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AMERICA'S CARBON ADVANTAGE

By leading and establishing a new order on climate and trade, America can leverage its significant carbon advantage to enhance the competitiveness of U.S. businesses, bring manufacturing jobs back to the U.S. and boost climate ambition around the world.

Catrina Rorke
Greg Bertelsen

CLIMATE LEADERSHIP COUNCIL

ABOUT THE AUTHORS

Catrina Rorke is Vice President of Research at the Climate Leadership Council. Previously, Ms. Rorke served as Director of Energy Policy at the R Street Institute where she founded the institute's energy and environment program.

Greg Bertelsen is CEO of the Climate Leadership Council. Previously, Mr. Bertelsen served as Senior Director of Energy and Resources Policy at the National Association of Manufacturers (NAM).

THE CARBON ADVANTAGE

ABOUT THE CLIMATE LEADERSHIP COUNCIL

The Climate Leadership Council is an international research and advocacy organization founded in collaboration with a who's who of business, opinion and environmental leaders to promote a carbon dividends framework as the most cost-effective, equitable and politically-viable climate solution.

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I. Executive Summary

The United States has a distinct carbon efficiency advantage compared to most of its trading partners, which can be leveraged into a competitive advantage with the implementation of a well-designed climate and trade policy. This conclusion is supported by a first-of-its-kind data analysis of the best and most recent publicly available information. Taking into account emissions from the full supply chain of products, this report provides an analysis of carbon intensity and trade flows and introduces modeling of a unilateral U.S. border carbon adjustment.

This report finds that the U.S. is more carbon-efficient than the world average and dramatically more carbon-efficient than key competitors. In other words, U.S. industry produces the same or similar goods as its competitors while emitting less carbon dioxide.

Other key findings include:

- Goods manufactured in the U.S. are 40% more carbon-efficient than the world average.
- The U.S. carbon advantage is 3X that of China and nearly 4X that of India.
- Currently, the U.S. imports 75% of its goods from less carbon-efficient countries.
- A Border Carbon Adjustment (BCA) would allow U.S. industries to leverage their carbon advantage and outcompete foreign production.
- Energy intensive U.S. industries, like steel, are uniquely positioned to gain a competitive advantage from a BCA.
- With the U.S. carbon advantage and a BCA in place, we would reduce reliance on foreign energy as well as imports of non-energy goods from China, India and other leading export nations.

Table A. America's Carbon Efficiency Advantage by Sector vs. BRIC, EU, & USMCA Countries

	USA	Brazil	Canada	China	EU	India	Mexico	Russia	World
Agriculture, forestry and fishing	1.0	1.2	1.4	1.2	1.2	0.9	1.6	1.8	1.0
Mining and extraction of energy producing products	1.0	1.1	1.6	2.2	0.9	5.9	1.5	2.2	1.3
Mining and quarrying of non-energy producing products	1.0	0.6	1.6	2.2	0.8	4.7	1.0	3.2	1.4
Mining support service activities	1.0	1.8	1.5	5.2	1.9	2.5	1.6	4.2	1.9
Food products, beverages and tobacco	1.0	1.0	1.0	1.4	0.8	1.5	0.9	1.8	1.1
Textiles, wearing apparel, leather and related products	1.0	0.8	1.0	1.8	0.8	2.3	1.1	1.9	1.5
Wood and products of wood and cork	1.0	1.0	1.3	1.8	0.9	3.7	1.7	2.9	1.4
Paper products and printing	1.0	0.9	1.0	1.7	0.8	2.3	1.1	2.4	1.2
Coke and refined petroleum products	1.0	0.9	1.3	1.6	1.3	1.8	1.9	1.7	1.3
Chemicals and pharmaceutical products	1.0	0.9	1.5	2.6	0.8	2.1	1.2	5.5	1.6
Rubber and plastic products	1.0	0.9	1.0	2.7	0.7	2.1	1.1	2.9	2.0
Other non-metallic mineral products	1.0	0.7	0.9	1.6	1.0	2.5	0.9	2.7	1.3
Basic metals	1.0	1.3	1.0	1.8	0.9	2.7	0.7	3.7	1.5
Fabricated metal products	1.0	1.3	0.9	3.1	0.9	6.1	1.4	4.8	1.8
Computer, electronic and optical products	1.0	2.5	2.3	5.7	2.1	8.0	3.4	7.4	4.0
Electrical equipment	1.0	1.5	1.2	3.1	1.0	3.9	1.4	4.8	2.2
Machinery and equipment	1.0	1.0	0.9	2.8	0.8	4.0	1.2	4.5	1.8
Motor vehicles, trailers and semi-trailers	1.0	1.2	0.9	2.4	0.7	3.5	1.0	3.6	1.3
Other transport equipment	1.0	1.3	0.9	2.8	0.8	3.5	1.3	3.2	1.5
Other manufacturing; repair and installation of machinery and equipment	1.0	1.0	1.0	2.8	0.7	4.2	1.7	4.1	1.9
Economy-Wide	**1.0**	**1.1**	**1.3**	**3.2**	**0.9**	**3.8**	**1.4**	**4.2**	**1.8**

Source: MacroDyn Group calculations based on data from the International Energy Agency, the World Input-Output Database environmental accounts and the Global Trade Analysis Project.

