Emissions and competitiveness impacts of U.S. climate and trade policies

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Abstract

U.S. policymakers are increasingly interested in carbon import tariffs to address domestic competitiveness and climate goals, sometimes in isolation from domestic climate policy. We evaluate current U.S. carbon tariff proposals using a quantitative trade model, yielding four findings. First, a U.S. carbon tariff by itself largely shifts greenhouse gas (GHG) emissions from U.S. trading partners to the United States, leading to increased U.S. GHG emissions and limited global GHG emissions reductions. Second, a U.S. carbon tariff paired with a domestic policy lowers global GHG emissions by five times that of a tariff-only policy, decreasing U.S. emissions while still increasing U.S. output in some targeted sectors. Third, if the domestic policy were a carbon tax, the U.S. tax revenue from a combined tariff and tax policy would be ten times that of a tariff-only policy. Fourth, a global climate club built on a carbon tariff-only approach would yield limited global GHG reductions, while a club built on carbon tariffs and domestic policy could achieve substantial GHG reductions.

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1 Introduction

Global climate negotiations have had limited success to date. Existing efforts have either resulted in country defections (e.g., Kyoto Protocol) or have been criticized for achieving limited greenhouse gas (GHG) abatement (e.g., Paris Agreement). In response, there is growing interest in using trade policy tools, and their enforcement and administrative regimes, as a component to global climate policy design.

The idea of integrating climate and trade policies is not new. Several U.S. GHG emissions trading proposals in the 1990s and 2000s feature a carbon import tariff to adjust for the carbon price borne by domestic producers. The climate club proposal uses imports tariffs as an incentive for adopting domestic action to facilitate global climate coordination (Nordhaus, 2015). And more recently, the E.U. has announced it will adopt a carbon import tariff starting in 2026 to offset the domestic cost of its emissions trading system.

In recent years, policy discussions in the U.S. have focused on carbon import tariffs on their own, without a complementary domestic climate policy. Arguments for such a policy are grounded in climate and U.S. competitiveness goals, but without the explicit logic that carbon import tariff should adjust for the (shadow) price of domestic climate policy. In some settings, the carbon tariff is being considered in sectors with domestic subsidies. Indeed, there are two carbon tariff bills in the U.S. Senate. The Clean Competition Act includes a domestic carbon tax and export subsidy alongside a carbon import tariff. The Foreign Pollution Fee has only a carbon import tariff.

This paper analyzes the economic and climate impacts of U.S. carbon import tariffs, with and without a complementary domestic policy, and in unilateral and multilateral settings. We deploy a standard global multisector quantitative trade model with microfoundations that allow for endogenous domestic GHG abatement (Shapiro, 2016; Shapiro and Walker, 2018; Hollingsworth et al., 2022). We calibrate the model with a global multiregion input-output dataset with sufficiently fine sectoral resolution to enable policy analysis on specific carbon intensive, trade exposed (CITE) sectors (Stadler et al., 2018). We then run policy scenarios that adhere closely to current climate and trade proposals in the U.S. Congress.

We find four results. First, a U.S. carbon import tariff on CITE sectors, by itself largely shifts GHG emissions from U.S. trading partners to the U.S., leading to increased U.S. GHG emissions and limited global GHG emissions reductions. Second, a U.S. carbon tariff paired with a domestic climate policy, lowers global GHG emissions by five times that of a tariff-only policy, lowering U.S. emissions while still increasing U.S. output in many CITE sectors, an objective for some policymakers itself. Third, if the domestic policy were a carbon tax, the U.S. tax revenue from a combined tariff and tax policy is ten times that of a tariff-only

policy. Fourth, a global climate club built on a carbon tariff-only approach yields limited global GHG reductions, but substantial GHG reductions can be achieved with a club built on carbon tariffs and domestic policy.

The paper is organized as follows. Section 2 details our theoretical framework while Section 3 covers the data used to calibrate our model. Section 4 presents our results. Section 5 provides a concluding discussion.

2 Theoretical Model

There are M sectors and N countries.

2.1 Households

Each country-sector has a mass of L_{jm} households and the mass of households in country j is $L_j = \sum_{m=1}^{M} L_{jm}$. Households in each country-sector have a Cobb-Douglas utility function over final sectoral goods that they purchase from a local final sectoral producer:

$$U_{jm} = \prod_{m=1}^{K} (Q_{jm})^{\alpha_m}.$$

Q_{jm} is the sector m final good produced in country j. The parameter α_m is the expenditure share of sector m and we assume $\sum_{m=1}^{M} \alpha_m = 1$. We assume that households cannot move across space, but they can freely move across sectors of employment. Since all households within a country face the same menu of goods prices, this implies that nominal (and real) wages must be equalized across sectors within a country.

2.2 Firms

2.2.1 Sectoral Intermediates

Intermediate sectoral goods are produced by perfectly competitive firms operating constant returns to scale Cobb-Douglas technologies. These firms use local labor and energy (measured in units of emissions) as inputs:

$$q_{jm} = \chi_{jm}^{\sigma_m - 1} L_{jm}^{\gamma_{jm}} E_{jm}^{1-\gamma_{jm}}$$

where χ_{jm} is country-sector productivity. Notice that in equilibrium, demand for energy is given by:

$$E_{jm} = (1 - \gamma_{jm}) \frac{p_{jm} q_{jm}}{p^E_{jm}}$$

where p^E_{jm} is the price of energy, and $p_{jm} q_{jm}$ are revenues gained by the intermediate producer.

