lost by WA shipyard owners (present discounted value)	**$2.56 million**

Discussion of the results. Subtracting the costs of the policy change from the benefits results in an estimated present value of about $3.25 million for out-of-state construction (see Exhibit 12). Of course, there is uncertainty around all of our parameter estimates. To account for this uncertainty, we ran our benefit-cost model 500,000 times while allowing our estimates to vary. This results in positive net benefits 54% of the time (see Exhibit A3 in Appendix I for more detail).

Exhibit 12

Benefits and Costs of Out-of-State Ferry Purchasing in 2015 Dollars

Program benefit:	
Expected acquisition cost savings to Washington State taxpayers	$10.5 million
Program cost:	
Loss of earned income to Washington shipyard workers	($4.69 million)
Loss of earned income to Washington shipyard owners	($2.56 million)
Total costs	($7.25 million)
Bottom line:	
Net benefits (benefits – costs)	**$3.25 million**
Benefit-to-cost ratio	**$1.45**
Probability of positive net benefits (risk analysis)	**54%**

Note:
Amounts do not sum due to rounding.

Economic Impact Analysis

In addition to the BCA outlined in the preceding section, WSIPP conducted an economic impact analysis (EIA).[52] This analysis was conducted using Regional Economic Models, Inc. (REMI). This model assesses how policy changes affect the broader Washington State economy.

BCA is performed to determine whether a policy change has a net monetary impact on individuals in society. The REMI model captures more general economic impacts from a policy change, including primary and multiplier effects.

Primary impacts are those that occur in the specific businesses or industry affected by a given policy and can include revenue, employment, and income.[53] In addition to primary effects, REMI estimates "multiplier" effects. These effects occur because the primary activity (ferry ship construction) generates additional business for other firms that supply inputs to the ferry construction process. Additional multiplier effects are generated when the extra income realized by shipyard workers and owners leads to additional consumption.

[52] Joint Legislative Audit and Review Committee (JLARC) staff contributed to the economic impact analysis for this legislatively required study. JLARC modeled several policy options in coordination with WSIPP staff using the REMI model.

[53] The REMI software refers to these effects as direct effects.

REMI reports on a wide array of outcomes, but in Exhibit 13 we focus on non-farm private employment and "value added," which is similar to Gross Domestic Product (GDP)[54] (detailed definitions for these are in Appendix VII). The main impacts of the analyzed policy change occur in the years 2021 and 2022 (when construction would occur). As a result of building a $130 million ferry out of state, we expect a decrease in Washington's shipyard employment (an average of about 280 jobs or about 4% of the forecasted shipbuilding and maintenance jobs in both 2021 and 2022).[55] The value that shipbuilding directly adds to the state GDP would also fall by an average of about $25 million in 2021 and 2022. After 2022, the selected outcome variables quickly resume a path that closely matches the baseline forecast.

Exhibit 13

Policy Simulation Results, Economic Impact Analysis:
Yearly Outcomes Averaged Over 2021-2022 (2015 Dollars)

Outcome	Baseline scenario	Alternate scenario	Total policy impact (= direct effect + multiplier effect)		
			Direct effect	*Multiplier effect*	*Total policy impact*
Private non-farm employment	3,599,945	3,599,286	-280	-379	-659
Value added	$492,068 million	$492,000 million	($25 million)	($43 million)	($68 million)

[54] We use value added instead of GDP for impact outcomes to facilitate the analysis of direct and indirect impacts in Exhibit 13. The two accounting concepts are virtually identical as can be seen from this definition provided by the Bureau of Economic Analysis (BEA): "The value added of an industry, also referred to as gross domestic product (GDP)-by-industry, is the contribution of a private industry or government sector to overall GDP. The components of value added consist of 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 (consisting of sales or receipts and other operating income, commodity taxes, and inventory change) and the cost of its intermediate inputs (including energy, raw materials, semi-finished goods, and services that are purchased from all sources)." See http://www.bea.gov/faq/index.cfm?faq_id=184.

[55] Note these are total jobs rather than employed persons. The same employed person could hold several jobs simultaneously.

V. Conclusion

The BCA and EIA provide somewhat contradicting information on the impact of moving ferry construction out of state. The BCA shows a small net positive benefit ($3.25 million). The EIA shows a negative impact on the state economy using a variety of different measures including a two-year average loss of about 659 jobs and about $68 million in value added to the state GDP. It is important to keep in mind the two types of analyses are not directly comparable, as they incorporate different assumptions and look at different information. The BCA is focused specifically on the direct impact of a policy change to specific groups in Washington State, while the EIA attempts to assess the indirect and long-term impacts of such a change to the entire state economy.

Neither analysis predicts a substantial impact on Washington's economy (either positively or negatively) from keeping ferry construction in state or moving construction to out-of-state shipyards. The BCA showed a positive net benefit only slightly more than half of the time in our simulations, and the average effect was only 2.5% of the total ferry purchase price. The EIA suggested that building a ferry out-of-state would have only a short term impact on the shipbuilding industry.

Appendices

Washington State Ferry Vessel Procurement

Appendix

I. Benefit-Cost Analysis Methodology and Results

The state legislature directed WSIPP to conduct an analysis of potential changes in ferry procurement practices in Washington State. The current policy is relatively unique among public entities in the U.S. and requires that Washington State Ferries (WSF), a division of the Washington State Department of Transportation (WSDOT), solicit and accept bids for the construction of new ferries only from shipyards located within Washington State. We examine a possible change in current procurement practice, namely relaxing the in-state requirement and opening bidding to all U.S. based shipyards (federal policy requires that U.S. ships be constructed in domestic shipyards). Specifically, we conduct a benefit-cost analysis of shifting ferry construction out of state. To be clear, this analysis is about procurement policy, acquisition costs, and the location of shipbuilding activity. This analysis is not concerned with the transportation-related impacts of ferry construction, since all of the alternative policy scenarios considered also involve the acquisition of the same infrastructure (i.e. new ferries).

In this appendix, we develop estimates of the likely benefits and costs resulting from a policy change to out-of-state ferry construction. Because these estimates embody some degree of uncertainty, we employ a statistical simulation model to evaluate the net benefits of a change in policy.

Framework for Benefit-Cost Analysis

Benefit-cost analysis (BCA) is an analytical tool developed by economists to systematically value all benefit and costs resulting from a government program or policy. This enables the calculation of the net benefit of the proposed policy change relative to a counterfactual, usually current policy,[56] where the net benefit of each policy alternative is calculated separately as its benefits, minus its costs. An important advantage of BCA is the calculation of a single bottom-line metric denominated in dollars: the net benefit associated

[56] As Vining et al. (2011) point out, implicit in this comparison is the establishment of a cause-and-effect relationship between the impacts of a policy or program change and the expected benefits and costs (pp. 8-9). That is, BCA must not attribute benefits and costs to a particular policy change if these outcomes would have occurred regardless of the policy adopted.

with a particular policy change.[57] BCA focuses on measuring benefits and costs for individual persons who have standing in the analysis.[58]

BCA has several other distinctive features including the discounting of the future stream of benefits and costs to present value; measurement of costs in terms of foregone opportunities; exclusion of benefits and costs that represent transfers between individuals;[59] and focusing largely on primary effects to avoid the potential for double counting of benefits or costs.[60] In addition, BCA assumes that productive inputs such as capital, labor, and natural resources are fully employed and, as such, reallocating those resources to implement a new policy will typically incur an opportunity cost.[61]

The estimation of benefits and costs almost always involves uncertainty, and WSIPP's approach to BCA is to directly model uncertainty by running multiple statistical simulations of the BCA, yielding both an estimate of the overall net benefit based on the average of the individual simulations and a distributional measure—the percentage of cases in which the net benefit exceeds zero. Although BCA results in a single measure of net benefits, our approach to BCA breaks down benefits and costs from the perspectives of different groups of persons, such as those directly affected by a policy and taxpayers more generally.

Exhibit A1

Conceptual Framework—Calculating Net Benefits of Out-of-State Ferry Construction

Benefits	Stakeholders
Expected acquisition cost savings	Washington State taxpayers
Costs	
Loss of earned income	Shipyard workers living in WA Shipyard owners living in WA
Net benefits	
Expected acquisition cost savings *minus* loss of earned income	

[57] Future streams of benefits and costs are measured in 2015 dollars, so the effects of general price inflation are removed from the analysis. Because ship construction costs have been rising faster than the general rate of inflation, we develop a shipyard specific price index for the analysis.

[58] It is important to note that BCA is concerned with the well-being of individual persons who have *standing*. Entities such as businesses, organizations, and governmental units are not persons and therefore do not have standing in BCA (however, the *owners* of businesses have standing if they are persons). In conducting studies for the Washington Legislature, WSIPP's approach is that all *current* Washington State residents have standing in the CBA.

[59] Transfers are excluded from BCA of government policies and programs. For example, taxes raised to fund an income transfer program represent a transfer from one group (taxpayers) to another group (program recipients) and as such are not counted as either a program cost or benefit. However, the administrative costs of collecting taxes and managing the income transfers would be counted as a cost. In addition, the distortionary effects of taxes on economic activity would be counted as a cost.

[60] Vining et al. (2011) explain that primary effects should always be included in BCA while the secondary effects (often referred to as second-round, spillover, side, pecuniary, or indirect effects) can and should be ignored to avoid double counting of benefits and costs (p. 115). Such secondary effects should only be included in BCA if secondary markets are distorted and prices in secondary markets change (pg 116). The focus on primary markets also means that multiplier effects are excluded from BCA (p. 20).

[61] The exception would be the case in which unemployed resources are used to implement a government program or policy. See Vining et al. (2011) for a discussion of alternative methods of evaluating the cost of using unemployed workers to implement a government program or policy (pp. 105-108). In the present analysis, we develop a methodology to account for the possibility of unemployed resources in the shipyard industry.

The conceptual framework for the calculation of the net benefits of changing to out-of-state ferry construction is displayed in Exhibit A1. To determine net benefits as described in Exhibit A1 requires the calculation of a number of intermediate parameters which are necessary for the analysis. The true values of these parameters are unknown. In this section we describe our methodology for estimating the parameter values. We also provide estimates of the degree of uncertainty that might be expected in our parameter estimates. The estimated parameter values and their associated variability are the inputs into our statistical simulation model to determine net benefits.

Benefits. Regardless of the procurement policy and the eventual location of ferry construction, our analysis assumes that an identical ship is acquired under any policy scenario.[62] Under the current policy, new ferries will be constructed in Washington State. We presume in this analysis that ferry construction shifts to an out-of-state shipyard under the change to an open bidding policy. However, no matter where a new ferry is constructed, the main benefit of a more inclusive bidding process is the potential for lower ferry acquisition costs. That is, under a revised procurement policy shipbuilders in other states may under-bid shipyards based in Washington State, resulting in a benefit for Washington State taxpayers. Alternatively, shipyards based in Washington State may adjust their behavior and offer more competitive bids when faced with a wider pool of potential competitors. Either way, a benefit is derived from lower acquisition costs.[63] Thus, the only differential in the future benefits is associated with the acquisition costs.[64]

Because the acquisition cost differential discussed above cannot be observed directly, we develop a statistical estimate based on regression models using historical data on ferry acquisition contracts in the U.S.[65] The estimate incorporates both the expected differential as well as the uncertainty associated with the estimate (see Appendix II for details). The BCA is based on statistical simulations calculating benefits based on myriad possible values of the acquisition differential.

Costs. We assume that the change in procurement policy would result in the acquisition of new ferries from outside of Washington State.[66] Such a shift would certainly result in a loss of in-state economic activity associated with ferry construction. However, whether or not there is a net loss of economic activity depends on the ease with which productive resources can be shifted to other economic activities. It is possible that productive inputs (capital, labor, and natural resources) engaged in ferry construction might easily move into other economic activities such as the construction of other types of ships or into other industries (e.g. other transportation industries or commercial building construction).[67] Another possibility is that transitioning away from ferry construction will be impossible and that resources that would have been employed building ferries will be permanently unemployed resulting in a loss of economic activity in

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[62] Because we assume that acquired ships will be identical under either procurement scenario, it follows that the future maintenance costs will also be identical under either procurement scenario.

[63] If ferry acquisition costs are lower, we assume the resulting savings are returned to individual taxpayers in proportion to taxes currently paid. An alternative to redistributing savings to taxpayers would be to increase other types of government spending. However, we have no guidance on specific areas where savings should be spent—should the savings be spent on highway construction or expanded early childhood education? Even with specific guidance, an estimate of the benefits resulting from this additional spending would require additional analysis beyond the scope of the present study.

[64] Ideally, the acquisition cost of a ferry would include both the initial cost of acquiring a new ferry *and* the present discounted stream of all future maintenance costs. However, if ferries are identical regardless of construction location, the stream of future maintenance costs will also be identical under both policy scenarios and the relevant comparison will depend solely on the initial acquisition costs.

[65] Our statistical estimates are subjected to extensive sensitivity analysis to determine the stability of the estimates under alternative statistical models.

[66] While a policy change may or may not result in ferry construction outside of Washington State, it will certainly increase the *probability* of construction outside of Washington State.

[67] In addition, workers may transition to entirely new occupations in other industries. The difficulty of doing so depends on the degree to which their specific occupational skills are transferable to other occupations.

Washington State. Perhaps more likely is an outcome that falls somewhere between these two extremes: some fraction of the productive resources will immediately transition into other economic activities, while other productive resources will not easily make the transition, resulting in some lost economic activity.[68]

In the discussion above, the ease with which productive resources can be shifted to other activities is a key determinant of the costs associated with out-of-state ferry construction. It is worth noting that if productive resources have been engaged in a particular economic activity (e.g. ferry construction) for a relatively long period of time, then the shift to new activities may be more difficult and slow. Conversely, if the industry is generally more dynamic, with shifts in production among various products occurring frequently, then the economic transitions of the type discussed above may occur more quickly and easily. Further, if the industry norm is characterized by variable activity over time—for example, relatively infrequent but large contracts for ships (both ferries and non-ferries) generating swings in economic activity and employment—then one might expect that productive resources used in this industry might be more flexible and able to shift to other activities fairly easily. To gauge the transition of labor and shipyards to other non-ferry activities, we estimate the relationship between past ferry construction and changes in the shipyard employment in Washington State (see Appendix IV for details).