- U.S. Carbon Advantage (foreign competitors less carbon efficient) [red]
- U.S. Carbon Disadvantage (foreign competitors more carbon efficient) [blue]
- U.S. Carbon Efficiency or Equivalent [white]

II. Quantifying Carbon Efficiency Across Borders

The U.S. has an efficient, innovative economy and an electricity system that has been steadily decarbonizing for a dozen years. Given these conditions, we would expect the U.S. to be more carbon-efficient than many of our trading partners, though to-date, we have lacked the data and analytical tools necessary to appropriately compare carbon intensities between countries and industries.

This report provides a pioneering analysis of how carbon emissions are embedded in global trade and compares the "carbon competitiveness" of the U.S. and its trade partner countries.[i] This is the first effort of its kind to assess carbon efficiency from whole supply chains, across industrial sectors, by country. While there are inevitable limitations to the granularity of the analysis given the highly aggregated sectoral data, this paper presents the clearest and most accurate picture of global trade in carbon to-date.

The Council commissioned a model that follows the carbon embedded in global trade using the latest publicly available data to calculate the emissions from 36 highly aggregated economic sectors across 64 individual countries in 2015.[ii, iii] Recognizing that the product of one sector is the intermediate input for another, the model rolls up trade across sectors and countries to provide a picture of supply chains overlaid with emissions data. Weighted by economic output, the model reveals the relative carbon efficiency of production, by sector, across countries.[iv]

The modeling of full supply chains provides a clearer picture of how existing climate policies interact with global trade. Even if a country is cleaner than its competitors and has policies that limit emissions from domestic production, its external supply chains contribute to the overall carbon footprint of its industries and the embodied emissions of its manufactured products.

To make inter-country comparisons more straightforward, the Council weights embodied emissions associated with economic output from each sector and country relative to the carbon intensity of U.S. output in the sector (U.S. = 1.0). If a number is larger than 1.0, it reflects that a country or sector is less carbon-efficient and that the U.S. has a carbon advantage; if the number is below 1.0, it reflects a country or sector that is more carbon-efficient than the U.S. **Table A** provides a summary of the analysis and the U.S. Carbon Advantage compared to some of our most significant trading partners.

U.S. Carbon Efficiency vs. Major Trading Blocks

The U.S. carbon advantage is especially apparent in comparison to the BRIC countries (Brazil, Russia, India and China), as demonstrated in **Table A**. This difference may be partially explained by the preferential production of more intermediate inputs and lower-value goods in the BRIC countries, though the full picture is complex. For example, the BRIC countries have large amounts of energy-intensive manufacturing and heavy dependency on carbon-intensive power sources. These countries have also undertaken only limited efforts to control carbon and other emissions.[v] **Table B** provides information on the carbon-intensity of economic activity and power generation in individual countries. With the exception of Brazil, which relies heavily on hydropower, the data shows BRIC countries to have economy-wide CO_2 intensities 3.2 to 4.2 times as high as the U.S.

The U.S. also appears to compare favorably against Mexico and Canada. Closely integrated North American supply chains underpin the U.S.' trade with its USMCA partners. The U.S. maintains a significant advantage on average across all sectors and wide advantages in a few sectors critical to the U.S. economy.

The data also suggests that the U.S. has a similar carbon efficiency to the European Union and a distinct carbon advantage in several key sectors, including agriculture, mining, petroleum refining, and electronics manufacturing. This trend holds despite 15 years of the E.U. Emissions Trading System (ETS) and abundant companion policies aimed at reducing emissions. This is partially attributable to significant gaps in ETS coverage. The E.U. has chosen to address leakage concerns by issuing free emissions allowances to 164 industries (representing more than 75 percent of manufacturing emissions) deemed "at risk of carbon leakage."[vi] By isolating industries from the ETS, the E.U. model forgoes opportunities to decarbonize these sectors and improve the carbon efficiency of European industry.[vii] There is also considerable variability across E.U. member states. More differentiation among the largest global traders in the E.U. is provided in the next section.