A key assumption to note on the firm side is that we abstain from modeling energy production and assume revenues that accrue to the energy sector are lost. Thus the price of energy is exogenous within the model.[1]

2.2.2 Local Sectoral Final Good

A local sectoral final good is produced as a CES aggregate of the country-specific, differentiated intermediate sectoral goods:

$$Q_{jm} = \left[\sum_{i=1}^{N} a_{ijm}^{\frac{1}{\sigma_m}} q_{ijm}^{\frac{\sigma_m - 1}{\sigma_m}} \right]^{\frac{\sigma_m}{\sigma_m - 1}}$$

where a_{ijm} is a taste parameter, σ_m is the elasticity of substitution between country-specific goods, and q_{ijm} is the demand by j for $i's$ sector m good. Profit-maximization yields the usual expression for CES demand:

$$q_{ijm} = a_{ijm} p_{ijm}^{-\sigma_m} P_{jm} Q_{jm} P_{jm}^{\sigma_m - 1}$$

where P_{jm} is the usual Dixit-Stiglitz price index.

2.3 Trade

Trade costs are iceberg so that $\tau_{ijm} \geq 1$ units of the good must be shipped from country i to country j for one unit to be delivered and we assume that $\tau_{jjm} = 1 \; \forall j, m$.

Perfect competition and this form of trade costs imply that the price of country j procuring a sector m good from country i is:

$$p_{ijm} = \tau_{ijm} \frac{w_i^{\gamma_{im}} \left[p^E_{im} \right]^{1 - \gamma_{im}}}{\chi_{im}^{\sigma_m - 1}} = \tau_{ijm} \frac{c_{im}}{\chi_{im}^{\sigma_m - 1}}$$

where we define $c_{jm} \equiv w_j^{\gamma_{jm}} \left[p^E_{jm} \right]^{1 - \gamma_{jm}}$. Inserting this expression for price into the demand function for the local sectoral final goods producer yields our equilibrium condition for trade

[1] This is equivalent to assuming that a separate energy sector produces an energy good with the production function that is symmetric to the production function for the final good.

flows:

$$X_{ijm} = a_{ijm}\chi_{im}\left[\tau_{ijm}c_{im}\right]^{1-\sigma_m} X_{jm}\left[P_{jm}\right]^{\sigma_m-1} = \frac{a_{ijm}\chi_{im}\left[\tau_{ijm}c_{im}\right]^{1-\sigma_m}}{\sum_{l=1}^{N} a_{ljm}\chi_{lm}\left[\tau_{ljm}c_{lm}\right]^{1-\sigma_m}} X_{jm}$$

where X_{jm} is total expenditures by j on sector m goods, and the second equation recognizes that the price index is:

$$P_{jm}^{1-\sigma_m} = \sum_{l=1}^{N} a_{ljm}\chi_{lm}\left[\tau_{ljm}c_{lm}\right]^{1-\sigma_m}$$

We can then express this as trade shares:

$$\lambda_{ijm} = \frac{a_{ijm}\chi_{im}\left[\tau_{ijm}c_{im}\right]^{1-\sigma_m}}{\sum_{k=1}^{N} a_{kjm}\chi_{km}\left[\tau_{kjm}c_{km}\right]^{1-\sigma_m}}.$$

2.4 Market Clearing

Market clearing implies that labor income in a country-sector must equal labor's share of total expenditures on that country-sector:

$$w_i L_{im} = \gamma_{im}\sum_{j=1}^{N} X_{ijm} = \gamma_{im}\sum_{j=1}^{N} \alpha_{jm}\lambda_{ijm}w_j L_j$$

where L_j is the total amount of labor in country j.

2.5 Equilibrium

The two equilibrium conditions are the market-clearing condition and the gravity equation

$$w_i L_{im} = \gamma_{im}\sum_{j=1}^{N} \alpha_{jm}\lambda_{ijm}w_j L_j \qquad X_{ijm} = \frac{a_{ijm}\chi_{im}\left[\tau_{ijm}c_{im}\right]^{1-\sigma_m}}{\sum_{l=1}^{N} a_{ljm}\chi_{lm}\left[\tau_{ljm}c_{lm}\right]^{1-\sigma_m}}\alpha_{jm}X_j$$

where we substitute in $X_{jm} = \alpha_{jm}X_j$ and X_j is total expenditures by j.

2.6 Solving the Model in Changes

We now show how to compute the effect of a change in a carbon price, captured by a change in the price of energy, by solving the model in changes. Let hats denote relative changes in variables: $\hat{x} = x'/x$ where primes denote some counterfactual, and unprimed variables are the factual outcome. With some algebra, we can express both of our equilibrium conditions

in terms of hat variables and data. First, the market-clearing condition can be expressed as:

$$\hat{w}_i \hat{L}_{im} = \gamma_{im} \sum_{j=1}^{N} \frac{X_{ijm}}{w_i L_{im}} \hat{X}_{ijm} \equiv \gamma_{im} \sum_{j=1}^{N} \gamma_{ijm} \hat{X}_{ijm}.$$

Note that $\hat{X}_{ijs} = \hat{\lambda}_{ijs} \hat{w}_j$ since α_{js} and L_j are constant, and we can also put trade shares into hat terms:

$$\hat{\lambda}_{ijm} = \frac{\hat{\chi}_{im} \hat{c}_{im}^{1-\sigma_m} \hat{\tau}_{ijm}^{1-\sigma_m}}{\sum_{l=1}^{N} \lambda_{ljm} \hat{\chi}_{lm} \hat{c}_{lm}^{1-\sigma_m} \hat{\tau}_{ljm}^{1-\sigma_m}}.$$

This then allows us to express both equilibrium conditions in changes:

$$\hat{Y}_{im} = \sum_{j=1}^{N} \gamma_{ijm} \hat{X}_{ijm} \quad \text{and} \quad \hat{X}_{ijm} = \frac{\hat{\chi}_{im} \hat{c}_{im}^{1-\sigma_m} \hat{\tau}_{ijm}^{1-\sigma_m}}{\sum_{l=1}^{N} \lambda_{ljm} \hat{\chi}_{lm} \hat{c}_{lm}^{1-\sigma_m} \hat{\tau}_{ljm}^{1-\sigma_m}} \hat{X}_{jm}$$

where $\hat{Y}_{im} \equiv \hat{w}_i \hat{L}_{im}$ is the change in income.