Exhibit A2 presents a more detailed description of our methodology for computing net benefits along with the parameters necessary to make the calculation. As noted in the Exhibit, some of the values are estimated using a variety of data sources and methods, while other values are calculated. In the following section, we define in detail each input parameter and document our method for estimating the parameter value. In addition, since each parameter estimate has some inherent uncertainty we also provide estimates of the variability of each parameter.

[68] Bartik, T.J. (2012). Including jobs in benefit-cost analysis. *Annual Review of Resource Economics, 4*(1), 55–73 describes a conceptual framework for BCA under less than full employment conditions.

Exhibit A2

Parameters Needed to Calculate Net Benefits of Changing to Out-of-State Ferry Construction

Parameter	Formula
Benefits	
Expected cost of ferry (2015 dollars) [1]	C
Ship inflation rate (relative to all prices) [1]	g
Years until construction begins[1]	t
Expected cost of ferry in future (2015 dollars)	$\mathbf{C^*} = Ce^{gt}$
Ferry acquisition costs relative to restricted bidding (percentage) [1]	s
Expected acquisition cost differential due to restricted bidding (dollars)	**C′** = s**C***
Costs	
Share of shipyard revenue spent on materials[1]	m
Income earned during ferry construction	(1-m)**C***
Share of income earned by shipyard workers[1]	w
Share of income earned by shipyard owners	(1-w)
Income earned by shipyard workers	**Y** = w(1-m)**C***
Income earned by shipyard owners	**O** = (1-w)(1-m)**C***
Share of income earned by shipyard workers living in WA[1]	r
Share of income earned by shipyard owners living in WA[1]	k
Income earned by shipyard workers living in WA	r**Y**
Income earned by shipyard owners living in WA	k**O**
Number of years to build a ferry[1]	d
Fringe benefit rate for shipyard workers in WA[1]	b
Payroll per WA shipyard worker[1]	P
Annual employment per WA ferry build	**A** = **Y**/[d(1+b)P]
Shipyard employment impact of ferry construction (percentage) [1]	f
WA shipyard industry employment[1]	E
Transitional unemployment share	**u** = fE/A
Income lost by shipyard workers living in WA	**urY**
Income lost by shipyard owners living in WA	**ukO**
Discounted net benefits	
Discount rate[1]	i
Present discounted values	
Expected acquisition cost differential (dollars)	PDV(**C′**)
Income lost by shipyard workers living in WA	PDV(**urY**)
Income lost by shipyard owners living in WA	PDV(**ukO**)
Net benefit	PDV(**C′**) – PDV(**urY**) – PDV(**ukO**)

Notes:

[1] These parameters were estimated using the data and methods established in the *Model Parameter Estimates* section (pgs. 29-32). All non-marked parameters were calculated using the listed formulas.

Model Parameter Estimates

Expected cost of ferry (2015 dollars) = C. To facilitate our analysis we begin with an estimate of the cost of a prototypical Olympic-class ferry which is consistent with the most recently constructed ferries for WSF. The *Tokitae* and *Samish*, completed in 2014 and 2015, respectively, are examples of this type of ship. These ships have a displacement of 4,384 tons, are equipped with 6,000 horsepower engines, and have a passenger capacity and a vehicle capacity of 1,500 and 144, respectively.[69] The acquisition cost for these ships, constructed under the current restricted bidding policy, is approximately $130 million (in 2015 dollars).[70] While our analysis is specific for these prototypical ships, the results can be proportionally scaled up or down for ships with larger or smaller acquisition costs.

Ship inflation rate (relative to all prices) = g. Historically, the cost of ship construction has increased faster than prices in general. To measure shipyard inflation, we compile two price indices—one for labor costs in shipyards and the other for steel prices used in ship construction.[71] We form a single shipyard price index as a weighted average of these indices, using the share of labor and materials costs in the shipyard industry as weights.[72] Based on this index, we find that between 1988 and 2014, shipyard costs have increased 0.86% faster than prices in general.[73] In our analysis, we express all results in 2015 dollars, but we adjust future ferry construction costs by this rate to account for future shipyard-specific cost escalation. We cannot be certain that shipyard costs will follow these historical patterns, however, so we set the variation in the shipyard inflation rate to be equal to 25% of the point estimate: 0.21%.

Years until construction begins = t. New ferries will be constructed at some indeterminate point in the future. Because benefits and costs must be discounted to present value, we need to specify a time period for ferry construction. In our analysis, we expect ship construction to be spread equally over a two-year period, beginning *t* years in the future. Based on the current WSF long-range plan, we analyze the impact of a prototypical Olympic-class ship beginning construction in 2021.

Ferry acquisition cost relative to restricted bidding (percentage) = s. This parameter measures the percentage differential in acquisition costs that are expected if ferries are constructed out of state. Negative values imply that acquisition costs will decrease under the alternate policy. We estimate this parameter using historical data on ferry ship acquisition. We use ordinary least squares (OLS) regression analysis to compare the costs paid by WSF for ferries with the costs of other ferry acquisitions in the U.S. since 1991, controlling statistically for ship size and characteristics. The full analysis is presented in

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[69] See WSDOT Ferries Division Fleet Guide, http://www.wsdot.wa.gov/NR/rdonlyres/AB031249-16EE-4422-BBEA-8D2C50A17D9C/0/FerryFleetGuideMarch2015FinalDraft.pdf.

[70] Washington State Department of Transportation, Ferries Division (2009). *Final Long-Range Plan*. Available at: http://www.wsdot.wa.gov/Ferries/Planning/. Information on WSF's updated procurement plan were provided to WSIPP via email (M. von Ruden (personal communication, June 28, 2016).

[71] Keating, E.G., Murphy, R., Schank, J.F., & Birkler, J. (2008), Using the steel-vessel material-cost index to mitigate shipbuilder risk. http://www.rand.org/pubs/technical_reports/TR520.html. For details on the price indices see these links: http://www.navsea.navy.mil/Home/05C/ShipbuildingIndices.aspx and http://www.navsea.navy.mil/Portals/103/Documents/05C/BLSIndex.xlsx.

[72] This information is available from the 2012 Economic Census and can be extracted from the Census Bureau's American Fact Finder web site (http://factfinder.census.gov). For the U.S. as a whole, labor costs and material costs represent 34.7% and 32.0% of total ship yard revenue, respectively (see table EC1231SG1: Manufacturing: Summary Series: General Summary: Detailed Statistics by Subsectors and Industries: 2012). We weight the shipyard labor price index by 34.7/(34.7+32.0) and the material price index by 32.0/(34.7+32.0).

[73] The rate of increase in general prices (measured by the implicit price deflator for GDP) between 1988 and 2014 was 2.09%. The rate of increase in our constructed price index for shipyards was 2.95%.

Appendix II.[74] We take the cost differential associated with WSF acquisition to represent all factors unique to WSF procurement practices, including the impact of restricted bidding. The median estimate for this figure is a cost savings of 9.37%. This methodology is not necessarily approximate but represents the best possible method given limitations of available data.[75] Because OLS estimates are probabilistic in nature, we also explicitly model the variability of our estimate using the median standard error from the regression model: 30.37%.[76]

Share of shipyard revenue spent on materials = m. A significant portion of shipyard revenue resulting from ferry construction will be spent on materials such as steel and various components (paint, engines, electrical components, etc.). In our benefit-cost analysis, we follow standard analytical practice and include impacts that occur in primary markets only. Thus, we focus on income earned by shipyard workers and shipyard owners, excluding the portion of revenue spent on materials. To this end, we need an estimate of the portion of revenue spent on materials which we derive from the 2012 Economic Census data for Washington State shipyards.[77] In 2012, this figure was 39.92%. We model the variability of this estimate using the standard deviation of values for Washington and the other six states for which there is comparable data; in 2012 this figure was 12.63%.[78]

Share of income earned by shipyard workers = w. Subtracting the cost of materials from shipyard revenue yields shipyard *value added* or the total income earned by shipyard workers and owners. This parameter is the share earned by workers, with the residual share going to shipyard owners. As with the share of revenue spent on materials, we derive this parameter using data for Washington State shipyards from the 2012 Economic Census. The share of labor income for Washington State shipyards in 2012 was 54.39%. The standard deviation for this parameter is computed across the Washington State value, plus the values for six states for which there is comparable data; the standard deviation for these seven states was 10.31%.[79]

Share of income earned by shipyard workers living in WA = r. Most, but not all shipyard workers will reside in Washington State. For the benefit-cost-analysis, we count benefits and costs that accrue to Washington State residents only. We obtained an estimate for this parameter using data from the Public Use Micro Sample (PUMS) of the America Community Survey (ACS). This is a household-based survey conducted by the Census Bureau. We use data for workers who reported working at a shipyard located in Washington

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[74] As a complementary analysis we also examined differences in shipyard labor costs across U.S. states with a major shipbuilding industry. This analysis is presented in Appendix VI.

[75] A preferred scenario for estimating the impact of restrictive bidding practices would require more data and more heterogeneous data. For example, our ability to produce better statistical estimates would be enhanced if multiple states had both restrictive and open bidding practices at different points in time with the timing of state policy regime changes varying across states.

[76] Thus, the 95% confidence interval for this variable is $9.37 \pm 1.96 \times 30.37\%$, or a range from −50.2% to 68.9%.

[77] Data from the 2012 Economic Census can be extracted from the Census Bureau's American Fact Finder web site (http://factfinder.census.gov). The shipyard industry is defined by NAICS code 336611. See Appendix III for a full definition of relevant industry classifications. The 2012 Economic Census provides state-level data for total shipyard revenue and value added. The proportion spent on materials can be obtained as 1 minus the ratio of value added to total revenue.

[78] Data describing the portion of total shipyard (based on NAICS code 336611) revenue spent on materials was available for six states other than Washington: 57.1% in Alabama, 40.9% in California, 52.4% in Florida, 72.2% in Louisiana, Oregon 54.2%, and 19.4% in Virginia. The random variable for this parameter is top-coded to not exceed 99% and bottom-coded to remain above 1%.

[79] Data describing payroll as a percent of total shipyard (NAICS code 336611) income (value added) was available for six states in addition to Washington. Since data on fringe benefits was not available at the state level for any states, we inflated all state-level payroll figures by 37.73% (the ratio of fringe benefits to payroll for the U.S. as a whole). Our resulting estimates of labor income earned relative to total shipyard income are: 76.3% in Alabama, 54.1% in California, 52.4% in Florida, 72.2% in Louisiana, Oregon 54.2%, and 51.7% in Virginia. In the simulations, this parameter is top-coded at 99% and bottom-coded at 1%.

State and tabulate their state of residence.[80] For the years 2001 through 2009 (the most recently completed business cycle), we find that 97.8% of these workers both worked and lived in Washington State. We compute this value separately for each of the nine years covered in the data and find that the standard deviation of this estimate is 1.4%.[81]

Share of income earned by shipyard owners living in WA = k. Some shipyard owners will reside in Washington State and others will be located in other states or countries. However, data on company ownership does not provide detailed information on owner's state of residence.[82] Therefore, we assume that 60% of the shipyard owners reside in Washington State. To reflect the large degree of uncertainty surrounding this estimate we assume a standard deviation of 20%.[83]

Number of years to build a ferry = d. Commonly, ferry construction requires two years and this parameter value is set to 2. However, this is easily adjusted if a ferry build is expected to have a longer or shorter duration. This parameter does not have any variability associated with it.

Fringe benefit rate = b. Worker compensation in the shipyard industry is comprised of both worker pay and fringe benefits. The ratio of fringe benefits to pay is available from the U.S. 2012 Economic Census data for the U.S. shipyard industry in aggregate (NAICS code 336611) but not separately for Washington State, thus the U.S. figure of 37.73% is used as a proxy for the rate in Washington State.

Payroll per WA Shipyard Worker = P. To estimate payroll per worker we use data for NAICS industry 336611 from the Economic Census for 2012 and the Business Patterns state summary file for 2012 and 2014. The 2012 values from Economic Census and Business Patterns state summary files were 55,456 and 59,316, respectively. Payroll per worker in the 2014 Business Pattern data was 57,026 but there is no comparable 2014 Economic Census data. Therefore, we use the ratio between the 2012 values to impute a 2014 value for the missing 2014 Economic Census data. The calculation is as follows— (55,456/59,316)×57,026 = 53,315.02. Finally, we use the actual Business Pattern data (57,026) and the imputed Economic Census data (53,315.02) to compute the mean and standard deviation for 2014. The mean is 55,170.5 and the standard deviation is 2624.06. [84]

Shipyard employment impact of ferry construction = f. A key parameter in the benefit-cost model is the extent to which employment in Washington State shipyards is increased or decreased by the presence or absence of a build contract from WSF. One the one hand, it is common to imagine that shipyard employment would decline as a result of the loss of a significant business contract such as a ferry procurement.[85] On the other hand, in-state shipyards may have many significant business opportunities to build and repair other ships.[86] Furthermore, many workers in the Washington shipyard industry are

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[80] The ACS survey does not identify industry codes at the six-digit level—the most detailed industry classification available is NAICS code 3366, which includes ship building and repair (NAICS code 336611) as well as boat building and repair (NAICS code 336612). See Appendix III for a discussion of industry classification codes.
[81] In the simulations, this parameter is top-coded at 100% and bottom-coded at 0%.
[82] For example, Todd Shipyards, a prominent Washington State business establishment, which has previously built ferries for WSF, was recently acquired by Vigor Industrial, a privately held company based in Portland. Given the available data on shipyard ownership, it is generally not possible to determine the state of residence for owners.
[83] In the simulations, this parameter is top-coded at 100% and bottom-coded at 0%.
[84] It is worth noting that this is very close to the estimate produced by Mefford (2013).
[85] For a discussion of the issues surrounding jobs in benefit-cost analysis see Bartik (2012).
[86] For example a news report (http://www.seattletimes.com/business/todd-shipyards-agrees-to-be-acquired-by-portland-firm/) about the shipyard industry in Washington State indicates that Todd Shipyards had renewed a five-year contract with the U.S. Navy for repair of aircraft carriers.

employed in a wide range of skilled occupations and likely to be highly employable elsewhere.[87] In this case, no unemployment of labor or shipyard capacity would result from the loss of a ferry project to an out-of-state shipyard.

