Washington State Institute for Public Policy

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The Impacts of a Buy American Steel Policy in Washington State

The 2021 Washington State Legislature directed the Washington State Institute for Public Policy (WSIPP) to conduct an analysis of the impact of a partial or exclusive domestic steel requirement on contracts and subcontracts authorized in the Washington State transportation and capital budgets.[1] Specifically, the legislature directed WSIPP to compare different types of steel made in the US and their uses, provide an inventory of similar requirements in other states, and identify requirements that maximize net benefits under such policies. Additionally, WSIPP was directed to investigate the likely impacts of a domestic steel requirement on the economy and workforce in Washington and examine how emissions of greenhouse gases would be affected.

This report presents our analysis, which is organized into four parts. Section I presents background on Buy American policies.[2] Section II details background on the steel industry and steel-making methods. Section III provides the economic analysis of the effects of a Buy American steel policy. Section IV presents the environmental analysis of the effects of a Buy American Steel policy.

Summary

This report details the domestic and international steel industry, including production methods, types of steel, and quality. We also review the history of the Buy American legislation, which establishes preferences for domestically produced goods in state and federal government contracts. We document similar legislation in other states and alternative domestic preference policies.

We evaluate the economic impact of a Buy American policy for steel in the state of Washington using a benefit-cost analysis (BCA) and an economic impact analysis (EIA). Our BCA finds that increased project costs from most of the Buy American Steel policies outweigh the potential additional income to steel industry workers. Our EIA finds that such a policy would support employment in the steel industry but would lead to net job losses in the economy overall. Both analyses suggest that the ultimate impact of a Buy American Steel policy in Washington would be small, with at most 12 jobs gained or 13 lost statewide.

This report also analyzes the environmental impact of a Buy American Steel policy in Washington. We find that net emissions of greenhouse gasses could either increase or decrease relative to a baseline of no policy. We are unable to determine which outcome is most likely due to uncertainty in how foreign steel suppliers would adjust output in response to the policy. Overall, the net change in emissions would be small, ranging from a decrease of 1.2% to an increase of 1.6% of state steel production generated emissions.

[1] Engrossed Substitute Senate Bill 5092, Chapter 334, Laws of 2021.

[2] Broadly, Buy American policies are mandates to purchase domestic steel rather than foreign steel for government projects.

I. Background of Buy American Steel Policies

Buy American Steel (BA Steel) policies are regulations that require the use of steel produced or fabricated in the United States. The United States Congress has passed two major BA Steel policies in the last 100 years. The first is the Buy American Act of 1933.[3] The second is the Buy America provisions of 1978.[4]

The *Buy American Act* applies to purchases made by federal government agencies and requires that construction materials and manufactured goods, including steel products, be made and manufactured primarily in the United States.[5] This Act, passed during the Great Depression, aimed to support domestic industry and national security by reducing reliance on imports.[6]

Buy America provisions, passed as part of the Surface Transportation Assistance Act of 1978, apply to federally funded transportation projects undertaken by nonfederal government agencies, such as state departments of transportation. These restrictions apply to both raw and fabricated steel, requiring that products be made in the US with US steel.

Exhibit 1

Legislative Assignment

… [An appropriation] is provided solely for the Washington state institute for public policy to conduct a cost-benefit analysis for an exclusive or partial American steel requirement for future contracts and subcontracts authorized in the ***capital*** *budget. The cost-benefit analysis must, to the extent feasible:*

- *Compare existing types and uses of steel to made in America steel alternatives including evaluation of quality;*
- *Examine benefits to Washington workers and the Washington economy;*
- *Examine lifecycle and embodied carbon greenhouse gas emissions;*
- *Identify requirements for purchasing American steel that minimize costs and maximize benefits; and*
- *Evaluate American steel requirements or preferences in other states.*

Engrossed Substitute Senate Bill 5092
Chapter 335, Laws of 2021

… [An appropriation] is provided solely for the Washington state institute for public policy to conduct a cost-benefit analysis for an exclusive or partial American steel requirement for future contracts and subcontracts authorized in the ***transportation*** *budget…*

Substitute Senate Bill 6165
67th Legislature, 2021 Regular Session

[3] Public Law (PL) 72-428. These provisions are now codified in 48 Code of Federal Regulations (CFR) 25.1 and 25.2.
[4] "Buy America" refers to a set of provisions contained in the Surface Transportation Assistance Act of 1978 (STAA; P.L. 95-599). These provisions are now codified in 23 CFR 635.410.
[5] Under the Buy American Act, "unmanufactured end products or construction materials qualify as 'domestic' if they are mined or produced in the United States. Manufactured ones are treated as 'domestic' if they are manufactured in the United States, and either (1) the cost of components mined, produced, or manufactured in the United States exceeds 50% of the cost of all components, or (2) the items are commercially available off-the-shelf items." Congressional Research Service (2016) Domestic Content Restrictions.
[6] Manuel, K., Dolan, A.M., Murrill, B.J., Perry, R.M., & Mulligan, S.P. (2016). *Domestic content restrictions: The Buy American Act and complementary provisions of federal law.* Library of Congress, Congressional Research Service.

Both the Buy American Act and Buy America provisions contain exemptions for goods that are not available in the United States, or for which the domestic price is significantly higher.[7] Buy America provisions also allow for minimal use of foreign steel products in the amount of 0.1% of the contract price or $2,500, whichever is greater.

In addition to these federal programs, 11 states have passed their own BA Steel policies. Details of state-level policies are found in Exhibit 2.[8] BA Steel policies have also been proposed in Florida, Kentucky, Maine, and Massachusetts. Common features of state policies include the following:

- *Products Covered*. Some restrictions require the use of US raw steel; others also require US fabrication. Some restrictions only cover structural steel products; others cover steel components in any manufactured products.
- *Projects Covered*. Some restrictions cover all public works projects; some only cover new construction; others only cover transportation projects.
- *Exemptions*. Most restrictions allow for exemptions in the case that domestic products are unavailable. Some restrictions also allow for exemptions when the use of domestic products would result in large cost increases.
- *Minimal Use Exemptions*. Some restrictions allow the use of a small amount of foreign steel to cover common off-the-shelf items such as fasteners.

Impact

Limited research exists on the impact of BA Steel policies. This is due in part to difficulties tracking relevant costs and benefits. Another complication is that some sources reporting on the impact of BA Steel policies are advocacy groups whose research may not be objective.

In general, research suggests a tradeoff between the gains for industries protected by policies and increases in costs for industries relying on the protected good. For example, a report by the Congressional Research Service suggests that there was a tradeoff between the gains for steel manufacturers and the cost of transportation projects.[9] They concede that this evidence is anecdotal.

Another study used a computable general equilibrium (CGE) model to simulate the effects of the Federal government eliminating both the Buy American Act and Buy America provisions.[10] They found that the loss of jobs in the manufacturing sector is offset by the increase in employment in other sectors, resulting in a net gain in jobs overall.

[7] The Buy American Act exempts products when the US price is "unreasonable." 48 C.F.R. §25.103(c) and 48 C.F.R. §25.202(a)(3). Buy America provisions allow the use of foreign steel when the increase in the total contract cost when using domestic products is greater than or equal to 25%.

[8] Additional details are presented in Section I of the Appendix.

[9] Platzer, M., & Mallett, W. (2017). *Effects of Buy America on transportation infrastructure and U.S. manufacturing: Policy options.* Congressional Research Services.

[10] Dixon, P., Rimmer, M.T., & Waschik, R. (2018). Evaluating the effects of local content measures in a CGE model: Eliminating the US Buy America(n) programs. *Economic Modelling, 68*. 155 - 166.

Exhibit 2

State-level Buy American Steel Policies

State	Year passed	Applies to transportation projects	Applies to other public works projects	Price increase threshold for exemption*	Exemption for unavailability of domestic products
Ohio	1977	Yes	Yes	No	Yes
Indiana	1978	Yes	Yes	15%	Yes
Pennsylvania	1978	Yes	Yes	No	Yes
Maryland	1981	Yes	Yes	20%	Yes
Illinois#	1984	Yes	Yes	10%	Yes
West Virginia	2001	Yes	Yes	No	Yes
New York^	2017	Yes	No	Discretionary	Yes
Texas	2017	Yes	Yes	20%	Yes
California**	2019	Yes	No	25%	Yes
New Jersey^	2021	Yes	No	25%	Yes
New Hampshire	2022	Yes	Yes	Discretionary	Yes

Notes:

* Some states allow an exemption when procuring domestic steel would incur costs above a certain threshold.

\# Applies to products valued at $500 or more.

^ Applies to contracts of $1 million or more.

** Minimal use of foreign steel of 0.1% of the contract value or $2,500, whichever is greater, is allowed.

This would suggest that Washington's raw steel manufacturers would be more likely than others in the industry to gain from a BA Steel policy. Washington's construction industries and others who currently rely on imported steel are likely to face higher costs. The BA Steel policy has an uncertain impact on steel fabricators, who may have higher input costs but may also have their production protected under these acts. We describe these players in more detail in Section II.

Alternative Policies

Since there is a relatively small amount of research on the impact of BA Steel policies, we also reviewed alternative policies state and federal policymakers have used to protect the steel industry.

Steel Tariffs.[11] Rather than requiring the use of domestic steel in government projects, a steel tariff imposes a tax on imported steel production, which is paid by the importing businesses. This increases the effective price of imported steel, making local steel more attractive by comparison.

[11] The Import-Export Clause of the United States Constitution prevents states from implementing steel tariffs without the consent of the US Congress (U.S. Const. art. I, § 10, cl 2). Washington would not be able to implement a steel tariff as an alternative to a BA Steel policy. We included a discussion of tariffs in this report because of its impact on Washington industries as well as for comparison.

Steel tariffs create similar tradeoffs to BA Steel policies. Industries protected by the tariff are more competitive in the domestic market. However, industries relying on goods protected by tariffs face higher costs for inputs. This could hurt their competitiveness if they do not have similar protections. There is a potential for the higher costs faced by the intermediate producers to be passed on to consumers through higher prices. Historically, steel tariffs have also encouraged other countries to implement retaliatory tariffs, making domestic industries less competitive in foreign markets.

One main distinction between the BA Steel policies and steel tariffs is that tariffs increase the price faced by all steel users, whereas BA Steel policies only impact purchases made by the government. Another distinction is that steel tariffs provide an additional source of tax revenue for the government. BA Steel policies may result in higher taxes to cover increased costs.

Steel Subsidies. As discussed above, federal and state governments have also supported domestic steel manufacturing through industry subsidies.

Subsidies are described in Title VII of the Tariff Act of 1930 as anything that "provides a financial contribution."[12] This includes, but is not limited to, providing steel manufacturers with grants or loans, granting tax credits or deductions, providing goods or services, or purchasing goods.[13]

Subsidies boost the protected industry's competitive advantage in the local market at a cost to taxpayers.

[12] Tariff Act of 1930 Title VII Chapter 2 Subtitle D Sec 771 (5)(b)(i) BA mandates may themselves also be considered steel subsidies because they provide industry support by purchasing domestic steel. For the purposes of this section, we focus on other steel subsidies.

[13] Tariff Act of 1930 Title VII Chapter 2 Subtitle D Sec 771 (5).

II. Steel Industry Background

To understand the potential impacts of Buy American policies on Washington State, it is useful to understand key aspects of the steel industry.

Steel, an alloy of iron, carbon, and other metals, is a critically important material in construction, engineering, and national defense in modern economies like the US.[14] It is used either directly or as an input to virtually every building, road, and manufactured consumer good across the globe.

This study focuses on two industries involved in the production of structural steel products. The first is the steel mill industry, which produces raw steel products in the form of bars, sheets, pipes, and other basic shapes. The second is structural metals manufacturing, which takes raw steel as an input to fabricate products such as building beams and joists, bridge sections, and other products used in building and transportation projects.[15] We refer to these products as raw steel and fabricated steel, respectively.

Steel in the United States and Washington State

Output and Employment

In 2021, global raw steel production was 1.95 billion metric tons.[16] The US produced 85.8 million metric tons, surpassed only by China, India, and Japan.[17] The value of US output was $145 billion for raw steel and $112 billion for fabricated steel.[18] Since 1988, US steel mill employment has fallen 58%, from 190,000 to 80,000.[19] In the same period, US fabricated steel employment has remained relatively stable and currently stands at 396,000. US steel employment over time is illustrated in Exhibit 3. Improved technology and worker productivity have driven the decline in steel mill employment. Since 1988, steel mill productivity has risen 159%, while fabrication productivity has risen 19%.[20]

[14] US Department of Commerce. (2018). *The effects of imports of steel on the national security.* Office of Technology Evaluation, Bureau of Industry and Security.

[15] Raw steel and fabricated steel correspond to North American Industrial Classification System (NAICS) codes 3311 and 3323, respectively. NAICS "is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy." For instance, NAICS 33 is manufacturing, 331 is primary metals manufacturing, and 3311 is iron and steel mills and ferroalloy manufacturing. United States Census Bureau. (Oct. 19, 2022). *North American Industry Classification System*.

[16] SP Global – Holman, J. and Brown, C. (Jan. 26, 2022) *Global crude steel production climbs 3.6% on year in 2021: worldsteel*.

[17] World Steel Association. (2020, January 27). *Global crude steel output increases by 3.4% in 2019*.

[18] U.S. Bureau of Labor Statistics. (2022). *Sectoral output for manufacturing: Iron and steel mills and ferroalloy production (NAICS 3311) and architectural and structural metals manufacturing (NAICS 3323) in the United States*.

[19] U.S. Bureau of Labor Statistics. (2022). *Employment for manufacturing: Iron and steel mills and ferroalloy production (NAICS 3311) and architectural and structural metals manufacturing (NAICS 3323) in the United States*.

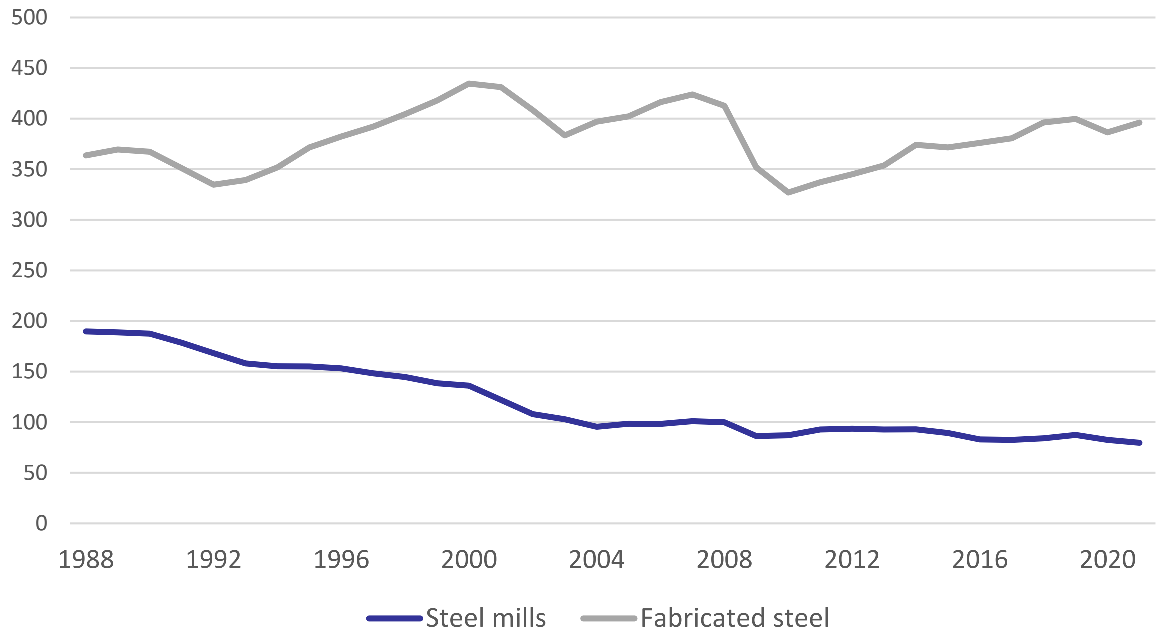
[20] U.S. Bureau of Labor Statistics (2022). *Output per worker for manufacturing: Iron and steel mills and ferroalloy production (NAICS 3311) and architectural and structural metals manufacturing (NAICS 3323) in the United States.*

In 2021, Washington State ranked 30th out of 32 states reporting steel mill employment, with 234 workers at 19 establishments.[21]

For steel fabrication, Washington ranked 19th out of 49 states reporting employment, with 7,803 workers at 331 establishments.[22]

Exhibit 3

United States Steel Industry Employment (Thousands of Workers)



Note:
Source: Bureau of Labor Statistics.

[21] Of these 19 establishments, the largest is Nucor Steel in Seattle, Washington's only steel mill. The others are smaller establishments likely involved in producing alloys, an operation that is included in NAICS 3311. The Bureau of Labor Statistics withholds some information to protect the identity of businesses in their censuses, and so we are unable to determine their operations with certainty. Bureau of Labor Statistics. (2022). *Quarterly census of employment and wages.*

[22] U.S. Bureau of Labor Statistics. (2022). *Quarterly census of employment and wages: Private, NAICS 3311 iron and steel mills and ferroalloy manufacturing and NAICS 3323 Architectural and structural metals manufacturing, all states and U.S*

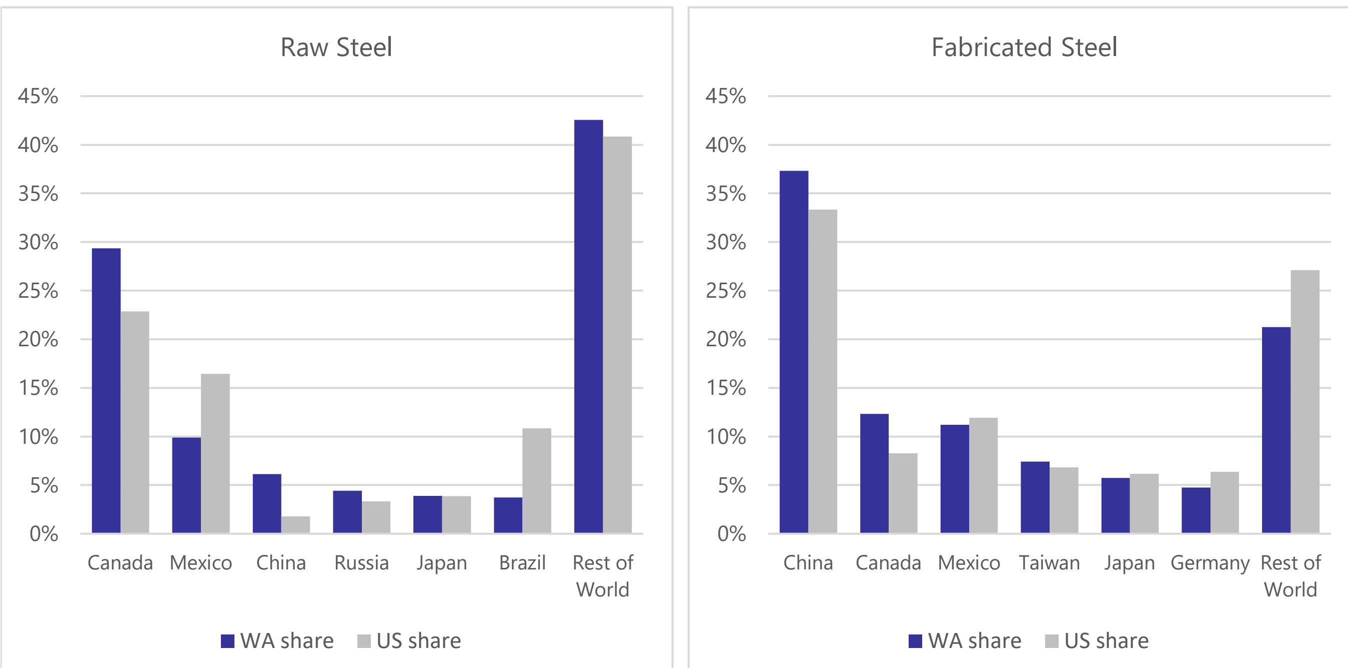
Imports

In 2021, the US imported 28.6 million metric tons of raw steel valued at $33.5 billion.[23] The import penetration rate (the percentage of steel use supplied by imports) was 26.6% for the US and 34.1% for Washington State.[24] Exhibit 4 shows the share of raw and fabricated steel imported by Washington State and the US from their top trading partners. In 2021, the US imported $8.9 billion of fabricated steel.

The US import penetration rate was 17.9%. Washington State had the highest import penetration rate of all states, at 28.0%. Washington State's above-average import penetration rates are important because a domestic steel requirement would affect comparatively more products in Washington, driving more production to the United States.

Exhibit 4

Top Steel Import Sources for Washington State and the US



Notes:
Presented in order of the share of Washington imports.
Source: US raw steel data from the International Trade Administration; Washington data estimated using USATRADE and Commodity Flow Survey data.

[23] International Trade Association. (2022). *Steel Imports Report: United States.*

[24] State import penetration estimates are based on 2017 USATRADE and Commodity Flow Survey data. Additional information is presented in the Methodological Appendix.

Global Steel Overproduction. The world's steel-making capacity has expanded dramatically in the past 25 years, far exceeding the increase in steel demand; by 2015, the gap between capacity and demand had reached 700 million metric tons or about 700% of US steel output.[25] Some of this over-capacity is "cyclical," resulting from flagging demand in economic downturns such as the Great Recession of 2008 or the more recent COVID-19 pandemic.

Other sources of the over-capacity are "structural," resulting from government subsidization of output, restrictions on foreign direct investment, and barriers to the exit of inefficient steel firms. Subsidization is cited as the primary reason for the current over-capacity problem. China, in particular, is commonly cited as having a large over-capacity problem in recent years, though over-capacity has historically also occurred in Europe and Japan.[26] Many governments around the world also place limits on the amount of foreign direct investment in their countries. These restrictions limit the entry of more efficient foreign firms into these markets, protecting less efficient local firms from competition. As a result, these less efficient firms do not go out of business, and steel is produced less efficiently overall.[27]

Regardless of government interventions, steel-producing firms face barriers to exit in the form of large startup costs that force many to stay in business just to pay them off when shutting down would be more efficient. Steel mills are also difficult to sell if not in use; the specialized nature of their structure and machinery means that they must undergo significant renovation to be put to other manufacturing uses.[28]

Generally, steel mills need to operate at around 80% capacity to maintain profitability.[29] Excess supply from over-capacity drives prices lower than they would have been without these subsidies. Mills in countries that provide substantial subsidies can continue producing at near-capacity rates even under general overcapacity, further pushing down international steel prices. Mills in countries without subsidies or limits on foreign direct investment may choose to produce below full capacity under these lower prices. This will lead to less profit than they might have had if prices had not been pushed down artificially. Unprotected firms may be forced out of business if profit losses are large enough. The lower production and/or closure of domestic steel contracts domestic supply increasing import penetration.

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[25] U.S. Department of Commerce (2018).

[26] Brun, L. (2016). *Overcapacity in steel: China's role in a global problem.* Duke Center on Globalization, Governance and Competitiveness.

[27] De Carvalho, A., Rimini, M., Mercier, F., & Burrai, V. (2020). *Barriers to exit in the steel sector.* Organization for Economic Cooperation and Development.

[28] Rosenbaum, D.I., & Lamort, F. (1992). Entry, barriers, exit, and sunk costs: An analysis. *Applied Economics, 24,* 297-304.

[29] Steel manufacturing is subject to economies of scale due to large scale investments in machinery and other capital necessary to begin production. Simply put, it becomes cheaper per metric ton of steel to produce at higher utilization rates. Producing below 80% capacity means that these mills operate inefficiently. Cardenas, P. (2019). *Death of the zombie steel firms and reduction of steel excess capacity in*

The over-capacity problem in the steel industry is important to keep in mind when considering the environmental impact of domestic steel regulations in Washington. Producing an extra metric ton of steel domestically because of a BA Steel policy does not necessarily mean that the metric ton of international steel it "replaces" does not get produced. Firms in other countries will likely continue to produce steel uninterrupted by Washington State policies. This phenomenon is discussed further in Section IV.

Steel Production

Steel Supply Chain

To understand how a Buy American Steel policy would affect the economy of Washington, it is important to understand the mill-to-contractor steel supply chain. Typically, steel passes through several links in the supply chain before its ultimate end-use.