To allow for unbalanced trade, we follow Dekle, Eaton and Kortum (2007), and define expenditure as $X_j = Y_j + D_j$, where D_j denotes the current account deficit. We assume the policy does not change the deficit, $D_j = D_j^{'}$. Using the properties of Cobb-Douglas preferences, we can express changes in expenditures in terms of changes in income and observed income and deficits: $\hat{X}_{js} \equiv \frac{X'_{js}}{X_{js}} = \frac{\alpha_{js} X'_j}{\alpha_{js} X_j} = \frac{X'_j}{X_j} = \frac{\hat{Y}_j Y_j + D_j}{Y_j + D_j}$. Combining this with our two equilibrium conditions in changes yields:

$$\hat{Y}_{is} = \sum_{j=1}^{N} \gamma_{ijs} \frac{\hat{\chi}_{is} \hat{c}_{is}^{1-\sigma_s} \hat{\tau}_{ijs}^{1-\sigma_s}}{\sum_{l=1}^{N} \lambda_{ljs} \hat{\chi}_{ls} \hat{c}_{ls}^{1-\sigma_s} \hat{\tau}_{ljs}^{1-\sigma_s}} \left[\frac{\hat{Y}_j Y_j + D_j}{Y_j + D_j} \right]$$

To obtain change in aggregate output and wages, denote the country-sector sales share by $\Gamma_{is} \equiv \frac{Y_{is}}{Y_i}$, such that

$$\hat{w}_i = \hat{Y}_i = \frac{Y'_i}{Y_i} = \frac{\sum_s Y'_{is}}{\sum_s Y_{is}} = \frac{\sum_s \hat{Y}_{is} Y_{is}}{\sum_s Y_{is}} = \sum_s \Gamma_{is} \hat{Y}_{is}$$

Such that the change in country-sector employment as $\hat{L}_{is} = \hat{Y}_{is} / \hat{w}_i$. The change in the final sectoral good price index is

$$\hat{P}_{js} = \left[\sum_j \lambda_{ljs} \hat{\chi}_{ls} \tau_{ljs}^{1-\sigma_m} \hat{c}_{ls}^{1-\sigma_m} \right]^{\frac{1}{1-\sigma_m}}$$

Denote the change in the carbon price as $\hat{\delta}_{is}$ and E_{is} is energy measured in units of its carbon content. Then, using the expression for Cobb-Douglas relative demand for energy versus labor, we can obtain the change in carbon/energy as a function of the change in the

energy price and the endogenous change in wages:

$$\hat{E}_{is} = \frac{\hat{w}_i \hat{L}_{is}}{\hat{\delta}_{is}} = \frac{\sum_{j=1}^{N} \gamma_{ijm} \hat{X}_{ijm}}{\hat{\delta}_{is}}.$$

3 Data

We use a global multiregion input-output (MRIO) database with GHG emissions intensities contained in Exiobase3, based on 2022 Comtrade bilateral trade data (Stadler et al., 2018). An advantage of Exiobase3 over other environmentally extended MRIO datasets such as GTAP-E and WIOD is having a finer resolution of 200 sectors enabling analysis of specific CITE sectors considered in current U.S. climate and trade proposals. Sector specific trade elasticities come from Ossa (2015).