U.S. Advantage by Sector

Even allowing for the inevitable limitations of this model, the data demonstrate that the U.S. is already a leader in low-carbon manufacturing: across all sectors, the U.S. is 40 percent cleaner than the world average. The U.S. carbon advantage is particularly pronounced in a few sectors critical to the U.S. economy: U.S. industries appear to be twice as carbon-efficient as international competitors in energy extraction (developing abundant domestic energy resources), rubber and plastics manufacturing (leveraging U.S. natural gas), and the manufacture of computer and electronic equipment (reflecting the highly sophisticated domestic technology industry).

The relative carbon efficiency of the U.S. economy is apparent across the national supply chain, from primary goods to finished products, reflecting an innovative domestic economy that pursues efficiency and technological improvement. The U.S. also ranks at or near the top among all countries in domestic value added to goods before export, reflecting a domestic tendency to self-supply; this self-supplying in turn reinforces the high carbon-efficiency of U.S. production.[viii]

While for some industries, such as computer and electronic equipment, the U.S. advantage is partially due to a domestic preference for producing finished goods with value added from lower-carbon activities, like product design, marketing and advertising, as the next sections demonstrate, it is clear that the overarching conclusion from this data is that the relatively carbon-efficient American economy presents a competitive opportunity in global trade.[ix]

Table B. Country-Level Electricity Profiles

	USA	Brazil	Canada	China	India	EU	Mexico	Russia	World
GDP CO2 intensity (Mt CO_2/$M)	286	298	382	983	1,068	264	411	1,213	468
Electricity CO2 intensity (Kt CO_2/GWh)	0.45	0.13	0.14	0.7	0.71	0.36	0.45	0.66	0.62

Source: MacroDyn Group calculations based on data from the International Energy Agency, the World Input-Output Database environmental accounts and the Global Trade Analysis Project.

- U.S. Carbon Advantage (foreign competitors more carbon intensive)
- U.S. Carbon Disadvantage (foreign competitors less carbon intensive)
- U.S. Carbon Intensity or Equivalent

Table C. America's Carbon Efficiency Advantage vs. Top Trading Partners

Largest U.S. Import Sources

Country	U.S. Imports Share	Index
China	19%	3.2
Canada	12%	1.3
Mexico	10%	1.4
Germany	5%	0.9
Japan	5%	1.1
United Kingdom	4%	0.6
India	4%	3.8
Korea	3%	1.8
France	2%	0.6
Italy	2%	0.9
World	100%	1.8

Largest U.S. Export Destinations

Country	U.S. Exports Share	Index
Canada	14%	1.3
China	12%	3.2
Mexico	10%	1.4
Japan	5%	1.1
United Kingdom	4%	0.6
Germany	4%	0.9
Korea	3%	1.8
France	3%	0.6
Brazil	3%	1.1
Ireland	2%	0.6
World	100%	1.8

Source: MacroDyn Group calculations based on data from the International Energy Agency, the World Input-Output Database environmental accounts and the Global Trade Analysis Project.

- U.S. Carbon Advantage (foreign competitors less carbon efficient)
- U.S. Carbon Disadvantage (foreign competitors more carbon efficient)

III. Opportunities in International Trade

The U.S. appears carbon competitive against its closest trading partners. **Table C** compares the carbon efficiency of the U.S. to the largest sources of U.S. imports and the largest destination markets for U.S.-produced goods.

The U.S. imports 75 percent of goods and ships 76 percent of exports to less carbon-efficient countries. Notably, the U.S. maintains an advantage against the highly developed economies of Japan and Korea, which are leading global traders across a wide range of product categories. Among our top 10 import and export partners (**Table C**) western European countries that are more carbon-efficient than the U.S represent a minority of trade. This reflects diversified global supply chains and the leading U.S. role in key high-value sectors (e.g., energy development and petroleum products). The U.S. remains the second largest global exporter of goods and has broadly diversified export markets.

U.S. Carbon Advantage Compared to China

The U.S. advantage is particularly stark in comparison to China, the only country with more global exports. The U.S. leads China in carbon efficiency across every one of the twenty sectors in this study by 20 percent (agriculture) to 500 percent (computer, electronics and optical products) and by a factor of 3.2 economy-wide.

This in part reflects different generation mixes in each country's electricity sector. **Table D** shows the relative carbon intensity of electricity in 2015, the year for which we have carbon index data. (Note that the U.S. has substantially decarbonized since then, lowering its relative share of fossil energy and displacing coal-fired electricity with natural gas.)