- *Producers* are primarily mills that produce molten crude steel and pour it into molds in a few key shapes such as beams, plates, channels, angles, and hollow structural sections. They may also make coils of steel or rebar.
- *Service centers* are large warehouses that store steel prior to use. They also perform limited services to prepare the steel for later stages in the supply chain. Most steel used in building and bridge construction passes through a service center.
- *Detailers* produce diagrams of the individual steel components of a project that will be fabricated from raw steel. Detailing typically happens under the purview of fabricators but is sometimes subcontracted out to third parties.
- *Fabricators* take steel from mills and service centers and cut, blast, drill, weld, and sometimes even paint it as specified by detailers for each project. Fabrication often takes place near the mill in which the steel was melted and poured, even if the final destination is farther away.
- *Erectors* assemble the fabricated components into final products based on detailed drawings by the project's engineer. Erectors are usually construction personnel or general contractors.[30]

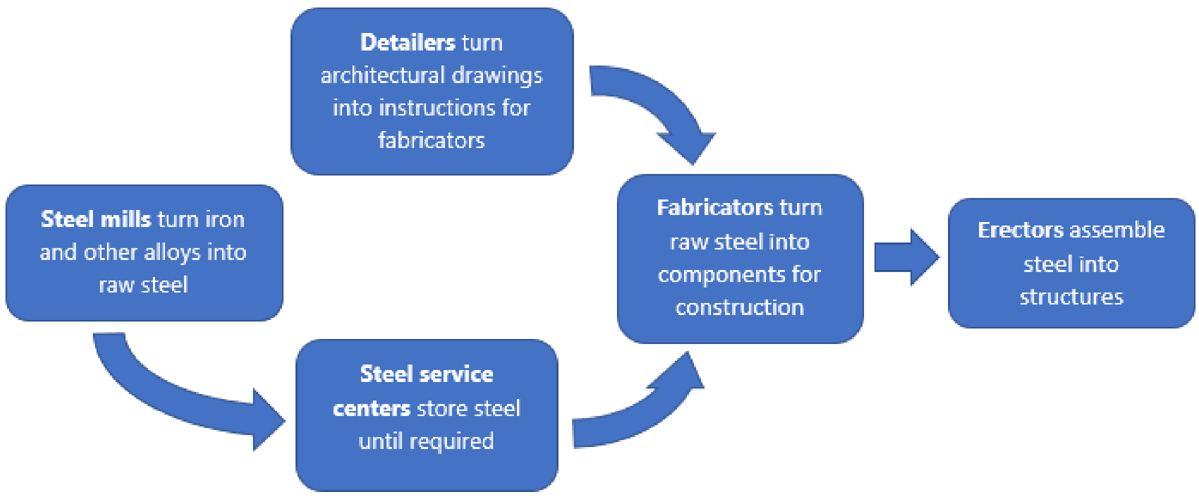
An increase in the demand for goods upstream in a supply chain generally leads to increased employment downstream. Members of the steel industry that we contacted as part of our outreach efforts indicated that job growth in the service center and fabricator industries could exceed job growth in the steel mill industry.[31] Exhibit 5 provides a graphical representation of the steel supply chain.

[30] American Institute of Steel Construction. (2022). *Steel supply chain: Understanding the structural steel supply chain to increase project value.*

[31] American Steel in Washington Working Group. (2022). *Meeting February 2, 2022.*

Exhibit 5

Steel Supply Chain



Steel Making Methods

There are two main methods for making raw steel: Blast furnaces and electric arc furnaces.

Blast furnaces (BF) are the traditional way of making steel. First, "pig iron" is created in a BF by smelting iron ore with other materials like coke (a type of processed coal) and limestone. The pig iron is then transferred to a basic oxygen furnace (BOF) where it is reheated and combined with different alloys to give the steel different properties.[32]

Electric arc furnaces (EAFs) typically use steel scrap for iron and can combine multiple metals into the desired alloy. They use electric arcs to heat the iron and other materials, leading to far fewer emissions of greenhouse gases than the more traditional BF-BOF production route. We describe these differences in detail in the Environmental Impact Section (Section IV) of this report.

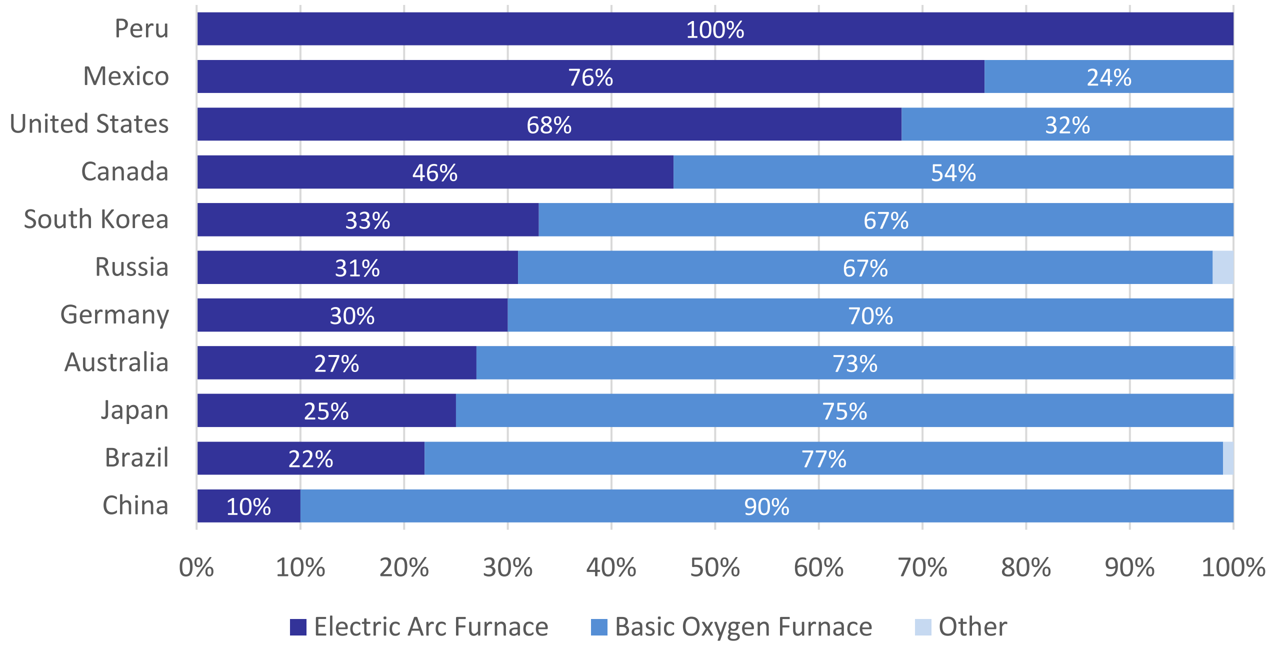
Other methods for steel production exist but are not used frequently. These include Open Hearth Furnaces (OHF), which use heat from the combustion of liquids or gasses nearby. Some steel mills also use a combination of the methods presented here. The prevalence of each steel-making method varies greatly across the globe. In 2019, about 72% of the world's total steel production was made in BOFs while about 28% was made in EAFs. However, in the US, only about 33% of steel output was made in BOFs and 67% was made in EAFs.[33] Exhibit 6 compares each of the US's top ten steel import sources by their production methods for steel. Washington's sole steel mill in Seattle is an EAF that recycles steel primarily from scrap.

[32] For instance, adding chromium will give the steel corrosion resistance. Alloying with other metals, such as molybdenum or tungsten, will make the steel exceptionally hard. The decision of which metals to alloy molten steel with ultimately depends on the finished steel's end use. Anderson, M. (2021, November 3). *What are the different grades of steel?*

[33] World Steel Association. (2019). *Steel statistical yearbook 2019: Concise version.*

Exhibit 6

Steel Production Method Share by Country



Notes:
Shown for US and Washington's top ten import sources for raw steel.
Source: Data from World Steel Statistical Yearbook 2019. The category "Other" represents the use of open-hearth furnaces and/or mixed methods.

Steel Quality

Our outreach efforts included meeting with representatives of the steelmaking and steel-fabrication industries. They conveyed that most foreign-produced steel is "metallurgically equivalent" to domestically produced steel, meaning that foreign steel is very similar or identical in observable properties to domestic steel.

Empirical research on the differences in the quality of steel manufactured in different countries is very limited. Most existing literature consists of case studies of specific projects where the quality of foreign steel became an issue in production. There is no evidence in the literature to suggest that certain countries or regions produce different qualities of steel in general.

Overall, we are not able to make a definite statement about the relative quality of US to foreign-produced steel. However, it is likely that steel sourced internationally for a given project will not be substantially different in quality than domestic alternatives.

III. Economic Effects of a Buy American Steel Policy in Washington

In this section, we estimate the potential economic effects of BA Steel policies in Washington. We first define four hypothetical policies. We then conduct a benefit-cost analysis (BCA) and an economic impact analysis (EIA) to estimate the effects of the policies.

We use the BCA to estimate monetary benefits to the Washington steel industry and costs paid by Washington taxpayers. The strength of this analysis is that it transparently identifies who benefits from the policy, how much they benefit, and the costs of policy implementation.

We use the EIA to take a broader look at the total economic effect of each policy. Unlike the BCA, the EIA accounts for "indirect"[34] and "induced"[35] effects. It also allows us to see how the policies will affect indicators such as employment and income over time. The drawback of this method is that because it considers the economy as a system, it is not possible to separate costs from benefits. The BCA helps us to better understand the mechanisms through which a policy is affecting the economy.

We compare the results of each analysis to develop a complete picture of how a potential BA Steel policy would affect the state. A more detailed account of our methodology can be found in the Methodological Appendix.

Policy Hypotheticals

Existing BA Steel policies differ in terms of the projects and products that they regulate. When choosing our policy hypotheticals, we focus on two dimensions that influence the policies' impacts.[36]

First, prospective policies could vary in the amount of steel covered. Higher coverage will increase the total costs and benefits associated with the policy.

Second, prospective policies could vary in the type of steel covered. This will change the stakeholders (mills, fabricators, contractors, etc.) affected by the policy.

We specify four hypothetical policies to compare to a baseline policy with no new regulations. Exhibit 7 illustrates how each of the policies varies based on the two dimensions identified.

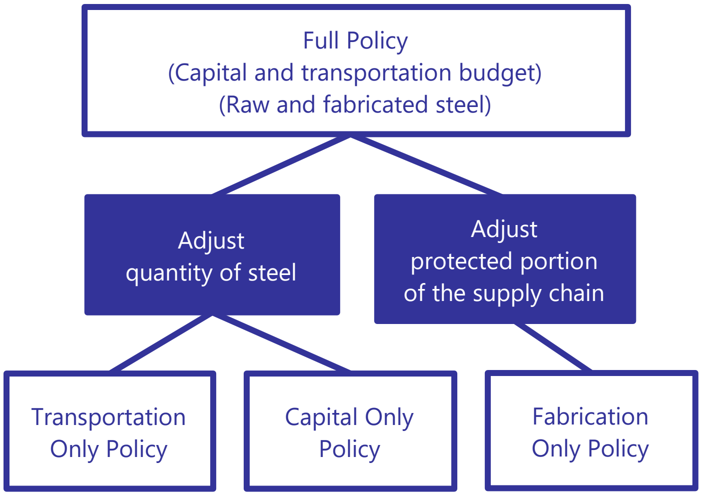
[34] Indirect effects are impacts on related industries. For example, higher steel costs will increase the materials costs in construction, which could cause a reduction in production or employment in this industry. Simultaneously, increased steel production and employment could lead to an increase in demand for janitorial services.

[35] Induced effects result from changes in income from the direct and indirect effects. For example, the increased employment in the steel industry will cause the new employees to spend more in retail businesses around the state.

[36] We do not have enough information on the actual steel used in transportation and capital projects to estimate other typical policy changes (e.g., the impact of including an exemption for products unavailable domestically, maximum price differences, or nuts and bolts exemptions).

Exhibit 7

Policy Scenarios



The *Full Policy* resembles the existing federal Buy America provisions. This policy would require that all steel products used in contracts and sub-contracts authorized in the Washington State transportation and capital budgets be fabricated in the United States using US-made raw steel.

We then adjust this model to determine if our results depend on the amount and type of steel impacted by the policy.[37]

The *Transportation Only Policy* assumes that the steel mandate only applies to the transportation budget.

The *Capital Only Policy* assumes that the steel mandate only applies to the capital budget.

The *Fabrication Only Policy* assumes that the steel mandate only applies to steel fabrication. Under this policy, domestic fabricators would be permitted to source foreign or domestic raw steel. Washington does not have many steel mills but has many steel fabricators. Requiring raw steel to be produced domestically would increase costs for Washington fabricators, while largely benefiting steel mills outside the state. Relaxing this requirement could allow Washington to capture a greater percentage of the policy benefits.

BA Steel Policy General Economic Effects

In our models, BA Steel policies limit the amount of foreign steel used in government contracts, leading to a decrease in steel imports, and an increase in domestic steel purchases. Some of these domestic purchases would come from Washington, stimulating the state economy. Since domestic raw and fabricated steel tends to be more expensive than foreign alternatives, project costs also tend to increase under BA Steel policies.[38]

[37] Since we do not have information on the specific types of steel used in the capital or transportation budgets, these two specifications only adjust the amount of steel that is required to be covered under the hypothetical BA policy.

[38] We make two general assumptions about how affected groups would respond to a Buy America requirement. First, we assume that all projects in the capital and transportation budgets would proceed as planned in response to higher steel prices. Second, we assume that contractors would fully comply with the regulation.

Value of Affected Steel

Steel products used in government projects can be produced in one of four ways:

1) US fabricated with US raw steel,
2) US fabricated with foreign raw steel,
3) Foreign fabricated with US raw steel, or
4) Foreign fabricated with foreign raw steel.

Under the Full Policy, products in the first category would already be compliant. Products in the other three categories would need to be replaced with fully domestic alternatives.

We estimate that in a typical year, state capital and transportation projects use $67.5 million of fabricated steel. Under the Full Policy, we estimate that $7.2 million of raw steel and $18.9 million of fabricated steel would need to be replaced with domestic alternatives to be compliant.[39] After accounting for higher US steel prices, these values amount to $9.1 million of raw steel and $20.3 million of fabricated steel. Additional details about our estimation methodology are included in the Methodological Appendix.

Crowding Out. Foreign and domestic steel products are close substitutes for one another.[40] If contractors on state-funded projects increase their demand for US steel, we expect production capacity constraints and price pressure to result in some current buyers being crowded out of the domestic market and switching to foreign alternatives. This means that the actual increase in US steel production will be less than the value of affected steel products.

Benefit-Cost Analysis

This section details our BCA methodology, including the estimation of the value of new Washington steel production, the amount of new income going to Washington workers and businesses, and the increased costs for taxpayers.[41]

[39] The value of raw steel includes foreign steel in both foreign fabricated and domestically fabricated products.
[40] Johanson, D.S., Schmidtlein, R.K., Kearns, J.E., Stayin, R.J., & Karpel, A.A. (2020). *Fabricated structural steel from Canada, China, and Mexico.* U.S. International Trade Commission Investigation Nos. 701-TA-616-617 and 731-TA-1432-1434.
[41] Our calculations depend on several parameters, such as the cost differential between foreign and domestic steel, the proportion of new US purchases that would be made in Washington State, and the proportion of revenue going to worker income. Additional information on our methodology for estimating these parameters is included in the Methodological Appendix.

Affected Groups

In our analysis, in-state steel mill and steel fabrication workers and business owners are beneficiaries of the policy because a BA Steel policy could directly affect their income by increasing Washington steel production. Washington taxpayers bear costs because they would face higher taxes due to the increased cost of procuring American steel.

Scenarios

For each of the policies detailed in the previous section, we estimate annual benefits and costs assuming typical rates of steel use.

Benefits and Costs of a Buy American Steel Policy

We estimate that annually, $7.2 million of raw steel and $18.9 million of fabricated steel that is currently imported would need to be replaced with US alternatives to comply with the Full Policy.[42] Sourcing US steel would result in a cost increase of $2.4 million. After accounting for existing buyers who would be crowded out of the domestic market, we estimate that US raw steel production would increase by $3.2 million, and US fabricated steel production would increase by $7.2 million. The value of steel products affected by different policies is presented in Exhibit 8.[43]

To estimate the share of new US production that would occur in Washington, we use data from the Census Bureau's Commodity Flow Survey, which reports interstate shipment patterns. We estimate that 13.4% of new US raw steel and 39.5% of new US fabricated steel would be purchased from Washington suppliers. These represent $432 thousand of new revenue for Washington steel mills and $2.8 million of new revenue for Washington steel fabricators.

Exhibit 8

Annual Value of Steel Products Affected by Different Policies (2019 Dollars)

Product	Full policy	Transportation only	Capital only	Fabrication only
Raw steel affected	$7.2 million	$885 thousand	$6.3 million	-
Raw steel US replacement cost	$9.1 million	$1.1 million	$8.0 million	-
New US raw steel production	$3.2 million	$395 thousand	$2.8 million	-
Fabricated steel affected	$18.9 million	$2.3 million	$16.6 million	$18.9 million
Fabricated steel US replacement cost	$20.3 million	$2.5 million	$17.8 million	$20.3 million
New US fabricated steel production	$7.2 million	$876 thousand	$6.3 million	$7.2 million

[42] The following section details our estimation of the effects of the Full Policy. Calculations for the Transportation Only, Capital Only, and Fabrication Only policies proceed in the same way. Relevant values for these policies are presented in Exhibits 6 and 7.

[43] Under the Fabrication Only Policy, it is likely that US fabricators would increase their purchases of US raw steel. But because raw steel is not regulated by this policy, we do not count it in the estimation of costs and benefits.

We estimate that Washington steel mill workers would earn $73 thousand in new income, and steel fabrication workers would earn $765 thousand in new income. At prevailing industry compensation, this income would support approximately 11 new Washington jobs.[44] We also estimate $96 thousand in new steel mill profit and $824 thousand in new steel fabricator profit for Washington businesses.

Results of Benefit-Cost Analysis

Subtracting total costs from total benefits, we estimate the net benefit of the Full Policy to be -$676 thousand annually. Estimated annual net benefits are -$83 thousand for the Transportation Only Policy, -$594 thousand for the Capital Only Policy, and $192 thousand for the Fabrication Only Policy. BCA results are presented in Exhibit 9.

In all four policies, steel workers and business owners benefit from increased income and profit, while taxpayers bear the additional cost of more expensive domestic steel.

The only policy with positive estimated net benefits is the Fabrication Only Policy. This is due to two primary factors. First, fabricated steel is more likely than raw steel to be sourced from Washington suppliers, meaning that benefits are higher for fabricators than for steel mills. Second, the price differential between foreign and domestic products is higher for raw steel than for fabricated steel. Together, these factors mean that requiring domestic fabrication results in higher benefits and lower costs relative to requiring domestic raw steel.

Exhibit 9

Annual Benefits and Costs of a Buy American Steel Policy in Washington (Thousands of 2019 Dollars)

Program benefit	**Full policy**	**Transportation only**	**Capital only**	**Fabrication only**
Income for Washington raw steel workers	$73	$9	$64	-
Income for Washington fabrication workers	$765	$93	$672	$765
Profit for Washington raw steel businesses	$96	$12	$84	-
Profit for Washington fabrication businesses	$824	$101	$723	$824
Total benefits	$1,758	$215	$1,543	$1,589
Program cost				
Increased cost of sourcing US steel	($2,435)	($298)	($2,137)	($1,397)
Bottom line				
Net benefit	($676)	($83)	($594)	$192
Benefit-to-cost ratio	$0.72	$0.72	$0.72	$1.14
% of simulations with positive net benefits	37%	37%	37%	61%
Annual steel jobs supported	11.3	1.4	9.9	10.7

[44] This estimate considers new jobs due to increased steel mill and fabricated steel production. It does not consider jobs potentially lost due to increased taxation and any associated reduction in statewide economic activity.

Sensitivity Analysis

To account for uncertainty in our estimates, we simulate our BCA model 500,000 times for each policy, allowing intermediate parameters to vary with each simulation. The Full, Transportation Only, and Capital Only policies result in positive net benefits in 37% of simulations. The Fabrication Only Policy results in positive net benefits in 61% of simulations. Sensitivity results are presented in the Methodological Appendix.

Our simulations account for uncertainty within our set of economic assumptions. We present an additional analysis of how effects might vary under different assumptions at the end of this section.

Economic Impact Analysis

To better understand how a BA Steel policy would impact the economy of Washington, we conduct a series of scenario simulations using a REMI model.[45] A REMI model is a powerful economic model constructed and maintained by Regional Economic Models, Incorporated (REMI); it is used by a variety of researchers and public and private organizations to model economic policies. A REMI model consists of thousands of equations that are updated annually to reflect real-world conditions and new data. The REMI model allows our EIA to investigate the impact of each policy on all industries in the economy, even those not directly regulated by each policy. This analysis also allows us to model paying for the cost of each policy. Finally, the REMI model allows us to forecast the impacts of each policy over many years, all the way to 2045.

In terms of describing the broad economic impacts of a BA Steel policy in Washington, the EIA greatly benefits from the addition of these abilities.

To enter each policy into the REMI model, we first translate each into a series of changes to the economy, or "shocks." Since each policy limits the amount of foreign steel that may be used for government contracts, we assume that each policy will lead to a negative shock to imports of raw steel (NAICS 3311) and fabricated steel (NAICS 3323). Additionally, since US steel (raw and fabricated) tends to be more expensive than most foreign alternatives, we also estimate cost shocks for each policy equal to the expected increase in project costs in the capital and transportation projects. We assume that each cost shock is financed through taxation. To translate each cost shock into tax increases, we assume that 57% of the cost increase is paid for by sales tax, 23% by business taxes, and 19% by property taxes. These numbers correspond to the share of total state tax revenue generated by each respective tax category.[46]

Generally, the benefits of each policy will be larger for larger import shocks; the more foreign steel is excluded, the greater the opportunity for Washington steel producers to step up production to meet demand, leading to more output, employment, and income. Conversely, higher cost shocks mean larger tax increases, leading to less spending by consumers and businesses and less employment, output, and income in the economy.

[45] For this study, we use the REMI Tax-PI version of the model with assistance from the staff of Washington's Joint Legislative Audit and Review Committee (JLARC).

[46] Smith, V., Oline, K., & Skiff, E. (2020). *Tax statistics.* Washington State Department of Revenue.

We run a total of 14 simulations; of these, 12 come directly from the four policies described in the Policy Hypotheticals at the beginning of this section, and the remaining two elaborate on the results for the Full Policy. For each policy, we run the following three scenarios:

1) A mean simulation, where shocks to imports of raw and fabricated steel as well as cost shocks are at their mean values;
2) A high-cost, low-benefit (HCLB) scenario, when cost shocks are high and import shocks are low; and,
3) A low-cost, high-benefit (LCHB) scenario, where cost shocks are low and import shocks are high.[47]

In addition to these 12 simulations, we run two other scenarios that we use to elaborate on the results of the Full Policy (which is most representative of other states' BA Steel regulations). The first of these simply takes the mean import and cost shocks generated for the Full Policy and scales them by a factor of five. We refer to this as the "Full-5 scenario"; it is intended to capture the impacts of the Full Policy in the event that we have dramatically underestimated the amount of steel used by the government. Comparing the results of the Full-5 scenario with the Full Policy will allow us to observe how consequential the amount of steel affected by the policy is to the economic outcomes. For instance, it may be that the Full Policy returns a net negative impact because not enough steel is brought home, whereas the Full-5 scenario may impact enough steel to cross some minimum threshold for benefits to begin outweighing costs.

Finally, we run a second additional scenario that re-enters the mean import shocks from the Full Policy into the REMI model *without* entering the increases in taxes associated with the Full Policy. We call this the "Full-No Tax" scenario. Comparing the results of this simulation to those of the Full Policy will help us understand the different impacts of the cost and import shocks on the economy of Washington. It should be noted that we cannot use this simulation to back out the *exact* impact of the taxes, because, under the Full Policy, economic outcomes are generated by both the increase in taxes and the import shocks interacting, not the sum of their individual contributions.

For all simulations, we focus on four key economic variables reported by REMI: employment, output in the steel sectors, income, and tax revenue. REMI's output allows us to look at changes in employment and income of individual sectors, which we analyze at length in the following section.

Results of Economic Impact Analysis (EIA)

Summary results for each simulation of the four policies are given in Exhibit 10. The results of the Full-5 and Full-No Tax scenarios are given in Exhibit 11. Mean, HCLB, and LCHB simulations for each policy return qualitatively similar results in terms of employment, output, income, and tax revenue. We briefly discuss key results for each variable of interest in the following subsections.

[47] For each HCLB scenario, we use cost and import shocks generated from our BCA model such that 5% of simulations resulted in both higher cost shocks and lower import shocks. For each LCHB scenario, we use cost and import shocks generated from our BCA model such that 5% of simulations resulted in both lower cost shocks and higher import shocks.

Employment. Columns 3 through 5 of Exhibit 10 detail estimated changes in employment under each policy scenario. The number reported in each represents the difference in employment between each policy scenario and the baseline of no BA Steel policy, averaged over every year in the simulation (2022-2045).

For example, a 1 in column 5 means that, on average, we estimate the given policy scenario resulted in the creation of 1 additional job per year compared to the baseline.