We develop a detailed methodology to compute the value and variability of this parameter from OLS regression equations relating Washington State shipyard employment to the history of WSF ferry construction contracts from 1977 to 2014. This methodology is outlined in Appendix IV. The estimated value of this parameter is taken to be the median of coefficients estimated across four competing specifications and is -0.0295. This median estimate is negative, suggesting that Washington shipyard employment was typically 2.95% lower in years with WSF ferry builds than in years without. However, the coefficients in these models are estimated imprecisely and are associated with a high level of variability (meaning that the effect is not statistically different from zero and could be either positive or negative). Taking a cautious approach, whenever the simulation yields a negative value for this coefficient we assume that there is no relationship between ferry construction and industry employment. This results in an estimated 1.25% impact of ferry construction on shipyard employment. Our estimate for the variability of this parameter is 6.15%, and is based on the median standard error from the four specifications.

Washington State shipyard industry employment = E. To estimate industry employment we used data for NAICS industry 336611 from the Economic Census for 2012 and the Business Patterns state summary file for 2012 and 2014. The 2012 values from Economic Census and Business Patterns state summary files were 4,033 and 3,829, respectively. Employment in the 2014 Business Pattern data was 3,268 but there is no comparable 2014 Economic Census data. Therefore, we use the ratio between the 2012 values to impute a 2014 value for the missing 2014 Economic Census data. The calculation is as follows—(4,033/3,829)×3,268 = 3,442.11. Finally, we use the actual Business Pattern data (3,268) and the imputed Economic Census data (3,442.11) to compute the mean and standard deviation for 2014. The mean is 3,355.06 and the standard deviation is 123.12.

Discount rate = i. Because a ferry build could occur at any point in the future, the value of final costs and benefits associated with a ferry acquisition must be converted to present day values using present discounted values. All costs and benefits associated with ferry construction are divided equally across the number of years in which the ferry build is expected to be completed and then discounted to present values. The current model is parameterized with a discount rate equal to 3.5%, the modal rate used in the WSIPP benefit-cost model.[88] The discount rate is allowed to vary randomly across simulations with a standard deviation of 0.75%, which yields a distribution of discount rates in the WSIPP specified range of 2% to 5%.[89]

Benefit-Cost Results

The estimation of benefits and costs almost always involves uncertainty and our approach is to directly model uncertainty by employing multiple statistical simulations, yielding both an estimate of the overall net benefit based on the *average* of the individual simulations as well as a distributional measure—the percentage of cases in which the net benefit exceeds zero. Although BCA results in a single measure of net benefits, our approach to BCA typically breaks down benefits and costs from the perspectives of

[87] Appendix V for the occupational distribution of ship and boat industry workers in Washington State and in other major shipbuilding states.
[88] Washington State Institute for Public Policy (June 2016). *Benefit-cost technical documentation*. Olympia: WA: Author. (http://www.wsipp.wa.gov/TechnicalDocumentation/WsippBenefitCostTechnicalDocumentation.pdf)
[89] In the simulations, this parameter is bottom-coded at 0%.

different groups of persons, in this case taxpayers, shipyard workers, and shipyard owners. The BCA presented for this evaluation differs from WSIPP's standard approach;[90] we developed a standalone benefit-cost model for the current analysis.[91]

We repeated the benefit-cost analysis 500,000 times, each time using unique and independent values of the input values for parameters described above. For each of the input parameters, we used computer software to generate random values that follow a normal distribution. Specifically, the distributions were normal with means and standard deviations as described in the previous section. For example, we estimate payroll per worker in the ship building industry to be $55,169. This estimate has a standard deviation of $2,622, reflecting its potential variability. In each of the 500,000 simulations, the value of this parameter is unique and independent of the values of the other parameters in the model. Because we explicitly model that uncertainty in our simulations, we know that payroll for the middle 50% of the simulations will range from $53,400 to $56,936. For the middle 80% of the distribution, the range will be $51,811 to $58,529. Statistical simulations are an ideal tool for benefit-cost analysis when, in the absence of exact values for key input parameters, we have plausible values along with reasonable estimates of the potential variability.

Exhibit A3 displays the results from the 500,000 statistical simulations. As noted in the Exhibit, some of the values represent input parameters calculated according to the methods discussed in the "Model Parameter Estimates" section (pgs. 29-32). Other values are calculated from the input parameters using the formulas provided in Exhibit A2. With the exception of the lower section titled "present discounted values," the values expressed in Exhibit A3 are *undiscounted*, making it is easier to follow the logical flow of the calculations. Because benefits and costs occur in the future, we discount all dollar values to the present. As noted above, the discount rate is drawn from a normal distribution with mean of 3.5% and a standard deviation of 0.75%.[92] This yields a distribution in which 90% of the discount rates in the simulation fall between 2.27% and 4.73%. In Exhibit A3, the underlying variation in the model parameters is reflected in the standard deviation. For a more intuitive sense of the parameter distributions we also include the inter-quartile range bounded by the 25th and 75th percentiles of the distributions.

Benefit results. The key parameter that drives the benefit side of the equation is *Ferry acquisition costs relative to restricted bidding*, which is parameter "*s*" in Exhibit A2. The value of this parameter represents the percentage change in ferry acquisition costs resulting from restricted bidding practices. Based on our empirical estimates (see Appendix II), this parameter can take on both positive and negative values. We take a cautious approach to estimating benefits and allow for either positive or negative values in this relationship. That is, we explicitly allow for the possibility that constructing ferries out of state might *increase* acquisition costs (resulting in negative benefits). In fact, this scenario occurs in 37.91% of the simulated outcomes. Overall, our analysis indicates that the present value of total benefits of a policy change would yield an average of $10,503,786 in the form of ferry acquisition cost savings. This average value has a large standard deviation of $34,191,538 that reflects the underlying variation across 500,000 simulated draws. The inter-quartile range for the present value of benefits is also quite large, ranging from -$12,503,904 to $33,493,600.

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[90] See http://www.wsipp.wa.gov/TechnicalDocumentation/WsippBenefitCostTechnicalDocumentation.pdf.

[91] Over the last 20 years, WSIPP has developed a custom benefit-cost model that addresses the benefits and costs of individually; based interventions (e.g., tutoring programs in K–12 education, programs to reduce recidivism for individuals in prison, substance abuse treatment, etc.). The policy question posed in this report is much broader than an individual intervention; rather than rely on our existing benefit-cost model for this analysis, we developed a new model specifically for the purpose of this assignment.

[92] Because costs and benefits in this analysis are temporally aligned, the choice of discount rate does not substantively affect the outcome of the analysis. The choice of discount rate will change the scale of net benefits but does not affect the distribution of net benefit outcomes or alter the relative size of costs and net benefits.

Cost results. The key parameter that drives the estimates of total costs is the *Shipyard employment impact of ferry construction* which is parameter "*f*" in Exhibit A2. The value of this parameter represents the relationship (measured in percentage terms) between a dichotomous variable representing the construction of a ferry in Washington State and total employment in Washington's shipyard industry. Based on our empirical estimates (see Appendix IV), this parameter can take on both positive and negative values. In 31.62% of the simulated outcomes, the value of this parameter is positive. In these cases, we conclude that shifting production outside of Washington will result in a loss of employment and income. However, in the remaining 68.38% of the simulated outcomes this parameter takes on a negative value. Because negative values would imply that shifting ferry construction outside of Washington State would actually *increase* total shipyard employment, we take a conservative approach and bottom code the parameter value to 0. The overall result for costs indicates an average of lost income to shipyard workers of $4,689,153 and to shipyard owners of $2,562,225, for a total of $7,251,378 (all figures discounted to present value). Again, it is important to note that there is considerable variation in these estimates—the standard deviation of total lost income is $14,291,208.

Net benefit results. Finally, the estimated present value of the net benefits of out-of-state construction is $3,252,409. Of course, there is a distribution of possible outcomes for net benefits that reflects the variation in the individual parameters underlying the analysis (see Exhibit A4 on pg. 36). In the distribution, 54.33% of the simulated outcomes (slightly more than half) yield positive net benefits.

Exhibit A3

BCA Results—Estimated Parameters and Calculated Values (500,000 Simulated Outcomes)

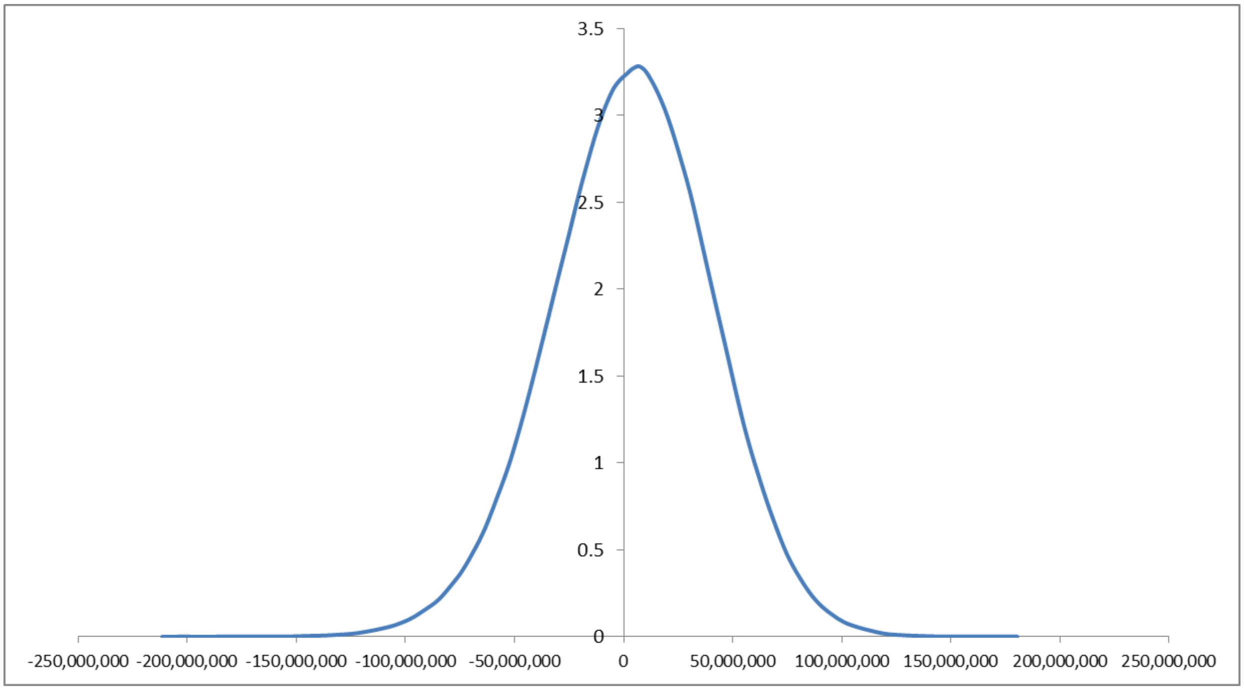
Parameter	Mean	SD	25th percentile	75th percentile
Benefits				
Planned ferry build year[1]	2021	-	-	-
Expected cost of ferry (2015 dollars) [1]	$130,000,000	-	-	-
Ship inflation rate (relative to all prices) [1]	0.86%	0.21%	0.72%	1.00%
Years until construction begins[1]	5	-	-	-
Expected cost of ferry in future (2015 dollars)	$135,716,543	$1,455,269	$134,732,550	$136,692,447
Ferry acquisition costs relative to restricted bidding (percentage) [1]	9.3%	30.4%	-11.1%	29.8%
Expected acquisition cost differential	$12,675,548	$41,232,253	($15,116,522)	$40,430,594
Costs				
Share of revenue to shipyard spent on materials[1]	40.0%	16.5%	28.7%	51.1%
Income earned during ferry construction	$81,467,742	$22,363,158	$66,336,049	$96,737,528
Share of income earned by shipyard workers[1]	54.4%	10.3%	47.4%	61.3%
Share of income earned by shipyard owners	45.6%	10.3%	38.7%	52.6%
Income earned by shipyard workers	$44,315,816	$14,959,982	$33,723,617	$53,802,232
Income earned by shipyard owners	$37,151,925	$13,412,738	$27,578,803	$45,560,515
Share of income earned by WA shipyard workers[1]	97.8%	1.3%	96.9%	98.7%
Share of income earned by WA shipyard owners[1]	59.8%	19.6%	46.5%	73.5%
Income earned by WA shipyard workers	$43,325,682	$14,640,290	$32,969,384	$52,609,006
Income earned by WA shipyard owners	$22,214,081	$11,123,674	$14,116,914	$28,608,737

Parameter	Mean	SD	25th percentile	75th percentile
Number of years to build a ferry	2	-	-	-
Fringe benefit rate for WA shipyard workers[1]	37.7%	-	-	-
Payroll per WA shipyard worker[1]	$ 55,169	$ 2,622	$ 53,400	$ 56,936
Annual employment per WA ferry build	292	100	222	355
Shipyard employment impact of ferry construction (percentage) [1]	1.25%	2.57%	0.00%	1.21%
WA shipyard industry employment[1]	3,355	123	3,272	3,437
Transitional unemployment share	14.3%	27.9%	0.0%	14.0%
Income lost by WA shipyard workers	$5,659,850	$11,063,357	$0	$5,992,177
Income lost by WA shipyard owners	$3,092,567	$6,848,524	$0	$2,439,070
Discounted values				
Discount rate[1]	3.50%	0.75%	2.99%	4.01%
Present discounted value of benefits: Expected acquisition cost differential (total benefits)	$10,503,786	$34,191,538	($12,503,904)	$33,493,600
Present discounted value of costs:				
Income lost by WA shipyard workers	$4,689,153	$9,174,547	$0	$4,949,286
Income lost by WA shipyard owners	$2,562,225	$5,680,024	$0	$2,018,786
Subtotal (total costs)	$7,251,378	$14,291,208	$0	$7,441,597
Present discounted value of net benefits (=total benefits-total costs)	$3,252,409	$37,052,634	($21,028,310)	$28,388,497
Distributional outcomes				
Percentage of simulated outcomes with positive net benefits	54.3%	49.8%	-	-
Percentage of simulated outcomes with positive shipyard employment impact	31.6%	46.5%	-	-
Percentage of simulated outcomes with positive ferry acquisition cost savings	62.1%	48.5%	-	-

Notes:
[1]These parameters were estimated using the data and methods established in the *Model Parameter Estimates* section (pgs. 29-32). All non-marked parameters were calculated using the formulas provided in Exhibit A2.
As noted in the text, some parameters were given a lower bound of 0.