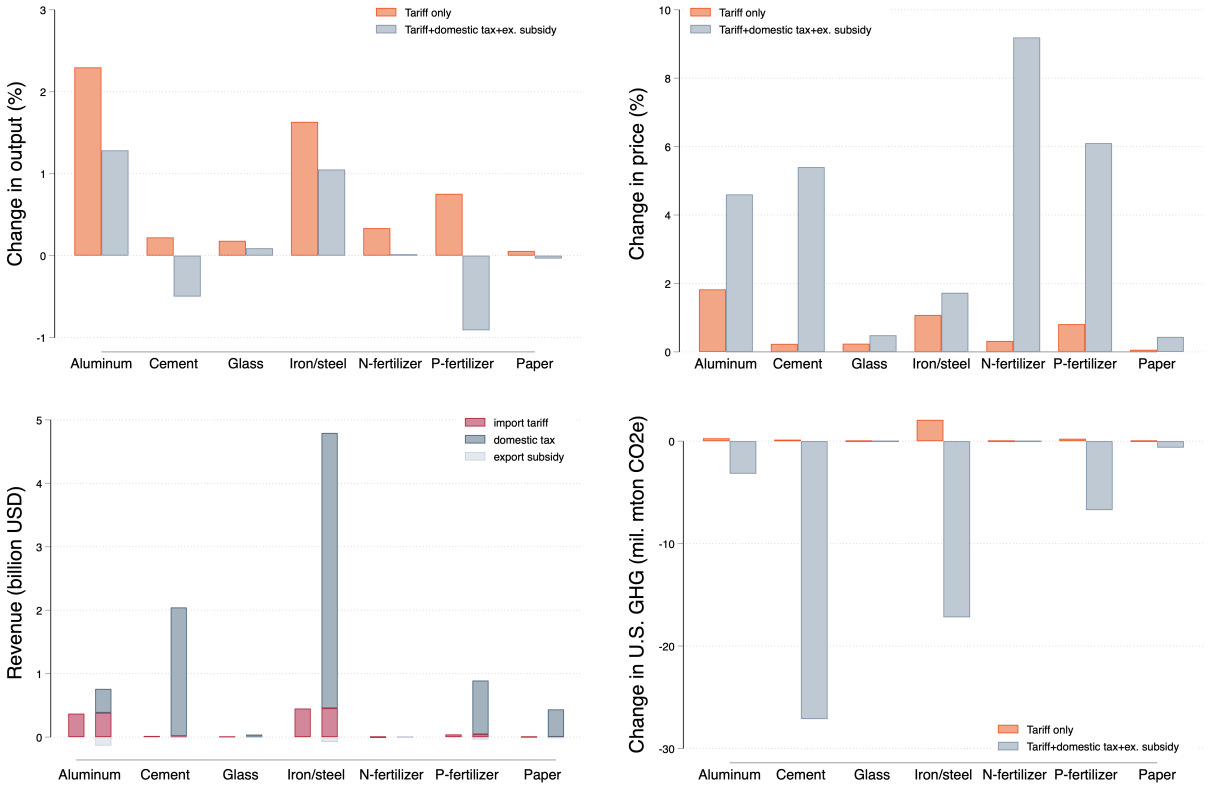
Per quantity GHG intensities are considered in all current U.S. climate and trade proposals. Where possible, we replace GHG intensity measures in Exiobase3, measured in CO_2e per output value with per quantity GHG intensity from other sources. For iron and steel and aluminum, we use country GHG intensities from Hasanbeigi (2022) and Hasanbeigi, Springer and Shi (2022). For cement and fertilizer, we use data from Vidovic D. and J. (2023). For all other sectors, we convert Exiobase3 per value GHG intensities to per quantity intensities using 2022 unit trade values from UN Comtrade. Figure A.1 plots country-specific GHG intensities (left column) as well as how those GHG intensities correlate the U.S. imports from each country as a share of U.S. consumption in each sector.

4 Results

4.1 Unilateral U.S. policies

We analyze two unilateral U.S. carbon tariff policies, one with and one without a complementary domestic carbon tax and export subsidy. Both policies affect products in the aluminum, cement, glass, iron and steel, N-fertilizer, P-fertilizer, and paper sectors, referred henceforth as carbon intensive trade exposed (CITE) sectors. Both policies imposes import tariffs if the average GHG intensity of a country of origin is greater than the the average U.S. GHG intensity, with the tariff constructed by multiplying the difference in GHG intensity between the exporter and the U.S. with \$55 per ton CO_2e. The policy that also includes a domestic carbon tax and export subsidy have those components similarly valued at \$55 per ton CO_2e. It thus adheres closest to the Clean Competition Act currently under consideration by the U.S. Senate.

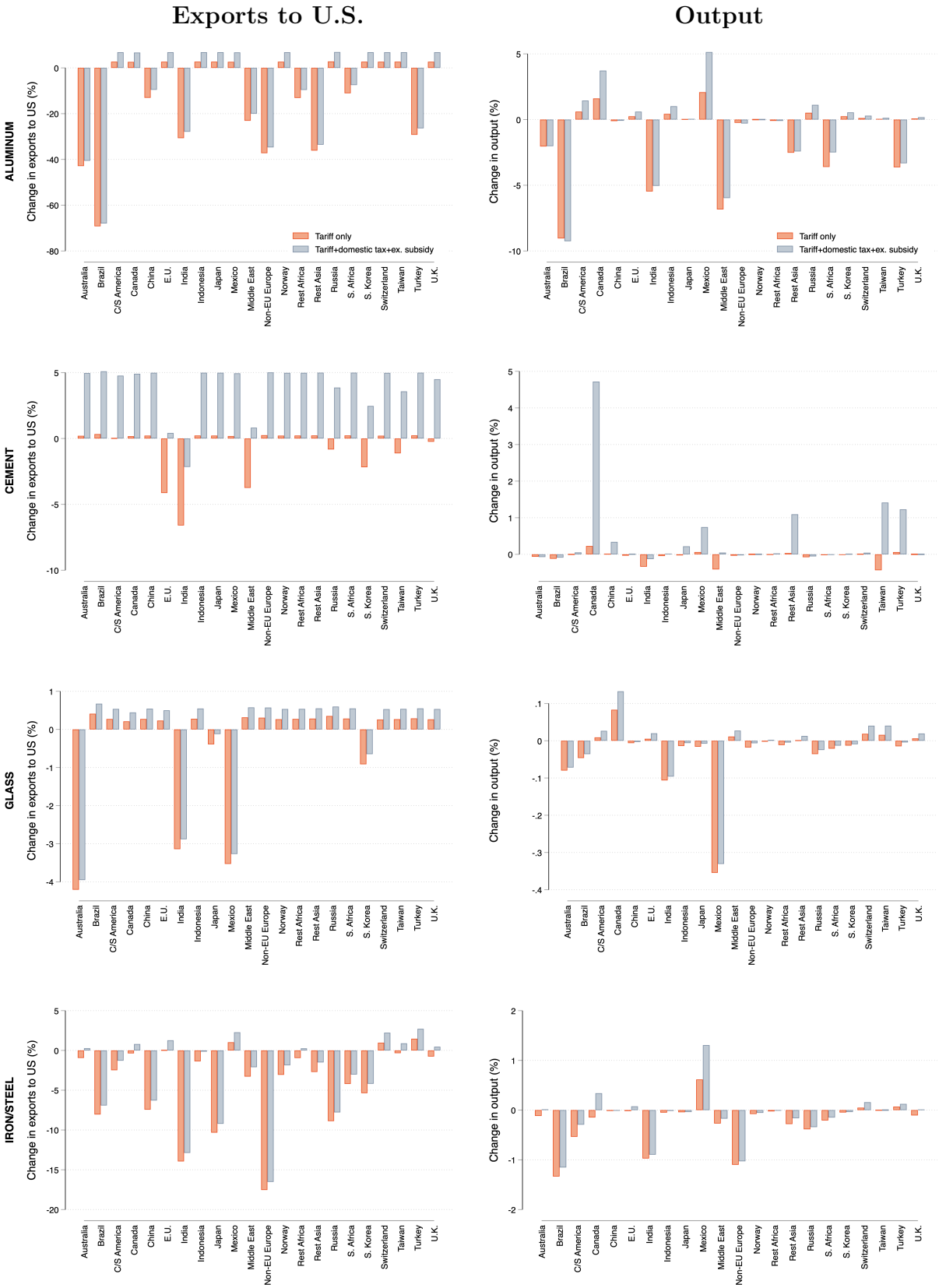
Figure 1: U.S. impacts of U.S. carbon tariffs with and without domestic policy