Exhibit 10

Summary Results for REMI Simulations,
Average Annual Changes from the Baseline, 2022-2045

(1) Policy	(2) Scenario	(3) Steel manu. jobs	(4) Steel fab. jobs	(5) Total jobs	(6) Gross income	(7) Disposable income	(8) Steel manu. output	(9) Steel fab. output	(10) Tax revenue (after policy)
Full	HCLB	1.34	5.03	(5.21)	($235)	($1,002)	$4,996	$1,829	($76)
	Mean	1.50	5.62	(1.03)	$325	($403)	$5,592	$2,041	($36)
	LCHB	1.86	6.99	12.05	$2,033	$1,495	$6,920	$2,537	$90
Transport. Only	HCLB	0.16	0.62	(0.63)	($27)	($121)	$612	$223	($9)
	Mean	0.18	0.69	(0.13)	$57	($49)	$684	$249	($4)
	LCHB	0.23	0.85	1.46	$247	$181	$844	$309	$11
Capital Only	HCLB	1.20	4.49	(4.22)	($160)	($830)	$2,835	$1,026	($63)
	Mean	1.34	5.01	(0.54)	$336	($302)	$3,137	$1,146	($28)
	LCHB	1.66	6.23	10.99	$1,842	$1,370	$3,927	$1,426	$83
Fabrication Only	HCLB	0.01	3.44	(12.51)	($1,491)	($2,017)	$43	$1,250	($153)
	Mean	0.02	5.61	(3.35)	($344)	($737)	$72	$2,035	($76)
	LCHB	0.03	7.82	6.83	$928	$695	$101	$2,837	$10

Notes:
Dollar amounts in 1,000s.
Numbers in parentheses are negative.

Exhibit 11

Additional Simulations
Average Annual Changes from the Baseline, 2022-2045

Simulation	Steel manu. jobs	Steel fab. jobs	Total jobs	Gross income	Disposable income	Steel manu. output	Steel fab. output	Tax revenue (after policy)
Full-5	7.51	28.10	(5.14)	$1,621	($2,015)	$27,959	$10,207	($181)
Full-No Tax	1.50	5.67	24.70	$3,474	$3,448	$5,594	$2,053	$225

Notes:
Dollar amounts in 1,000s.
Numbers in parentheses are negative.
The final column reports tax revenue after additional revenue from each policy's tax shock is accounted for.

The mean and HCLB simulations for the four policies show consistent though small decreases in total employment; the LCHB simulations show consistent though small gains to total employment. All four policies would lead to job growth in both the steel manufacturing (NAICS 3311) and fabrication (NAICS 3323) sectors. In all simulations, job gains in the fabrication would be several times larger than those in the raw steel manufacturing sector. Small additional job gains would be found in the wholesale trade (NAICS 42); professional, scientific, and technical services (NAICS 54); administrative, support, waste management and remediation services (NAICS 56); and transportation and warehousing (NAICS 48). These are all sectors that directly serve the steel manufacturing and fabrication industries (i.e., are down- or upstream in the steel supply chain).

Other sectors, such as retail (NAICS 44-45), healthcare and social assistance (NAICS 62), construction (NAICS 23), and accommodation and food services (NAICS 72) see estimated net job losses under each policy-scenario combination. When we run the model using the import shocks for the Full Policy without the increases in taxes in the Full-No Tax scenario, the losses to these sectors nearly disappear; this suggests that job losses in these industries are largely due to the tax increases in the four policies. Higher taxes generally increase the costs of personal consumption and also doing business, leading to lower demand for goods in some sectors and fewer jobs. Overall, in all but the LCHB scenarios, losses in these sectors would be severe enough to lead to net job losses in the state despite gains in industries closely related to steel.

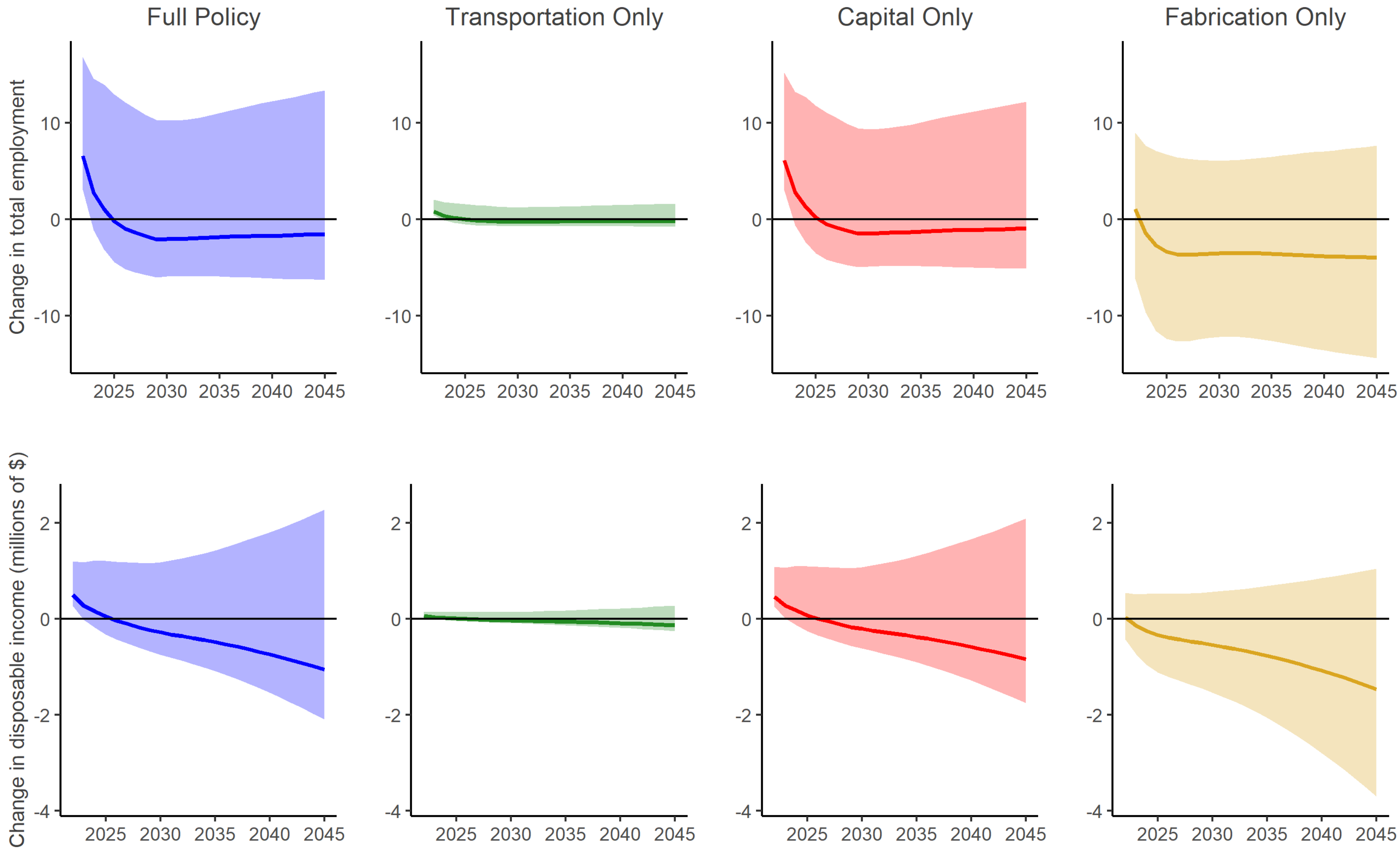
Compared to the other policies, the Fabrication Only Policy would see very little job growth in raw steel manufacturing employment. This suggests that a policy only mandating domestic fabrication will do little to support employment in the raw steel manufacturing industry.

Finally, similar employment patterns to the mean scenarios for the Full, Transportation Only, and Capital Only Policies are found in the results of the Full-5 scenario, suggesting that these results are relatively stable even if dramatically more steel than estimated were to be affected by each policy.

The first row of Exhibit 12 reports the time paths for total employment relative to the baseline for all 12 policy-scenario combinations. The dark central line represents the estimated difference between total employment under each policy compared to the no BA Steel policy baseline. A value of more than 0 indicates that a given policy created jobs compared to the baseline. The shaded area of each graph is the area between the HCLB and LCHB scenarios that represent the range of likely outcomes of the model based on our BCA calculations.
Once again, we see that the results of the mean scenarios for the Transportation Only and Capital Only Policies are qualitatively similar to the Full Policy. These policies exhibit initial modest increases in total employment relative to baseline. After the first few years of each policy, though, the economy begins to lose jobs relative to the baseline, leveling off a few jobs below the baseline for most of the simulation window. The Full Policy has the most dramatic impact on employment, followed by the Capital Only Policy and then the Transportation Only Policy. The Full Policy regulates both the capital and transportation budgets and thereby regulates more steel than either of these policies alone, so it makes sense that it would have the most pronounced economic impacts.

Exhibit 12

Employment and Disposable Income relative to Baseline, by Simulation, 2022-2045



Note:
REMI predicted changes in total employment and disposable income relative to baseline by policy scenario.

The Fabrication Only Policy has a different impact on employment than the other three policies, likely because it does not substantially support jobs in the raw steel manufacturing industry. Overall, the Fabrication Only Policy leads to the most job losses relative to the baseline.

Note that the upper bound of the shaded area in each graph outlines a scenario in which employment under each policy is higher in all years than the baseline. While the mean scenarios suggest these policies will ultimately lead to job losses, these LCHB scenarios do lead to sustained job gains in the economy. Thus, it is at least possible that these policies could support employment under some combinations of cost and import shocks.

Income. We now turn to the model's projections of income under each policy scenario. We focus on two measures of income. The first, gross income, is the sum of all income of workers in Washington; a positive number for gross income means that workers in the state are making more income in the aggregate. The second measure is disposable income, which is simply gross income less taxes. Disposable income is the amount of money that people have to spend on goods and services.

Columns 6 and 7 of Exhibit 10 detail estimated changes in income under each policy scenario. The Full, Transportation Only, and Capital Only Policies display similar estimated income results. Under mean scenarios, gross income in the state would increase despite overall employment declining. This is because all policies would create jobs in higher-paying industries (raw and fabricated steel manufacturing) than the jobs they would eliminate (retail and accommodation and food services).

The Full-5 scenario, which would impact more steel than the Full, Transportation Only, and Capital Only Policies, also displays the same pattern, but once again, at a larger magnitude. The Fabrication Only Policy, which would not be effective at supporting growth in the raw steel manufacturing industry, sees gross income loss under the mean scenario. All four policies see estimated gross income losses under HCLB scenarios and gains under LCHB scenarios.

Disposable income, on the other hand, would fall under all HCLB and mean scenarios despite the increase in gross income. These decreases are because of the increase in taxes under each policy. Only the LCHB scenarios report disposable income gain. Thus, while it is possible that these policies could lead to disposable income gains, it is relatively unlikely. Disposable income is a good proxy for welfare because it captures the ability of households to purchase goods and services; these results suggest that under most scenarios, households would be made slightly worse off by each policy. It should be noted that the reported changes are statewide, so individual households are unlikely to see much change in their welfare overall.

Comparing the mean of the Full Policy to the Full-No Tax scenario shows the dramatic impact of taxes on income results. We would expect that the Full-No Tax scenario would result in greater disposable income than the Full Policy since the two use the same import shocks, but the Full Policy has higher taxes. However, the estimated increase in gross income under the Full Policy ($325 thousand) is tiny compared to the estimated increase in the Full-No Tax scenario ($3.47 million). The introduction of the tax increases to pay for the Full Policy would have a drastic negative impact on new income in the state. This is the result of the jobs displaced by the taxes, as discussed above.

The bottom row of Exhibit 12 plots the time paths of disposable income for each policy. Generally, disposable income appears to roughly follow employment, initially jumping before slipping into negative territory for mean and HCLB simulations. For all policies in these scenarios, disposable income would move further and further below the baseline values over time. Once again, we see that the upper bound on the shaded area for each disposable income graph is positive and upward sloping, suggesting that some LCHB combinations of shocks can lead to sustained disposable income growth under each policy.

Output. Columns 8 and 9 of Exhibit 10 detail estimated changes in output under each policy scenario. All policies and simulations would lead to increases in output in both steel sectors, demonstrating that these policies would support steel production in Washington. As with employment and income, the impact of each policy on output clearly scales with the amount of steel; comparing means in the Full and Transportation Only Policies to the Capital Only Policy, The Full Policy results in the largest output gains in both sectors, followed by the Capital Only Policy, and lastly the Transportation Only Policy. The Full-5 scenario, which impacts the most steel, sees the largest estimated increases in output in these sectors.

Again, comparing output between the Full and Fabrication Only Policies demonstrates the impact of mandating that raw steel be manufactured domestically. The Full Policy would lead to millions of additional dollars' worth of output in the raw steel manufacturing sector while such gains would be much smaller under the Fabrication Only Policy. Therefore, these REMI model results suggest that fabricators would likely seek internationally manufactured raw steel unless they are constrained by the law.

Finally, the Full-No Tax scenario is estimated to have slightly larger output gains in the steel sectors than the Full Policy, but only marginally so. Since the Full Policy and the Full-No Tax scenario differ only in that the Full Policy has increases in taxes, the closeness of these results suggests that the taxes levied to pay for each policy would have little impact on output by themselves.

Tax Revenue. Column 10 of Exhibit 10 reports the estimated change in total state tax revenue after the tax increase from each policy has been accounted for. Once again, we see that all HCLB and mean scenarios would return net losses while LCHB scenarios would return similarly sized net gains. The change in tax revenues is likely in response to changes in employment and disposable income; Washington consumers would simply have less money to spend on goods, and hence would make fewer and smaller transactions. In particular, this would lead to a large drop in sales tax revenue which appears to drive the overall estimated decrease in revenue. It may also be the case that consumers, seeing higher taxes, would choose to spend a greater share of their disposable income on non-taxed items, further decreasing tax revenue.

Economic Impact Analysis (EIA) Summary. Our EIA indicates that the gains to income and employment in the steel industries of a BA Steel policy would likely be offset by income and employment losses in other industries affected by the taxes required to pay for such a policy. Were it possible to implement such a policy without paying for it via taxation, it would likely lead to some modest employment, output, income, and tax revenue gains across the economy, as demonstrated by the Full-No Tax scenario. Once the requisite taxes to cover the expected increase in the cost of such a policy are accounted for, the net returns to the economy in all but the LCHB scenarios would be slightly negative in terms of employment, disposable income, and tax revenue.

We found that a BA Steel policy would support employment and output in the Washington steel industry at all links in the steel supply chain. However, these jobs and income would come at the expense of jobs in other sectors such as retail, construction, and other services, leading to net losses in total employment. In essence, these policies move employment and income from some sectors of the economy towards others, representing a reallocation of economic activity rather than a catalyst for new activity.

Taken all together, the results of our REMI simulations suggest that a BA Steel policy would have only limited impacts on the economy of Washington. The overall magnitudes of the estimated changes for all policies, even in the Full-5 scenario, are relatively small, representing fractions of percent differences from the baseline values. While such policies may have some benefits for certain industries, most everyday Washingtonians and most industries would see no change at all, and the impacts of the policy would likely be dwarfed by other macroeconomic phenomena. For instance, consider the Full Policy results in Exhibit 10. The HCLB and LCHB scenarios predict a net change in employment of -5.21 and 12.05. The US Bureau of Labor Statistics estimates that Washington State's total employment average across January through September of 2022 was 3.5 million.[48] Thus, even though these two scenarios predict opposing changes in employment as a result of the Full Policy, the magnitude of those changes means that a very small share of the workforce of Washington would actually be affected.

[48] US Bureau of Labor Statistics. (2022). Economy at a Glance: Washington.

These BA Steel policies lead to some members of the economy being better off and some being worse off. Those workers who are able to find new employment in the high-paying raw and fabricated steel industries under these policies would certainly gain. Likewise, businesses in these industries would see increased profits, as detailed in the BCA. On the other hand, those workers in industries such as retail, accommodation and food services, and health care would be made worse off as some jobs are lost due to increased taxes. All consumers and businesses would also be made slightly worse off from the increased taxes, as demonstrated by the decrease in disposable income under most scenarios. In essence, each one of these policies would move wealth and income away from some sectors of the economy towards others.

Comparison of BCA and EIA Results

The results of our BCA and EIA are qualitatively similar. Both predict that the net effect of a BA Steel policy would be small, with some uncertainty around net gains or losses. The two analyses also agree that the policies that regulate raw steel would likely return negative net benefits to the state in terms of income. Both analyses predict that all policy scenarios examined as part of this study would create jobs in the steel industries but that economic gains would be largely or entirely offset by the associated increase in procurement costs.

A direct comparison of the results of the BCA and EIA is difficult to make because of their different methodologies. The BCA focuses on the direct effects of each policy on the steel industry while the EIA estimates how these effects ripple throughout the state economy leading to job and income changes across many industries. The way the two methods model the costs of each policy differs as well. The BCA treats the increased cost of purchasing steel for government contracts as the cost side of each policy whereas the EIA treats the lost jobs and income resulting from the taxes to pay for each policy as the cost.

These differences mean that the two analyses will come to different conclusions on the net impacts of each policy. For example, the BCA predicts that the full policy will lead to an increase of $838 thousand in statewide gross income.[49] By contrast, the EIA estimates an increase of only $325 thousand in statewide gross income per year. This is because the EIA incorporates the impact of paying for the policy via taxes on other jobs in the state; the elimination of these jobs leads to losses in gross income and hence the smaller estimate. This example illustrates the difference between looking at the direct effects of each policy (as in the BCA) and the indirect and induced effects of each policy (as in the EIA).

[49] This number comes from the sum of new income to Washington workers in the raw ($73 thousand) and fabricated ($765 thousand) steel sectors.

The differing methodologies between the two analyses lead them to disagree on the impacts of the Fabrication Only Policy in particular. Of the four policies tested in the BCA, the Fabrication Only Policy is the only policy that returns a positive net benefit to Washington in more than 50% of simulations. By contrast, the EIA finds that the Fabrication Only Policy leads to fewer jobs and lower gross and disposable income than the other policies which regulate both raw and fabricated steel. This discrepancy between the two analyses is likely due to indirect and induced effects accounted for by the REMI model used in the EIA. The incorporation of taxation in the REMI model leads to job losses (and subsequent gross income losses) in other sectors that are not captured by the BCA. Therefore, the EIA predicts more adverse outcomes from the Fabrication Only policy than does the BCA.

Discussion of Economic Assumptions

The results of both the BCA and the EIA depend on several assumptions. This section discusses how different assumptions could affect economic outcomes.

Crowding Out. Our analysis assumes that when contractors on state-funded construction projects introduce new demand to the US steel market, suppliers would meet that demand through some combination of increasing production and shifting sales away from existing customers. We estimate that 35% of new demand would be met with new production. To test the sensitivity of our results, we calculate the percentage of BCA simulations that result in positive net benefits at different values of this parameter. Exhibit 13 shows the results of this analysis.

For illustration, consider two cases. If we assume that only 25% of new demand is met with the new production, then the Full, Transportation Only and Capital Only Policies result in positive net benefits in 18% of simulations, while the Fabrication Only Policy results in positive net benefits in 36% of simulations. If we instead assume that 75% of new demand is met with the new production, then these proportions increase to 85% and 99%, respectively.

This parameter strongly influences whether a BA Steel policy would result in a net benefit to the Washington economy. Because of a lack of empirical estimates, there is substantial uncertainty around its value. Policy features that encourage new production rather than crowding out existing buyers are key to increasing benefits and reducing costs. Some such features are detailed in the next section.

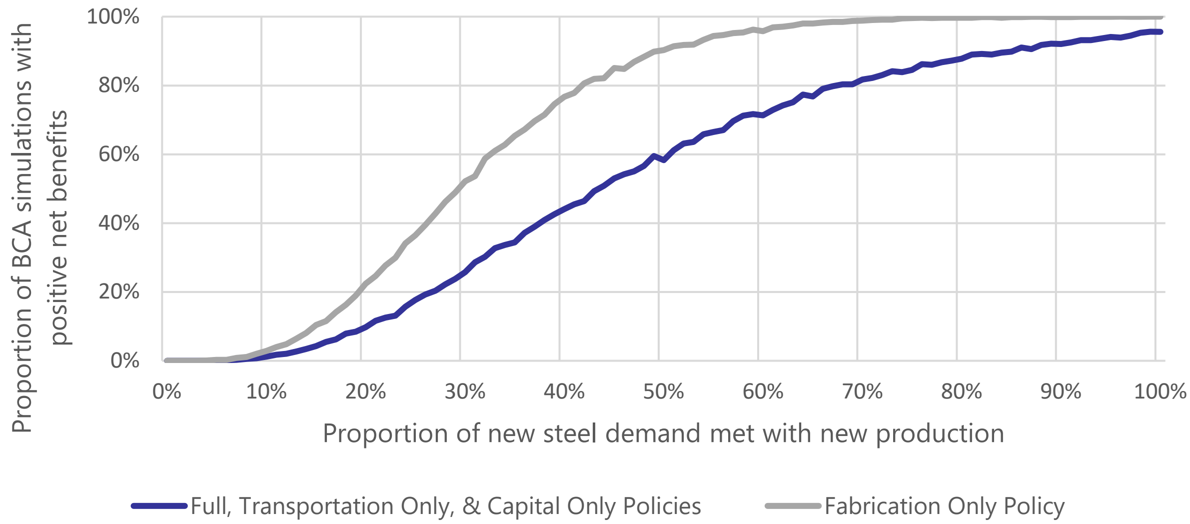
Project Delays & Cancellations. One assumption is that all capital and transportation projects would proceed as planned. However, it is possible that higher steel prices could result in some projects being modified, delayed, or canceled. Construction projects that previously planned to use structural steel products might substitute materials without domestic use requirements like cross-laminated timber,[50] although this effect is likely to be small.[51] If projects were delayed or canceled due to higher prices, we would expect a reduction in associated construction activity.

[50] House Capital Budget Committee, personal communication, January 20, 2022.

[51] Johanson et al. (2020).

Exhibit 13

Percentage of BCA Simulations with Positive Net Benefits
vs Percentage of New Demand Met with New Production



Forgoing State Funding. For some projects, the cost savings of using foreign steel may outweigh the value of state funding. In such cases it may be preferable to forego state funding. The Tacoma Narrows Bridge project is an example of this phenomenon at the federal level. Using foreign steel saved an estimated $30 million, and the project chose to forego federal funding as a result.[52]

Another possibility is that planners may strategically segment a project into multiple contracts, consolidating parts of the project that contain significant amounts of steel, allowing them to invoke price differential provisions or forego state funding for those that contain significant amounts of steel.[53] In these cases, we would expect both costs and benefits to be reduced.

[52] Laird, L. (2005). *Tacoma Narrows Bridge steel procurement.* Washington State Department of Transportation.
[53] This practice has historical precedent in the case of the Bong Bridge between Duluth, MN and Superior, WI in the 1980s and in the case of the Bay Bridge between San Francisco and Oakland, CA in the early 2000s. National Academies of Sciences, Engineering, and Medicine (NASEM). (2020). *Buy America requirements for federal highway projects.* Washington, DC: The National Academies Press.

Compliance. Another assumption is that contractors would fully comply with the regulation. Under federal Buy America provisions, there have been instances of noncompliance, resulting in litigation expenses, project delays, and other costs. Examples of noncompliance include unintentionally exceeding minimal use thresholds[54] and false certification of compliance with the regulation.[55] Such cases would increase the cost of a BA Steel policy by an indeterminate amount.

Price-setting Power. Domestic steel prices are partly determined by the level of competition in the market. A common objective of BA Steel policies is to shield the domestic industry from foreign competition. But a potential side effect is that domestic steel firms may gain the power to raise the prices they charge to contractors on state-funded construction projects because they do not face competition from foreign firms. If this were the case, then cost increases would be higher than those estimated in the BCA.

Investment & Innovation. The effect of a BA Steel policy on innovation and capacity investment is unclear. Steel mill investments are capital-intensive and time-consuming.[56] On the one hand, if steel producers can count on additional purchases from state construction projects, this could reduce uncertainty around future revenue flows and help justify investments in increased capacity. On the other hand, if producers know that state construction projects are required to purchase domestic steel, they may feel less pressure to innovate and stay abreast of foreign competitors.

Discussion

Our analysis concludes that a BA Steel policy would result in new business for Washington's steel industry, which would be offset by higher steel costs. Because of uncertainty around prices, the responsivity of steel producers, and other factors, it is not possible to say whether net benefits, employment effects, or income effects would be positive or negative.

We estimate that most new domestic steel demand would be met not by increasing production but by crowding out existing purchasers. We also estimate that most new steel production would occur in other states, but the increased costs would be borne solely by Washington State.

[54] For example, in 1990, a contractor on a federally funded ferry restoration project in Alaska miscalculated the value of foreign steel in fabricated toilet/shower modules. As a result, the contractor exceeded the minimal use threshold and was obliged to remove the modules, resulting in project delays. NASEM (2020).

[55] For example, in 2016, a Wisconsin architectural firm entered a guilty plea and agreed to pay fines to resolve criminal and civil claims regarding allegations that they had "repackaged materials and falsified documents relating to some federally funded construction projects in order to hide that it was using noncompliant foreign materials." US Department of Justice. (2016, January 5). *Wisconsin architectural firm to plead guilty and pay $3 million to resolve criminal and civil claims* [press release].

[56] A representative of Nucor Steel Seattle, Inc. indicated that they would need to see evidence of consistently higher demand over a 20–40-year period to justify investments in increased production capacity. P. Jablonski (personal communication, October 5, 2022).

Here we discuss how the structure of a BA Steel policy could affect these two dynamics in a way that increases benefits and reduces costs.

Products Covered. Regulating products that reflect the strengths of the Washington steel industry could affect benefits in two ways. First, it could increase the proportion of purchases made in Washington as opposed to other states. Second, it could increase the proportion of new demand met with new production if local suppliers can easily increase output.