Table D. Electricity Carbon Intensity and Fossil Fuel Mix, U.S. vs. China

	USA	China
National-Level Electricity CO_2 Intensity (Kt CO_2/GWh)	0.45	0.70
Coal Share	34%	70%
Oil Share	1%	0%
Natural Gas Share	32%	3%
Total Fossil Fuel Share	**67%**	**73%**

Source: MacroDyn Group calculations based on data from the International Energy Agency, the World Input-Output Database environmental accounts and the Global Trade Analysis Project.

China's ambition to dominate manufacturing and innovation has been well documented.[x] While the country's economic plans favor the export of more carbon-efficient goods,[xi] China continues to expand its coal power fleet.[xii] And as they continue to power their present and planned trade with coal, China is promoting carbon-intensive industrialization in other emerging economies, often through new coal facilities financed under the Belt and Road Initiative. If this trend continues, high-carbon manufacturing from emerging economies will lock global supply chains into carbon-intensive pathways.

The U.S. carbon advantage demonstrated within these highly aggregated sectors reflects a carbon advantage across individual industries in which the U.S. is a world leader in carbon efficiency. While the data in this study unavoidably combines individual industries, other analyses using slightly different but comparable metrics show a parallel picture of the relative carbon intensities of more specific product lines. We offer two examples in which U.S. carbon-efficient production is being challenged by China: steel (in basic metals) and solar panels (in computers, electronics, and optical products).

The U.S. steel industry is the most energy-efficient of any major steel producing country.[xiii] Numerous factors contribute to this, including a domestic preference for lower-carbon manufacturing techniques and materials and abundant low-carbon energy sources.

Industry Examples: Steel & Solar Panels

There are two main processes for creating steel, the Basic Oxygen Furnace (BOF) and the far more efficient and less carbon-intensive alternative, the Electric Arc Furnace (EAF). Two-thirds of steel production in the U.S. occurs at EAFs; China and Russia (1st and 7th among global exporters) are more reliant on the energy-intensive (and emissions-intensive) BOF, based primarily on burning high-carbon coking coal. The U.S. also uses more recycled steel scrap as the primary feedstock for EAF steel production, rather than materials produced from iron ore. To better illustrate the differences across regions, **Figure 1** illustrates just how much more energy-intensive iron and steel production is amongst international competitors than the U.S.[xiv]

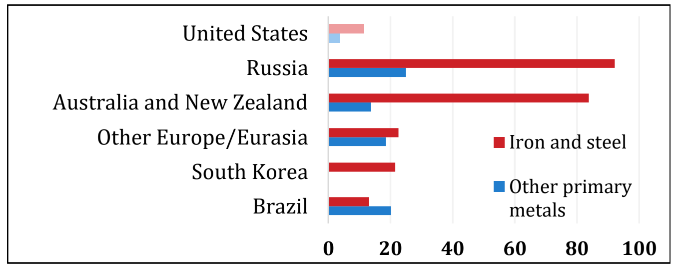
The U.S. steel industry also benefits from abundant domestic natural gas. In 2014, natural gas accounted for 34 percent of the U.S. steel industry's final energy use – significantly higher than most other countries.[xv] Natural gas use, especially in BOF steel production, provides a lower carbon footprint than coke-based production.

The U.S. carbon efficiency advantage is also apparent in the computer, electronic and optical product category. Included in this category is solar panels – an area in which U.S. manufacturing is a standout leader in carbon efficiency.

The National Renewable Energy Laboratory (NREL) shows the average carbon footprint of crystalline silicon solar panels manufactured in the U.S. to be around 40 g CO_2e/kWh and thin film solar panels to be around 30 g CO_2e/kWh.[xvi]

Figure 1. Basic Metal Industry Energy Intensity in Select Regions, 2018

Energy consumption per unit of industrial ouput (thousand British thermal units per dollar)



Source: U.S. Energy Information Administration, World Energy Projection System Plus Model. August 2018.

A study of life cycle manufacturing emissions for Chinese-manufactured crystalline silicon highlighted differences in the electricity-intensive silicon purification process, a critical process for crystalline silicon solar cells. As a result, life cycle emissions in China are roughly double that of U.S. production – 71 g CO_2e/kWh.[xvii] China has higher levels of emissions throughout the manufacturing process and especially in that crucial electricity-intensive phase.[xviii] Representing more than 60 percent of global silicon-based solar manufacturing, China's high carbon solar cells are crowding out lower-carbon manufacturers of solar technologies.