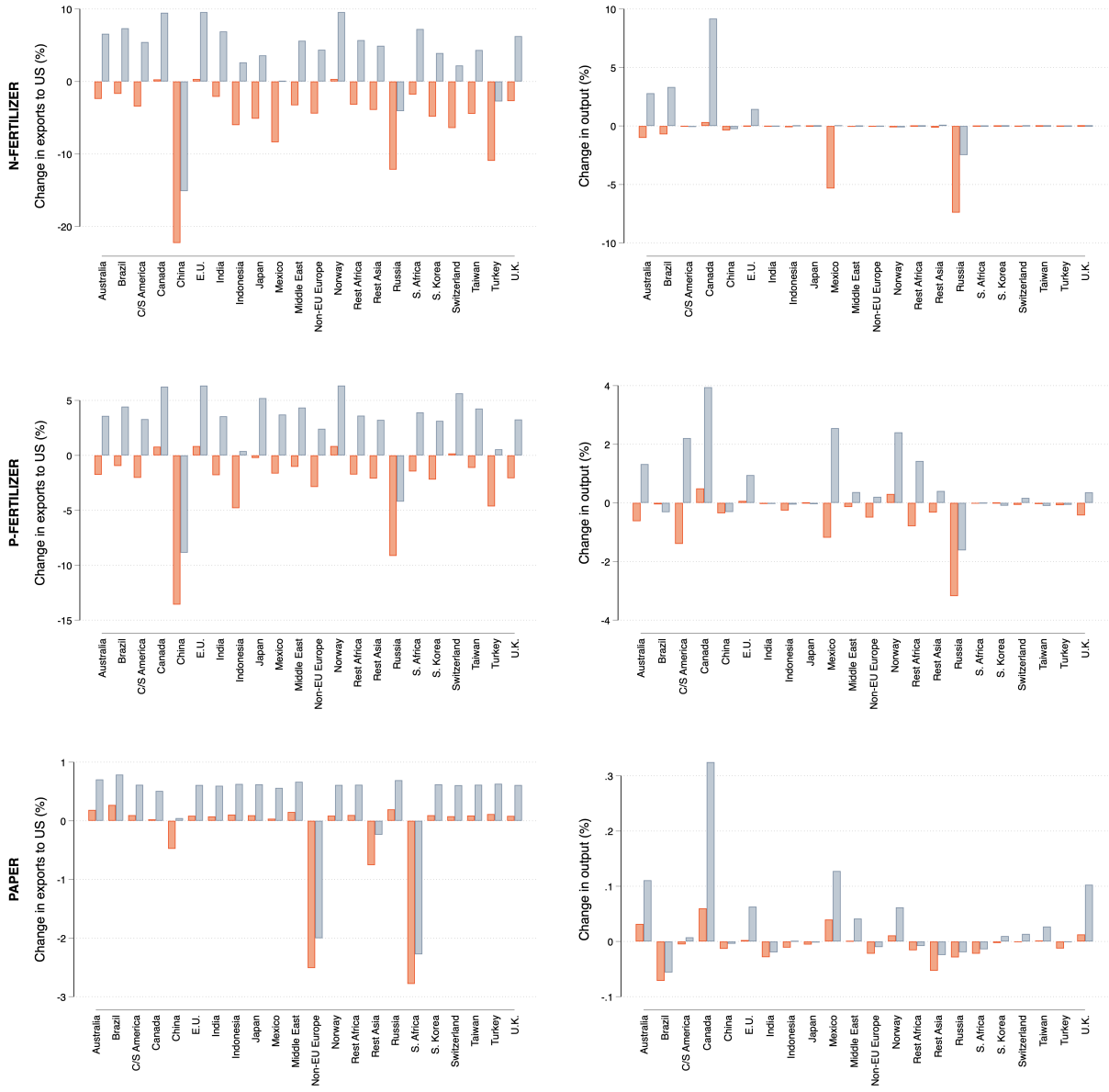


Notes: Change in U.S. output value (%), output price (%), government revenue (billion USD), and GHG emissions (million mtons CO_2e) between a combined import tariff, domestic tax, and export subsidy policy and a carbon import tariff-only policy.