Outreach to industry representatives indicates that Washington steel mills specialize in rebar products and smaller structural shapes.[57] Regulating products in these categories would be more likely to benefit Washington businesses. Expanding into new product types is capital-intensive and more difficult than expanding the production of existing products.

Projects Covered. Our outreach to industry representatives suggested that there is not a significant difference in Washington producers' ability to fulfill transportation and capital project orders.

Exemptions. As mentioned in the previous section, it is possible that additional costs would arise due to noncompliance with a BA Steel policy. The history of federal Buy America provisions suggests that a minimal-use exemption for foreign steel is more flexible and less prone to misunderstanding than exemptions for specific products.[58] Minimal use exemptions also enable contractors to apply their foreign steel allowance to products that are more expensive domestically.

However, allowing exemptions for products that Washington does not specialize in making could reduce costs with a minimal effect on benefits. Contractors could access less expensive foreign products without adversely affecting Washington steel producers.

[57] Smaller structural shapes include angle iron, channels, and flats. P. Jablonski (personal communication, October 5, 2022).

[58] NASEM (2020).

IV. Environmental Impact of Steel and Buy American Steel Policies

This section addresses the environmental impacts of steel production and any corresponding changes in the magnitude of these impacts resulting from a Washington BA Steel policy.

Environmental Impacts of Steel Production

Greenhouse Gases

Particular attention has been paid in the last 40 years to industry-generated emissions of greenhouse gases (GHGs because of their contribution to human-made climate change.[59] Steel is one of the most energy-intensive industries worldwide and contributes significantly to the emission of GHGs. The industry alone is responsible for about 9% of global emissions and 25% of all emissions from manufacturing industries.[60] Greenhouse gases emitted during the steel-making process include carbon dioxide, carbon monoxide, methane, and nitrous oxides. Each of these gases has different impacts on climate change.[61] It is common to aggregate all GHG emissions with their individual "warming potential" into a single number that captures their combined impact in terms of metric tons of carbon dioxide, known as carbon dioxide equivalent (CO_2e). We follow this convention throughout the report.

The intensity of emissions per metric ton of steel produced varies widely by production method, location, and destination. For instance, the Intergovernmental Panel on Climate Change (IPCC) estimates that the direct emissions of the basic oxygen furnace (BOF) production method come to 1.58 metric tons of carbon dioxide per metric ton of steel produced, whereas direct emissions from electric arc furnaces (EAFs) are only 0.18 metric tons of carbon dioxide per metric ton of steel.[62]

Steel production also generates emissions from electricity usage. Different locations use various sources of energy (e.g., coal, wind, gas) in different combinations. Each energy source will generate emissions at different rates, leading to more differences in emissions between locations. Emissions are also generated from the mining of coal and iron ore, and the transportation of those raw materials to mills where they can be turned into steel. Finally, emissions are generated by transporting steel from the production mill to the point of consumption.

[59] National Aeronautics and Space Administration. (2022). *What is the greenhouse effect?*

[60] Hasanbeigi, A., & Springer, C. (2019). *How clean is the U.S. steel industry: An international benchmarking of energy and CO_2 intensities.*

[61] US Environmental Protection Agency. (2022). *Understanding global warming potentials.*

[62] The BF-BOF production route involves the cooking of coal into coke, which explains a large portion of the difference in emissions between production methods. Intergovernmental Panel on Climate Change. (2019). *2019 refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Chapter 4.*

All of the above factors mean steel produced in different countries can have starkly different emissions per metric ton. For instance, a country that uses primarily blast furnace (BF)-BOF production methods and generates electricity primarily through the burning of coal would be expected to have much higher emissions of GHGs than a country that primarily uses EAF technology and generates electricity from more renewable sources. For a particular country or region, the total emissions per metric ton of steel produced are known as its steel emissions factor. We will use emissions factors to estimate the expected change in emissions resulting from a potential BA Steel policy.

The US is routinely estimated to have one of the lowest steel emissions factors in the world,[63] and hence moving from international to domestic steel production may seem like a good way to reduce global GHG emissions. However, because of the previously detailed global steel over-capacity problem, it is not necessarily true that an additional unit of steel produced domestically prevents the same unit from also being produced internationally. Thus, shifting steel production to domestic sources may actually increase global emissions. It is also possible that suppliers of steel may simply swap domestically sourced steel from other demanders towards government contractors, resulting in no change in demand or production domestically or internationally.

There is no way of telling whether and by how much the passage of a BA Steel policy would reduce international production. Therefore, in our analysis of environmental impacts, we model the complete, partial, and non-replacement of international production.

Other Environmental Impacts

The production of steel also causes other forms of pollution besides GHGs. Other air pollutants include sulfur dioxide, hydrogen sulfides, lead, nickel, arsenic, cadmium, chromium, copper, zinc, selenium, mercury, and particulate matter, all of which can cause breathing, vision, and circulatory problems and can be harmful to animal and plant life.[64] The cooling of steel and production of coke also uses a substantial amount of water, and although 90%-95% of this water can be recycled for further internal use, the runoff from operations can cause pollution of nearby water sources.[65] Water pollutants include organic matter, oil, metals, suspended solids, benzene, phenol, acids, sulfides, sulfates, ammonia, cyanides, thiocyanates, thiosulfates, and fluorides. Many of these chemicals are toxic to aquatic life, even in concentrations that are safe for humans. Suspended particles can also block out sunlight and hinder photosynthesis for aquatic plants.[66] Steel production can also cause ground pollution in the form of slag, sludge, sulfur compounds, heavy metals, oil and grease residues, and salts.[67] Most of these other non-GHG pollutants are more localized than GHGs. They also vary by production method, with EAFs producing far fewer of these pollutants than BOFs or OHFs.[68]

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[63] Hasanbeigi & Springer (2019).

[64] Doushanov, D.L. (2014). Control of pollution in the iron and steel industry. Department of Fuel, Institute of Organic Chemistry, Bulgarian Academy of Sciences, Bulgaria. *Pollution Control Technologies, 3.* Retrieved from U.S. Environmental Protection Agency. (2022). *Sulfur dioxide basics*.

[65] Colla, V., Matino, I., Annunziata Branca, T., Fornai, B., Romaniello, L., & Rosito, F. (2017). Efficient use of water resources in the steel industry. *Water 2017, 9*(11), 874.

[66] Doushanov (2014) and Biswas, J. (2015). Evaluation of various method and efficiencies for treatment of effluent from iron and steel industry: A review. *International Journal of Mechanical Engineering of Robotics Research, 2*(3).

[67] Doushanov (2014).

[68] Aula, M., Haapakangas, J., Heikkila, A., Iljana, M., Kemppainen, A., Roininen, J., . . . Visuri, V. (2012). *Some environmental aspects of BF, EAF and BOF*. University of Oulu, Faculty of Technology, Department of Process and Environmental Engineering.

Environmental Impacts of Buy American Steel Policies in Washington

In our final analysis of the report, we estimate the expected annual change in GHG emissions resulting from each policy examined in Section III. To do this, we first estimate total carbon dioxide equivalent emissions for each country and US state from which Washington obtains steel used in government projects. Our estimates of these emissions factors account for emissions from the following three sources:

- *Direct* emissions, which are generated by the manufacturing process of raw steel (melting and pouring);
- *Indirect* emissions, which are generated by the production of electricity necessary to support steel manufacturing; and,
- *Transportation* emissions, which are from the transportation of steel goods between locations. This includes not only finished products but also raw steel on its way to being fabricated.

We assemble each of these individual emissions factors into a single aggregate estimate for each policy based on the sources of steel allowed by each. By comparing the emissions factors for each policy to a baseline generated by Washington's current steel sourcing patters, we can estimate the expected change in emissions per metric ton of steel.

As mentioned above, the global over-production of steel may mean that sourcing an additional unit of steel domestically does not mean that a corresponding reduction in steel production takes place internationally. Additionally, if steel distributors have a mix of US- and non-US-made steel items, they could simply give more US-made steel products to government buyers and more international-made steel products to other buyers. Taken together, these possibilities mean that a BA Steel policy in Washington could lead to no reduction in foreign production of steel, meaning that the emissions from that production would still occur.

It is impossible to estimate the extent to which foreign production would decline in response to any of the policies under consideration. Therefore, we provide our estimates for the change in emissions resulting from each policy across a range of "replacement rates" which are meant to capture uncertainty in the amount of steel production abroad in response to a BA Steel policy in Washington. For instance, a replacement rate of 100% would mean that one metric ton of increased production of steel domestically from a policy would result in a one metric ton reduction in foreign production. A 30% replacement rate would mean that each domestic metric ton of steel produced domestically would result in 0.3 fewer metric tons being produced internationally, and so on. This method will produce a range of emissions changes corresponding to each policy at various levels of replacement.

We base our analysis on estimates of the amount of steel affected by each policy as in the BCA above. Unfortunately, data on emissions from the fabrication of steel are not available and so we consider only emissions from the production of the raw steel used in fabrication. For more details on how we construct each emissions factor see the Environmental Appendix.

Results of Emissions Analysis

Exhibit 14 provides a comparison of steel emissions factors in the US and among Washington's top import sources for raw and fabricated steel. As estimated elsewhere, the US is among the cleanest producers of steel in the world. This is because the US uses a relatively large share of EAFs for steel production, which is much cleaner than the traditional BOF method. Producing steel domestically also results in far less emissions from the transportation of steel to Washington as compared to international production.

Exhibit 15 depicts our estimates for the change in metric tons of carbon dioxide equivalent emissions per year under each policy at various replacement values for foreign-produced steel. The maximum potential reduction in emissions comes from The Full Policy (which affects the most steel) at 100% replacement, which would lead to an estimated 2,221 fewer metric tons of GHGs (which is equivalent to removing 500 personal automobiles from the road) each year.[69] In comparison, the steel industry in Washington is estimated to have emitted 180,000 metric tons of carbon dioxide equivalent[70] 2,221 metric tons represent just 1.2% of this number.

On the other hand, if the degree of replacement of foreign production of steel under the Full Policy is smaller, the policy could actually result in a net *increase* in emissions. If not enough foreign steel is offset by increased domestic production, then even though domestic production is less GHG-intensive than most foreign production, net emissions will be higher under the policy that without it. This happens for the Full Policy at a replacement rate of 56% or less. In the extreme case of 0% replacement, we estimate that the Full Policy could increase to nearly 3,000 metric tons of GHGs per year (or about 650 cars annually).. Our methodology estimates that this can compared to total steel production generated emissions (only 1.6% of that number).

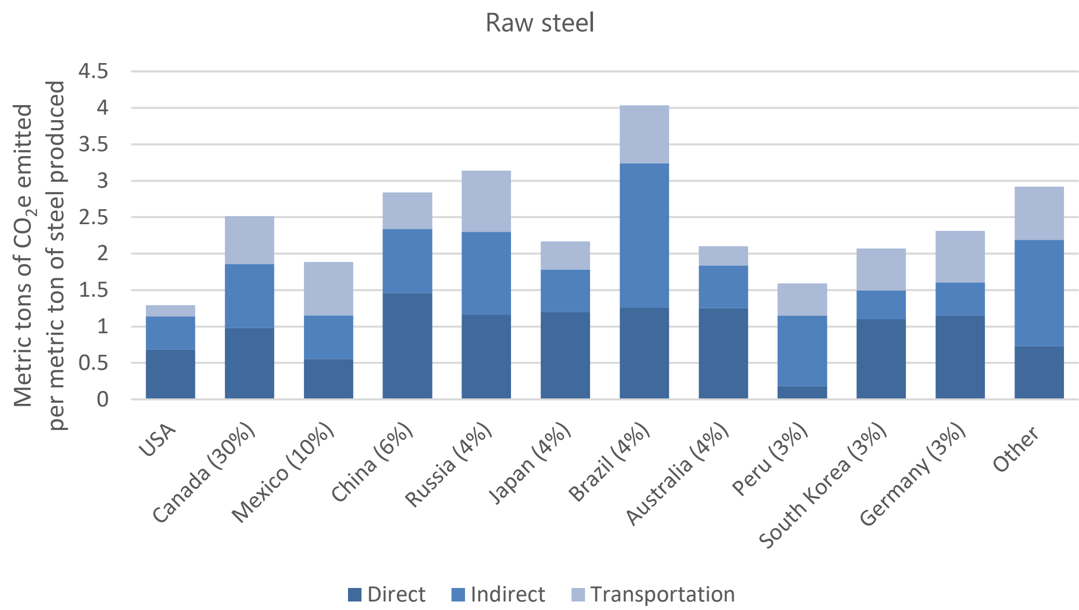
The Transportation Only and Capital Only Policies affect less steel than the Full Policy, and hence the changes in emissions they bring about are also smaller in magnitude than those of the Full Policy at each replacement rate. For these policies, the replacement rate at which net emissions start to increase under each is also 56%.

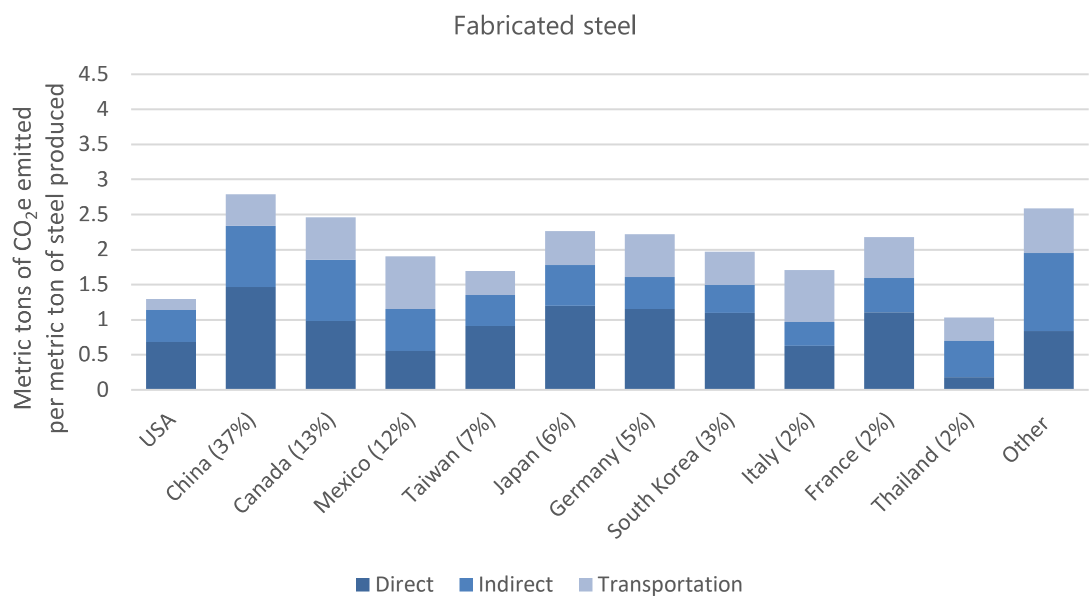
[69] The EPA estimates that a typical personal passenger vehicle emits about 4.6 metric tons of CO_2 annually. US Environmental Protection Agency. (2022). *Greenhouse gas emissions from a typical passenger vehicle.*

[70] Washington Department of Commerce. (2021). *Washington State industrial emissions analysis.*

Exhibit 14

Estimated Emissions Factors for Raw Steel Manufacture,
Top Import Source Countries for Washington (Import Penetration in Parentheses)





<u>Notes</u>:
All emissions factors are given in metric tons of CO_2 equivalent/metric ton of raw steel manufactured.
Percentages given are share of total imports to Washington.
"Other" is constructed as an average of emission factors of all other source countries weighted by their respective import penetration rates to Washington.
Note that several countries appear in both graphs; we repeat their emissions factors for consistency.

The Fabrication Only Policy allows the production of raw steel to occur internationally, while the other policies mandate that all raw and fabricated steel production take place domestically. Since emissions from international production of raw steel and shipping to the US tend to be higher than domestic direct, indirect, and transportation emissions (see Exhibit 14 above), this means that the Fabrication Only Policy will allow greater emissions at 100% replacement than the Full Policy, even though they both regulate all steel in the capital and transportation budgets. For the Fabrication Only Policy, net emissions increase compared to the absence of a BA Steel policy for replacement rates of 73% or less.

Discussion

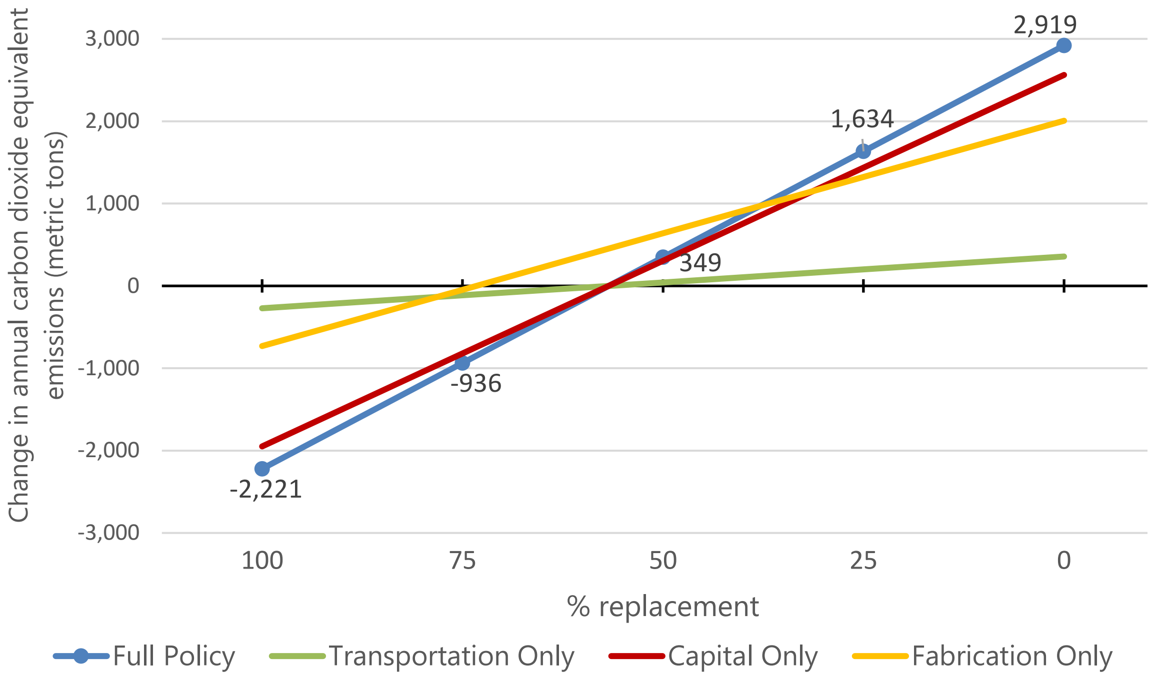
Overall, our environmental analysis of potential BA Steel policies in Washington State produces ambiguous results. Whether net emissions increase or decrease under each policy is largely driven by the response of foreign producers to changes in demand for their steel. If foreign producers respond to decreases in demand for steel from Washington State government contractors by decreasing their production in tandem, then such a policy would likely decrease GHG emissions. On the other hand, if foreign producers are relatively unresponsive to changes in demand by Washington State, it is likely that BA Steel policies in the state would lead to increases in GHG emissions.

While it is impossible to know exactly how foreign producers would respond to changes in steel demand from the Washington State Legislature, it is unlikely that they would be very responsive. During our outreach efforts, industry representatives indicated that steel producers largely choose how much to produce based on world prices for steel. Since the amount of steel used in projects in the Washington State Capital and Transportation Budgets is a tiny fraction of global demand, change resulting from a BA Steel policy in the state would have virtually no impact on global prices. Therefore, it is likely that the replacement rate for foreign production would be relatively small.

Even in the most extreme cases, however, our analysis indicates that the change in emissions resulting from a state-level BA Steel policy would be small compared to overall emissions from steel production in the state.

Exhibit 15

Estimated Change in Global Carbon Dioxide Equivalent Emissions for Each Policy at Various Replacement Rates



Note:
Value labels are provided for the Full Policy.

V. Conclusion

Overall, the analyses conducted in this report suggest that requiring all or some steel in the Washington Capital and Transportation Budgets to be milled and/or fabricated domestically would have a limited impact on the state economically and environmentally. The BCA concluded that the costs of a BA Steel policy would be larger than the benefits under most scenarios and versions of such a policy. The EIA showed that while a BA Steel policy would support a handful of new jobs in the raw and fabricated steel industries in the state, the additional taxes needed to pay for the resulting increases in project cost would decrease employment in other industries. Overall, the economy would lose a few jobs per year compared to a baseline of no policy.

The changes in employment and income resulting from a BA Steel policy suggested by both the BCA and EIA are small in comparison to the state economy as a whole, ranging from a loss of 13 jobs to a gain of 12 jobs statewide.

The environmental analysis found that total greenhouse gas emissions could either increase or decrease as a result of a state BA Steel policy. Our results show that sourcing domestic steel for Washington State generates fewer emissions per metric ton of steel than any international alternative. However, some portion of the international steel that would be replaced by domestic steel under such a policy would likely still be manufactured and generate emissions.

If international steel producers do not adjust their output in response to a BA Steel policy, then the policy could end up encouraging more emissions. For this reason, it is not possible to determine with certainty whether a BA Steel policy in Washington State would lead to more or less greenhouse gas emissions than the status quo of no BA Steel policy.

Our analysis shows, however, that even in the most extreme cases, the impact of such a policy on emissions would be small—we predict a change of between -1.2% and +1.6% of steel production emissions in the state.

Appendices

The Impacts of a Buy American Steel Policy in Washington State

Appendices

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I. Proposed and Existing State-level Buy American Steel Policies

Exhibit A1

Proposed and Existing State-level Buy American Steel Policies

State	Year passed	Policy	Restriction applies to	Restriction requirements	Exemptions
Ohio*	1977	Ohio implemented a Buy American steel policy in House Bill 618 of the 1977 legislative session.	“Any building or structure, including highway improvements” that receives state funding.	Steel products “used for load-bearing structural purposes” be made “from steel made in the United States.”	The restriction allows for a minimal amount of foreign steel products in bridge projects, at the discretion of the director of transportation, and allows for exemptions in the case that suitable domestic products are not available.
Indiana**	1978	Indiana implemented a Buy American steel policy in Public Law 27 of the 1978 legislative session. It is currently codified in IC 5-16-8.	“Every contract for the construction, reconstruction, alteration, repair, improvement or maintenance of public works” that receives state funding.	Steel products are made in the US using US steel.	The restriction allows for an exemption in the case that suitable domestic products are not available. It also allows for an exemption in the case that the price difference between contract bids using domestic products and foreign products exceeds 15%. This percentage may be increased to 25% “if the head of the public agency determines that the use of steel or foundry products of domestic origin would benefit the local or state economy through improved job security and employment opportunity.”
Pennsylvania***	1978	Pennsylvania implemented a Buy American steel policy in Public Law 3 of the 1978 legislative session.	“Every contract document for the construction, reconstruction, alteration, repair, improvement or maintenance of public works” that receives state funding.	Steel products are made “from steel made in the United States.” It also applies to steel used in machinery, furniture, and transportation equipment.	The restriction allows for exemptions in the case that suitable domestic products are not available.

Notes:

*Using domestic steel products in state supported projects, Ohio Revised Code § 153.011 (1977 & rev. 2012).

**Steel procurement for public works, Indiana Code § 15-16-8 (1978 & rev. 2016).

***Steel products procurement act, Pennsylvania Statutes § 73.25.1881-7 (1978 & rev. 2013).

Exhibit A1

Proposed and Existing State-level Buy American Steel Policies

State	Year passed	Policy	Restriction applies to	Restriction requirements	Exemptions
Maryland*	1981	Maryland implemented a Buy American steel policy in an emergency provision in 1981. It is currently codified in the Maryland State Finance and Procurement Statutes, Sections 17-301 to 17-306.	Contracts for "constructing or maintaining public work[s]."	Steel products are made using US steel.	The restriction allows for an exemption in the case that suitable domestic products are not available. It also allows for an exemption in the case that the price difference between domestic steel products and foreign steel products exceeds 20%. This percentage is increased to 30% "if the steel product is produced in a 'substantial labor surplus area' as defined by the United States Department of Labor." The restriction does not apply when it would "conflict with a federal law or grant affecting a contract."
Illinois**	1984	Illinois implemented a Buy American steel policy in Public Act 83-1030 (Senate Bill 0133) of the 1983-84 legislative session.	"Each contract for the construction, reconstruction, alteration, repair, improvement or maintenance of public works made by a public agency."	Steel products "used or supplied in the performance of that contract or any subcontract thereto" be manufactured or produced in the United States.	The restriction does not apply to expenditures of less than $500. It allows for an exemption in the case that suitable domestic products are not available, or "when its application is not in the public interest." It also allows for an exemption in the case that "obtaining the specified products, manufactured or produced in the United States would increase the cost of the contract by more than 10%."
West Virginia***	2001	West Virginia implemented a Buy American steel policy in House Bill 2207 (Senate Bill 124) of the 2001 legislative session.	The construction or alteration of "any building or structure, including, but not limited to, roads or highways" that receives state funding.	Steel products are made in the US using US steel.	The restriction allows for an exemption in the case that suitable domestic products are not available. It also allows for an exemption in the case that the value of foreign steel products does not exceed one-tenth of one percent of the total contract cost or $2,500, whichever is greater.