Furthermore, the U.S. is one of the top innovators and manufacturers of second-generation solar technology, such as cadmium telluride solar cells or thin film technology. These panels avoid the energy-intensive processes associated with purifying silicon, cutting the carbon footprint in half compared to conventional silicon-based solar PVs.[xix] The U.S. is well positioned to develop the next generation of photovoltaic technologies: the U.S. ranks highly in measures of innovative capacity, accounting for 31 percent of global photovoltaic patent applications and investing more in solar research and development as a share of the domestic industry than any other nation.[xx]

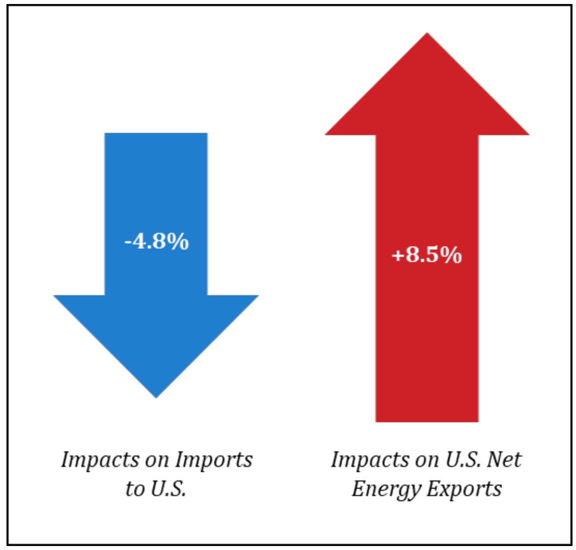
IV. Leveraging America's Carbon Advantage Through a Border Carbon Adjustment

One policy lever can simultaneously strengthen the competitive position of U.S. industry, enable greater ambition in domestic climate action, and encourage other countries to follow suit: a Border Carbon Adjustment (BCA).[xxi] For U.S. industries that are more carbon-efficient than their overseas counterparts, a BCA shifts relative prices so that the competitive advantage falls to the cleanest, domestically produced products rather than cheaper, carbon-intensive products from overseas.

The Council proposes a BCA as part of its Baker-Shultz Carbon Dividends Plan for precisely these reasons. The BCA would remove the carbon fee paid from goods that are exported from the U.S. and impose the carbon fee on goods that are imported to the U.S.[xxii] Exports would be rebated for carbon fees paid in the manufacturing or development process, providing them an equal playing field against foreign production in international markets. Imports from countries with lower carbon efficiencies would pay more than imports from countries with higher carbon efficiencies. For example, because of their higher emissions, imported basic metals from China would pay a carbon fee almost twice as high as that on the same metals produced in the U.S. This ensures that U.S. industries can leverage their carbon advantage to outcompete foreign production domestically.

The BCA has the potential to create distinct benefits for clean domestic manufacturers based on differences in carbon efficiency. To appreciate the specific impacts that carbon efficiency differences will have on trade, Oxford Economics (OE) modeled how a unilateral U.S. BCA would change exports and imports for fuel and non-fuel goods in the first five years of a carbon dividends program.[xxiii]

Figure 2. Impacts of Border Carbon Adjustment on Energy Trade in 2025



Source: Author calculations based on modeling from Oxford Economics for the Climate Leadership Council, Energy Information Administration

OE estimates that exports of both fuel and non-fuel goods continue along current projections. In other words, the BCA ensures that domestic carbon policy does not jeopardize the international competitiveness of U.S. industry.