Figure 1 and Table 1 shows the impact of the two unilateral U.S. policies on output value, output price, government revenue, and GHG emissions for each sector. A carbon tariff on its own increases U.S. output in targeted sectors, but the combined policy also increases output in some sectors, notably in aluminum, iron and steel, glass, and N-fertilizers. This is because the additional cost introduced by the domestic carbon tax is more than offset by the added domestic demand from the carbon import tariff, allowing output to increase in those sectors. Output prices increase in all sectors and are higher under the combined policy. Total government revenues are notably higher in the combined policy than the tariff-only policy, with substantially more revenue coming from the domestic fee than the import tariff, consistent with the high domestic share of consumption for these sectors. In general, the total government revenue from the combined policy is about ten times that of the tariff-only policy.

Figure 2: Trading partner impacts of U.S. carbon tariffs with and without domestic policy





Notes: Country-specific changes in exports to U.S. (%, left column) and output value (%, right column) across CITE sectors (rows) between a combined import tariff, domestic tax, and export subsidy policy and a carbon import tariff-only policy.

A tariff-only policy primarily increases U.S. GHG emissions while a combined policy can result in sizeable U.S. GHG reductions. This is because a carbon tariff serves as an output subsidy on U.S. producers, allowing more U.S. production (and emissions) in lieu of foreign production (and emissions) without inducing substantial decreases in GHG intensities from foreign producers, as shown in Figure 2. Indeed, all GHG abatement in the tariff-only policy comes from U.S. trade partners, which together with increased U.S. emissions results in limited global GHG abatement. By contrast, a combined policy induces lower U.S. GHG

intensities and thus substantial U.S. emissions reductions, resulting in five times the global GHG abatement than a tariff only policy. This is summarized in Table 1.

Table 1: U.S. economic and climate impacts of unilateral U.S. climate and trade policies

	U.S. economic impacts					Climate impacts		
Sectors	Output change	Price change	Dom. tax revenue	Tariff revenue	Ex. sub. revenue	U.S. GHG	Other GHG	Global GHG
	%		(bil. USD)			(mil. tons CO2e)		
Policy: import tariff + domestic tax + export subsidy								
Aluminum	1.28	4.60	0.38	0.38	−0.13	−3.18	−8.87	−12.04
Glass	0.09	0.49	0.03	0.01	−00	−0.02	−0.01	−0.03
Cement	−0.5	5.4	2.03	0.02	−0.01	−27.13	0.51	−26.62
Iron/steel	1.05	1.73	4.34	0.46	−0.08	−17.19	−4.27	−21.46
N-fertilizer	0.02	9.19	−00	−00	−00	−0.03	−00	−0.03
P-fertilizer	−0.91	6.10	0.85	0.04	−0.04	−6.73	0.06	−6.67
Paper	−0.04	0.44	0.43	−00	−0.02	−0.63	−00	−0.63
		Total:	8.05	0.92	−0.28	−54.91	−12.57	−67.48
Policy: import tariff only								
Aluminum	2.3	1.83	0	0.37	0	0.28	−10.04	−9.77
Glass	0.18	0.24	0	0.01	0	−00	−0.01	−0.01
Cement	0.22	0.23	0	0.02	0	0.15	−0.33	−0.18
Iron/steel	1.63	1.08	0	0.45	0	2.08	−5.29	−3.2
N-fertilizer	0.34	0.32	0	−00	0	−00	−00	−00
P-fertilizer	0.75	0.81	0	0.04	0	0.23	−0.18	0.06
Paper	0.06	0.06	0	−00	0	−00	−00	−00
		Total:	0	0.89	0	2.75	−15.84	−13.1

Notes: Impacts of a combined import tariff, domestic tax, and export subsidy policy and a carbon import tariff-only policy on change in U.S. output value (%), U.S. output price (%), domestic tax U.S. government revenue (in billion USD), import tariff U.S. government revenue (in billion USD), export subsidy U.S. government expenditure (in billion USD), U.S. GHG emissions (in million tons CO_2e), non-U.S. GHG emissions (in million tons CO_2e), and global GHG emissions (in million tons CO_2e). Results shown for each CITE sector and summed across CITE sectors where appropriate.

4.2 Multilateral policies

We consider several climate club memberships. Countries within a climate club must adopt an equally-price domestic carbon tax and remove any carbon import tariffs or export subsi-

dies on goods traded amongst club members. Club members, however, jointly impose carbon import tariffs and export subsidies on trade with non-club members.

Table 2 shows the GHG emission consequences of different climate club membership configurations. Climate clubs built on combined trade and domestic climate policies can achieve substantial global GHG abatement, which increase with the number of club members. For comparison, a climate club on just these seven CITE sectors consisting of the U.S., the rest of OECD, India and Brazil achieves global GHG abatement of a similar magnitude to the entirety of Mexico's annual GHG emissions.

By contrast, a climate club built on just carbon tariffs, achieves substantially lower global GHG abatement. This abatement rises with the number of club members initially but then falls as more countries join the club. This is because a carbon tariff-only policy largely shifts emissions from club to non-club members. As the number of club members rise, there are fewer non-club members to push GHG abatement onto, leading to falling global GHG abatement. In the limit where every country is in a carbon tariff-only club, global GHG abatement is zero with the world back to where it is today: no carbon tariffs and no domestic policy.