Exhibit A4

Distribution of Present Value of Net Benefits (500,000 Simulated Outcomes)



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II. Estimating the Acquisition Cost Premium Resulting from Restricted Bidding

In this Appendix, we develop an estimate of the percentage cost premium that WSF incurs due to the restricted bidding options in place in Washington State. Our method builds upon an approach first used by the State Auditor's office in 2013.[93] This approach is to use U.S. historical data on ferry costs, statistically adjusted for differences in ship size and characteristics, to estimate the average premium paid by WSF for ferry construction relative to other ferry purchasers around the U.S. The methodological details of this analysis and detailed results are discussed below.

Using this regression-based approach we estimate that, as a result of the restricted bidding process, WSF pays a premium ranging from –12.57% to +39.81%. The median estimate is +9.37%. This means that, on average, we expect WSF to pay 9.37% more for ferry construction due to restricted bidding. However, this premium could be as high as 39.81% or as low –12.57%. Negative estimates imply that bids from out-of-state shipyards would be higher than in-state shipyards by as much as 12.57%. In the case of negative estimates, we assume WSF would accept the low bid from in-state shipyards, hence, the relevant range for our estimates is +39.81% to 0%. Because this estimate is uncertain, in subsequent analysis we consider a range of plausible values for this estimate. Specifically, for use in the benefit-cost analysis, we employ a statistical simulation model (called Monto Carlo analysis) in which we explicitly model the possibility that this estimate will vary. In particular, we assume that the estimated premium will follow a normal distribution with a mean of +9.37% and a standard deviation of +30.37%. In the simulation model, we truncate estimates at a lower bound of zero.

Historical ferry cost data—Regression method

This approach relies on a data set provided to WSIPP by the State Auditor's office including detailed information on ferry acquisition costs and ferry characteristics for 39 ferries procured nationally between 1991 and 2012. We use this data to estimate an ordinary least squares (OLS) regression model using the following specification:

$$\text{Ln(C)} = \beta_0 + \beta_1 \text{ WSFDummy} + \beta_2 \text{ Built\_WA} + \beta_3 \text{ X}$$

Where,

- *C* is the total cost of ship construction (adjusted for inflation),
- *WSFDummy* is a binary dummy variable indicating that the ferry purchaser is WSF,
- *Built_WA* is a binary dummy variable indicating construction in WA State for a purchaser other than WSF, and
- *X* is a vector of control variables including ship size and detailed ship characteristics.

Our specification is similar, but not identical, to the analysis presented in the state auditor's report. In particular, because the model is expressed in semi-log form the estimated coefficient on *WSFDummy* is easily converted to the percentage differential associated with ferry acquisitions by WSF.[94] It is important to note the variable *WSFDummy* captures all factors associated with WSF acquisition practices including restricted bidding. For example, WSF may be more or less efficient in procurement practices than other purchasers and these impacts will be measured by *WSFDummy* as well. Alternatively, WSF might request certain ship characteristics that we are unable to measure and observe in our data set. If these

[93] State Auditor's Office (2013).

[94] The percentage difference is exp(*WSFDummy*)—1. See Halvorsen, R., & Palmquist, R. (1980). The interpretation of dummy variables in semilogarithmic equations. *American economic review, 70*(3), 474-75.

unmeasured characteristics are unique to WSF and affect costs, then the variable *WSFDummy* will capture the impact of these factors. In this case, our estimate of the impact of restricted bidding will be contaminated by these other factors and moreover, the direction of bias will be unknown. Because of uncertainty about the precise interpretation of the coefficient on *WSFDummy,* we will conduct our benefit-cost analysis using a range of plausible estimates for the effect of restricted bidding.

Since we do not know the direction or magnitude of these other impacts, we cannot say whether the coefficient on *WSFDummy* represents a lower or upper bound estimate of the restricted bidding premium. Therefore we will consider our estimate to be a central point in a probabilistic distribution of possible outcomes. It is worth noting that any impacts associated with construction practices in Washington which are independent of restricted bidding and other Washington-specific purchasing practices will be measured by the coefficient on the variable *Built_WA*. This variable will capture the costs specific to ferry construction in the state. Since other (non-Washington) purchasers do not practice restricted bidding, this estimate does not include any of the impacts associated with Washington State's procurement restrictions. Thus, the coefficient on *Built_WA* can be interpreted as the construction cost differential for WA state shipyards when ferries are built for non-WSF purchasers (who are free of the restricted bidding policy).

The data set provided by the state auditor's office includes ship characteristics such as size (measured in tons) and capacity of passengers and vehicles as well as other ship characteristics. The variable definitions along with descriptive statistics for each variable are provided in Exhibit A5.

The state auditor's data included information for a selected list of 39 ferries constructed in the U.S. from 1991 to 2012. We attempted to augment this data set by extending the data window farther into the past—including data for the pre-1980 period—and by filling in missing ships constructed since 1980. While we were able to gather some information for additional ships we are not able to replicate the complete set of information on the ship characteristics included in the auditor's data set. Because of this limited data availability, we are unable to expand the analysis beyond the original data collected by the state auditor's office.

Exhibit A5

Descriptive Statistics for Variables included in Regression Analysis

Variable Name	Definition	Mean	Standard deviation
Pfinal	Cost of ferry	42.970	51.825
Ln_pfinal	LN(Pfinal)	3.116	1.161
WSFDummy	1 if built for WSF, 0 otherwise	0.154	0.366
Built_WA	1 if built in WA for purchaser other than WSF, 0 otherwise	0.154	0.366
tons	Lightship weight in tons	1,255.507	1,436.157
Tons_sq	$Tons^2$	3,585,958.011	7,716,617.009
PassengerCapacity	Number of passengers	857.359	1,210.581
VehicleCapacity	Number of vehicles	53.282	49.410
HullMaterial	Steel=1, aluminum=0	37.692	12.868
ServiceLife	Projected number of service years	7,237.385	7,152.128
HorsePower	Engine horsepower	0.821	0.389
FoodService	Staff=1, self-serve=0	0.769	0.427
passengerAmenities	Comfort=1, basic=0	0.615	0.493
DoubleEnded	Loads from either end=1, 0 otherwise	0.487	0.506
HDummy	Subject to certification by federal regulators under subchapter *H*, 0 otherwise	0.641	0.486
opLBS	Designed to operate in lakes, bays, and sounds, 0 otherwise	0.615	0.493

Results

Because the exact model specification cannot be known, our empirical strategy involves exploring the data by estimating a variety of model specifications (12 in all) including various combinations of variables with a goal of demonstrating a degree of robustness in the results. The results for 12 model specifications are presented in Exhibit A6. These model specifications range from a minimal set of statistical control variables to a fully-specified model comparable in spirit to the model reported by the state auditor's office. In the most minimal specification, we include a set of control variables that measure the ship's size (weight, engine horsepower, and passenger and vehicle capacity) but no other specific ship characteristics. The fully-specified models include virtually all of the variables included in Exhibit A5. The adjusted R-squared for each of the models is quite high, ranging from 0.87 to 0.93. Generally, the models are stable and the estimated coefficients for key control variables (tons, tons_sq, passenger Capacity, vehicle capacity, and horsepower) robust with respect to the particular model specification. The estimated coefficient for the variable of interest *WSFDummy* ranges from -0.1344 to +0.3351 with a median estimate of +0.0896. None of these estimated coefficients are statistically significant. These estimates correspond to estimated percentage differentials for the cost of WSF purchases ranging from -12.57% to +39.81% with a median estimate of +9.37%. As discussed above, we will take the median estimate (+9.37%) from these 12 models as the point estimate of the percentage premium paid as a result of restricted bidding. We estimate the precision of this estimate by computing the median standard error from the 12 different regression models.[95] This yields an estimated standard error of 30.37%. Because the point estimate is uncertain, in subsequent analysis we consider a range of plausible values. Specifically, in the benefit-cost analysis, we employ a statistical simulation model (called a Monte Carlo analysis) in which we explicitly model this uncertainty. In particular, we assume that the estimated premium will follow a normal distribution with a mean of +9.37% and a standard deviation of +30.37%. In the simulation model, we truncate estimates at a lower bound of zero—that is, WSF will never pay more for an out-of-state shipyard bid when there is a lower bid from an in-state shipyard.

Another variable of interest is *Built_WA*. This variable captures the cost differential (either positive or negative) of ferries built in Washington State for buyers other than WSF. The estimated coefficients for this variable range from -0.3468 to +0.3047 with a median coefficient of -0.1143. Again, none of these coefficients passes the test of statistical significance. These estimates correspond to percentage differentials ranging from -29.31% to +35.63% with a median estimate of -10.80%. The implication of the median estimate is that when the purchaser is not WSF, the cost of ferries constructed in shipyards in Washington State is, on average, 10.8% less than if constructed in elsewhere in the U.S. However this estimate is not statistically significant and the range of estimates across the models is quite variable and includes both positive and negative values.

[95] This calculation involves two steps. First, we compute the median t-statistic associated with the coefficient on *WSFDummy* in each of the 12 models. Using this value, we then compute the median standard error as the median coefficient divided by the median t-statistic (0.0896/0.2950 = 0.3037).

Exhibit A6

Regression Analysis, Ferry Costs

variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Intercept	1.3415 ***	2.6404 ***	2.2153 ***	2.6301 ***	2.0206 ***	2.2581 ***	2.0713 ***	2.0778 ***	2.2998 ***	2.3387 ***	1.7699 **	1.6789 ***
	(0.1916)	(0.2039)	(0.4237)	(0.5201)	(0.4991)	(0.6044)	(0.5493)	(0.5702)	(0.5007)	(0.5205)	(0.6771)	(0.4336)
WSFDummy	0.2253	0.2817	0.2351	0.3351	0.0064	0.1022	0.0405	0.0481	0.0769	0.1188	-0.1073	-0.1344
	(0.2815)	(0.2624)	(0.2642)	(0.2713)	(0.2617)	(0.3334)	(0.3015)	(0.3323)	(0.2713)	(0.2992)	(0.4077)	(0.3710)
WA_built_not_WSF	-0.3468	-0.2610	-0.3276	-0.2344	-0.1148	-0.2282	-0.1105	-0.1137	0.3047	0.2935	0.1305	0.1001
	(0.2343)	(0.2133)	(0.2201)	(0.2281)	(0.2046)	(0.2266)	(0.2088)	(0.2193)	(0.2417)	(0.2478)	(0.3116)	(0.2552)
tons	0.0021 ***	0.0026 ***	0.0025 ***	0.0024 ***	0.0026 ***	0.0022 ***	0.0027 ***	0.0027 ***	0.0031 ***	0.0030 ***	0.0022 ***	0.0022 ***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0003)	(0.0004)	(0.0004)	(0.0006)	(0.0004)	(0.0006)	(0.0006)	(0.0005)
tons_sq	-2.7E-07 ***	-3.1E-07 ***	-3.0E-07 ***	-3.1E-07 ***	-3.3E-07 ***	-2.9E-07 ***	-3.4E-07 ***	-3.3E-07 ***	-4.2E-07 ***	-4.0E-07 ***	-3.2E-07 ***	-3.2E-07 ***
	(5.3E-08)	(5.2E-08)	(5.2E-08)	(5.1E-08)	(4.6E-08)	(5.3E-08)	(5.1E-08)	(7.6E-08)	(5.4E-08)	(7.3E-08)	(7.2E-08)	(6.7E-08)
PassengerCap	-3.2E-04 **	-3.4E-04 ***	-3.4E-04 ***	-2.3E-04	-2.7E-04 **	-2.5E-04 *	-2.7E-04 **	-2.6E-04 *	-3.4E-04 ***	-3.2E-04 **	-1.8E-04	-1.8E-04
	(1.3E-04)	(1.2E-04)	(1.2E-04)	(1.4E-04)	(1.3E-04)	(1.4E-04)	(1.3E-04)	(1.5E-04)	(1.2E-04)	(1.4E-04)	(1.6E-04)	(1.5E-04)
VehicleCapacity	-3.0E-03	-3.7E-03	-3.4E-03	-1.0E-03	-2.9E-03	8.4E-04	-3.4E-03	-3.2E-03	-1.5E-03	-7.4E-04	3.0E-03	2.8E-03
	(0.0028)	(0.0026)	(0.0026)	(0.0031)	(0.0028)	(0.0035)	(0.0035)	(0.0042)	(0.0032)	(0.0039)	(0.0030)	(0.0028)
ServiceLife											0.0115	0.0124
											(0.0140)	(0.0129)
Horsepower	7.1E-05 ***		2.6E-05	-1E-06	1.3E-06	-1.3E-06	1.5E-06	1.6E-06	-1.8E-05	-1.8E-05	-4.9E-06	
	(1.2E-05)		(2.3E-05)	(3.0E-05)	(2.7E-05)	(3.0E-05)	(2.7E-05)	(2.8E-05)	(2.5E-05)	(2.6E-05)	(2.8E-05)	
HullMaterial		-1.4249 ***	-0.9952 **	-0.7017	-0.7643 *	-0.2804	-0.8570	-0.8384	-0.8277	-0.7257		
		(0.2236)	(0.4370)	(0.4836)	(0.4262)	(0.5975)	(0.5789)	(0.6667)	(0.5203)	(0.5995)		
DoubleEnded				-0.7917	-0.3764	-0.8322	-0.3483	-0.3714	-0.7484	-0.8801	-1.2601 **	-1.1838 ***
				(0.5904)	(0.5371)	(0.5873)	(0.5586)	(0.6871)	(0.5230)	(0.6444)	(0.5353)	(0.3129)
AmnPass					0.4780 ***		0.5004 **	0.4863	0.6760 ***	0.6018 **	0.4345 *	0.4363 *
					(0.1558)		(0.1836)	(0.3006)	(0.1771)	(0.2730)	(0.2326)	(0.2280)
AmFood						0.4009	-0.0854	-0.0742	-0.1254	-0.0653	0.2733	0.2673
						(0.3382)	(0.3533)	(0.4052)	(0.3179)	(0.3635)	(0.2516)	(0.2445)
HDummy								0.0189		0.1031	0.2299	0.2253
								(0.3157)		(0.2849)	(0.2589)	(0.2527)
OpLBS									-0.4643 **	-0.4712 **	-0.4517 **	-0.4405 **
									(0.1703)	(0.1743)	(0.1813)	(0.1668)
R_Square	0.893	0.905	0.909	0.914	0.936	0.918	0.936	0.936	0.950	0.950	0.949	0.949
Adj_R_Sq	0.869	0.884	0.885	0.888	0.913	0.889	0.910	0.906	0.927	0.925	0.922	0.925

Sample size is 39. Standard errors in parenthesis.
Statistical significance indicated by *** (.01), ** (.05) and * (0.10).