Notes:

*Buy American steel act, Code of Maryland Regulations § 21.11.02 (1981 & rev. 1989).

**Steel products procurement act, Illinois Compiled Statutes § 30.565.4 (1984).

***Preference for the use of domestic steel products in state contract projects, West Virginia Code § 5A-3-56 (2001 & rev. 2020).

Exhibit A1

Proposed and Existing State-level Buy American Steel Policies

State	Year passed	Policy	Restriction applies to	Restriction requirements	Exemptions
New York*	2017	New York implemented a Buy American steel policy in State Assembly Bill A8427A (Senate Bill S6639A) of the 2017 legislative session.	"All contracts over $1 million for the construction and reconstruction of surface roads and bridges."	"Structural steel permanently incorporated" into the project be made in the US, "from the initial melting stage through the application of coatings."	The restriction allows for an exemption if domestic products would "increase the cost of the contract by an unreasonable amount;" if suitable domestic products are not available; if the restriction "would result in the loss or reduction of federal funding;" if foreign products are needed to maintain critical infrastructure; or if the restriction would conflict with an existing reciprocal trade agreement.
Texas	2017	Texas implemented a Buy American steel policy in House Bill 2780 (Senate Bill 1289) of the 2017 legislative session.	Contracts to "construct, remodel, or alter a building, a structure, or infrastructure."**	Steel products are made in the United States, "from initial melting through application of coatings."	The restriction allows for an exemption in the case that suitable domestic products are not available, or "when its application is not in the public interest." It also allows for an exemption in the case that "obtaining the specified products, manufactured or produced in the United States would increase the cost of the project by more than 20%." *Other comments*: a fiscal note on SB 1289 states that "such a requirement could allow the cost of projects to increase by up to 20%" Overall, the fiscal note concluded that there is an "indeterminate" fiscal impact.***
California****	2019	California implemented a Buy American steel policy in 2019 in the Caltrans Construction Manual, Chapter 3, Section 604.	Caltrans projects, "regardless of funding source."	"Steel materials permanently incorporated into the work… 42include[ing] steel components of a manufactured product" be fabricated in the US with US steel. It allows for minimal use of foreign steel in the amount of 0.1% of the total contract bid or $2,500, whichever is greater.	The restriction considers other exemptions only if they are first approved by the Federal Highway Administration.

Notes:

*New York Buy American Act, A08427A, 2017 Biennium, Reg. Sess. (New York, 2017).

**S.B. 1289, 2017 Biennium, Reg. Sess. (Texas, 2017).

***Fiscal Note for S.B. 1289, 2017 Biennium, Reg. Sess. (Texas, 2017).

****Buy America, California Department of Transportation Construction Manual § 3-604 (2019).

Exhibit A1

Proposed and Existing State-level Buy American Steel Policies

State	Year passed	Policy	Restriction applies to	Restriction requirements	Exemptions
Kentucky	2020	Kentucky considered a Buy American steel policy in House Bill 114 of the 2020 legislative session. **The bill was not passed.**	The restriction would have applied to any "contract for the construction or maintenance of a public building or public work."*	The restriction would have required that steel goods "supplied as a primary component in the performance of the contract" be made in Kentucky.	The restriction would have allowed for an exemption in the case that suitable domestic products are not available. It also would have allowed for an exemption in the case that the inclusion of Kentucky steel would increase the project or contract by an "unreasonable amount." A fiscal note on HB 114 noted that 38.6% of construction outlays are spent on materials.**
Maine	2021	Maine considered implementing a Buy American steel policy in Senate Paper 461 (Legislative Document 1411) of the 2021 (130th) legislative session**. The policy was vetoed.**	The restriction would have applied to contracts for public improvements.	The restriction would have required that "steel used or supplied in the performance of the contract" must be manufactured in the United States.***	The restriction would have allowed for an exemption in the case that suitable domestic products are not available. It also would have allowed for an exemption in the case that the inclusion of US steel would increase the project or contract by an "unreasonable amount," as defined by the relevant state department. *Other comments*: A fiscal note on LD 1411 states that the requirement could "increase costs to all state agencies and public higher educational institutions." It also states that the law will "require additional positions to research which products are manufactured in the United States, to review all contracts and to implement and enforce the waiver process" and estimates the cost of four full-time administrative positions to be between $252 thousand and $278 thousand per year.****

Notes:

*H.B. 114, 2020 Biennium, Reg. Sess. (Kentucky).
**Fiscal Note for H.B. 114, 2020 Biennium, Reg. Sess. (Kentucky).
***Maine Buy American and Build Maine Act. L.D. 1411, 2020 Biennium, 2021 First Special Session
****(Maine). Fiscal Note for L.D. 1411, 2020 Biennium, 2021 First Special Session (Maine).

Exhibit A1

Proposed and Existing State-level Buy American Steel Policies

State	Year passed	Policy	Restriction applies to	Restriction requirements	Exemptions
New Jersey	2021	New Jersey implemented a Buy American steel policy in Assembly Bill 5064 (Senate Bill 853) of the 2021 legislative session.	Contracts involving the "construction, reconstruction, alteration, repair, maintenance, or improvement of any surface highway or bridge"* valued over $1 million.	Permanently incorporated steel products are made in the US with US steel.	The restriction allows for an exemption if domestic products would "increase the cost of the contract by an unreasonable amount;" if suitable domestic products are not available; if the restriction "would result in the loss or reduction of federal funding;" if foreign products are needed to maintain critical infrastructure; or if the restriction would conflict with an existing reciprocal trade agreement.
New Hampshire	2022	New Hampshire implemented a Buy American steel policy in House Bill 1503 of the 2022 legislative session.	"any contract for construction, reconstruction, alteration, repair, improvement, or maintenance of a public building or public works." **	Permanently incorporated fabricated structural steel products made in the US with US steel should be given "strong consideration and preference."	The restriction does not mention any specific exemptions. *Other comments*: A fiscal note on HB 1503 states that there would be an "indeterminable" increase in state expenditures due to the law.
Florida	2022	Florida considered a Buy American steel policy in House Bill 619 of the 2022 legislative session. **The bill was not passed.**	The restriction would have applied to all public works projects.	The restriction would have required that "products made primarily of iron or steel" be made in the US with US steel.***	The restriction would have allowed for an exemption in the case that suitable domestic products are not available. It would also have allowed for an exemption in the case that using US steel would increase the total project cost by more than 20%. It would also have allowed for an exemption in the case that the value of foreign steel products does not exceed one-tenth of one percent of the total contract cost or $2,500, whichever is greater. A fiscal note on HB 619 states that the law would have an "indeterminate but potentially negative fiscal impact." ****

Notes:

* New Jersey Buy American Act. A5064, 2020 Biennium, Reg. Sess. (New Jersey 2020).

** HB1503, 2020 Biennium, Reg. Sess. (New Hampshire 2022).

*** H.B. 619, 2020 Biennium, Reg. Sess (Florida, 2022).

**** Fiscal Note for H.B. 619, 2020 Biennium, Reg. Sess. (Florida, 2022).

Exhibit A1

Proposed and Existing State-level Buy American Steel Policies

State	Year passed	Policy	Restriction applies to	Restriction requirements	Exemptions
Massachusetts*	2022	Massachusetts considered a Buy American steel policy in Senate Bill 2546 of the 2022 legislative session. **The bill is currently under consideration.**	The restriction would apply to any contract for the "construction, reconstruction, alteration, repair, improvement or maintenance of a public building or public works."	The restriction would require that steel products be made in the US with US steel.	The restriction would allow for an exemption in the case that suitable domestic products are not available, or in the case that using US steel would increase the total project cost by more than 25%. Some governmental bodies would only need to comply with the regulation for projects exceeding $500 thousand and could apply for an exemption if they receive fewer than three domestic contract bids.

Note:
*H.B. 192, 2020 Biennium, Reg. Sess (Massachusetts, 2022).

II. Methodological Appendix

BCA Framework

Benefit-Cost Analysis (BCA) is an analytical tool for comparing alternative policy options. BCA can be conducted before a policy is implemented as a way of forecasting potential effects, or after a policy is implemented as a way of calculating benefits and costs retrospectively. WSIPP's approach to BCA proceeds in several steps.

First, we specify a set of alternative policies to compare to a baseline policy involving no new regulations. In this case, policy alternatives are chosen to illustrate a range of plausible regulatory structures. Second, we identify groups who might benefit or bear costs due to the policy. Third, we estimate the monetary value of benefits and costs experienced by those groups. These calculations are based on economic theory and assumptions about how different groups would respond to new economic pressures. Finally, we perform sensitivity analysis to account for uncertainty in our estimates. This involves conducting statistical simulations and testing the robustness of our results to different assumptions.

Our BCA model produces three summary statistics for each policy: net benefits, benefit-to-cost ratio, and a measure of risk.[71] Net benefits are equal to benefits minus costs. The benefit-to-cost ratio is equal to benefits divided by costs, with values greater than 1 indicating positive net benefits. The risk measure is calculated as the percentage of model simulations that result in positive net benefits.

Benefits

In this report, we consider the impact of requiring that all steel products used in contracts and sub-contracts authorized in the Washington State Transportation and Capital Budgets be fabricated in the United States using US-made raw steel. In our analysis, beneficiaries of a BA Steel policy are steel workers who experience increases in earned income, and steel business owners who experience increased profit. Our analysis assumes that all regulated projects would proceed as planned, replacing foreign steel with US alternatives. Some of these new US purchases would result in US steel producers increasing their output, while other purchases would simply replace existing production as existing buyers switch to foreign suppliers due to price and capacity constraints. For new production, some would occur in Washington State. We assume steel mills and fabricators would increase production by hiring workers and paying them according to average industry wages.

Different methods exist to calculate the benefit of new wages. One method is to calculate the increase in wages for affected workers. For instance, if a steel mill hires a new worker at an annual wage of $100 thousand and that worker was previously earning an annual wage of $80 thousand, the benefit would be $20 thousand. In our analysis, we follow the method described in Bartik (2021):[72]

> *…before the new job leads to additional employment, it will typically lead to a job chain of upgrading opportunities for the currently employed. A new job may be filled by someone already employed. This 'job switcher' must have gained from this voluntary move. The job switcher's old job is now vacant. That job vacancy may be filled by someone already employed, who also will upgrade his or her job. Ultimately the chain is broken by the hiring of someone not employed in that labor market. (p. 14)*

[71] While this BCA is conducted outside of WSIPP's standard BC model, it does follow similar methods. See WSIPP's Benefit-Cost Technical Documentation for additional information.

[72] Bartik, T.J. (2012). Including jobs in benefit-cost analysis. *Annual Review of Resource Economics, 4*(1), 55-73.

Hence, in our analysis, we count the full value of new wages on the benefit side to capture the effect of the job chain dynamic.

Costs

A Buy American Steel policy places a constraint on contractors who would otherwise purchase foreign steel. We assume that contractors would face higher costs for domestic replacement steel and that they would pass those cost increases on to the capital and transportation budgets through higher bid prices. In our model, the ultimate bearers of these increased costs are Washington taxpayers.

Model Parameter Estimates

This section of the Appendix describes parameters used in the benefit-cost analysis and economic impact analysis sections and how they are estimated.

Value of Fabricated Steel Products in Capital and Transportation Budgets that Would be Newly Subject to BA Regulations (S_0). For both the capital and transportation budgets, we reached out to the Legislative Evaluative and Accountability Program Committee (LEAP) for a list of construction projects in each budget and were provided with a data file containing appropriation amounts, names, and short descriptions for each project. These are the main data that we worked with to calculate the average steel demand by the government in calendar years.

For consistency, and to account for inflation, we translate all steel costs from both budgets into 2019 dollars.[73] Since steel must first be fabricated before being used in construction, we assume that all steel demanded by the state government is fabricated (NAICS 3323).

Estimating Steel Use in the Transportation Budget. We closely match the methodology laid out in a fiscal note provided courtesy of the Washington State Department of Transportation (WSDOT) from 2019.[74] The Department of Transportation was tasked with estimating the cost increase that would result from a total exclusion of foreign steel from WSDOT contracts. Based on bid price history, WSDOT estimates that about 1.5% of the total value of construction contracts funded by the Highway Improvement and Highway Preservation Programs goes to steel.

To estimate steel usage in the transportation budget not already covered by federal Buy America laws, we took the following steps:

1) Compile all biennial budgets between 2007 and 2021;
2) Filter out all programs already receiving federal funding (and therefore already subject to BA mandates);
3) Filter down to only those projects funded by Highway Improvement or Highway Preservation Programs;[75]
4) Apply the 1.5% rule to each biennium; and
5) Divide steel demand proportionally across the two years based on annual construction expenditures from the Census Bureau's annual Survey of Local and State Government expenditures.[76]

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[73] RS Means, a program described below, measures the value goods used in construction in 2019 dollars; we convert other measures to 2019 dollars as well for consistency.

[74] Washington State Department of Transportation. (2019). *American/Recycled Steel in Pub Works Projects* (Fiscal note).

[75] WSDOT determined in its fiscal note that the vast majority of steel use occurs in these two programs. We follow the assumptions outlined there.

[76] We assume that the share of steel demand in each year of each biennium is proportional to the share of construction expenditures. Data are not available for 2022, so we assume that half of the steel estimated for the 2021-23 biennium is used in 2021.

This gives us an estimate of around $17.3 million in steel from the transportation budget that would newly come under Washington State-level BA Steel policy each year.

Estimating Steel Usage in the Capital Budget. Unlike the transportation budget, there is no wholesale rule of thumb for estimating steel usage on capital projects. Therefore, we had to estimate steel usage on a project-by-project basis. To estimate steel usage in the capital budget, we took the following approach:

1) Filter out all projects receiving less than $100 thousand in state money in the state Capital Budget.[77] This narrows our project list down to approximately 22,000 projects.
2) Filter down to only those projects whose descriptions contained the word "build" or the string "constr" (which is meant to catch words such as "construct," "construction," and "constructing").[78] This narrows our project list down to approximately 7,600 projects.
3) Read through each of the remaining 7,600 projects and decide whether each project should be considered.[79]
4) Sort the projects into two main categories which we designate as "standard" and "non-standard," corresponding to whether we feel confident that we can estimate their steel usage using RS Means.[80]
    a) To estimate standard projects:
        i. Assign each project in the standard category to the nearest city for which RS Means has cost estimates.
        ii. Select an RS Means structure type that most closely matches the building description in the capital budget.
        iii. Estimate the square footage of the project.[81]
        iv. Model two different framing types, generating high and low steel use estimates.
        v. Estimate the value of known steel items (excluding rebar) in the project.[82]
        vi. Estimate the usage of rebar in reinforced concrete.[83]

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[77] Small projects are unlikely to use much steel in their construction given the high cost of steel relative to other inputs. Large projects receiving a small portion of their total budget from the state may opt to not receive state funding because of the price difference between domestic and foreign steel.

[78] Our outreach efforts informed us that only substantially new construction would use much steel, and we feel that these keywords ultimately allow us to filter out many irrelevant project items. It is likely, however, that some omitted projects contain steel usage.

[79] For instance, budget entries that detail new construction of specific educational facilities are included; projects that deal only with renovation are filtered out. Large block funding appropriated for general construction, such as wastewater treatment plant or fish hatchery construction, is included.

[80] RS Means is a construction cost estimation software from Gordian that allows users to enter a building type (e.g., college classroom building), framing type (e.g., steel joists/brick veneer), and various scale parameters (e.g., story height, perimeter, gross square feet) and delivers a breakdown of the various construction materials needed to assemble said the building along with a location-specific estimate of the various costs. We specifically use the Square Foot Estimator, which comes preloaded with building types, accessed via RS Means Online.

[81] For many projects, the square footage of the building is reported directly in the budget; for others, a quick web search for news articles related to their opening turns up square footage; the remaining projects, for which square footage is not available, we assume to have the default size suggested by RS Means.

[82] We use string search tools to extract items that we know contain steel. These include items that explicitly have the word "steel" in their description, blocks of reinforced concrete, and joists.

[83] We estimate the usage of rebar in reinforced concrete by taking the volume of each block and applying estimates of Ugochukwu, S., Nwobu, E., Udechukwu-Ukohah, E.I., Odenigbo, O., & Ekweozor, E. (2020). Regression models for predicting quantities and estimates of steel reinforcements in concrete beams of frame buildings. *Journal of Scientific Research and Reports, 26,* 60-74; for joists, we take the square root of the floor area of each structure in gross square feet to be the length of each joist and apply the weight/meter estimates presented in Canam. (2010). *Joist catalog.* Steel Joist Institute.

vii. Estimate steel usage for the project by adding our estimate of known steel items and rebar, taking the average of the high and low steel use estimates for each project.

b) To estimate non-standard projects:

i. Group projects into categories and apply "rules" across all projects falling into each category. Exhibit A2 presents each category of non-standard projects and our method of steel estimation.[84]

5) Divide steel demand proportionally across the two years based on annual construction expenditures from the Census Bureau's Annual Survey of Local and State Government expenditures.

This gives us an estimate of around $59.2 million in steel from the capital budget that would newly come under Washington State-level BA Steel policy each year. Adding this estimate to our transportation budget estimate gives us a total government steel demand estimate of $67.5 million per year.

Exhibit A2

Categories of Non-Standard Projects And our Steel Use Estimation Strategies

Non-standard category	Description	Estimation strategy
Block funding	Large appropriations to agencies for general construction/operation	Call receiving agencies for guidance
Canopies	Covers for aircraft	Modeled using side-less hangar on RS Means
Elevators	Replacement/installation only, not repairs or modernization	$12,500 + $15/floor, formula developed with help from Jeff Stull of Otis Elevators
Fencing	For correctional facilities	Assume 25% of cost is labor, the rest is steel
Hatcheries	Fish rearing facilities	Assume 14.48% of cost is steel, using estimates from Dept. of Fish and Wildlife
SCAP	Elementary, middle, Jr. High and High schools constructed in part with funding from the School Construction Assistance Program (block funding)	Model a handful of such schools on RS Means, estimate steel usage per square foot and apply an average across all such funded projects
Transportation	Parking lots and other transportation related non-building construction	Apply the 1.5% rule from WSDOT that we use in the transportation budget
Water treatment	Wastewater treatment plants, decant facilities, etc.	Apply 12.11% rule according to steel usage in the Water District of Lakewood

[84] There were some additional projects that did not fit into any category; for these, we either contacted the agency receiving the funding for specific estimates or omitted them from consideration.

Estimating Total State Steel Demand. To calculate the impact of the BA Steel policy in the EIA we estimate total state steel demand. Estimates of the total amount of steel demanded in Washington are not available. We, therefore, impute steel demand using data on national consumption of steel by industry and the share of each industry's GDP in Washington State.[85] For instance, if the total national steel demand is 100 million metric tons, a particular sector is responsible for 5% of total national steel consumption and 2% of the GDP of that industry is generated in Washington, then we assume that the demand for steel of that sector in Washington is $5\% \times 2\% \times 100$ million metric tons = 0.1 million metric tons. Summing across all public and private industries gives us total steel demand. We translate this into demand for fabricated steel using a U.S. Bureau of Economics Analysis (BEA) estimate of the share of revenue spent on steel by fabricators.[86] This gives us an estimate of the value of fabricated steel used by these industries.

Data on total US apparent consumption comes from the US Geological Survey's Mineral Commodity Summary data on iron and steel;[87] steel shipments by end-use industry are provided curtesy of American Iron and Steel Institute (AISI);[88] the share of each industry's output in Washington is obtained from the BEA's GDP and personal income data series.[89]

Combining these numbers with our state government demand estimates, we estimate that the Washington State Legislature accounts for approximately 2.7% of the total state demand annually.

Steel Imports. We estimate that between 2007-2021, the average annual value of fabricated steel products used in projects in the capital and transportation budgets not already subject to federal Buy America requirements was $67.5 million.[90] Some of this steel is already domestically milled and/or fabricated and hence would be compliant with a BA Steel policy. To calculate the value of products that would currently be noncompliant with a BA Steel policy, we estimate the proportion of raw and fabricated steel consumed in Washington State that comes from foreign sources.

Current Source Location of Raw Steel and Fabrication (p_{fd}, p_{df}, p_{ff}). Under a BA Steel policy, we assume that fabricated steel products that use foreign-made raw steel and/or are fabricated abroad would be replaced with domestic alternatives. We estimate the current proportion of fabricated products that would need to come into compliance using an International Trade Commission model.[91] This model estimates state-level import penetration rates (the proportion of state consumption supplied by imports) by industry at the 3-digit North American Industrial Classification System (NAICS) code level. Using 2017 trade data from USATRADE[92] and interstate product shipment data from the Census Bureau's Commodity Flow Survey (CFS),[93] we estimate that the import penetration rate in Washington for fabricated metal products (NAICS code 332) is 28.0%.

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[85] Everyday households and consumers typically do not purchase much steel directly. This fact allows us to focus only on industrial demanders.

[86] U.S. Bureau of Economic Analysis. (2018). Input-output accounts data.

[87] National Minerals Information Center. (2022). *Iron and steel statistics and information*. United States Geological Survey.

[88] T. Gill, American Iron and Steel Institute (personal communication, June 20, 2022).

[89] Bureau of Economic Analysis. (2022). *Regional data: GDP and personal income*. [Data set].

[90] In 2019 dollars.

[91] Riker, D. (2022). State-level import penetration. U.S. International Trade Commission Economics Working Paper Series No. 2022-03.

[92] U.S. Department of Commerce and U.S. Census Bureau. (2017). Exports & imports by NAICS commodities.

[93] U.S. Department of Transportation, Bureau of Transportation Statistics, U.S. Department of Commerce, U.S. Census Bureau. (2020). 2017 commodity flow survey datasets: 2017 CFS Public Use File (PUF).

Some foreign-fabricated products use US-made raw steel. These products involve raw steel made in the US that is shipped abroad, used in the production of fabricated products, and then re-exported to Washington State for use. To calculate the proportion of products in this category, we use data from the US International Trade Administration (USITA) on the steel mill product import penetration rates of Canada and Mexico.[94] USITA estimates that in 2019, 89% of US raw steel exports went to either Mexico (45%) or Canada (44%).[95] The third largest destination, China, received 1% of US raw steel exports. Because the value of rebounding products from other countries is negligible,[96] we restrict our analysis to Mexico and Canada. USITA estimates that in 2017, the United States supplied 15.1% of Mexico's raw steel consumption and 30.7% of Canada's raw steel consumption. We use these values as estimates of the proportion of fabricated steel products from those countries using US-made raw steel. Combining these values with our previous estimates of Washington's fabricated metal product import penetration rate, we estimate that 1.5% of current fabricated products consumed in Washington were fabricated in Canada or Mexico using US-made raw steel (p_{df}). The remaining 26.5% of foreign-fabricated products use foreign raw steel (p_{ff}).

Seventy-two percent of products currently fabricated domestically use a mix of foreign and domestic raw steel. To calculate the proportion that uses foreign raw steel, we combine CFS data on fabricated metal products with state-level import penetration rates for primary metal products (NAICS code 331). We calculate the share of Washington's fabricated product consumption coming from each state along with that state's primary metal product import penetration rate. By summing across states, we calculate the proportion of Washington's domestically fabricated products that use foreign raw steel. For example, 11.1% of Washington's domestic fabricated products come from California, and California's primary metal products import penetration rate is 36.1%, so we estimate that (11.1%) × (36.1%) = 4.0% of Washington's domestic fabricated products are fabricated in California using foreign raw steel. Summing across all states including Washington, we estimate that 24.6% of Washington's fabricated steel products are fabricated domestically using foreign raw steel (p_{fd}). The remaining 47.4% are fabricated domestically with US-made raw steel and would not be affected by the BA Steel policy. These estimates are summarized in Exhibit A3. State-level import penetration rates are presented in Exhibit A4.