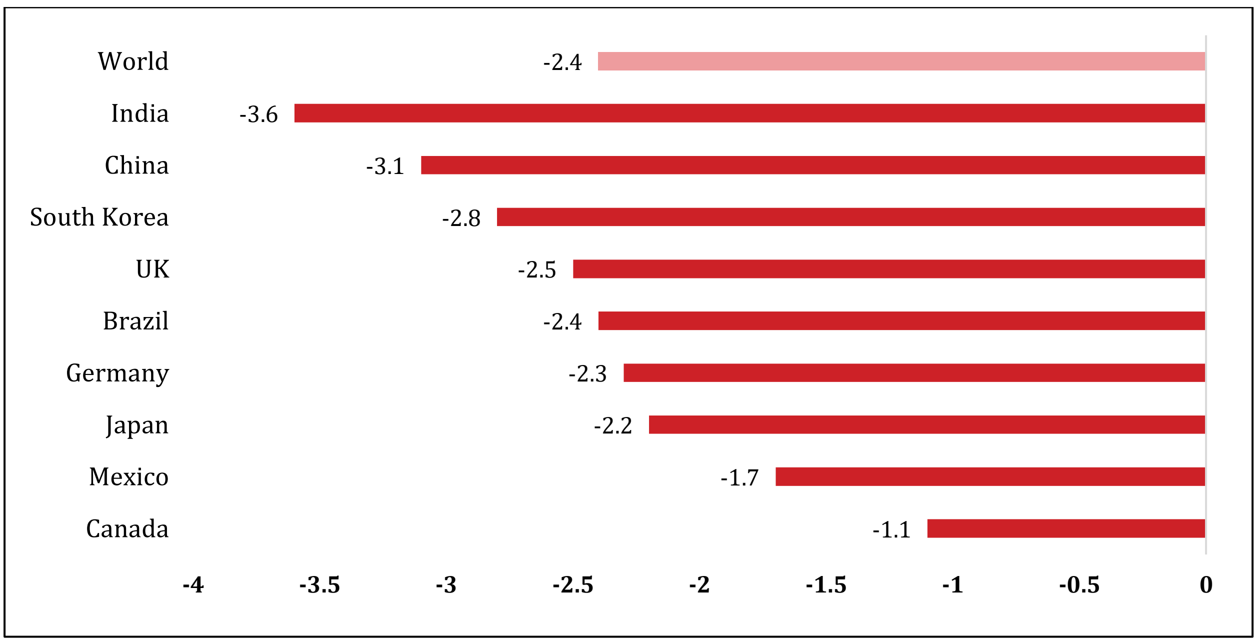
On imports, the benefits of monetizing the carbon advantage are striking. By the fifth year, imports of energy goods decline 4.8 percent below baseline, thereby reducing reliance on foreign energy. At the same time, imports of non-energy goods decline 2.4 percent relative to business as usual.[xxiv] The reduction in imports under a BCA comes from two sources: a more carbon-efficient U.S. economy consumes fewer energy-intensive materials and cleaner U.S. industries supply a greater percentage of that lower domestic demand. As a consequence, U.S. energy exports – which are considerably less carbon-intensive than global energy resources – can continue to grow even as imports shrink (see **Figure 2**).

Changes to trade in non-energy goods from specific countries are shown in **Figure 3** and demonstrate that imports from India and China fall most dramatically in the presence of a BCA, reflecting the higher carbon intensity of these two countries. The same trend holds across industries; **Figure 4** shows that import shares decline most significantly in the sectors in which the U.S. holds the greatest carbon efficiency advantage.[xxv]

This reduction in imports from high-emitting countries and sectors demonstrates that the BCA translates greater carbon efficiency to concrete competitive advantages for U.S. firms that are cleaner than their competitors. In the presence of a national carbon price that accelerates investments in low-carbon solutions and innovation, the U.S. advantage only stands to widen.

Figure 3. Border Adjustment Impact on Real Non-Fuel Goods Imports by Country

[% difference from base, 2025]



Source: Oxford Economics for the Climate Leadership Council

V. Increasing Global Climate Ambition

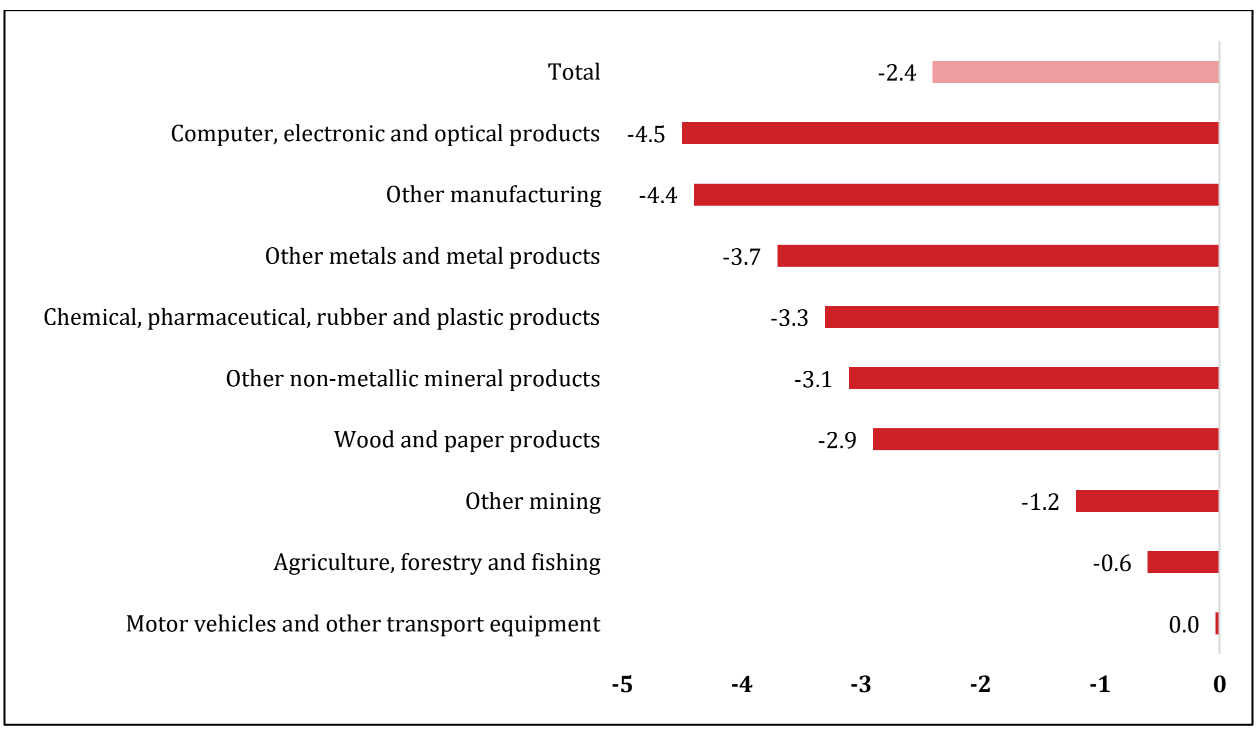
The case for greater climate action is made on environmental grounds. Those who oppose decisive U.S. climate policy often cite concerns that climate solutions could put the U.S. economy at a competitive disadvantage with its trading partners, reduce American living standards, or do little to reduce global emissions if other countries like China and India don't do their fair share. As the data presented here suggest, greater U.S. competitiveness and climate ambition are not just mutually compatible, but mutually reinforcing. Unilateral U.S. action to introduce a carbon price and BCA can create an international market for carbon efficiency.