III. Industrial Classification Systems

In 1997, data collection by the U.S. federal government for classifying data on U.S. business establishments transitioned from the Standard Industrial Classification (SIC) code system to the North American Industry Classification System (NAICS). While the NAICS system is the primary system relevant to the data used in the report, some pre-1997 data is classified according to the older SIC system. For the purposes of examining the shipbuilding industry, this change is of little consequence. The correspondence between the two different classification systems for this industry is exact and is shown below in Exhibit A7. Both classifications systems include the same two sub-industry groups—"ship building and repair," and "boat building and repair." Detailed descriptions of each of these classifications are given below. [96]

Exhibit A7

Industry classification	SIC (pre-1997)	NACIS (1998 – present)
Ship and boat building and repair	3730	3366
Ship building and repair	3731	336611
Boat building and repair	3732	336612

The industrial classification system is hierarchical in nature, thus, the more highly disaggregated industries (NAICS 336611 and 336612 or SIC 3731 and 3732) combine to form the totals for the more aggregated industries (NAICS 3366 or SIC 3730). The first of these groupings (NAICS 336611 or SIC 3731) encompasses commercial ship building and is the industry most relevant to the full analysis in the report. However, some data sources (such as the American Community Survey) only include the broader industry classification (NAICS 3366 or SIC 3730), which is the aggregation of the two underlying sub-industries— it is noted when this is the case.

These industrial codes correspond to all privately-owned business establishments engaged in ship building and repair. Government-owned shipyards are not included in the industry classification. Ship repair conducted in floating dry docks is classified elsewhere in NAICS 488390—this has been consistent under both the SIC and NAICS classification systems. Referring to the more recent NAICS classifications, each sub-industry category is described in the next section.[97]

[96] http://www.census.gov/eos/www/naics/concordances/concordances.html and http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012.
[97] http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=336611&search=2012%20NAICS%20Search and http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=336612&search=2012%20NAICS%20Search.

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336611 Ship building and repairing

This U.S. industry comprises establishments primarily engaged in operating a shipyard. Shipyards are fixed facilities with drydocks and fabrication equipment capable of building a ship, defined as watercraft typically suitable or intended for other than personal or recreational use. Activities of shipyards include the construction of ships, repair of ships, conversion and alteration, the production of prefabricated ship and barge sections, and specialized services, such as ship scaling. A detailed listing of types of establishments follows.

Exhibit A8

NAICS Ship Classifications by Sub-Industry Category

2012 NAICS	Corresponding index
336611	Barge building
336611	Cargo ship building
336611	Container ship building
336611	Dredge building
336611	Drilling and production platforms, floating, oil and gas, building
336611	Drydock, floating, building
336611	Ferryboat building
336611	Fireboat building
336611	Fishing boat, commercial, building
336611	Hydrofoil vessel building and repairing in shipyard
336611	Naval ship building
336611	Oil and gas offshore floating platforms manufacturing
336611	Passenger ship building
336611	Patrol boat building
336611	Sailing ships, commercial, manufacturing
336611	Ship dismantling at shipyards
336611	Ship repair done in a shipyard
336611	Ship scaling services done at a shipyard
336611	Ships (i.e., not suitable or intended for personal use) manufacturing
336611	Shipyard (i.e., facility capable of building ships)
336611	Submarine building
336611	Towboat building and repairing
336611	Tugboat building
336611	Yachts built in shipyards

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336612 Boat building

This U.S. industry comprises establishments primarily engaged in building boats. Boats are defined as watercraft not built in shipyards and typically of the type suitable or intended for personal use. Included in this industry are establishments that manufacture heavy-duty inflatable rubber or inflatable plastic boats (RIBs).

Exhibit A9

NAICS Boat Classifications by Sub-Industry Category

2012 NAICS	Corresponding index
336612	Air boat building
336612	Boat yards (i.e., boat manufacturing facilities)
336612	Boats (i.e., suitable or intended for personal use) manufacturing
336612	Boats, inflatable plastics (except toy-type), manufacturing
336612	Cabin cruiser
336612	Dories building
336612	Hovercraft building
336612	Inflatable plastic boats, heavy-duty, manufacturing
336612	Inflatable rubber boats, heavy-duty, manufacturing
336612	Motorboat, inboard or outboard, building
336612	Pleasure boats manufacturing
336612	Rigid inflatable boats (RIBs) manufacturing
336612	Rowboats manufacturing
336612	Sailboat building, not done in shipyards
336612	Underwater remotely operated vehicles (ROVs) manufacturing
336612	Yacht building, not done in shipyards

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IV. The Impact of Ferry Construction on Employment in the Washington State Shipbuilding Industry

It might seem obvious that building ferries in Washington State will increase total employment in Washington State shipyards. However, economic theory tells us that in an economy in which labor and capita are fully employed, or nearly so, there will necessarily be offsetting decreases in economic activity elsewhere in the economy as resources are shifted to ferry construction. Thus, it is possible that the construction of a ferry might simply displace the construction of another non-ferry ship project. If so, we would expect to observe no net increase in employment in the shipyard industry. A related possibility is that increases in shipyard employment may reduce employment in other industries. For example, workers in some highly skilled occupations, such as welding, may be drawn to employment in the shipyards when economic activity in the shipyards increases, resulting in decreases in employment in other industries such as construction.

The main benefit of adopting an open bidding policy would be the potential for reduced ferry acquisition costs. These savings represent a benefit to Washington State taxpayers. Open bidding is likely (but not certain) to shift the production of ferries from in-state shipyards to out-of-state shipyards. In this analysis, we specifically look at the impact of shifting ferry construction out-of-state. This shift may entail a loss of income for Washington State residents—both workers in the shipyards, as well as the owners of the shipyards. Such a loss of income would represent costs imposed on some Washington State residents. The size of this effect will depend on how quickly shipyard workers and owners are able to transition to other economic activity in response to the loss of ferry building activity. For shipyard owners this will entail finding new customers; shipyard workers have the additional option of finding new employment in other industries. The net benefit of a change to out-of-state construction is equal to the benefits from the acquisition savings realized by Washington taxpayers minus the loss of income to shipyard workers and owners.

In this section, we use historical data to look for evidence of an empirical relationship between total employment in Washington State's ship building industry and the construction of Washington State Ferries. We estimate a time-series regression for total employment in the Washington State shipbuilding industry for a 38-year period from 1977 to 2014. The model is simple and parsimonious: we explain shipyard employment as function of a long-run time-trend and binary variables indicating the construction of a Washington State ferry. We find that employment growth in the shipbuilding industry has declined an average of 2.3% annually between 1977 and 2014. This result is extremely stable across a variety of model specifications.

To ensure that our results were robust, we explore a variety of model specifications. We do not find any empirical evidence of a relationship between ferry construction and shipyard employment in Washington State. Indeed, in various specifications of the model, we find that the percentage change corresponding to median point estimate of the impact of ferry construction on employment is -2.98% with a range that included both positive and negative values (-13.03% to 0.98%). Negative values imply that ferry construction results in lower total employment in the shipyard industry. Using the median estimated impact (-2.98%) implies that there would be approximately 97 *fewer* Washington State shipyard jobs as a result of ferry construction. It is worth noting that our empirical analysis typically finds no statistically significant relationship between employment and ferry construction with the exception of one model specification in which the impact was negative. This means we cannot reject the hypothesis that there is no relationship between ferry construction and shipyard employment. Generally, these results are

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consistent with the idea that ferry construction simply displaces other projects in the shipyards. Historically, there is no evidence of slack capacity in the shipyard industry which could be easily shifted into the construction of additional ferries. Thus, the opportunity cost of building ferries in Washington State is likely the loss of other non-ferry ship construction projects.

Data

We measure employment using annual data from the state summary file of the County Business Patterns prepared by the U.S. Census Bureau for the years from 1977 to 2014 (see Exhibit A10 on pg. 49). The shipbuilding industry is formally defined as privately-owned establishments engaged in the construction and repair of ships, including Standard Industry Codes (SIC) codes 3731 (prior to 1998) and NAICS code 336611 (from 1998 on). (See Appendix III in this document for details on the structure and content of these industry classifications.)

The underlying source of the County Business Pattern data is administrative data prepared by individual business establishments for the Social Security Administration. The data covers virtually all workers in the U.S. and 100% of workers in shipyards. Because of disclosure requirements protecting the individual reports by specific establishments, employment data was suppressed for three years: 1981, 1990, and 1991. We impute these missing values by using information tabulated for various ranges of establishment employment levels. Although the individual employment levels for each establishment are not reported, we use the midpoint of the ranges to generate plausible values for total employment in the shipbuilding industry in Washington State.

We do not know the exact dates corresponding to the interval for the construction of ferries in Washington. However, we do know the date in which each ferry was originally placed into service. We assume the employment effects resulting from ferry construction would have occurred in the year to, or the two years prior to, the ferry entering service. We construct binary indicator variables based on both of these concepts and test alternative specifications of the model using both versions. We can further distinguish between ferries that were newly built and those that were rebuilt. Thus, we construct two versions of the indicator variables: one corresponding to the newly built ferries only and a second version corresponding to newly built and rebuilt ferries.

Statistical Model

To investigate the relationship between ferry construction and shipyard employment, we estimate the following regression model:

$$EMP_t = A\ FERRY_t\ e^{rt}$$

In this specification, EMP_t is total employment in the Washington shipyard industry in year t, A is a constant term, $FERRY_t$ is a binary variable indicating ferry construction in year t, r is the long-term growth of employment in Washington's shipyard industry, and t is the four-digit year ranging from 1977 to 2014. Taking natural logs yields:

$$Ln(EMP_t) = Ln(A) + FERRY_t + rt$$

Thus, the regression equation to be estimated is:

$$Ln(EMP_t) = \beta_0 + \beta_1 FERRY_t + \beta_2 t$$

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The estimated coefficient on t (β_2) is the average annual percentage growth rate in employment in Washington's shipyard industry. The coefficient on *FERRY* (β_1) captures any impact of ferry construction. The estimated percentage impact on shipyard industry employment is equal to $e^{\beta 2} - 1$.[98]

Because the model is a time-series specification, serial autocorrelation is a potential problem. To insure that the estimated coefficients are not statistically biased, we estimated the equation using an autoregressive model with two lags. The resulting Durbin-Watson statistics from various models are close to 2, ranging in values from 2.12 to 2.16. We experimented with shorter and longer lag structures and the results are qualitatively similar to what is shown in Exhibit A11. Indeed, the results are qualitatively similar even when the model is OLS without a correction for serial correlation.

Results

Exhibit A11 presents the results from four alternative specifications of the model corresponding to the specification of the binary indicator variables. In the first two versions, we include only the new ship builds and the binary indicator variables are *B1* and *B2: B1* corresponds to a single-year construction period (the year prior to ferry completion) and *B2* corresponds to a two-year construction period (the two years prior to ferry completion). We also expanded the concept to include both new and rebuilt ships (binary indicator variables *BR1* and *BR2*), again using the same two versions of construction periods.

The estimated long-term growth of industry employment is quite stable. The median estimate is -2.3% and the range is -2.5% to -2.27%. These estimates are all statistically significant.

The estimates of the percentage impact of ferry construction on shipyard employment are quite mixed and range from -13.03% to 0.98%. The median estimated impact is -2.98%. These estimated coefficients are typically not statistically significant, except in one case where the impact of ferry construction on shipyard employment is negative. Applying the estimated median percentage impact on the 2014 shipyard employment level, we find the estimated impact of ferry construction on shipyard employment is 97 fewer jobs. However, the range of estimates from Exhibit A11 indicates that the estimated impact of ferry construction on shipyard employment could range from 426 fewer jobs to 32 additional jobs.

Summary

Based on this analysis, we conclude that there is no empirical evidence of a relationship between Washington State Ferry construction and total employment in Washington's shipyard industry. This is consistent with ferry construction displacing other activities in the shipyard industry.

[98] Halvorson & Palmquist (1980).

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Exhibit A10

Employment in Shipbuilding and Repair Industry, Washington State, 1977-2014

Year	Employment
1977	5,617
1978	7,172
1979	9,065
1980	10,696
1981	10,476
1982	13,496
1983	11,145
1984	8,748
1985	6,847
1986	4,480
1987	4,763
1988	5,514
1989	5,680
1990	5,214
1991	4,928
1992	3,529
1993	2,910
1994	2,598
1995	2,957
1996	3,326
1997	3,575
1998	3,190
1999	3,301
2000	3,491
2001	3,099
2002	2,628
2003	3,281
2004	3,421
2005	3,782
2006	4,011
2007	4,033
2008	4,411
2009	4,644
2010	3,935
2011	3,937
2012	3,829
2013	3,805
2014	3,268

Source: U.S. County Business Patterns; see text for details.