Exhibit A3

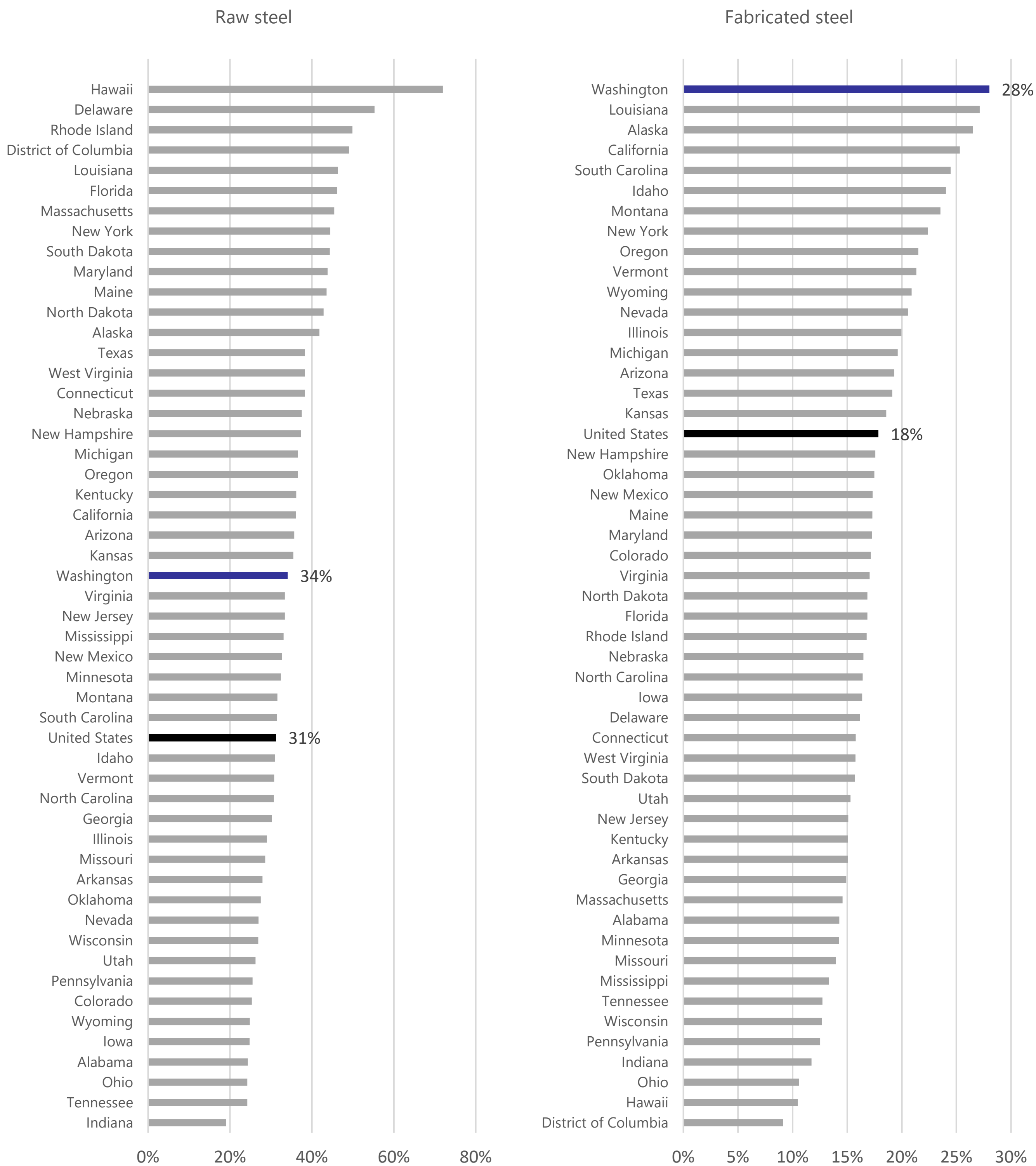
Origin of Raw Steel and Fabrication for Steel Products Consumed in Washington

		Fabrication source		
		Domestic	**Foreign**	
Raw steel source	**Domestic**	47.4%	1.5%	49.0%
	Foreign	24.6%	26.5%	51.0%
		72.0%	28.0%	100.0%

[94] Steel Import Monitoring and Analysis. (2019). *Steel Imports Report: Canada and Mexico.* U.S. International Trade Administration.
[95] Steel Import Monitoring and Analysis. (2020). *Steel exports report: United States.* U.S. International Trade Administration.
[96] The third largest US raw steel export destination is China. US raw steel accounts for less than one hundredth of 1% of China's raw steel consumption. Steel Import Monitoring and Analysis. (2020). *Steel imports report: China. U.S.* International Trade Administration.

Exhibit A4

State Import Penetration Rates for Raw and Fabricated Steel Products, 2017



Note:
Data from USATRADE and Commodity Flow Survey, 2017.

Raw Steel Share of Fabricated Product Value (p_{raw}). As specified, a BA Steel policy would affect both steel fabrication and raw steel production. To estimate the amount of raw steel that is required to produce a dollar of fabricated steel output, we use 2007 and 2012 data from the Bureau of Economic Analysis' Input-Output Accounts. Expressed as a proportion, the average amount of architectural and structural metals manufacturing output spent on steel mill products is 22.6% with a standard deviation of 0.9 percentage points.

Percent Cost Increase to Source US Raw Steel (C_{raw}). International raw steel prices are typically reported by product type in four aggregates—US, Europe, China, and World Export—each of which is an average of observed prices in their respective regions. Courtesy of World Steel Dynamics, we obtain a bi-monthly time series for each of these aggregates from January 2017 to May 2022 across four broad steel product types: hot-rolled band, cold-rolled coil, reinforcing bar, and plate. Of these, only the hot-rolled band is a complete series, and so we take hot-rolled band prices to represent steel prices in each geography. We assume that all steel in the US can be bought at the reported US hot-rolled band price. To approximate foreign steel costs, we remove the US share of the reported World Export price. However, the price for foreign raw steel does not represent the full cost paid by US demanders of foreign steel, because they must also pay costs for freight and insurance. Using data from the Census Bureau's USA Trade Database, we compare the average "customs value" (the price of the good itself) with the average "cost, insurance, freight value" (which includes freight and insurance) of imported steel and find that insurance and freight on average increase the total amount paid by demanders by 2.78%. We increase the World Export price (with US share removed) by this amount. Finally, we account for shipping costs for steel within the US. Freight costs usually accrue on a metric ton-mile basis. To price domestic freight costs, we first use CFS data to calculate the average number of miles that steel has to journey to get to Washington for both domestic and imported steel; these distances are 895 and 1,325 miles, respectively. We then calculate freight costs by taking estimates of truck and rail freight rates by ton-mile from a Congressional Budget Office study from 2016 and then averaging them weighted by the share of steel transported by each mode (86% by truck at 15.6 cents/ton-mile and 14% by rail at 5.1 cents/ton-mile), first converting these numbers into dollars per *metric ton*-mile.[97] This gives us an average domestic freight cost of 15.48 cents per metric ton-mile. Domestic freight costs for domestic and foreign-made steel are then average mileage to Washington multiplied by this number for every metric ton consumed in Washington. We add these to each respective price.

Directly comparing the US to World Export steel prices would overestimate the cost increase resulting from a BA Steel policy. This is because only 34.1% of raw steel in Washington is foreign-sourced, while the remaining 65.9% is sourced domestically. Therefore, the average price paid by Washingtonian raw steel purchasers is actually an average of US and World Export raw steel prices weighted by 65.9% and 34.1%, respectively. The average price premium for US raw steel products is 27.7% with a standard deviation of 26.0 percentage points.

[97] Huneke, W.F., Brennan, W.J., Boyles, M.J., & Smith, M.E. (2009). Study of railroad rates: 1985-2007. Surface Transportation Board, Office of Economics, Environmental Analysis & Administration, Section of Economics.

Percent Cost Increase to Source US Fabricated Steel (C_{fab}). There are tens of thousands of fabricated steel products, many of which are built custom for projects and will have a unique price. Accounting for all these products individually is well beyond the scope of this report. Instead, we choose to treat fabricated steel as if it were a single good with a single international price and domestic price. We construct US fabricated steel prices using data from the BEA and our raw steel cost estimates.[98] The BEA publishes make-use data tables that include the share of final revenue for certain industries that are spent on raw materials from other industries. The metal fabrication sector (NAICS 332) is estimated to spend 22.6% on raw materials from the primary metals manufacturing sector (NAICS 331). This implies that the US fabricated steel price is equal to the US raw steel price estimated above, divided by 0.226.

A 2020 International Trade Commission study reports that on average between 2016 and 2019, the difference in bid prices between US and foreign-fabricated steel goods was 4.3%.[99] To extrapolate this over the entire study window, we compare the relative value of the domestic producer price index and import price index for NAICS 332 available from the federal reserve bank of St. Louis.[100] Specifically, we normalize the difference between the two measures to be 4.3% over 2016-2019 and use the resulting scaling factor and the gap between the two indices to estimate the price gap for each month between January 2017 and May 2022. Note that since our data come from bids, which include freight and insurance, we do not need to estimate these costs in our analysis as we did with raw steel. We construct an estimate of the current experienced price in Washington (in the absence of a BA Steel policy) as a weighted average of the four ways for fabricated steel to be melted, poured, and fabricated. For US fabricated steel made from domestic and foreign raw steel, we divide the above calculated US and World Export prices by 0.226. We do the same calculation for foreign fabricated steel but also apply the mark down associated with lower foreign fabrication costs. We average these four prices using their relative prevalence calculated in our import penetration model as weights (see Exhibit A3). We then take the US raw and fabricated price, divided by this average as our price ratio. The average price premium for US fabricated products is 7.4% with a standard deviation of 3.6%.

Price Correlation. Using the price data described above, the sample correlation coefficient between the US raw steel price premium and the US fabricated steel price premium is 0.506. We use the transformation method described in Cario & Nelson (1997)[101] to obtain correlated samples for price increases.

Percent of New Raw Steel Revenue and New Fabricated Product Revenue that Represents New Production (N_{raw}, N_{fab}). Under a BA Steel policy, we assume that contractors on state capital and transportation projects would face a domestic procurement requirement for steel products. We expect this to result in upward price pressure and supply capacity constraints in the domestic steel product market. Because contractors on non-state projects are not subject to the regulation and because foreign and domestic fabricated products are close substitutes,[102] we expect that some contractors not subject to the regulation would be crowded out of the domestic market and into foreign markets. The amount of crowding out depends on how responsive domestic suppliers are to demand changes and how easily buyers can switch to non-US suppliers. At one extreme, new steel demand could displace existing purchases one-for-one, leaving US steel production unchanged. At the other extreme, this demand could be met entirely with new production.

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[98] U.S. Bureau of Economic Analysis. (2018).
[99] Johanson et al. (2020).
[100] U.S. Bureau of Labor Statistics. (2022). Producer price index by industry: Fabricated metal product manufacturing and import price index by industry: Fabricated metal product manufacturing.
[101] Cario, M.C., & Nelson, B.L. (1997). *Modeling and generating random vectors with arbitrary marginal distributions and correlation matrix* (pp. 1-19). Technical Report, Department of Industrial Engineering and Management Sciences, Northwestern University, Evanston, Illinois.
[102] Johanson et al. (2020).

To estimate the proportion of new demand that results in new production, we use USITC elasticity estimates for fabricated structural steel products.[103] Because contracts for Washington capital and transportation projects represent a small portion of total US steel demand, we assume that the domestic supply and demand functions are locally linear. This allows us to use the following formula:

$$N = \frac{E_s}{E_s + E_d}$$

Where *N* is the proportion of new demand that results in new production, E_d is the absolute value of the elasticity of total demand for US steel products with respect to changes in the US price, and E_s is the price elasticity of US steel supply. We allow the supply elasticity to vary uniformly between 0 and 5. The USITC estimates include a measurement of the elasticity of US demand for all steel products (foreign and domestic) with respect to changes in the US price and an estimate of the substitution elasticity of relative US consumption of foreign and domestic steel to their relative prices. Because they do not include a direct estimate of the elasticity of total demand for US steel products with respect to changes in the US price, we use the substitution elasticity estimate as a proxy for this value. We allow it to vary uniformly between 3 and 5.

Under this method, the average proportion of new demand representing new production is 35.4% with a standard deviation of 15.7 percentage points.

Percent of New Raw Steel for Domestic Fabricated Products that Occurs in Washington ($WA_{raw,fd}$). For products that are currently domestically fabricated using foreign raw steel, we assume that contractors would continue buying fabricated products from their current source states and that fabricators would source replacement raw steel following existing interstate trade patterns. Because contractors in all states have experience complying with federal Buy America provisions and because state import penetration rates for raw steel are mostly below 50%,[104] we expect that contractors could source BA-compliant fabricated products from all states. To estimate the proportion of replacement raw steel for products in this category that would be sourced from Washington, we combine CFS data on fabricated metal products and primary metal products with state-level import penetration rates for primary metal products. For example, Washington currently consumes some fabricated products that are made in California using foreign raw steel. We estimate that California would source 4.2% of its domestic replacement raw steel from Washington. Summing across states, we estimate that 13.4% of newly regulated raw steel in domestically fabricated products would be sourced from Washington.

Percent of New Raw Steel for Foreign Fabricated Products that Occurs in Washington ($WA_{raw,ff}$). For products that are currently fabricated abroad using foreign raw steel, we assume that replacement fabricated products, and in turn, domestic raw steel, will come from sources that follow existing interstate trade patterns. To estimate the proportion of raw steel that would be sourced from Washington, we combine CFS data on fabricated metal products and primary metal products with state-level import penetration rates for fabricated metal products. For example, Washington currently consumes some foreign fabricated products that use foreign raw steel. We estimate that Washington would source 11.1% of its domestic replacement fabricated products from California. To produce these products, we estimate that California would source 4.2% of its raw steel from Washington. Summing across states, we estimate that 13.3% of newly affected raw steel in foreign fabricated products would be sourced from Washington.

[103] Ibid.
[104] Only Hawaii, Delaware, and Rhode Island have estimated raw steel import penetration rates above 50%.

Percent of New Fabrication that Occurs in Washington (WA_{fab}). For products that are currently fabricated abroad, we assume that domestic replacements will follow existing interstate trade patterns. To estimate the proportion that would be produced in Washington, we use 2017 CFS data to calculate the proportion of Washington's fabricated metal products that are produced in Washington. This value is 39.5%.

Percent of Revenue Spent on Materials (m_{raw}, m_{fab}). A portion of steel product revenue is spent on materials including input metals, electricity, and other supplies. To estimate this proportion, we use data from the 2012[105] and 2017[106] Economic Census[107] for Washington State. For primary metals, the mean proportion of revenue going to materials was 60.5% with a standard deviation of 3.1 percentage points. For fabricated products, the mean was 42.7% with a standard deviation of 1.8 percentage points.

Percent of Value Added Earned by Workers (w_{raw}, w_{fab}). The Economic Census defines value added as total revenue minus materials expenditures. The amount going to workers is equal to industry payroll plus benefits. To estimate the proportion of value-added earned by workers, we use data from the 2012 and 2017 Economic Census for Washington State.[108] For primary metals, the mean was 43.8% with a standard deviation of 2.5 percentage points. For fabricated products, the mean was 49.3% with a standard deviation of 5.5 percentage points.

Percent of Workers Living in Washington (r_{raw}, r_{fab}). We restrict our calculation of worker income benefits to those workers who reside in Washington. Using annual American Community Survey data from 2011-2019,[109] we estimate the proportion of workers at Washington businesses who reside in Washington. For primary metals, the mean was 97.5% with a standard deviation of 3.0 percentage points. For fabricated products, the mean was 95.6% with a standard deviation of 3.4 percentage points.

Payroll Per Worker (P_{raw}, P_{fab}). To estimate payroll per worker, we use 2012-2020 County Business Patterns data for Washington State.[110] We convert the annual industry payroll to 2019 dollars and divide it by total employment. To include the value of fringe benefits, we use the ratio of fringe benefits to payroll from the 2017 Economic Census. For fabricated products, the fringe benefit ratio was 28.6%, and the mean payroll plus benefits were $71,568 with a standard deviation of $2,808. For iron and steel mills, the fringe benefit ratio was 38.6%, and the mean payroll plus benefits were $132,215 with a standard deviation of $9,056.

A summary table of parameter distributions is found in Exhibit A5. Formulas for calculating benefits and costs are shown in Exhibit A6. Exhibit A7 illustrates the benefits of the BCA.

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[105] U.S. Department of Commerce, U.S. Census Bureau. (2015). *2012 Economic Census, Subject Series: Manufacturing Detailed Statistics by Subsectors and Industries (EC1231SG1).*
[106] U.S. Department of Commerce, U.S. Census Bureau. (2020). *2017 Economic Census, Geographic Area Statistics: Manufacturing Summary Statistics for the U.S., States, and Selected Geographies (EC1731BASIC).*
[107] *NAICS codes 331 and 3323.*
[108] Ibid.
[109] NAICS codes 331M and 332M.
[110] NAICS codes 331110 and 3323.

Exhibit A5

Parameter Estimates Used in the BCA and EIA

Parameter	Distribution	Parameter 1	Parameter 2	Comment
Value of fabricated steel products in capital and transportation budgets	-	$67,469,758	-	Fixed value based on analysis of biennial budgets, 2007-2021
Percentage of fabricated steel that is made in the US with foreign raw steel	-	24.6%	-	Fixed value using state-level import penetration estimates, 2017
Percentage of fabricated steel that is made abroad with US raw steel	-	1.5%	-	Fixed value using state-level import penetration estimates and Canada & Mexico import penetration data, 2017
Percentage of fabricated steel that is made abroad with foreign raw steel	-	26.5%	-	Fixed value using state-level import penetration estimates, 2017
Raw steel share of fabricated product value	Beta	525.3	1,797.3	BEA I-O make-use tables, 2007 & 2012
Percentage cost increase to source US raw steel	Gamma	1.1	0.2	World Steel Dynamics
Percentage cost increase to source US fabricated steel	Gamma	4.2	0.02	USITC cost estimate, BLS producer price and import price indices
Steel supply elasticity	Uniform	0	5	USITC supply elasticity estimates
Steel demand elasticity	Uniform	3	5	USITC substitution elasticity estimates
Percent of new raw steel for domestic fabricated products that occurs in Washington	-	13.4%	-	Fixed value using state-level import penetration estimates, 2017
Percent of new raw steel for foreign fabricated products that occurs in Washington	-	13.3%	-	Fixed value using state-level import penetration estimates, 2017
Percent of new fabrication that occurs in Washington	-	39.5%	-	Fixed value using CFS, 2017
Percent of raw steel revenue spent on materials	Beta	148.0	96.8	Economic Census, 2012 & 2017
Percent of fabricated steel revenue spent on materials	Beta	317.2	425.3	Economic Census, 2012 & 2017
Percent of raw steel value added earned by workers	Beta	173.3	222.1	Economic Census, 2012 & 2017
Percent of fabricated steel value added earned by workers	Beta	40.9	42.1	Economic Census, 2012 & 2017
Percent of raw steel workers living in Washington	Beta	25.0	0.6	American Community Survey, 2011-2019
Percent of fabricated steel workers living in Washington	Beta	33.9	1.6	American Community Survey, 2011-2019
Payroll per raw steel worker	Normal	$132,215	$9,056	County Business Patterns, 2012-2020
Payroll per fabricated steel worker	Normal	$71,568	$2,808	County Business Patterns, 2012-2020

Note:
Normal distribution parameters refer to mean and standard deviation.
Beta distribution parameters refer to α and β.
Gamma distribution parameters refer to shape and scale.
Demand elasticity refers to the percent reduction in total quantity of US steel demanded in response to a 1% increase in the US price.

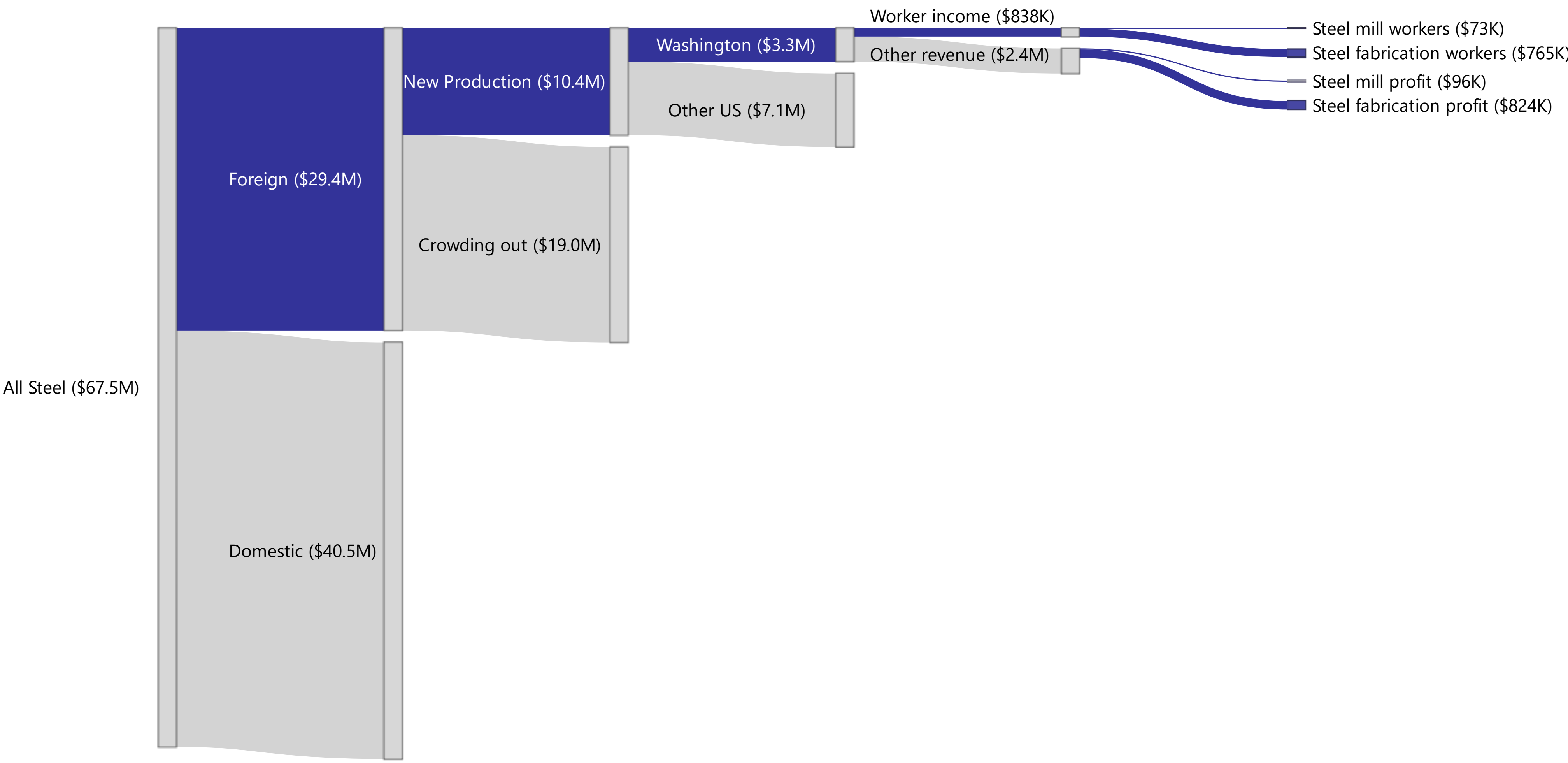
Exhibit A6

Calculation of Benefits and Costs

Parameter	Formula
Value of fabricated steel in capital and transportation budgets	S_0
% of fabricated steel that is made in the US with foreign raw steel	p_{fd}
% of fabricated steel that is made abroad with US raw steel	p_{df}
% of fabricated steel that is made abroad with foreign raw steel	p_{ff}
Raw steel share of fabricated product value	p_{raw}
% cost increase to source US raw steel	C_{raw}
% cost increase to source US fabricated steel	C_{fab}
% of new raw steel revenue that represents new production	N_{raw}
% of new fabricated steel revenue that represents new production	N_{fab}
% of new raw steel for domestic fabricated products that occurs in Washington	$WA_{raw,fd}$
% of new raw steel for foreign fabricated products that occurs in Washington	$WA_{raw,ff}$
% of new fabrication that occurs in Washington	WA_{fab}
% of raw steel revenue spent on materials	m_{raw}
% of fabricated steel revenue spent on materials	m_{fab}
% of raw steel value added earned by workers	w_{raw}
% of fabricated steel value added earned by workers	w_{fab}
% of raw steel workers living in Washington	r_{raw}
% of fabricated steel workers living in Washington	r_{fab}
Payroll per raw steel worker	P_{raw}
Payroll per fabricated steel worker	P_{fab}
Costs	
Baseline value of foreign raw steel in US-fabricated steel	$R_{0,fd} = (p_{raw})(p_{fd})(S_0)$
Baseline value of foreign raw steel in foreign-fabricated steel	$R_{0,ff} = (p_{raw})(p_{ff})(1+C_{fab})(S_0)/(1+C_{raw})$
Replacement cost of foreign raw steel in US-fabricated steel	$R_{1,fd} = (1 + C_{raw})(R_{0,fd})$
Replacement cost of foreign raw steel in foreign-fabricated steel	$R_{1,ff} = (1 + C_{raw})(R_{0,ff})$
Baseline value of affected fabricated steel	$F_0 = (p_{df} + p_{ff})(S_0)$
Replacement cost of affected fabricated steel	$F_1 = (1 + C_{fab})(F_0)$
Cost increase due to Buy America restriction	$\mathbf{C = (R_{1,fd}-R_{0,fd}) + (F_1-F_0)}$
Benefits	
New US raw steel revenue from US-fabricated steel	$R_{US,fd} = (N_{raw})(R_{1,fd})$
New US raw steel revenue from foreign-fabricated steel	$R_{US,ff} = (N_{raw})(R_{1,ff})$
New US fabricated steel revenue	$F_{US} = (N_{fab})(F_1)$
New Washington raw steel revenue	$R_{WA} = (WA_{raw,fd})(R_{US,fd}) + (WA_{raw,ff})(R_{US,ff})$
New Washington fabricated steel revenue	$F_{WA} = (WA_{fab})(F_{US})$
New Washington raw steel worker income	$Y_{raw} = (1 - m_{raw})(w_{raw})(r_{raw})(R_{WA})$
New Washington fabricated steel worker income	$Y_{fab} = (1 - m_{fab})(w_{fab})(r_{fab})(F_{WA})$
New Washington raw steel profit	$O_{raw} = (1 - m_{raw})(1 - w_{raw})(R_{WA})$
New Washington fabricated steel profit	$O_{fab} = (1 - m_{fab})(1 - w_{fab})(F_{WA})$
New Washington raw steel employment	$E_{raw} = Y_{raw} / P_{raw}$
New Washington fabricated steel employment	$E_{fab} = Y_{fab} / P_{fab}$
Combined new Washington worker income and profit	$\mathbf{B = Y_{raw} + Y_{fab} + O_{raw} + O_{fab}}$
Net benefits	$\mathbf{N = B - C}$