The domestic case for a U.S. carbon policy along these lines is important; but just as important is the impact an aggressive U.S. climate policy will have on international climate diplomacy. U.S. inaction will no longer be an excuse for others to hide behind; on the contrary, countries will now find both the international diplomatic pressure and their own companies' interests aligned to encourage greater ambition.

Unlike past attempts at international climate cooperation, this approach does not depend on complex multi-country negotiations and agreements to get started. Rather, this approach relies on U.S. leadership in establishing the rules for the interaction of international trade and climate action, leveraging its more carbon-efficient economy and creating a strong incentive for others to follow.

Figure 4. Border Adjustment Impact on Real Non-Fuel Goods Imports by Sector

[% difference from base, 2025]



Source: Oxford Economics for the Climate Leadership Council

VI. Conclusion

This paper demonstrates that the U.S. enjoys wide advantages in carbon efficiency against trade powerhouses like China and India and that the proposed BCA will reduce imports most from the highest-emitting countries, improving the ability of U.S.-based firms to compete and monetize their significant carbon advantage.

More research and better facility- and product-level reporting could undoubtedly help further illuminate the carbon advantage for U.S. manufacturing. At present, publicly available data covers limited countries at a relatively high level of sectoral aggregation. The Council and others will continue to explore mechanisms to create this data record as global reporting and industry standards develop to satisfy this level of detail.

The U.S. carbon efficiency advantage against competitors worldwide identified in this report is large and presently unrecognized in domestic policy and in the rules of global trade. As a consequence, lower cost, higher emitting overseas production continues to win out, creating a globalized economy that disadvantages the cleanest producers and fails to account for carbon emissions and global climate change. U.S. leadership has the potential to dramatically change this – overnight it will raise the value of reducing carbon emissions for companies worldwide, regardless of what their own governments may choose to do.

Contrary to some of the rhetoric opposing federal climate action, an ambitious U.S. policy to price emissions including a BCA will turn the existing U.S. carbon advantage into a competitive advantage. No other policy exists to unilaterally improve the competitive position of U.S. firms, reduce domestic carbon emissions, and encourage global emissions reductions.

ENDNOTES

i. Data and analysis from MacroDyn Group; separate technical report pending.

ii. Data retrieved from two sources: "Inter-Country Input-Output Tables." Organization for Economic Cooperation and Development (December 2018). Accessed March 2020. https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm And from Roman, M.V., et al. "World Input-Output Database Environmental Accounts." European Commission Joint Research Centre (May 2019), accessed March 2020. https://ec.europa.eu/jrc/en/publication/world-input-output-database-environmental-accounts

iii. The 36 economic sectors are described by the United Nations International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4 (2008). The MacroDyn report includes country-level data for 64 countries and a "Rest of World" category for countries with insufficient data in the underlying databases.

iv. A full summary of the methodology, including a detailed construction of the Leontief Matrix that underlies this analysis, is available in the pending MacroDyn technical report.

v. David Bailey, Geoffroy Dolphin, and Ryan Rafaty. "The Case for an Economy-Wide Carbon Fee." Climate Leadership Council, October 2019. https://clcouncil.org/media/The-Case-For-An-Economy-Wide-Carbon-Fee.pdf

vi. European Economic Commission. "Commission decision of 24 December 2009 determining pursuant to directive 2003/87/EC of the European parliament and of the council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage." Official Journal of the European Union L 1 (2010): 10-18.