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Exhibit A11

Estimated Impact of Ferry Construction on Shipyard Employment, Washington State, 1977-2014

	Model	Mean of dummy variable	Estimated coefficient	t-statistic		Estimated percentage effect#	R-squared	Durbin-Watson	AR structure
Control for ferries built									
Ferry (1 prior year)	1	0.263	-0.022	-0.36		-0.022	0.139	2.16	2
Time (*t*)	1		-0.023	-2.26	*				
Ferry (2 prior years)	2	0.342	-0.038	-0.58		-0.037	0.144	2.13	2
Time (*t*)	2		-0.023	-2.31	*				
Control for ferries built or rebuilt									
Ferry (1 prior year)	3	0.526	0.010	0.21		0.010	0.136	2.12	2
Time (*t*)	3		-0.023	-2.26	*				
Ferry (2 prior years)	4	0.658	-0.140	-2.78	**	-0.130	0.307	2.15	2
Time (*t*)	4		-0.025	-2.79	**				
Time-trend only model									
Time (*t*)	5		-0.023	-2.31	*		0.136	2.13	2
N obs	38								
*significance < 0.05									
**significance <0 .01									

Note:
#Calculated as *exp(coeff)-1*, where *coeff* is the estimated OLS regression coefficient from an equation with a logged dependent variable. See Halvorson & Palmquist (1980).

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V. Major Occupations of Shipyard Workers

The distribution of workers in the ship and boat building industry (NAICS 3366) across occupations is tabulated from household-level data from the American Community Survey for the years 2001-2009 and shown in Exhibit A12. Occupational distributions are tabulated separately for workers in Washington State shipyards and for those in shipyards in the other eight major shipbuilding states (based on size of employment in this industry). Occupational categories with at least 1% of industry employment in either Washington or in the other eight major shipbuilding states are included.[99]

Exhibit A12

Major Occupations of Workers Reporting Work in Ship and Boat Building, (NAICS 3366), American Community Survey PUMS, 2001-2009

Census Occupation Code	Occupation Title	Percent of Ship and Boat Building Workers: Washington State	Percent of Ship and Boat Building Workers: Major Shipbuilding States
7750	Miscellaneous Assemblers and Fabricators	7.53	3.64
7700	First-Line Supervisors/Managers of Production and Operating Workers	5.97	6.79
8140	Welding, Soldering, and Brazing Workers	5.51	9.86
6350	Electricians	5.40	5.25
6230	Carpenters	5.12	2.68
6440	Pipelayers, Plumbers, Pipefitters, and Steamfitters	4.11	4.45
7330	Industrial and Refractory Machinery Mechanics	3.82	2.90
430	Managers, All Other	3.67	3.13
1440	Marine Engineers and Naval Architects	3.58	3.77
8810	Painting Workers	2.98	2.96
9620	Laborers and Freight, Stock, and Material Movers, Hand	2.57	1.70
8960	Production Workers, All Other	2.48	1.46
7560	Riggers	2.43	1.34
7210	Bus and Truck Mechanics and Diesel Engine Specialists	2.11	1.00
1550	Engineering Technicians, Except Drafters	1.84	1.18
8160	Lay-Out Workers, Metal and Plastic	1.52	1.43
6400	Insulation Workers	1.44	1.02
1460	Mechanical Engineers	1.42	0.87
5600	Production, Planning, and Expediting Clerks	1.27	1.69
7340	Maintenance and Repair Workers, General	1.21	0.72
8220	Metalworkers and Plastic Workers, All Other	1.19	2.38
530	Purchasing Agents, Except Wholesale, Retail, and Farm Products	1.18	0.77
7000	First-Line Supervisors/Managers of Mechanics, Installers, and Repairer	1.15	0.62
5620	Stock Clerks and Order Fillers	1.11	0.64
5700	Secretaries and Administrative Assistants	0.96	1.39
8740	Inspectors, Testers, Sorters, Samplers, and Weighers	0.95	1.77
1530	Engineers, All Other	0.83	1.83
2630	Designers	0.46	2.33
6520	Sheet Metal Workers	0.34	1.39
	Major Occupations -- Total	74.17	70.94

[99] Alabama, California, Connecticut, Louisiana, Maine, Mississippi, Texas, and Virginia.

VI. Differences in Shipbuilding Labor Cost across States

We examine several national data sources that provide information on labor cost differentials between shipbuilding in Washington State and elsewhere. Interest in labor costs derives from the fact that ferry construction costs are driven by the costs of inputs in the production process. We assume that all shipyards purchase non-labor inputs in national markets and therefore face roughly the same costs for these inputs. Labor costs can differ by region, however, and as such these are likely to be the primary determinants of ferry construction costs differences across states and regions. Regional labor cost differences as measured here can result from a number of factors. Measured differences can reflect differences in worker skill and productivity levels that cannot be accounted for in this analysis, they can reflect competitive conditions in regional labor markets, or they can reflect different state by state sub-industry mixes within the aggregate ship and boat building industry identified here. Such differences in labor costs are unlikely to be affected by whether Washington State restricts ferry purchases to in-state producers or not.

We derive estimates of labor cost differentials for the Washington State shipyard industry, drawing on data from two types of data sources. First, we use state summary data on payroll (and when available, on other costs of compensation as well) in the shipbuilding industry to calculate payroll per employee as a measure of labor costs. Such data are available from two different U.S. Census Bureau products—the state summary of the County Business Patterns data and the 2012 Economic Census. In addition, we draw on individual-level data from the Public Use Micro Samples (PUMS) of the American Community Survey (ACS). The Census Bureau has implemented the ACS by conducting an annual survey of approximately two million households each year since 2000. Our analysis of each of these data sources is discussed below.

Aggregate Labor Cost Data

To analyze labor costs in the ship building and repair industry (NAICS 336611) in Washington and other states we compile data from the Economic Census for five year intervals from 1997 through 2012. (The Economic Census survey is conducted by the Census Bureau every five years in years ending in 2 and 7). We use data on total industry employment and payroll to calculate payroll per worker. Our analysis focuses on the nine states with the largest shipbuilding activity in the U.S. Together these nine states comprise approximately 90% of the total employment in the shipbuilding industry in 2012. The nine states are Alabama, California, Connecticut, Louisiana, Maine, Mississippi, Texas, Virginia, and Washington.

Since 1997, there has been a general decrease in labor costs (as measured by payroll per worker) in Washington State relative to the U.S. as a whole and relative to the other eight large shipbuilding states. However, in the most recent data for 2012, a mixed picture emerges. Payroll per employee in the Washington State shipyards is below the U.S. average, but slightly above the other eight comparison states.

It is important to note that among the eight comparison states, payroll data is suppressed for three states: Connecticut, Maine, and Mississippi. The Census Bureau suppresses data when there are a small number of business establishments in a state and publication would violate data confidentiality protections. For those states, it provides a range of possible employee counts rather than an exact number. The Census Bureau reported there were between 5,000 and 9,999 shipbuilding and repair employees in Connecticut and Maine in each of the four the time periods and between 10,000 and 24,999 employees in Mississippi

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during the last three time periods. In Exhibits A13 and A14, we report an imputed value at the midpoint of those ranges (7,500 and 17,500 respectively) for the states and time periods with suppressed data.

We also compile data from Census Bureau's County Business Patterns data (state summary files). These data are collected from individual establishments by the Social Security Administration for administrative purposes and obtained by Census Bureau for research purposes. Again, we compute payroll per worker for two recent years (2012 and 2014). The 2014 data is the most recent data available and the 2012 data allows a direct comparison with the Economic Census data.

Exhibit A13

	Total employment				Payroll per worker			
	1997	**2002**	**2007**	**2012**	**1997**	**2002**	**2007**	**2012**
Alabama	2,644	2,818	2,648	5,002	29,250	35,487	47,502	48,258
California	8,179	6,568	7,470	10,383	32,691	40,861	49,548	49,302
Connecticut	7,500	7,500	7,500	7,500	N/A	N/A	N/A	N/A
Louisiana	13,276	12,869	13,627	10,894	30,789	30,933	40,027	54,577
Maine	7,500	7,500	7,500	7,500	N/A	N/A	N/A	N/A
Mississippi	12,535	17,500	17,500	17,500	N/A	N/A	N/A	N/A
Texas	3,087	3,092	4,536	5,078	30,194	38,456	49,150	57,706
Virginia	22,086	20,077	22,943	27,300	37,271	45,881	51,612	59,441
Washington	3,597	3,244	4,615	4,033	38,291	44,564	48,676	55,456
U.S.	97,065	87,355	98,510	105,192	34,548	41,486	49,266	59,753
Nine state total employment	80,404	81,168	88,339	95,190				
% of U.S.	82.8%	92.9%	89.7%	90.5%				
Mean					32,039	38,324	47,568	53,857
WA relative to:								
U.S.					10.8%	7.4%	-1.2%	-7.2%
Eight states					19.5%	16.3%	2.3%	3.0%

Source: 1997, 2002, 2007, and 2012 Economic Census.
Note:
Employment data in shaded cells is imputed at the midpoint of reported range due to data suppression. The Census Bureau reported that there were between 5,000 and 9,999 shipbuilding and repair employees in Connecticut and Maine in 1997, 2002, 2007, and 2012 and between 10,000 and 24,999 employees in Mississippi in 2002, 2007, and 2012.

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Exhibit A14

Employment, Payroll and Payroll per Worker in the Ship Building and Repairing Industry

Nine largest ship building states, NAICS code 336611						
	2012			2014		
	Employment	Payroll ($1,000s)	Payroll per worker	Employment	Payroll ($1,000s)	Payroll per worker
Alabama	4,816	$245,781	$51,034	5,764	$305,200	$52,949
California	11,755	$507,187	$43,146	9,142	$499,659	$54,655
Connecticut	7,500	n/a	n/a	7,500	n/a	n/a
Louisiana	10,084	$592,656	$58,772	7,443	$421,800	$56,671
Maine	7,500	n/a	n/a	7,500	n/a	n/a
Mississippi	17,500	n/a	n/a	17,500	n/a	n/a
Texas	5,074	$288,243	$56,808	4,558	$281,683	$61,800
Virginia	37,500	n/a	n/a	37,500	n/a	n/a
Washington	3,829	$227,122	$59,316	3,268	$186,361	$57,026
Mean (excluding Washington)			$52,440			$56,519
Washington relative to large states			13.11%			0.90%
U.S.	108,311	$6,399,464	$59,084	106,734	$6,607,133	$61,903
Washington relative to U.S.			0.39%			-7.88%

Source: 2012 and 2014 County Business Patterns, State Summary Files.
Note:
Employment data in shaded cells is imputed at the midpoint of reported range due to data suppression. The Census Bureau reported that there were between 5,000 and 9,999 shipbuilding and repair employees in Connecticut and Maine and between 10,000 and 24,999 employees in Mississippi.

These data present a somewhat consistent picture for 2012. While the Economic Census data shows Washington State labor costs at 3.0% above the average for other ship building states, the Business Patterns data show Washington at 13.1% above the average for these other states. Compared to the U.S. average, however, the Economic Census data has Washington 7.2% below average in 2012 while the Business Patterns data shows Washington quite close to the national average. The two data sources are more closely aligned when the comparison is the U.S. as a whole. In 2014, the Business Patterns data suggest that Washington State's labor costs are nearly identical to the average for the other large ship building states and that Washington costs have fallen to nearly 8% below the U.S. average.

Individual Level Earnings Data

An alternative approach to estimating Washington's labor costs differences is to employ individual level data on wage and salary earnings to estimate differences in pay between ship and boat building and repair workers (NAICS 3366) in Washington State and those in the other major shipbuilding states. This comparison differs from the two above in that the focus is necessarily on the broader industry which includes both ship and boat building (NAICS 3366 instead of NAICS 336611). The data used here are derived from a household-based survey rather than an establishment-based survey. However, these data include richer information about workers including human capital variables such as education and potential experience. These variables are important because experience and education are proxies for labor productivity. Thus, the estimates produced below control for differences in labor productivity across states that would be linked to education and potential experience.

Data are drawn from the PUMS from ACS for the years 2001-2009. These years represent the most recent complete business cycle in the U.S. economy. Estimates based on the entire business cycle will "average out" any effects that might be associated with one particular point in the business cycle.

Sample. Workers included in the analysis are those aged 18-65 who had positive earnings from an employer in the year immediately prior to the survey, positive weeks and hours worked in that year, and who also reported that their most recent employment occurred in the ship and boat building industry (NAICS code 3366). The industry profile for industry 3366 combines the more disaggregated industries ship building and repair (336611) and boat building and repair (336612). In states with significant ship building activity, NAICS code 3366 will likely consist of a mix of both ship and boat building. In states without significant ship building activity, however, employment in the boat building sector (NAICS code 336612) will likely dominate NAICS code 3366. To address this issue, we restrict the sample to workers in the nine states with significant ship building activity, using the criteria of largest employment in shipbuilding (NAICS 336611) in the 2012 Economic Census of Manufacturing as discussed above. This approach restricts the comparison of Washington State workers to workers in states with a more similar industrial profile.[100]

Variables. Earnings measured are those from wage and salary employment only. Earnings from self-, farm- or family-employment are not included in the analysis. Earnings from all years are adjusted to 2014 dollars using the GDP Implicit Price Deflator.

In the ACS, earnings measures refer to totals for the 12-month period immediately preceding the survey. In contrast, the identification of industry of employment refers to the job held last week or, if the respondent is not currently employed, to the most recently held job within the past five years.[101] If the job held last week has not been long-lived then the earnings measured may correspond less than completely to the rate of earnings in the current industry of employment.

In some specifications, control variables for key worker productivity characteristics are included in the analysis as well. These are years of education for each worker (based on reported educational attainment) and estimated years of potential work experience (calculated as an individual's age minus their years of education minus six). Education in the ACS is coded categorically as different levels of educational attainment (e.g. high school graduation, some college but no degree, Associates degree, etc.) and these have been coded to the years of education that would normally be implied. In some cases, the educational attainment level specified represents a possible range of years of schooling. In these cases, the midpoint of the range is used. The educational attainment categories coded are slightly different for the ACS for 2001-2007 and for 2008-09. The categories and coding for each case are shown in Exhibit A15 (on the next page).