Exhibit A7

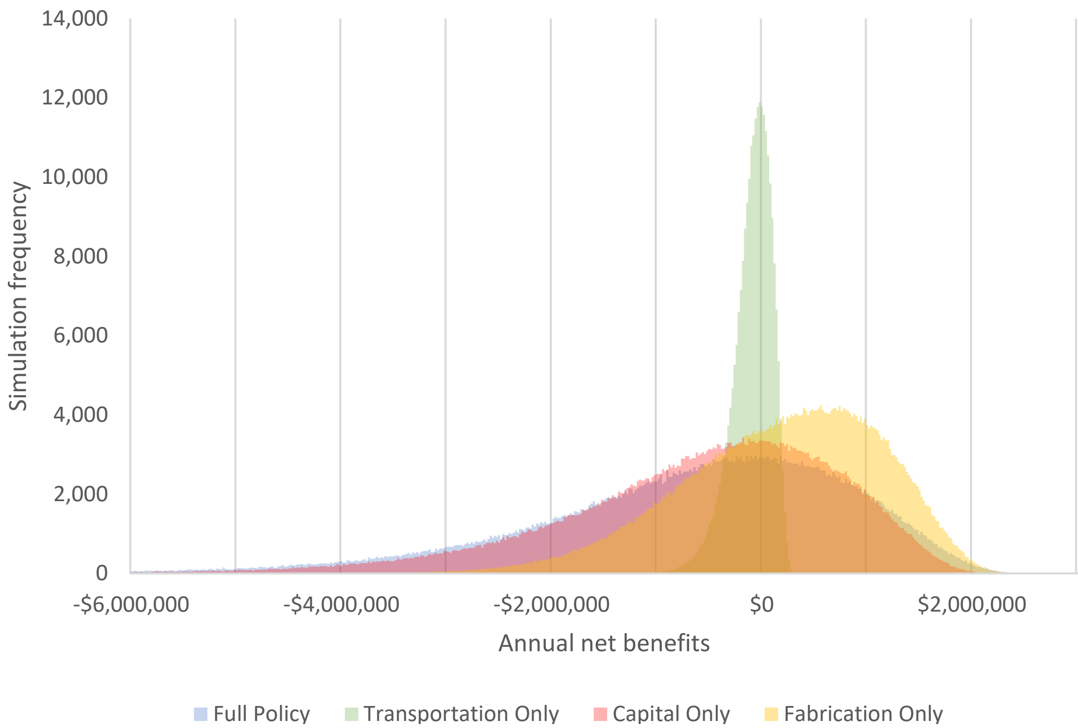
Benefits in the BCA



Parameter Simulation. We model uncertainty around parameter estimates using random variables. We model proportions using beta distributions,[111] cost increases using gamma distributions, and other variables using normal distributions. Random variables are specified with means and variances equal to their sample counterparts. We simulate the BCA model 500,000 times, with each simulation drawing independent samples of each parameter.[112] This results in different benefit and cost estimates for each simulation. For instance, a simulation in which domestic steel prices are not much higher than foreign steel prices and a high proportion of steel revenue goes to income and profit would result in relatively small costs and large benefits. Simulating the BCA in this way enables us to see how sensitive our results are to different plausible assumptions. In the cases of our three policies, The Full, Transportation Only, and Capital Only Policies resulted in positive net benefits in 37% of simulations. The Fabrication Only Policy resulted in positive net benefits in 61% of simulations. Calculations for the Transportation Only and Capital Only Policies are equivalent to those for the Full Policy but on a smaller initial value of affected steel. For this reason, the proportion of simulations with positive net benefits is nearly identical, while the variance in net benefits is smaller for the Transportation Only and Capital Only Policies. Histograms of net benefits for each of the four primary policies are presented in Exhibit A8.

Exhibit A8

Histogram of Net Benefits from Simulations of each Policy



[111] Proportion parameters relating to import penetration are treated as fixed values due to data limitations. Import penetration estimates are based on Economic Census data that is published every five years. We use fixed values to avoid estimating multiple interdependent parameters based on two observations.

[112] All parameter distributions are independent of one another, except for price increases, which are correlated.

Sensitivity Analysis. We test the robustness of our BCA results under a different treatment of steel mill profit. Among Washington steel mill establishments, Nucor Steel Seattle, Inc. employs the majority of employees. Nucor Seattle is a subsidiary of Nucor Corporation, a publicly traded company based in North Carolina. As a result, most profit would benefit individuals outside of Washington. We test an alternate specification that does not count this value as a benefit.

This specification affects the Full, Transportation Only, and Capital Only policies. Annual benefits are reduced for these policies by $96 thousand, $12 thousand, and $84 thousand, respectively. The benefit-to-cost ratio is reduced from $0.72 to $0.68, and the percentage of simulations with positive net benefits is reduced from 37% to 35%. BCA results of this specification are presented in Exhibit A9.

REMI Methodology

To capture and model the economic effects that would result from a BA Steel policy, we turn to simulations conducted with the REMI Tax-PI model licensed to the Joint Legislative Audit and Review (JLARC) Committee. REMI does not, however, feature input options that correspond to particular policies such as BA Steel; instead, we must model the policy as a series of economic changes (shocks) to the model's baseline status quo predictions. There are many potential ways to do this, and we develop our method after a rigorous review of the model equations and many test simulations. Ultimately, we decide to model each of our example policies as a series of simultaneous shocks to imports in the raw steel manufacturing and architectural steel fabrication sectors and concurrent tax increases we expect to be necessary to pay for each. We run a total of 14 simulations. For each of the four policies detailed in the Policy Hypotheticals section, we run a mean, LCHB, and HCLB scenario (12 total); the details of which are explained below. In addition, we run two robustness checks. Below, we detail how we develop and implement each shock as well as the assumptions we make in doing so.

Exhibit A9

Annual Benefits and Costs of a Buy American Steel Policy in Washington (Thousands of 2019 Dollars)

Program benefit	**Full Policy**	**Transportation only**	**Capital only**	**Fabrication only**
Income for Washington raw steel workers	$73	$9	$64	-
Income for Washington fabrication workers	$765	$93	$672	$765
Profit for Washington raw steel businesses	-	-	-	-
Profit for Washington fabrication businesses	$824	$101	$723	$824
Total benefits	$1,662	$203	$1,459	$1,589
Program cost				
Increased cost of sourcing US steel	($2,435)	($298)	($2,137)	($1,397)
Bottom line				
Net benefit	($772)	($95)	($678)	$192
Benefit-to-cost ratio	$0.68	$0.68	$0.68	$1.14
% of simulations with positive net benefits	35%	35%	35%	61%
Annual steel jobs supported	11.3	1.4	9.9	10.7

Shock Generation

Import Shocks. We employ a similar but slightly different methodology for determining the economic impact of each policy from the BCA. Overall, the total amount of steel affected by the policy is the same as in the BCA; however, rather than try to predict how much new demand there would be for Washington-made steel, we enter the full amount of affected steel as a negative import shock and allow REMI, which has many built-in features to predict where additional domestic production would take place, to determine the increase in steel production in Washington. We use the same repeated simulation procedure as the BCA to estimate the expected amount of affected steel for each policy scenario.

REMI allows us to enter the import shocks as either a level or a percent change, of which we choose the latter. While the amount of steel used in state government contracts varies widely from year to year, the share of imported steel used by the government compared to total steel import demand in the state is relatively stable. Expressing these shocks as a share of total steel import demand additionally allows government demand to grow over time into the future as the state economy continues to grow, whereas level shocks do not.

We use our industry share method described above to estimate total steel demand in Washington and use our estimates of state government steel demand to obtain a statewide estimate of raw steel demand. The next step is to determine how much of this demand for raw steel will first need to be fabricated and to price that share accordingly so that we can use it in our modeling process. The data from AISI tell us how much raw steel different industries eventually consume; we first sort these industries into direct demand (for raw steel) and indirect demand (for fabricated steel). We then filter out the portion of direct demand from our aggregate demand estimate, leaving the remaining demand for raw steel as indirect (in need of fabrication).

Finally, we convert these estimates from metric tons into 2019 dollars using the prices constructed under the BCA. Our shock values for imports are then given by the respective ratios of government import demand (estimated above) to total state import demand for raw and fabricated steel.

We enter these shocks to NAICS sector 3311 (“Iron and Steel Mills and Ferroalloy Manufacturing”) for raw steel and NAICS sector 3323 (“Architectural and Structural Metals Manufacturing”) for fabricated steel after assessing that these are the REMI-modeled sectors that most closely match those that would be impacted directly by these policies. For import shocks, REMI has the option to simulate resulting impacts without altering the ability of steel users to access steel. We select this option to ensure that 1) contractors working on government projects do not adjust their production techniques, as per our assumptions in the BCA and EIA sections; and 2) all other demanders of steel may continue to act as if they were purchasing steel in the absence of the policy, as they would not be affected these policies.

Tax Revenue Shocks. Our Monte Carlo exercises also give us a distribution of expected cost increases. Domestic raw and fabricated steel is almost always more expensive than foreign alternatives, meaning that mandating US-made steel will almost certainly lead to increased project costs. Since we assume that all projects proceed at an increased cost, we need to model the paying of these costs, as they inevitably lead to economic impacts in addition to those caused by the import shocks. These impacts include decreased consumer spending and possible corresponding job losses in sectors particularly sensitive to taxation, such as retail, recreation, and accommodation services.

We choose to cover increased costs in our simulations by increasing revenue from taxes by a fixed percentage for each year under consideration. The cost increases of each policy scenario are calculated identically to the BCA methodology above. To translate these cost increases into taxes, we first express each simulation's expected cost increase as a share of total tax revenue in 2022; this gives us the percent that overall tax revenue must increase each year to cover each policy. We multiply baseline tax revenue in each year 2022-2045 to get the level change of revenue in each year. We then assign 57% of each yearly increase to come from sales tax, 23% from business taxes, and 19% from property taxes; these shares correspond to the average contribution of each type of tax to total state tax revenue.

Policy Scenario Combinations. As mentioned previously, we run a total of 14 simulations: Three for each policy and an additional two elaborations on the Full Policy. For each policy we model, we run an HCLB, mean, and LCHB scenario, derived from the results of our BCA simulation exercises. In those exercises (detailed above), we run 500,000 example draws to obtain a distribution of potential raw and fabricated steel import and cost shocks.

REMI Output

A typical REMI simulation will yield yearly output until 2045 for thousands of variables across many industries, populations, and geographies. The purview of our study tasks us with assessing the "benefits to Washington workers and the Washington economy" of a BA Steel policy, a statement that could technically cover most or all of the reported output variables. To narrow the scope of the study to something practical, we instead choose to focus on output in the raw steel (NAICS 3311) and steel fabrication (NAICS 3323) industries, employment across many industries and the economy in general, income to households in the state, and tax revenue. We believe that these outcomes give a fairly holistic picture of the impact that a BA Steel policy would have on Washington workers and the Washington economy without delving into unnecessary detail. In the body of the report, we highlight both the average impacts of these variables and their entire time path over the 2022-2045 study window.

III. Environmental Appendix

This section of the Appendix describes our methodology and data sources for our estimation of the environmental impact of each policy modeled in the paper. To assess the net change in emissions resulting from each, we compare the carbon dioxide equivalent emissions factor of the United States with those of the foreign sources for steel in Washington. An emissions factor is the average total metric tons of carbon dioxide equivalent greenhouse gasses emitted per metric ton of steel produced in a country.[113] Fully accounting for all the sources of greenhouse gas (GHG) emissions along the steel-to-contractor supply chain would be impossible, so we choose to focus on three main emissions sources: emissions from the milling ("melting and pouring") of raw steel (direct emissions), emissions from the generation of electricity sources used to produce that steel (indirect emissions), and emissions from transporting the steel to Washington (transportation emissions).

Different countries across the globe will have different emissions per metric ton of steel that they produced for a variety of reasons. First, different countries use different combinations of milling technology; some rely heavily on the Basic Oxygen Furnace (BOF) route while others use more Electric Arc Furnaces (EAFs). This will lead to different amounts of direct emissions. The prevalence of different energy sources, such as coal, gas, or renewables, also varies widely by country, and thus the electricity used to power steel milling in each country will differ widely in its cleanness. Finally, countries are located at different distances from Washington and use different methods of transporting freight goods like steel both within them and to the US. The mix of railroad versus truck versus container ship will cause emissions from transportation to vary between countries. By summing all these differences up into emissions factors (total metric tons of GHGs emitted per metric ton of steel produced) and comparing what steel would be allowed under each policy, we can get an idea of how much emissions will change under each.

All of the steel used by the state government under consideration must be fabricated to be used in projects in the transportation and capital budgets. As detailed in Section III of the report, this means that there are four possible ways that steel can be first milled and then fabricated: milled domestically and fabricated domestically, milled domestically and fabricated abroad, milled abroad and fabricated domestically, or milled abroad and fabricated abroad. In the BCA appendix, we describe how we determined what share of fabricated steel in Washington comes from each of these production routes. Because steel from each combination of milling and fabricated travels different routes across the world, leading to different amounts of emissions from transportation, we must consider each of these cases separately.

As noted in Section IV, we are not able to compute direct and indirect emissions occurring from the fabrication process. This problem is described more in the following subsection. Our estimates should therefore be understood to only pertain to the milling process of steel for direct and indirect emissions. However, our analysis still allows us to account for the transportation emissions generated by transporting fabricated steel to Washington. We are also able to account for emissions generated by the transportation of raw steel to the place of fabrication for about 75% of the steel under consideration.

[113] U.S. Environmental Protection Agency. (2022). *Basic information of air emissions factors and quantification*.

This section of the Appendix first describes how we calculate direct, indirect, and transportation emissions from each source of steel in Washington, both domestically and abroad. We then detail how we account for emissions from each combination of milling and fabricating abroad or domestically, including appropriate modifications to the methodology for each emissions factor. Next, for each policy considered in Section III, we use our estimates to construct emissions factors for any additional domestic steel production and replaced international production. Finally, we use these emissions factors and the amount of steel impacted by each policy to deduce the total likely change in emissions resulting from each. Throughout, we aggregate the emissions, from all links in the supply chain, of different GHGs such as carbon dioxide, methane, and nitrous oxides, into units of carbon dioxide equivalent (CO_2e).[114]

Methodology for Calculating Direct, Indirect, and Transportation Emissions Factors

Direct Emissions

Direct emissions come from the actual physical process of making steel, the "melting and pouring" or "milling" of steel. The biggest factor in determining a country's direct emissions factor is the prevalence of each steel production method (EAF, BOF, etc.) therein; each method has a different amount of carbon equivalents emitted per metric ton of steel produced. The IPCC's 2006 Guidelines for National Greenhouse Gas Inventories provide the baseline estimates of emissions of greenhouse gases per metric ton of steel (which are themselves emissions factors) produced by the method and are summarized in Exhibit A10. Electric arc furnaces, as we can see, are far more efficient in producing steel in terms of emissions than blast furnaces or open-hearth furnaces (another less common production method used sparingly in Russia and China in our data).

Exhibit A10

Emissions per Metric Ton of Steel Produced by Method

Method	Emissions factor (EF_m)
Blast furnace	1.58
Electric arc furnace	0.18
Open hearth furnace	1.72
Mixed methods (world average)	1.096

Note:
Source: IPCC 2006 Guidelines for National Greenhouse Gas Inventories. Mixed methods is the world average for steel production across all countries and production methods.

[114] Different greenhouse gasses, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxides (NO_x), have differently sized impacts on climate change; for instance, the emission of a metric ton of methane causes about 25 times as much warming as a metric ton of carbon dioxide. "Carbon dioxide equivalent emissions" here means that all greenhouse gasses have been converted into their warming potential in terms of metric tons of carbon dioxide.

The World Steel Association annually publishes data on steel production by method at the country level, allowing us to compute what share of total steel output is made via which production method.[115] The direct emissions factor for each country is then simply an average of the emissions factors for each production method weighted by the share of steel produced by that method. That is,

$$Direct_c = \sum_m share_{m,c} \times EF_m,$$

for each production method *m* and in each country *c*, EF_m is the emissions factor for method *m*, and $share_{m,c}$ is the share of steel production occurring via method *m* in country *c*. For countries not reported in World Steel Associations annual publication, we assume that their direct emissions are decently approximated by the world average.

Indirect Emissions

We now turn to indirect emissions, which are emissions generated by the production of electricity eventually used in the raw steel manufacturing process. The volume of emissions in each country resulting from electricity use will depend on the sources of energy used in a particular country; countries that use relatively more fossil fuels such as coal and oil for electricity generation will emit more GHGs per metric ton of steel production than countries that use relatively more renewable energy sources, such as wind and solar. Understanding the differences in energy generation for steel production between countries is, therefore, crucial to characterize the environmental tradeoffs between domestic and foreign-made steel.

It is common for countries to report the consumption of energy by generation method at the sector level in a data table known as an energy balance. An energy balance for a given industry in a country records the total demand for energy in the sector as generated by various sources like those above. The United Nations (UN) publishes an international master file of energy balances for most countries in the world. We consider emissions from energy generated from the following sources: coal and peat, oil, oil products (such as kerosene), natural gas, the burning of waste and biomass, and renewables (which aggregates across renewable sources like hydro, wind, solar, tidal, and geothermal).

Exhibit A11

Emissions Factors for Energy Sources

Energy source	Emissions factor (EF_e)
Coal/peat	97.4
Oil	73.6
Oil products	72.2
Natural gas	56.2
Biomass/waste	106.4
Renewables	11.4*

Notes:
Source: IPCC 2006 Guidelines for National Greenhouse Gas Inventories
* Constructed as a weighted average of the worldwide prevalence of hydro, wind, solar, geothermal, and ocean derived power.

[115] World Steel Association. (2022).

The energy balances from the UN report the total amount of energy demanded by the raw steel industry in each country by a power source.[116] To obtain emissions factors for energy consumption, we need to translate total energy use into metric tons of CO_2e emissions and divide it by the total output of steel. Each energy source has its own emissions factor, which reports the amount of CO_2 equivalent GHGs emitted per unit of energy produced. For instance, burning enough coal to generate one TJ of energy involves the emission of 97.4 metric tons of carbon dioxide equivalent GHGs. Emissions factors for each energy source considered are reported in Exhibit A11; the emissions factors for coal/peat and biomass/waste are an equally weighted average across sub-categories of these energy sources. Total emissions from each energy source can then be computed as the amount of energy used by the industry from each source multiplied by the corresponding emissions factor. We then sum these numbers up across energy sources within each country and divide them by crude steel output. That is,

$$Indirect_c = \frac{\sum EF_e \times EnergyUse_{e,c}}{Output_c},$$

for each energy source *e*. We obtain estimates of all emission factors for all but electricity from the IPCC 2006 Guidelines for National Greenhouse Gas Inventories chapter on static combustion. We construct an emission factor for electricity by weighting the emissions factors obtained from the National Renewable Energy Laboratory[117] for hydro, wind, solar, tidal, and geothermal by their respective worldwide prevalence, reported by Smil (2016).[118]

Some countries, such as the United Arab Emirates, only report energy use at the manufacturing level, not specifically steel manufacturing. Were we to take indirect emissions from electricity across all manufacturing sectors and divide it by steel output we would drastically over-estimate the emissions generated per metric ton of steel produced in these countries, as steel manufacturing makes up only a fraction of energy used in all manufacturing. Instead, we use all other countries with both data on production technology shares and steel-specific energy balances and all available years (2011-2019) to estimate the following regression:

$$JoulesPerTonne_c = \beta_1 BFshare_c + \beta_2 EAFshare_c + \beta_3 OHFshare_c + u_c,$$

Where $JoulesPerTonne_c$ is total joules used by the steel industry divided by steel output in metric tons in country c, $BFshare$, $EAFshare$, and $OHFshare$ are each country's share of BF, EAF, and Open Hearth Furnaces (OHF) methods using in steel production (out of 100%), u is an error term, and β_1, β_2 and β_3 are the parameters to be estimated (note that there is no constant term in this regression in order to avoid extreme multicollinearity). We use our estimates of these parameters to predict how many joules are required to produce a metric ton of steel in each country and assume that the breakdown of joules by energy source follows that of the broader manufacturing sector. In using this equation in this way, we are implicitly assuming that the amount of energy required to produce steel is partly a function of the technological mix within a given country.

A handful of countries do not report any energy balance information. We deal with these separately in the following sections covering each milling-fabrication combination to get to Washington.

[116] United Nations Statistics Division. (2012-2019). Energy Balances. Retrieved from.
[117] National Renewable Energy Laboratory. (2021). *Life cycle greenhouse gas emissions from electricity generation: Update.* U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Operated by the Alliance for Sustainable Energy, LLC.
[118] Smil, V. (2016). *Energy Transitions: Global and National Perspectives (Second Ed.).*

Transportation Emissions

Transportation emissions are generated all along the steel supply chain, in shipping steel from its place of milling to its place of fabrication, and from its place of fabrication to its final demanders' locations. During this journey, the steel crosses state and national borders, traveling by various modes of freight (such as truck, rail, or ship). Each of these modes leads to emissions of GHGs at different rates, and the prevalence of each mode varies widely with geography and nationality. This means that the emissions generated by steel shipping between any two locations will be highly idiosyncratic. We calculate transportation emissions separately for each combination of foreign/domestic milling and fabricating because of this. However, we detail how we generally approach transportation emissions.

Generally, our methodology is to treat the journey of steel to Washington as a set of segments. The emissions generated along each segment depend on 1) the length of the segment in kilometers, and 2) the mode of transit. We specifically consider four modes of freight: truck, rail, inland/coastal towing, and container ship.[119] Of these, the first three are used for shipping over land while container ships are used for shipping across the ocean.

We assume emissions from transportation accrue on a metric ton-kilometer basis, i.e., every metric ton of freight transported one kilometer releases a certain quantity of GHGs. We use estimates of truck, rail, and inland/coastal towing (by ship) emissions per metric ton-kilometer published by the EPA.[120] For emissions from container ships used to transport steel across international waters, we turn to Business for Social Responsibility's (BSR) 2020 Global Container Shipping Trade Lane Emissions Factors. The EPA's factors apply to all locations where truck, rail, and inland/coastal towing occur; the BSR factors are assessed on a route-by-route basis (e.g., Africa to the west coast of North America will have different emissions per metric-ton-kilometer than Europe to the east coast of North America). Our estimate of emissions along each segment (say from location *j* to *k*) is then an average of emissions per metric ton-kilometer of each freight mode, weighted by the prevalence of each mode along that segment, times the distance in kilometers:

$$Trans_{j,k} = distance_{j,k} \times \sum_{m} share_m * EF_m,$$

Where $share_m$ is the share of freight traveling via mode m between *j* and *k*, and EF_m is the emissions factor for m (in metric tons of CO_2e/metric ton-kilometer of freight). See table YYY for the emissions factors we use.

Exhibit A12

Emissions Factors for Transportation by Mode

Freight mode	Emissions factor	Source
Truck	204	EPA, Emissions Factors for Greenhouse Gas Inventories, 2021
Rail	17.4	EPA, Emissions Factors for Greenhouse Gas Inventories, 2021
Inland towing	33.2	EPA, Emissions Factors for Greenhouse Gas Inventories, 2021
Container ship	(By Route)	BSR Clean Cargo Emissions Report, 2021

Note:
Emissions factors given in grams of CO_2e per metric ton-kilometer of freight.

[119] We do not consider air as a mode of freight for steel. Internationally and domestically, very little steel is shipped via plane, given the material's weight and the high cost of air freight.

[120] U.S. Environmental Protection Agency. (2022). *GHG emission factors hub*. EPA Center for Corporate Climate Leadership.

Steel coming from international sources will first be produced in a mill (and possibly also fabricated). It must then make the journey by land freight (truck, rail, inland/coastal towing) to the port to be shipped internationally. On its way to Washington, it then, via container ship, makes the journey to one of the 40 US port districts. It will then be put on land freight again to be shipped to Washington. Thus, it is convenient to think of steel's journey from each location to another internationally as having three legs: 1) from origin to port, 2) from port to port across the water, and 3) from the port of arrival to the final destination. Almost all international steel under consideration has a journey that looks like this. Steel milled and fabricated domestically, however, is much simpler, traveling from mill to site of fabrication and finally to Washington, mostly by land. In the subsequent section, we detail how we estimate the distance traveled and assign emissions for steel being milled/fabricated internationally and domestically.

Calculating Emissions for Steel Milled/Fabricated Internationally and Domestically

Since steel that is milled and fabricated in different locations internationally and domestically will take different routes by different modes of freight to reach Washington, we will need to consider each such combination separately. This section walks through the process of first obtaining an estimate of the emissions generated from each combination of international and domestic milling and fabrication for steel under a baseline of no BA Steel policy in Washington. We then discuss how implementing each BA Steel policy would change each estimate, if at all.