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viii. Inu Manak and Logan Kolas. "Supply Chains and Interdependence: Is this Really a Problem that Needs Solving." Cato Institute, June 2020. https://www.cato.org/blog/supply-chains-interdependence-really-problem-needs-solving

ix. The OECD maintains an interesting database on "Trade in Value-Added" (TiVA), which tracks the value add from specific industries in specific countries (the same countries and industries analyzed in this study). That database supports the finding that many U.S. industries add large amounts of value to intermediate goods before final domestic sale or export. See "Trade in Value Added." Organization for Economic Cooperation and Development (December 2019). Accessed July 2020. http://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm

x. See, e.g. Pillsbury, Michael. The Hundred-Year Marathon: China's Secret Strategy to Replace America as the Global Superpower. New York: Henry Holt and Company, 2015.

xi. Pan, Chen, et al. "Emissions embodied in global trade have plateaued due to structural changes in China." Earth's Future, Volume 5, Issue 9, September 2017. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017EF000625

xii. Christine Shearer, Aiqun Yu, and Ted Nace. "Out of Step: China is driving the continued growth of the global coal fleet." Global Energy Monitor, November 2019. https://endcoal.org/global-coal-plant-tracker/reports/out-of-step/

xiii. American Iron and Steel Institute. 2019-20 Profile. https://www.steel.org/industry-data/reports

xiv. Energy Information Administration. Today in Energy: The basic metals industry is one of the world's largest industrial energy users. February 20, 2019. https://www.eia.gov/todayinenergy/detail.php?id=38392

xv. Hasanbeigi, Ali, et al. "Comparison of carbon dioxide emissions intensity of steel production in China, Germany, Mexico, and the United States." Resources, Conservation and Recycling, Volume 113, October 2016. https://www.sciencedirect.com/science/article/abs/pii/S0921344916301458

xvi. National Renewable Energy Laboratory. Fact Sheet: Life Cycle Greenhouse Gas Emissions from Solar. November 2012. https://www.nrel.gov/docs/fy13osti/56487.pdf

xvii. Yue, Dajun, Fengqi You, and Seth B. Darling. "Domestic and overseas manufacturing scenarios of silicon-based photovoltaics: Live cycle energy and environmental comparative analysis." Solar Energy, Volume 105, July 2014. http://isen-dev.tech.northwestern.edu/doc/pdf/news/scholarlypapers/FYou_SolarEnergy_July2014.pdf

xviii. Ibid.

xix. First Solar. Sustainability Report. 2017. http://www.firstsolar.com/en/Resources/Knowledge-Center/Sustainability-Report

xx. National Renewable Energy Laboratory. On the Path to Sunshot: Emerging Opportunities and Challenges in U.S. Solar Manufacturing. Donald Chung, Kelsey Horowitz, and Parthiv Kurup, NREL/TP-7A40-65788, May 2016. https://www.nrel.gov/docs/fy16osti/65788.pdf

xxi. See e.g. Baker, James A., George P. Shultz, and Ted Halstead. "The Strategic Case for U.S. Climate Leadership." Foreign Affairs, May/June 2020.

xxii. Climate Leadership Council. The Baker Shultz Carbon Dividends Plan Bipartisan Climate Roadmap. April 2020. https://clcouncil.org/Bipartisan-Climate-Roadmap.pdf

xxiii. Oxford Economics modeled the Border Carbon Adjustment feature of Baker Shultz Carbon Dividends Plan as described in the Roadmap for the Climate Leadership Council.

xxiv. Oxford Economics examined fuel & non-fuel impacts separately and in different models. For fuels, Oxford used its proprietary OE GEM model and impacts on fuel trade are determined from the BCA in concert with the other aspects of the Carbon Dividends Plan. For non-fuel goods, Oxford used the GTAP model and reported impacts for the BCA separately from the other aspects of the Plan.

xxv. Note that Oxford modeling relies upon a different set of sector classifications than MacroDyn modeling. Oxford relies on industry classifications from the Global Trade Analysis Project; MacroDyn relies on the United Nations' International Standard Industrial Classification. A translation between the two different systems is described by the Global Trade Analysis Project here: https://www.gtap.agecon.purdue.edu/databases/contribute/concordinfo.asp

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