Table 2: Climate impacts of multilateral climate and trade policies

	U.S.	Other club	Non-club	Global
	(mil. tons CO2e)			
Policy: import tariff + domestic tax + export subsidy				
U.S. only	−54.91	0	−12.57	−67.48
U.S. + E.U.	−54.78	−314.48	−28.69	−397.95
U.S. + OECD	−54.04	−555.77	−58.07	−667.89
U.S. + OECD + India + Brazil	−54.1	−692.25	−31.51	−777.87
Policy: import tariff only				
U.S. only	2.75	0	−15.84	−13.1
U.S. + E.U.	2.55	6.37	−33.19	−24.26
U.S. + OECD	2.22	14.59	−61.27	−44.46
U.S. + OECD + India + Brazil	1.58	22.41	−33.28	−9.29

Notes: Impacts of a combined import tariff, domestic tax, and export subsidy policy and a carbon import tariff-only policy on change in U.S. GHG emissions, other club member emissions, non-club emissions, and global emissions (all in million tons CO_2e).

5 Conclusion

To come...

References

Dekle, Robert, Jonathan Eaton, and Samuel Kortum. 2007. "Unbalanced trade." *American Economic Review*, 97(2): 351–355.

Hasanbeigi, A. 2022. "Steel Climate Impact–An International Benchmarking of Energy and CO2 Intensities, Global Efficiency Intelligence, Florida, United States."

Hasanbeigi, Ali, Cecilia Springer, and Dinah Shi. 2022. "Aluminum Climate Impact. An International Benchmarking of Energy and CO2 Intensities."

Hollingsworth, Alex, Taylor Jaworski, Carl Kitchens, and Ivan J Rudik. 2022. "Economic geography and the efficiency of environmental regulation." National Bureau of Economic Research.

Nordhaus, William. 2015. "Climate clubs: Overcoming free-riding in international climate policy." *American Economic Review*, 105(4): 1339–1370.

Ossa, Ralph. 2015. "Why trade matters after all." *Journal of International Economics*, 97(2): 266–277.

Shapiro, Joseph S. 2016. "Trade costs, CO2, and the environment." *American Economic Journal: Economic Policy*, 8(4): 220–254.

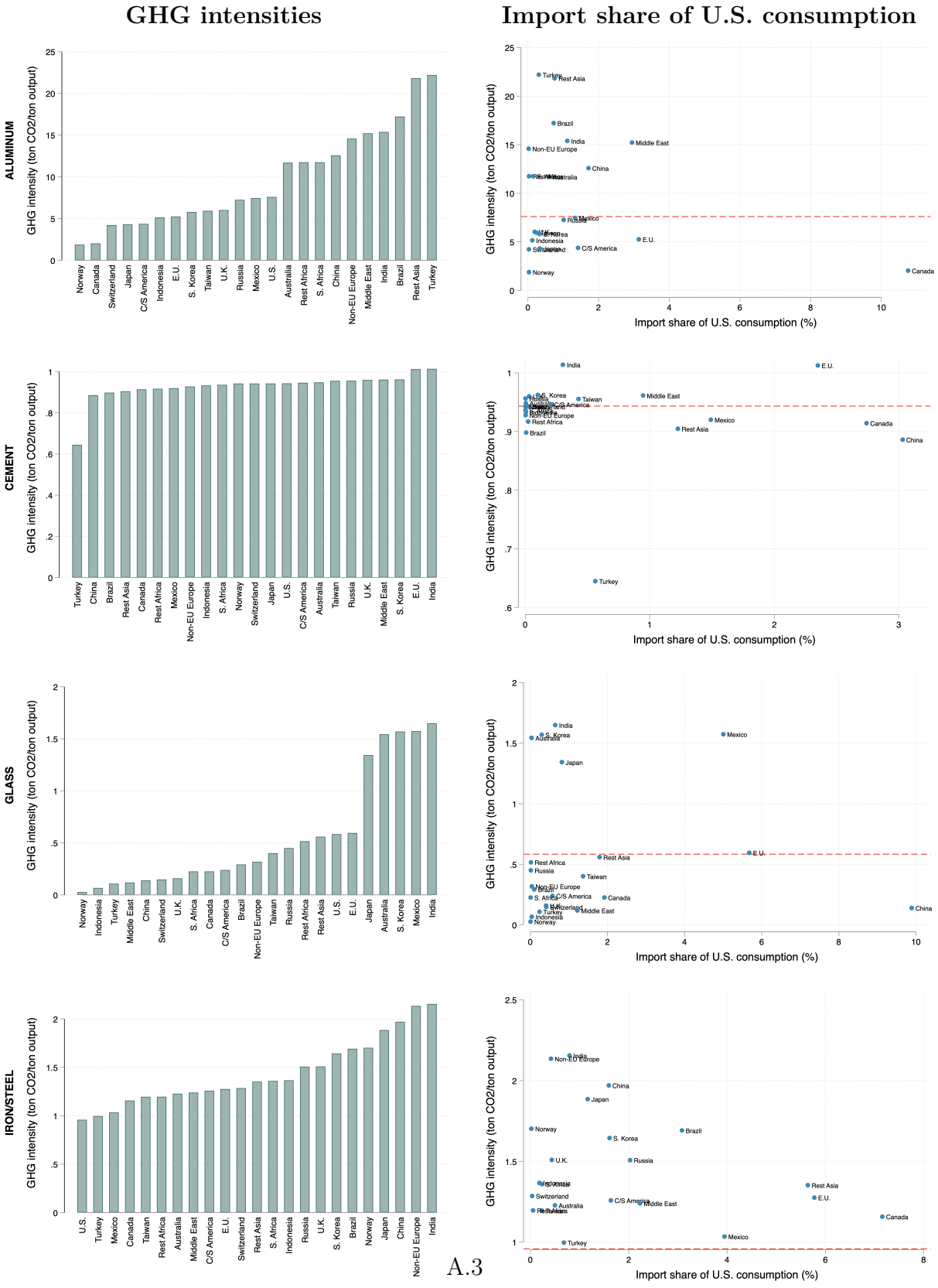
Shapiro, Joseph S, and Reed Walker. 2018. "Why is pollution from US manufacturing declining? The roles of environmental regulation, productivity, and trade." *American Economic Review*, 108(12): 3814–3854.