Estimated equation. Washington State earnings differentials are estimated from OLS regression based on the following equation:

$$(1)\quad Ln\ AE = a + b\ WA + c\ Year + d\ Ed + e\ Exp + f\ Exp^2$$

[100] For the purposes of identifying state, the location of worker's place of work is used. In some cases, particularly when metropolitan areas are next to or cross state boundaries, a worker's state of residence may actually be different from the state in which they work.
[101] If a person held more than one job last week, then information is recorded for the job at which they worked the most hours.

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Where *AE* represents annual earnings, *WA* is an indicator for workers living in Washington State, *Year* represents a series of indicator variables for years 2002-2009, and *Ed* and *Exp* represent years of education and potential work experience as defined above. Coefficient *b* is an estimate of the percentage pay difference between workers in Washington State and those in other included states in the same industry. All equations are estimated using the ACS PUMS population weights. As is typical for the estimation of earnings equations, a semi-log form is used to better fit the typical pattern of earnings. One consequence of using the natural log of the dependent variable is that the coefficient on any indicator variable can be interpreted as an approximate percent change in the dependent variable that is associated with a change in the indicator variable.[102]

Results. Estimated coefficients for *equation (1)* are presented below in Exhibit A15 with and without controls for education and potential work experience. The inclusion of controls for worker productivity has a small effect on the estimated differential for Washington State workers. Coefficients on all included variables are highly statistically significant. The coefficient comparing earnings in Washington to earnings in other states with significant shipbuilding industries is estimated as either 0.061 or 0.073, depending on the inclusion of worker productivity controls in the equation. These imply that either 6.3% or 7.6% higher earnings for Washington State workers in this industry as compared with workers in the same industry in other major shipbuilding states. These figures are an average across the years included (2001-2009) and are consistent with the measures derived from the Economic Census above for roughly the same time period.

Exhibit A15

Coding of Years of Education According to Educational Attainment, by ACS Year

ACS 2001-07		ACS 2008-09	
Educational Attainment Categories	Estimated Years of Education	Educational Attainment Categories	Estimated Years of Education
01 .No schooling completed	0	01 .No schooling completed	0
02 .Nursery school to grade 4	2.5	02 .Nursery school, preschool	0
03 .Grade 5 or grade 6	5.5	03 .Kindergarten	0
04 .Grade 7 or grade 8	7.5	04 .Grade 1	1
05 .Grade 9	9	05 .Grade 2	2
06 .Grade 10	10	06 .Grade 3	3
07 .Grade 11	11	07 .Grade 4	4
08 .12th grade, no diploma	12	08 .Grade 5	5
09 .High school graduate	12	09 .Grade 6	6
10 .Some college, but less than 1 year	12.5	10 .Grade 7	7
11 .One or more years of college, no degree	14.5	11 .Grade 8	8
12 .Associate's degree	14	12 .Grade 9	9
13 .Bachelor's degree	16	13 .Grade 10	10
14 .Master's degree	18	14 .Grade 11	11
15 .Professional school degree	18	15 .12th grade - no diploma	12
16 .Doctorate degree	21	16 .Regular high school diploma	12
		17 .GED or alternative credential	12
		18 .Some college, but less than 1 year	12.5
		19 .1 or more years of college credit, no degree	14.5
		20 .Associate's degree	14
		21 .Bachelor's degree	16
		22 .Master's degree	18
		23 .Professional degree beyond a bachelor's degree	18
		24 .Doctorate degree	21

[102] The precise percentage difference is exp(*b*) – 1. See Halvorsen and Palmquist (1980).

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Exhibit A16

OLS Regressions Explaining Pay in the Ship and Boat Building Industry (NAICS 3366), 2001-2009 (standard errors in parentheses)

Dependent variable:	Major shipbuilding states[#] Ln annual earnings			
Intercept	10.680 (0.026)	***	8.768 (0.053)	***
Work in Washington State indicator	0.061 (0.023)	***	0.073 (0.021)	***
Education (years)			0.093 (0.003)	***
Potential work experience (years)			0.049 (0.002)	***
Potential work experience-squared			-0.001 (0.0000)	***
Year dummies included	Yes		Yes	
N	6,461		6,461	
Adj R-squared	0.006		0.218	

Note:
[#]Alabama, California, Connecticut, Louisiana, Maine, Mississippi, Texas, Virginia, and Washington.

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VII. Economic Impact Analysis

In addition to the BCA outlined in Appendix I, WSIPP conducted an economic impact analysis (EIA) of how the alternative policy scenarios would affect various aspects of the state's economy. This analysis was conducted using Regional Economic Models, Inc.'s (REMI) Tax-PI software (v 1.7.105) software program.[103] Joint Legislative Audit and Review Committee (JLARC) staff contributed to the economic impact analysis for this legislatively required study. JLARC modeled several policy options in coordination with WSIPP staff using the REMI model.

REMI software is used by state agencies in about two-thirds of U.S. states and is also widely used by private sector research and consulting firms. Tax-PI is a software tool that embodies a specific implementation of the more general concept of economic impact analysis. In particular, the REMI software allows for the assessment of a specific policy change—such as requiring that ferries be built in Washington State—on economic effects and demographic outcomes. REMI is sectoral-based model containing 160 industrial sectors classified using NAICS codes. The model has been customized to reflect the particular industrial composition of the Washington State economy.

Current policy requires the construction of ferries in Washington State. A change in that policy to allow open bidding from shipyards across the U.S. would increase the possibility that future ferry construction would take place outside of Washington State. We used the REMI model to assess how shifting ferry construction out of state would result in a reduction of business activity (sales) in Washington State Shipyards (NAICS code 336611).[104] Specifically, the REMI model projects two future scenarios: a baseline scenario based on the current policy environment and an alternate scenario resulting from the policy change. The difference between the two scenarios represents the projected policy impact. The baseline scenario leaves current policy unchanged and projects key outcomes for the state economy over the next 25 years. The alternate scenario is identical to the baseline in every respect but one: we assume there will be a $130 million (in current dollars) reduction in ferry construction spread equally over 2021 and 2022.[105] We select 2021 as the starting point for this scenario because the Washington State Ferry Vessel Procurement Plan, as updated in 2016, anticipates beginning construction of a new 144-car ferry in that year.[106] WSF estimates a $130 million cost of the hypothetical ferry ship in current year dollars.[107]

The REMI model captures impacts from a policy change. Primary impacts are those that occur in the specific businesses or industry affected by a given policy.[108] In this case, the affected industry is the ship and boat building industry (NAICS code 3366). The construction of a ferry in Washington State increases revenues, employment, and income in the shipyard industry. In particular, earnings will increase for

[103] See Waters (1976) for a description of the differences in evaluative studies (such as BCA) and impact studies (such as EIA). Vining et al. (2011) have a similar discussion pp. 8-9, and 18-20.

[104] NAICS code 336611 is the most detailed industry code for the industry classification associated with ferry construction. This category includes ship building and repair and focuses on all types of ships including ferries, barges, other commercial vessels, and military ships, though it excludes boats. Boats are recreational in nature, while ships are commercial. NAICS code 336612 incorporates boat building, while NAICS code 3366 is the broader classification that incorporates both ship and boat building and repair.

[105] Historical analysis of ferry ship construction indicates that material costs make up a greater percentage of the costs in the first year, while labor costs make up a greater percentage in the second year of construction. We chose to evenly distribute the costs because the true distribution added complexity while having only a negligible impact on the results.

[106] Washington State Department of Transportation, Ferries Division. (2009), Information on WSF's updated procurement plan was provided to WSIPP via email (von Ruden, M. personal communication, June 28, 2016).

[107] M. von Ruden (personal communication, June 28, 2016).

[108] The REMI software refers to these effects as direct effects.

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workers, and the owners of the shipyard will experience an increased return to their capital investment in the shipyard industry.

In addition to primary effects, there are secondary effects or multiplier effects. These effects occur because the primary activity (ferry ship construction) generates additional business for other firms that supply inputs to the ferry construction process. Businesses in the shipyard industry will increase their purchases of intermediate goods and services which are used in the production of ferries. Examples might include intermediate products such as steel, and electricity as well as intermediate services such as accounting, and legal representation. In addition, secondary or multiplier effects are generated when the extra income realized by shipyard workers and owners leads to additional consumption spending in the economy, which in turn generates still more economic activity. REMI fully accounts for both of these multiplier effects, and refers to them as indirect effects and induced effects, respectively. The REMI model also explicitly models "leakages" from the local economy. That is, the model accounts for the fact that not all of the secondary spending will occur in Washington State.

Outcomes

REMI produces a wide array of outcomes, but here we focus on a several selected key indicators that capture the broad impact on the economy. These include non-farm private employment, total state population, and value added.[109] Exhibit A17 provides detailed definitions of these concepts.

Exhibit A17

Economic Impact Outcomes

Outcome	Definition
Private non-farm employment	Employment comprises estimates of the number of jobs (full-time plus part-time) by place of work for all industries except government and farm. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included, but unpaid family workers and volunteers are not included.
Population	Population reflects mid-year estimates of people, including survivors from the previous year; births; special populations; and three types of migrants (economic, international, and retired).
Value added	The sum of value added for private non-farm industries, state and local government, federal civilian, federal military, and farm sectors.

Notes:
These definitions are provided in documentation for the (REMI) Tax-PI software (v 1.7.105) software program.

[109] We use value added instead of gross domestic product for impact outcomes to facilitate the analysis of direct and indirect impacts in Exhibit A19. The two accounting concepts are virtually identical as can be seen from this definition provided by the Bureau of Economic Analysis (BEA): "The value added of an industry, also referred to as gross domestic product (GDP)-by-industry, is the contribution of a private industry or government sector to overall GDP. The components of value added consist of 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 (consisting of sales or receipts and other operating income, commodity taxes, and inventory change) and the cost of its intermediate inputs (including energy, raw materials, semi-finished goods, and services that are purchased from all sources)." See http://www.bea.gov/faq/index.cfm?faq_id=184.

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As would be expected, the main impacts of the analyzed policy change occur in the years 2021 and 2022. These results are displayed in Exhibit A18. As a result of the policy change we would expect an average yearly decrease in employment of about 659 jobs in 2021 and 2022.[110] GDP will fall by about $68 million in each year as well. By the end of 2022, population in the state is forecasted to be 112 below the baseline forecast. After 2022, the selected outcome variables quickly resume a path that converges with the baseline forecast.

Exhibit A18

Policy Simulation Results, Economic Impact Analysis

Yearly outcomes averaged over 2021-2022			
Outcome	**Baseline scenario**	**Alternate scenario**	**Policy impact**
Private non-farm employment	3,599,945	3,599,286	-659
Population	7,740,957	7,740,845	-112
Value added	$492,068 million	$492,000 million	($68 million)

Note:
Value added is measured in millions of 2014 dollars. Numbers may not sum exactly due to rounding.

The total policy impacts displayed in Exhibit A18 can be broken into direct effects and multiplier effects. Direct impacts are a result of the extra income earned by shipyard workers and owners as a result of building the ferry. Multiplier impacts occur in other parts of the economy. For example, the shipyard building the ferry will purchase a wide range of goods and services required as inputs in the ferry construction process. These purchases will generate income in other parts of the Washington State economy. Further, as a result of increased income consumers will increase their purchase of a wide range of goods and services. This activity will also contribute to multiplier effects. Exhibit A19 displays the total policy impact (replicated from Exhibit A18) broken down into direct and multiplier effects. The results indicate that somewhat less than half of the total forecasted impact is a direct impact occurring in the ship and boat building industry—more than half of the forecasted impacts occur outside of the ship and boat building industry.

Exhibit A19

Policy Impacts, Economic Impact Analysis
Yearly Outcomes Averaged Over 2021-2022

Outcome	**Baseline scenario**	**Alternate scenario**	**Total policy impact (= direct effect + multiplier effect)**		
			Direct effect	*Multiplier effect*	*Total policy impact*
Private non-farm employment	3,599,945	3,599,286	-280	-379	-659
Value added	$492,068 million	$492,000 million	($25 million)	($43 million)	($68 million)

[110] Note that these are total jobs rather than employed persons. The same employed person could hold several jobs simultaneously.

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VIII. Case Studies on Ferry Procurement

BC Ferries

BC Ferries (British Columbia Ferry Services Inc.) operates the ferry services in British Columbia, Canada, linking the mainland of the province to various coastal communities. BC Ferries is the largest ferry operator in the world, with a fleet of 34 vessels that serve 47 terminals.[111] Unlike WSF, which is committed to standardizing its fleet into specific classes of vessels, BC Ferries has a greater amount of variation in its ships. BC Ferries has significantly shifted how it operates and procures ferries over the last 30 years.

BC Ferries' history of shipbuilding parallels that of the Pacific Northwest. The region experienced a boom in shipbuilding during World War II, but by the 1990s, the regional industry had contracted. The provincial government created an initiative whereby private shipyards would build a series of four high-speed ferries. The construction would be overseen by BC Ferries. The goals of the program were to meet regional transportation needs, generate jobs, and training and revitalize the shipbuilding industry through future exports of aluminum fast ferries.[112]

As a Crown corporation, BC Ferries was intended to operate relatively independently from elected government; however, in practice, business decisions were still made by elected officials, which undermined the intent of the organizational structure.[113] According to a report from the Office of the Auditor General of British Columbia, the ten-year plan was taken over and significantly modified by political leadership (the minister in charge of the Crown Corporations Secretariat). A long-term plan with a timetable and costs for the proposed fast ferries was published. Although BC Ferries no longer had direct control over their long-term plan, the agency was still responsible for achieving the goals the plan laid out.