Domestically Milled and Fabricated Steel

We begin with steel that is both milled and fabricated within the US, which makes up 47.7% of all steel used in Washington. Steel in this category is first milled in some locations within the US, then shipped to another location for fabrication, before finally being shipped to Washington for use in government contracts. Direct and indirect emissions are generated at the site of milling and transportation emissions accrue as the material is shipped between locations.

We calculate direct and indirect emissions per metric ton of steel produced using the methodology outlined above, giving an estimate of 1.14 metric tons of CO_2 equivalent emitted per metric ton of steel produced. We assume that this applies to all steel milled in the US, regardless of location.

To estimate emissions generated by traveling between milling and the site of fabrication, we turn to the Commodity Clow Survey (CFS) from the US Census Bureau, which reports the value of goods shipped between US states by sector. For this leg of the journey, we use data on NAICS industry 331 (primary metal manufacturing) to get the share of metals commodities going from each state to each other; we assume that the shipping patterns of raw steel goods (NAICS 3311) follow the same shipping patterns as the broader primary metals industry. The CFS data also gives us the average distance traveled between states and the share of freight making the journey by rail or truck (within the US, primary metals are not reported as shipping via other modes). Applying a weighted average of the emissions factors for these two modes times the average distance gives us an estimate of the emissions generated traveling between the sites of milling and fabrication for this steel.

To estimate emissions generated by transportation between the site of fabrication and Washington, we again turn to the CFS for shares of steel from each state, distance traveled, and modal split. Since this leg of the journey is carried out post-fabrication, we use data for NAICS 332 (fabricated metal products) to proxy for the movements of NAICS 3323. Emissions along this leg are also a weighted average of the emissions factors for truck and rail (again, other modes are not reported) times the distance to Washington.

We now have estimates of the emissions generated from the milling of steel from each state, and the transport of that raw steel to each other state for fabrication. The last step is to assemble these into a single estimate of emissions generated by domestically milled and fabricated steel. We do this by weighting each state of milling to the state of fabrication emissions estimate by the share of domestically milled and fabricated steel it represents in Washington. For instance, suppose Washington gets 2% of its domestically fabricated steel from Oregon and Oregon gets 5% of its domestic raw steel from California. Then, weights applied to California milled and Oregon fabricated steel would instead be 2% × 5% = 0.001. By this method, we estimate an emissions factor for domestically milled and fabricated steel of 1.66 metric tons of CO_2e per metric ton of steel used in Washington government contracts.

Foreign Milled and Fabricated Steel

We now turn to steel that is milled and fabricated abroad, which makes up 24.6% of the steel in Washington. The state obtains steel like this from around 180 different countries. Unlike with domestically milled and fabricated steel, we do not know the location of milling and fabrication within each country due to a lack of data. We also do not know the country of origin of the raw steel used in fabricated steel exports to Washington. Thus, we make two simplifying assumptions:

- Fabricated steel shipped to Washington from abroad is made with raw steel from the same source country, and
- Fabrication in each country that exports fabricated steel to Washington is carried out at the site of milling.

These are necessary simplifications to deal with the lack of available data around the world on internal country freight movements.

We pursue a detailed methodology for a limited set of the countries which comprise the top 15 and 10 largest import sources of raw and fabricated steel in Washington, respectively. We simplify this methodology and apply it to the next 48 largest steel import sources for the state. Overall, we account for emissions from around 98.5% of all foreign milled and fabricated steel. We first describe our methodology for top-import source countries and then describe the methodology for the other 48.

We begin by estimating direct and indirect emissions for the top import countries using the methodology described the in preceding sections. We then estimate transportation emissions to Washington by breaking its transportation into three segments or "legs": 1) from the mill to the port of departure, 2) from the port of departure to the US port district, and 3) from the US port district to Washington. It is easiest to describe our methodology for these legs separately as follows.

Leg 1: From Foreign Mill to Foreign Port of Departure. Here we account for emissions generated by the transit of new raw and fabricated steel from the mill to the port from which it is shipped abroad. In most countries, steel is manufactured in a large number of locations; after manufacture, steel is shipped to a large number of ports. Country-level data that reports manufacture and shipments of steel from mill to port cities are not available. Therefore, we assume that steel milling and fabrication take place in the largest steel-producing city in each country under study. We also assume that all steel is shipped abroad from each country's largest port city. While these assumptions are a simplification, they allow us to estimate emissions from foreign inland transportation with the available data.[121]

[121] Unfortunately, it is not possible to know whether this will bias our estimate up or down; however, by not accounting for emissions generated by traveling between the site of milling and fabrication, it is likely that we will produce underestimates of the true emissions generated on this leg.

For the countries of Canada, Mexico, and Russia, countries that border both the Pacific and Atlantic oceans, we establish the largest port on both coasts and assume that all freight bound for Atlantic/Pacific US port districts embarks via the corresponding port.

First, using GIS tools in the statistical language R, we draw a straight line ("as the crow flies") between each country's largest steel city and its relevant largest port. We take the length of this line to be the average distance traveled by steel within each country c. To translate this distance into emissions, we assume that steel is transported according to the same modal shares as total freight in each country. The OECD publishes data on total freight transported by mode for most of the countries in Washington's top import sources.[122] We find additional data on freight in Peru, [123] the UAE,[124] Taiwan,[125] South Africa,[126] Brazil,[127] and Thailand[128] by searching specifically for data from those countries. For each country, we then multiply this distance by a weighted average of each country's mode shares multiplied by each mode's emissions factor. For instance, Brazil's largest port city is Santos, and its largest steel manufacturing city is Rio de Janeiro. The straight-line distance between these cities is 502 kilometers. Suppose that 80% of freight in Brazil travels by truck, 15% by rail, and 5% by inland/coastal towing. Then our estimate of emissions accrued between the mill and the port of departure would be

$$Emissions = 502 \times \left(0.80 \times EF_{truck} + 0.15 \times EF_{rail} + 0.05 \times EF_{towing}\right)$$

Leg 2: From Foreign Port to US District Port. We now account for emissions from the transport of steel across borders from each import source to each US port district that supplies Washington. For coastal US port districts (i.e., districts with seaports), we begin by obtaining the distance between each import source country's largest port and each such district port. We use S&P Global Platts' Portworld distance calculator tool to do this; this tool allows users to enter a starting and destination port and calculates the length of the optimal shipping route between them.[129] We allow Portworld to route shipments through the Bosporus Strait, Panama Canal, and Suez Canal. This gives us the distance between each foreign-domestic port combination considered. To translate these distances into emissions per metric ton of steel, we turn to Business for Social Responsibility's (BSR) 2020 Global Container Shipping Trade Lane Emissions Factors report on clean cargo, which reports CO_2e emissions per 20-foot equivalent unit (TEU) for a variety of accounting methods and freight types.[130] We specifically use their well-to-wheel estimates for dry (non-refrigerated) cargo, which accounts for emissions from both th.2e burning and production of fuel. The estimates of emissions per TEU-km are specific to the region of departure and region of arrival. Therefore, we sort each foreign-to-domestic port route into the provided region pairs from the BSR emissions factors data and apply the appropriate emissions factor. To convert TEU-km's to metric ton-km, we assume that each TEU equates to 24 metric tons, according to Marine Insight, a popular container freight information source.[131]

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[122] Organization for Economic Cooperation and Development. (2022). *Freight transport. OECD data.*
[123] Peru's main rail system does not serve freight traveling between Pisco (largest steel producing city) and Lima (largest port), and so we assume that all transportation of steel freight takes place via truck.
[124] The UAE does not have a well-developed rail freight transportation system, and so we assume that all steel freight takes place via truck. Augusteijn, N. (2022). *United Arab Emirates gear up for rail.*
[125] Taiwan's largest steel producing city and largest port are the same, Kaohsiung. Therefore, our methodology estimates foreign inland transportation emissions to be 0 for Taiwan.
[126] Department of Transportation: Republic of South Africa. (2019). *Freight transport.* In Department of Transportation: Republic of South Africa (Final Draft Report), National transport master plan (NATMAP) 2050 Synopsis report (7.1-7-17).
[127] Wolff, M.G.D.C., & Caldas, M.A.F. (2018). *A model for the evaluation of Brazilian road transport: A sustainable perspective*. *Journal of Advanced Transportation, 2018*, 1–12.
[128] Panichakarn, B. (2015). Multimodal transportation strategy for southern Thailand: A study of water transportation connecting to road transportation of containerized transporters. *Dynamics in Logistics,* 505–513.
[129] S&P Global (2022). *Portworld.*
[130] Business for Social Responsibility. (2021). *2020 global container shipping trade lane emissions factors: Clean cargo.*
[131] Menon, H. (2022, March 3). *What is TEU in shipping – Everything you wanted to know.* Marine Insight.

There are a handful of US port districts that are landlocked and yet still receive a large amount of steel imports from countries with which they do not share a land border. For instance, we estimate that about 51% of raw steel shipments entering the US at the port of Great Falls, Montana that are eventually bound for Washington are from Peru. Very few shipments in these ports arrive by air, implying that steel entering the US at these ports likely comes via ground transportation through the nearest country, Canada or Mexico. Therefore, we assume that steel shipped via container ship first arrives in the closer of these two countries in the relevant port (based on the coast), and then journeys the straight-line distance between said port and the US district port in question via the mean inland freight patterns of the country of arrival. For instance, Peruvian steel bound for Great Falls, Montana would initially be shipped by container ship to Vancouver, Canada, before being put on train cars or trucks to be carried from Vancouver to Great Falls. The sum of the emissions from water and inland freight gives us our estimate of emissions for these districts.

We assemble an estimate of average emissions for the foreign port to US district port leg of internationally milled and fabricated steel as the sum of emissions generated from each country's port of departure to each US district port weighted by the share of each country's Washington bound exports going through each district port. For instance, if 60% of Brazil's Washington-bound steel goes to the New York City port district and 40% through Los Angeles, then the emissions generated by this leg of that steel's journey would be

$$Emissions = 0.60 \times trans_{Braz}^{NY} + 0.40 \times trans_{Braz}^{LA},$$

where $\boldsymbol{trans_{Braz}^{NY}}$ are emissions estimated to be generated between Brazil and New York City.

Leg 3: From District Port to Washington. Here, we calculate emissions generated by shipping the steel from each US port district to the state of Washington. This is done very similarly to the estimation of transportation emissions for domestically milled and fabricated steel, using the CFS data to obtain distance and freight shares. Here though, we assume that the distance between each district port and Washington can be decently approximated by the distance between the state that contains each port and Washington. Additionally, to aggregate these emissions, we use the same weights as used during leg 2 above. i.e., if 60% of steel from Brazil bound for Washington arrives in New York City, then the emissions generated from shipping from New York to Washington would be given a weight of 60% in the aggregation.

Emissions for Foreign Milled and Fabricated Steel for Other Countries. The top 15 and 10 source countries for imported raw and fabricated steel to Washington account for 83% and 87% of steel imports, respectively. The remaining 17% and 13% are spread over 127 and 181 countries, respectively. Computing emissions factors for all these countries using the above full methodology would be infeasible due to the lack of data and the time required. Instead, we account for emissions from most of the steel production in these remaining countries using a simplified methodology.

For the remaining countries, we filter these lists down to only those countries with an import share to Washington greater than or equal to 0.1%. This brings the list of countries down to 48 and still accounts for over 98.5% of both raw and fabricated steel imports to the state. For these countries, we compute direct and indirect emissions identically to the above.

We simplify leg one of the international freight journey by instead finding the largest port city by population and drawing a straight line from that city to the geographic centroid of each country. We take the length of this line to be the average distance traveled. We then apply the same OECD estimates of total freight by mode in each country and the emissions factors used for transportation as above. For those countries without reliable freight data, we assume the modal split follows the same breakdown as the average of all other countries in our sample. For landlocked countries without a port city, we draw a line to the nearest port city elsewhere in the sample and take this to be the distance traveled to the port. We also assume that steel from these countries departs for the US from whatever said nearest port is.

We similarly simplify emissions calculations for leg two by using straight-line distance with an adjustment based on our routing information from the top import source countries. After determining the straight-line distance between each country's largest port and each US district port, we assign each pairing a route such as "Africa to East Coast of the US" as delineated in BSR's shipping route emissions data (there are 32 of these). We likewise assign routes to each country-district pair from the top import countries. We then take the average ratio by route of the Portsworld estimated distance to the straight-line distance of each pair in the top import source countries (from here on, we refer to these ratios as "route ratios"). Then, for every route appearing among the remaining countries, we multiply the straight-line distance by the corresponding route ratio. This inflates the straight-line distance estimates to account for navigation through canals or around landforms that straight-line distances by themselves would ignore. We then apply the BSR route-specific emissions factors to each of these modified distances to estimate total emissions by route over water. This method saves us from having to enter tens of thousands of origin-destination pairs in Portsworld.

Leg three is performed identically for the remaining countries as for the top import sources.

Finally, to obtain an average emissions factor for foreign milled and fabricated steel, we add together each country's direct, indirect, and leg 1, 2, and 3 emissions, weighting by the share of foreign milled and fabricated steel they make up in Washington. This gives us an emissions factor for this steel of 2.37 metric tons of CO_2 equivalent GHGs per metric ton of steel.

Steel Fabricated Domestically from Foreign Raw Steel

We estimate that 24.6% of the steel used in Washington is fabricated somewhere in the US using steel from abroad. This steel is milled in foreign countries and then shipped to locations throughout the US for fabrication via one of the US port districts. After fabrication, it is shipped to Washington. Washington receives fabricated steel from 41 states; each of these states, in turn, receives the raw steel used in that fabrication from an average of 142 countries that arrive via all 40 port districts. To estimate an overall emissions factor for steel fabricated domestically after being milled internationally, we must calculate direct and indirect emissions of the steel industries in each country and also transportation emissions generated from shipping steel from each country to each port district to each state and finally to Washington and weight them accordingly.

To calculate the emissions of each combination of the country of milling, district port of entry, and state of fabrication, we use a methodology similar to that used for foreign milled and fabricated steel. We calculate direct and indirect emissions identically to the above. For countries where neither production method shares nor energy balances are available, we use the World Steel Association's estimate of 1.89 metric tons of CO_2e per metric ton of steel milled for direct and indirect emissions.[132]

[132] World Steel Association. (2021). *Climate Change and the Production of Iron and Steel.*

We calculate emissions from the transportation of steel between locations similarly to our methods for foreign milled and fabricated steel in countries outside the top 15 and 10 import sources of raw and fabricated steel. The only difference here is that raw steel, upon arriving in the US, travels first from district ports to each state of fabrication. We use the CFS data to assign emissions to this additional leg using its estimates of distance traveled by mode between states.

Once again, our final estimate of the emissions generated from steel fabricated domestically using foreign raw steel will be an average of the emissions generated by each country-district port-state combination weighted by the share of steel taking each route. These shares are calculated as the product of the share of domestically fabricated steel using foreign-milled steel coming from a particular state, times the share of that state's steel coming from that country via that district. Using this formula, estimate that each ton of steel coming to Washington via this production route produces 2.50 metric tons of CO_2e.

Steel Fabricated Internationally from Domestic Milled Steel

Finally, we consider steel made from domestic raw steel but fabricated abroad. This steel comprises only about 1.5% of all steel used in Washington. Of this steel, the overwhelming majority is fabricated in Canada and Mexico; we, therefore, omit other countries from consideration in this category. This will cause us to slightly underestimate emissions from this steel.

We assume that steel in this category is first milled in states around the country, producing the US direct and indirect emissions of 1.14 metric tons of GHG per metric ton of steel. We obtain the quantity of raw steel from each state bound for Canada and Mexico from the Census' USA Trade database on state exports. Next, we assume that the steel is sent to the nearest US port district to each state of origin to be exported. We use the CFS data on distance traveled by mode for the NAICS 331 industry to estimate emissions generated from this stage of transportation. Emissions are again calculated as an average of the emissions factors for truck and rail freight weighted by each state's modal share.

Next, we assume that the steel makes the international crossing. For steel shipped to coastal port districts, the steel journeys via container ship to one of two ports in Canada and Mexico depending on which coast the district port lies on: Vancouver, Canada and Manzanillo, Mexico if on the west coast, or Montreal, Canada and Veracruz, Mexico if on the west coast. Here we again draw a straight line between ports and apply the corresponding route ratio calculated under the foreign milled and fabricated steel section. We then use the BSR emissions factors for container shipping. Then, we assume that the steel makes its way to the largest steel-producing cities in each country, Toronto, Canada and Monterrey, Mexico, via average land freight patterns in each country (using the OECD data again). We draw a straight line between each port and its country's largest steel city to approximate distance. For landlocked US port districts near the border of each country, we assume that the steel is transported directly to the site of fabrication in each country via land freight (thus skipping the container ship segment of the journey that steel from coastal districts makes).

After fabrication in the steel cities, we assume that the steel is shipped back to US district ports according to the shares of fabricated steel that are eventually bound for Washington. Again, the data for these shipping patterns come from USA Trade and the CFS and are imputed via the techniques outlined in the BCA appendix. We also assume that the fabricated steel shipped back from Canada and Mexico is representative of the share of total raw steel exports to these countries; i.e, if California is responsible for 5% of US raw steel exports to Mexico, then 5% of the fabricated steel made with US raw steel that gets shipped back to Washington will also have been milled in California. This assumption makes it easier to calculate shares when we aggregate to a single emissions factor below.

We assume fabricated steel bound for Washington via coastal port districts first travels to the largest port in each country on the same coast (as was done for raw steel headed to each country). We apply OECD estimates of freight mode shares in each country to calculate emissions for this leg of the journey. Thereafter, we assume that the fabricated steel is loaded on containerships and shipped to each coastal port district. We again draw a straight line between ports, modify it by its corresponding route ratio, and apply the relevant BSR emissions factor to estimate emissions. As before, we assume that landlocked ports ship the steel over land using the modal shares given by OECD for each country. Finally, we use the CFS data to estimate the distance traveled by mode back to Washington, completing the journey of the steel.

Lastly, we aggregate emissions from each of the above routes. We first add up the direct, indirect, and transportation-generated emissions for each state-country-district port combination to get the total emissions for each route. Then we average these emissions using the share of all steel in this category taking each route as weights. These shares will be equal to the US exports to each country made by each state times the share of fabricated steel from each country re-entering each port district. From this method, we estimate that Washington-bound steel fabricated in Canada and Mexico from US-made raw steel leads to about 1.73 metric tons of CO_2e GHGs. Note that none of our examples of Buy American policies allow for steel in this category to be used in state government contracts.

Calculating Expected Change in Emissions

Summing up across emissions factors from each milling/fabrication combination above and weighting by the share of all fabricated steel in Washington that they represent respectively, we estimate that every metric ton of fabricated steel in Washington leads to the production of 2.06 metric tons of CO_2e emissions.

We now detail how we use our estimates of emissions from each milling and fabrication combination of sourcing for steel to estimate the change in emissions resulting from our hypothetical policies. First, for each policy, we estimate how much steel would be produced domestically rather than internationally for a representative year. Next, we determine which international/domestic combinations of milling and fabrication will be allowed under each policy. Next, we account for various rates of replacement in foreign steel production, which we treat as a percent of total steel impacted by each policy.[133] Finally, determine the emissions generated by the steel that is being replaced and subtract these. Our final estimate for the change in emissions for each policy is the difference in the emissions factors for steel under the status quo of no BA Steel policy in Washington and the emissions factor of each policy for a given rate of replacement times the amount of steel affected by each policy.

The amount of steel brought home under the Full, Transportation Only, and Capital Only Policies in 2019 US dollars was already estimated in the BCA section of this report. Since our emissions factors are estimated with respect to metric tons of steel, we convert these dollar amounts into metric tons by dividing each by the average US price for steel; the resulting quantities are 2,961 metric tons for the Full Policy, 326 metric tons for the Transportation Only Policy, and 2,599 metric tons for the Capital Only Policy. The Fabrication Only Policy regulates the portion of steel regulated under the Full Policy that is fabricated abroad but does not regulate the portion fabricated domestically with foreign steel. This amounts to 1,567 metric tons of steel.

[133] Recall from Section IV that "replacement" refers to the case in which foreign producers of steel adjust their production of steel in reaction to decreased demand from Washington State government contracts under a BA Steel policy. We use replacement rates in our analysis below to represent the amount of foreign steel that is replaced by domestic steel, i.e., the share of foreign production that does not occur because of a BA Steel policy in Washington.

The Full and Fabrication Only Policies regulate the greatest amount of steel as they apply to all steel in the capital and transportation budgets combined. The Fabrication Only Policy, however, does not bring home any steel that is already fabricated domestically, and so impacts less steel in terms of emissions compared to the Full Policy. Any bias resulting from not estimating direct and indirect emissions from fabrication will be more pronounced here. The Transportation Only and Capital Only Policies only apply to the transportation and capital budgets, respectively, and so the amount of steel they impact is necessarily smaller.

Next, we determine what emissions factor to use for steel that is brought home. The Full, Transportation Only, and Capital Only Policies require that affected steel be milled and fabricated domestically. Thus, these policies use the value of domestically milled and fabricated steel, 1.66 metric tons of CO_2e per metric ton of steel. The Fabrication Only Policy allows for steel that has been fabricated domestically regardless of the location of milling. One of our assumptions of the BCA is that Washington continues to source steel domestically according to existing patterns, using domestic steel to replace foreign steel. Under this assumption, the correct emissions factor for the Fabrication Only Policy will be the sum of the emissions factors for domestically fabricated steel made from foreign and domestic raw steel weighted by their prevalence relative to each other. This gives us an emissions factor of 1.95 metric tons of CO_2e per metric ton of steel for the Fabrication Only Policy.

Next, we consider the rate of replacement of foreign steel production. Unless domestic production of the newly domesticated steel under each policy leads to a one-to-one reduction in foreign production of the replaced steel, emissions will not decline by the full difference between the baseline and policy-specific emissions factors. Instead, some portion of that production will still occur abroad. Steel production will still generate direct and indirect emissions; however, since the steel produced will no longer be demanded in Washington, transportation emissions will not be generated. The emissions factor for that steel will then be the average of direct and indirect emission factors for foreign milled and fabricated steel with the transportation emissions removed. We estimate this emissions factor to be 1.84 metric tons of CO_2e per metric ton of steel produced. Thus, the emissions that would occur under each policy would be equal to that policy's emissions factor plus 1.84 times the share of foreign steel that still gets made despite having been replaced by domestic steel.

To make the final comparison of emissions under each policy to the baseline, we need to consider the emissions that would have been generated under the baseline on the steel brought home. This is simply an average of the emissions factors for milling/fabrication combinations of steel that are not allowed under each policy weighted by their share of their sum. The Full, Transportation Only, and Capital Only policies allow only domestically milled and fabricated steel, and so eliminate steel that is either milled or fabricated abroad. The steel being replaced therefore has an emissions factor of

$$(0.246 \times 2.50 + 0.015 \times 1.73 + 0.265 \times 2.37)/(0.246 + 0.015 + 0.265) = 2.41,$$

Where 2.50 is the emissions factor for foreign milled and fabricated steel, 1.73 is the emissions factor for foreign fabricated steel using domestic raw steel, and 2.37 is the emissions factor for domestically fabricated steel using foreign raw steel. 0.246, 0.015, and 0.265 are the respective shares of total steel in Washington that they represent (as reported in Exhibit A4). A similar calculation using only foreign fabricated steel emission factors yields a value of 2.33.

We are now ready to calculate the expected change in emissions resulting from each policy at a given replacement value. This value will be the difference between emissions generated under a baseline of no BA Steel policy and the emissions under the policy. As an example, suppose that 100 metric tons of steel are brought back to the US under the Full Policy and suppose that this replaces foreign production by 70%. Under a baseline of no policy, that 100 metric tons would have generated 2.41 × 100 metric tons = 241 metric tons of CO_2e GHGs. Producing that steel domestically generates 1.66 × 100 metric tons = 166 metric tons of CO_2e GHGs. Since only 70% of international steel is replaced, 30% of that steel gets made abroad, releasing 1.84 metric tons of CO_2e GHGs per metric ton of steel. This means, 1.84 × 30% × 100 metric tons = 55.2 metric tons of CO_2e GHGs are still released internationally. The change in emissions under A is then the sum of emissions under A (166 + 55.2) minus the emissions that would have accrued without the policy (241), giving a final change in emissions of 166 + 55.2 – 241 = -19.8 metric tons of CO_2e GHGs.

Exhibit A13

Expected Change in Emissions from Each Policy

Parameter	Full Policy	Transportation Only	Capital Only	Fabrication Only
EF for US replacement steel	1.66	1.66	1.66	1.95
EF for international steel	2.41	2.41	2.41	2.33
Steel affected (metric tons)	2,961	362	2,599	2,961
Replacement rate	**Change in emissions (metric tons CO_2e) per year**			
100%	(2,221)	(271)	(1,949)	(730)
75%	(936)	(114)	(821)	(46)
50%	349	43	307	638
25%	1,634	200	1,434	1,322
0%	2,919	357	2,562	2,006

Notes:
Values in parenthesis represent decreases in emissions.
All values are calculated using a foreign direct and indirect emissions factor of 1.84 for steel that is not replaced by additional domestic production.

Exhibit A13 presents the steel affected, relevant emissions factors, and estimated emissions reductions reported in Section IV for each policy at various levels of replacement.

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