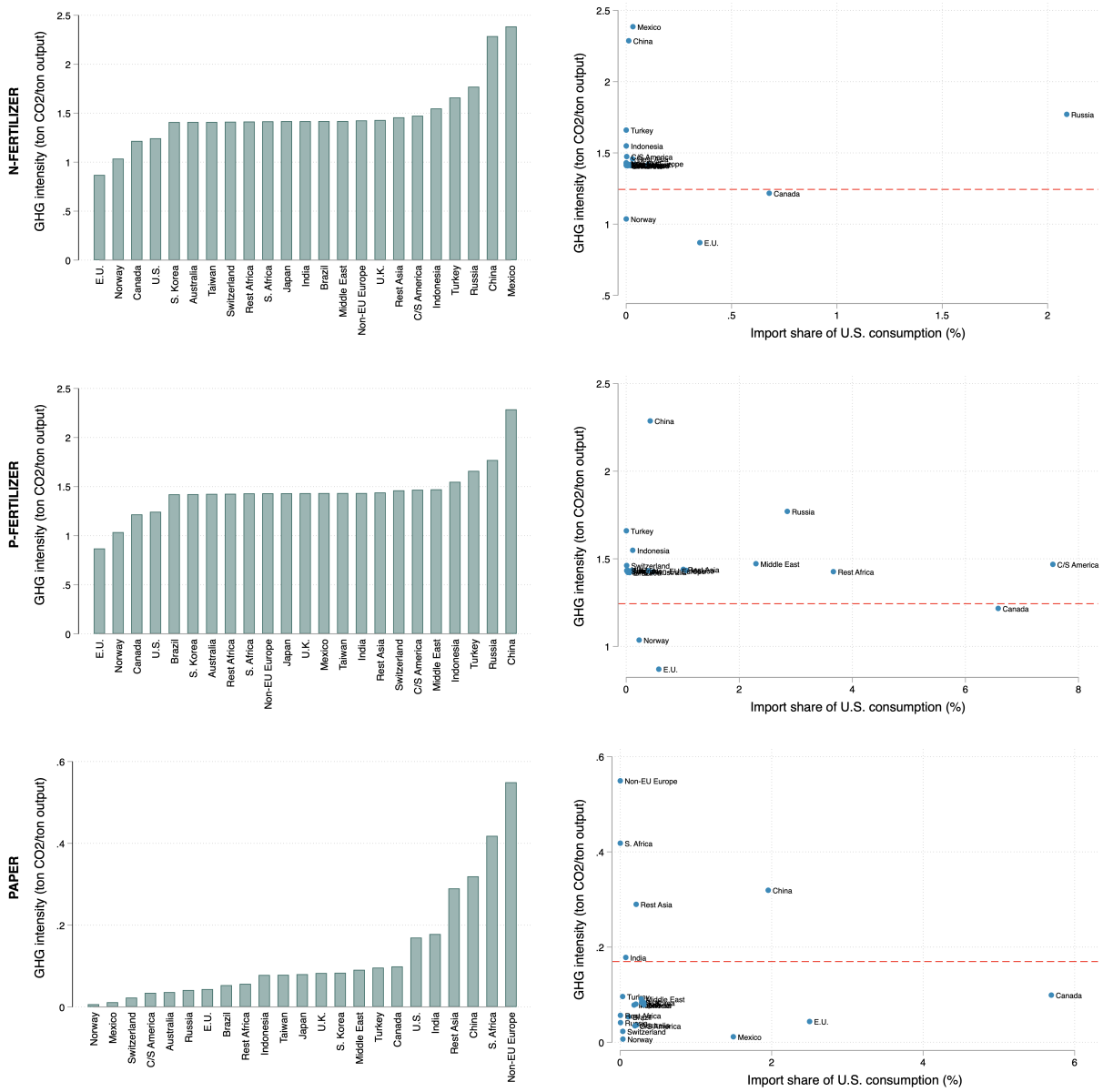
Stadler, Konstantin, Richard Wood, Tatyana Bulavskaya, Carl-Johan SÃ¶dersten, Moana Simas, Sarah Schmidt, Arkaitz Usubiaga, JosÃ© Acosta-FernÃ¡ndez, Jeroen Kuenen, Martin Bruckner, Stefan Giljum, Stephan Lutter, Stefano Merciai, Jannick H. Schmidt, Michaela C. Theurl, Christoph Plutzar, Thomas Kastner, Nina Eisenmenger, Karl-Heinz Erb, Arjan de Koning, and Arnold Tukker. 2018. "EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables." *Journal of Industrial Ecology*, 22(3): 502–515.

Vidovic D., Marmier A., Zore L., and Moya J. 2023. "Greenhouse gas emission intensities of the steel, fertilisers, aluminium and cement industries in the EU and its main trading partners." , (KJ-NA-31-653-EN-N (online)).

A Appendix Figures

Figure A.1: GHG intensities and Import share of U.S. consumption by country





Notes: Country-specific GHG intensities (CO_2e per ton, left column) and import share of U.S. consumption (%, right column) across CITE sectors (rows).