Later, BC Ferries discovered that none of the local shipbuilding yards was willing to be the lead shipyard on the fast ferries project. None of the shipyards had capacity to handle the entire ferry construction process, which led BC Ferries to acquire a site for the final assembly. BC Ferries created a wholly owned subsidiary to take on project management and the substantial amount of the risk that comes with a construction project.[114]

The cost for the ferries stretched from a projected $210 million to $463 million, and the schedule fell over two years behind.[115] In its original ten-year plan, BC Ferries had advocated a cautious approach to fast ferry construction, including the leasing of fast ferries for trials. However, this testing was removed from the final plan, and the resulting ferries were not suitable for rough water along the routes. The ferries were also plagued by mechanical problems and caused a high wake. The ferries used a significant amount of fuel, and when gas prices spiked, the operational costs increased significantly. The third class in the series was completed but never put into service, and the fourth ferry was never constructed. The ferries were dry docked for years and then sold for about $19 million.[116]

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[111] http://www.bcferries.com/about/More_Information.html
[112] http://www.bcauditor.com/sites/default/files/publications/1999/report5/report/review-fast-ferry-project-governance-and-risk-management.pdf, p. 5.
[113] Ibid, p. 12.
[114] Ibid, p. 23.
[115] Ibid, p. 7.
[116] http://www.cbc.ca/news/canada/british-columbia/b-c-fast-ferries-sold-to-uae-buyer-1.852093

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A BC Auditor's report concluded that the construction of the ferries was done before sufficient testing of the design because the ferries could not hold up in the water conditions of the routes. The auditor's office also noted that there was no evaluation of whether the policy goal of revitalizing the shipbuilding industry could be achieved through domestic construction of fast ferries.[117] The "fast ferry fiasco," as it became known, resulted in the replacement of the board of directors and much of senior management and led to the restructuring of the corporation.

With the passage of the Coastal Ferry Act in 2003, BC Ferries changed from a provincial Crown corporation into an independently managed, publicly owned company.[118] This legislation, which followed an independent review of BC Ferries, moved BC Ferries further from government and closer to the private sector. In 2004, BC Ferries disqualified all of the Canadian shipyards from bidding on three new vessels and only considered bids from European shipyards.

Unlike WSF, which is required by the Jones Act to build ferries inside the U.S., BC Ferries can purchase internationally constructed ships, but has to pay a 25% import duty.[119] In 2004, BC Ferries awarded a three-ship contract worth $325 million ($267 million U.S.) to a German shipyard. BC Ferries' president stated that even with the import duty, construction in Germany would save almost $80 million.[120] In 2014, BC Ferries again awarded another three-ship contract to a European shipyard, this time to one in Poland.[121]

Alaska Marine Highway System

In the last decade, the Alaska Marine Highway System (AMHS) has changed how it purchases ferry ships. As one of the largest public ferry operators in the U.S., AMHS may provide some lessons learned for Washington State. However, there are a number of factors that distinguish the two ferry systems.

AMHS operates fewer routes and ships than Washington State Ferries (WSF). It has only 11 ships and serves 33 Alaskan communities, 28 of which aren't connected to the road system.[122] Conversely, WSF has a larger fleet of 24 vessels that sail to 20 terminals. Some of the routes served by AMHS are also substantially longer than those served by WSF. AMHS does operate some shuttle ferries that depart their home port in the morning, travel to destination ports, and then return to their home port on the same day.[123] AMHS' fleet also includes mainline and Aurora class vessels that can sail for multiple days and have crew quarters as well as possibly passenger staterooms.

Alaska's longer ferry routes serve more remote communities and are less profitable than shorter routes. AMHS's ships must be capable of operating in rougher water than WSF, particularly in the winter months. Ships that sail to Canada must be certified under the International Maritime Organization's Safety of Life at Sea (SOLAS) regulations. The requirements for greater seaworthiness, overnight accommodations, and regulatory compliance contribute to the complexity and cost of AMHS ferries.

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[117] http://www.bcauditor.com/sites/default/files/publications/1999/report5/report/review-fast-ferry-project-governance-and-risk-management.pdf, p. 6.
[118] http://www.bcferries.com/about/More_Information.html
[119] However, BC Ferries has been able to receive retroactive relief from these import duties in the past: http://www.timescolonist.com/news/local/jack-knox-ferries-make-headway-as-b-c-lobbies-for-federal-cash-1.2132867
[120] http://www.professionalmariner.com/February-2007/Construction-to-begin-in-Germany-on-large-double-enders-for-BC-Ferries/
[121] http://www.vancouversun.com/technology/Ferries+awards+contracts+three+ships+Polish+yard/9997896/story.html
[122] http://www.dot.state.ak.us/amhs/doc/reports/econ_15.pdf p. 6.
[123] http://www.dot.state.ak.us/amhs/alaska_class/documents/change_122012.pdf p. 1.

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The Alaska State Legislature has substantially changed its procurement practices over the last 30 years. The four ships purchased in the 1990s and 2000s were done so through open competition and subsidized by federal grant money. The current round of ship procurement was allocated through a non-competitive process that went without federal funds in order to guarantee that the ships were built in Alaska.

1990s: Kennicott. By the 1990s, the AMHS fleet had several ships nearing the end of their useful lives. According to an Alaskan Department of Transportation report, the top priority was replacing one of the larger mainline ships. However, the state also wanted a replacement ship that could travel across the Gulf of Alaska and respond to oil spills, which was relevant in the wake of the Exxon Valdez disaster. Building a ship that could meet this need would also make its purchase eligible for using federal emergency vessel funds.

The resulting Kennicott was completed in Mississippi by Halter Marine in 1998 at a cost of nearly $80 million. Controversy followed the construction. Halter Marine sued the state for $46 million for causing its cost overruns, but the shipyard filed for bankruptcy before the suit was settled. Alaska eventually settled the lawsuit by paying a subcontractor an amount between $500,000[124] and $1.2 million [125] according to contradictory sources.

2000s: Fast ferries. AMHS's next round of ferry procurement was also marked by controversy. In order to reduce operating costs, AMHS developed a plan of purchasing four smaller fast ferries that require smaller crews and operate only part of each day or week. According to an Alaskan DOT report, most of the funding to build the Fairweather and Chenega was provided by grants from the Federal Transit Administration and the Federal Highway Administration. The ships were built by Derecktor Shipyards in Bridgeport, Connecticut in 2003-2004 and 2004-2005.

The ships began experiencing mechanical difficulties immediately following delivery.[126] They had difficulty operating in the harshest weather of the routes and experienced more canceled sailings in the winter than was expected. The engines were also the subject of a drawn-out lawsuit between the state and the engine manufactures and the shipyard.[127] The fast ferries used more fuel than traditional ferries especially when routes are too short for the ferries to maintain top speed. When fuel costs unexpectedly increased, it resulted in dramatically escalated operational costs. In response to the problems with the fast ferries, the legislature did not approve the two additional ferries needed to complete the proposed four-ship fast ferry system.

However, AMHS did purchase one additional ship in the 2000s to create the system's first single shuttle route.[128] Conrad Shipyards in Louisiana built the Lituya, which was a smaller and less technical ship based off the design of offshore oil platform supply vessels.

[124] http://www.sitnews.us/0706news/070806/070806_marine_highway.html
[125] http://www.dot.state.ak.us/amhs/doc/reports/system_analysis.pdf
[126] The State of Alaska has been involved with a long-running lawsuit with the engine manufacturer according to the following: http://www.ktoo.org/2013/10/16/fast-ferry-engines/
[127] http://www.ktoo.org/2013/10/16/fast-ferry-engines/ Note that the shipyard went bankrupt before an agreement was reached, but Alaska was able to reach a settlement with the German engine manufacturer.
[128] http://www.dot.state.ak.us/amhs/doc/reports/system_analysis.pdf

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2010s: Current round of ship procurement. Beginning in 2006, AMHS began the design process for the ship intended to be the first Alaska Class Ferry. The vessel was initially envisioned as a day shuttle ferry with a roll-on-roll off design that would allow cars to load and exit through the stern/bow. The Alaska Department of Transportation and Public Facilities (DOT&PF) began working with naval architecture firm, Elliott Bay Design Group, to create a design study report. The report was completed in 2009 and had multiple changes from the original design, including the elimination of a bow door, an increased ferry length, and the addition of crew quarters. While the initial 2006 cost estimate for the ship was placed at between $25 million and $30 million, the estimate in 2009 had climbed to $120 million (both unadjusted).[129] In 2010, the Alaskan State Legislature appropriated $60 million to pay for the ferry, and was matched by $68 million in Federal Highway Administration funds.

Later in 2010, the recently-elected governor announced that AMHS would return the federal funds and scrap the designs develop so far. Instead, the governor stated that AMHS would build two small ships for the same $120 million budget and construction would happen in Alaska. The de-federalization of the project made it possible for AMHS to control the bidding process, including limit bidding to in-state shipyards.[130] In 2011, the state legislature appropriated an additional $60 million for the project, bringing the total funding amount to $120 million.

To negotiate the price of the new ferries, AMHS used a "construction manager/general contractor" (CMGC) process. Only Vigor Alaska was invited to participate in the CMGC bidding process. Vigor Alaska leases the Ketchikan shipyard, which is owned by the state's Alaska Industrial Development and Export Authority. Unlike a traditional low-bid process, the shipyard is involved early in the design process. Then, when the shipyard is familiar enough with the design to accurately estimate its cost, the shipyard negotiates a "guaranteed maximum price" at which it can be profitable and which the state thinks is fair.[131] The shipyard can develop a design that reduces construction costs through their knowledge of the construction process and information on the costs of components. The construction schedule can also be set collaboratively. For example, the ferry construction can be ramped up during summer seasons when Alaska's shipyards have less maintenance work. AMHS was able to negotiate with Vigor Alaska to construct the two day ferries for the $120 maximum agreed upon price.[132]

Both BC Ferries and AMHS illustrate different ways that public ferry systems have responded to the challenges of ferry procurement. Ferry construction is a niche market and the shipbuilding industry is highly concentrated. While BC Ferries has responded by opening up the bidding process, AMHS has used a CMGC process to reduce uncertainty and lower costs with its local shipyard.

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[129] http://www.dot.state.ak.us/amhs/alaska_class/documents/change_122012.pdf pp. 1-2
[130] Ibid.
[131] http://www.adn.com/print/article/20141005/new-ferry-contract-part-effort-create-shipbuilding-industry-alaska
[132] http://www.marinelog.com/index.php?option=com_k2&view=item&id=7763:vigor-alaska-to-build-two-new-amhs-ferries&Itemid=230

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IX. Recent History of WSF Vessel Procurement

Over the last 30 years, the majority of new ferry construction for WSF has been led by a single Seattle-based shipyard. Todd Pacific Shipyards, later acquired by Vigor Industrial, has been the lead shipyard in the construction of the last eight ships and three classes of ferries; however, other shipyards have collaborated on their construction.

Between 1994 and 1998, Todd Pacific Shipyards built the first car ferries built for WSF in 20 years. The three Jumbo Mark II class ferries are the largest ferries in the WSF fleet, with a capacity of 2,500 passengers and 202 vessels.[133] Despite this addition, the fleet had a number of aging vessels including four steel electric class ferries that had been constructed in 1927. WSF abruptly retired those four ferries after finding corrosion during an inspection. This action led to a crisis on the Port Townsend-Keystone route, with residents left without regular ferry service. WSF leased a Pierce County ferry to try to fill in the gap and requested bids for a 50-car ferry to serve that route. The single bid they received on the project from Todd Shipyards was rejected at $9 million over the engineer's estimate of about $17 million.[134] At the time, WSF explained the resulting higher bid as resulting in part from changes to the design, and Todd Shipyards also pointed to the strict one-year timeline for the project.[135]

In an effort to quickly construct a replacement for the steel electric ferries, WSF then purchased a design for a new 64-car ferry based on the Island Home. The original ferry had been constructed in 2005 by V.T. Halter Marine of Mississippi for the Steamship Authority (SSA), which oversees Massachusetts' ferry operations.[136] In November 2008, WSF released a new request for proposals (RFP) for two 64-car vessels based on this design. A 2013 State Auditor's Office Report analyzing WSF's vessel construction costs reported that the sole bid on this two-vessel contract came from a consortium of shipyards led by Todd Shipyard. The bid was about 30% over the engineer's estimates for the two ferries.[137]

During the SAO audit process, WSF explained that they purchased the design for a number of reasons—using an existing design would reduce design time; the design already used the propulsion systems that WSF had in storage; and the Island Home operates in a similar seasonal environment.[138] The final cost for the first ferry built on this design, the Chetzemoka, was significantly higher than the price for the Island Home.[139] The $87 million Chetzemoka included $10 million in change orders.[140] The original purchased design was modified via change orders for a number of reasons, including addressing excessive vibrations in the drive train; bringing the ferry into greater similarity to the fleet; and extending the length of the ferry.[141] Errors in the design and additional Coast Guard requirements not caught before construction began also caused delays.[142] The SAO identified these change orders as one of the main driver in the vehicle's cost. WSF

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[133] http://www.evergreenfleet.com/mark2.html
[134] http://www.seattletimes.com/seattle-news/state-rejects-todd-shipyards-ferry-bid/
[135] Ibid.
[136] Officially, this is the Woods Hole, Martha's Vineyard and Nantucket Steamship Authority.
[137] https://www.sao.wa.gov/state/Documents/PA_Ferries_Vessel_Construction_ar1008884.pdf, p. 19.
[138] Ibid, p. 25.
[139] According to the SAO's analysis which adjusted prices to 2011 dollars using a shipbuilding specific index, the Chetzemoka was about $87 million and the Island Home was about $48 million.
[140] SAO Report, p. 29. note that the $87 million (cost is in adjusted 2011 dollars) and includes $3.1 million for a propulsion system that WSF had previously acquired.
[141] For a good description of the changes made, see: http://www.professionalmariner.com/October-2010/Chetzemoka/.
[142] http://www.kitsapsun.com/news/local/new-state-ferry-five-weeks-late-and-counting-and-the-costs-are-mounting-ep-419524915-357553471.html

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completed the three Kwa-di Tabil class ferries between 2009 and 2011 (see Exhibit 2 on page two of the main report for the specific contracts award and paid amounts for these vessels).

In 2007, WSF signed a contract with a consortium of Washington Shipyards led by Todd Shipyards to build 144-car ferries. This construction was put on hold during the process of building the replacements for the steel electrics. In 2011, WSF renegotiated the price and construction schedule for the first 144-car ferry. Construction of the/ new Olympic class ferry started in early 2012, and the Tokitae was delivered in 2014. The Washington State Legislature then funded the construction of the second 144-car ferry (the Samish) in June 2012, which was delivered in 2015. Funding for the third Olympic class ferry was authorized by the legislature in spring of 2014 (the Chimacum is currently under construction), and the most recent Olympic class vessel (the Suquamish) was authorized in 2015 and has an expected delivery date of 2017.

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