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Short-term Economic Effect of EU-CBAM on Japanese Industries

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Short-term Economic Effect of EU-CBAM on Japanese Industries*

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Abstract

This paper utilizes the 2015 Japanese Domestic Input-Output table and empirically analyzes the short-term impact of the EU-CBAM on the Japanese industry. We compare four scenarios reflecting the Japanese response to the implementation of EU-CBAM. The results show that the impact of the implementation of a "new" carbon price within Japan is smaller when the targeted industries are restricted to items regulated under CBAM, namely cement, iron and steel and fertilizers. Furthermore, if effective carbon rate is used to calculate the industry specific carbon price needed to match the EU-ETS permit price, then the impact of the regulated industries is mitigated. This suggests that tax reforms, switching energy taxes to carbon taxes, are needed to mitigate the short-term impact of carbon pricing policies. This will enable Japanese exporting industries to comply with EU-CBAM regulations by reporting their explicit carbon prices.

Keywords: carbon pricing, carbon border adjustment measure, input-output analysis, effective carbon rates, carbon leakage

JEL classification: Q54, Q56, Q58, Q48

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1. Introduction

As the international community moves towards carbon neutrality, carbon pricing has been considered the key instrument to provide economic incentives to reduce emissions. By implementing carbon pricing, emitters of carbon have the choice of either reducing emissions and avoid payments for the emissions or continue to emit carbon and pay for the emissions.

However, the price of emitting carbon differs between countries/regions due to stringency of climate policies implemented in each country/region. The asymmetrical climate policy has spurred concerns towards competitiveness and carbon leakage issues, especially when strengthening domestic climate policies. As a countermeasure, cost containment measures such as tax deductions, free allocation of emission permits, and exclusion from regulation have been provided to energy intensive trade exposed (EITE) industries. Cost containment measures can level the playing field, but also reduces the effectiveness of carbon pricing.

Border tax adjustment has also been considered, since the implementation of the European Union's Emission Trading Scheme (EU-ETS). Unlike cost containment measures, border adjustment measures do not lower the effectiveness of carbon pricing while leveling the playing field by raising the price of imported goods from regions with low or no carbon price.

In 2022, EU announced that they will implement carbon border adjustment mechanism (CBAM) starting with the transition phase in 2023 and moving to full-scale in 2026. The regulated products are cement, iron and steel, aluminum, fertilizers, electricity and hydrogen. The aim of the implementation is to encourage trade partners to implement compatible carbon pricing instruments.

The EU-CBAM has issues such as WTO compatibility and is widely opposed by developing countries because they may come at the cost of economic growth in these regions. Developed countries are also skeptical about the effectiveness of the CBAM. However, countries need to come up with strategies to cope with the changing trade environment, while addressing climate change.

In the analysis, we will assume that the Japanese governments' strategy is to implement a carbon tax, which is an explicit carbon price, to adjust the carbon price to the same level as the EU-ETS emission permit price. By taking this strategy, Japanese industries will not be "punished" and the EU borders for not bearing the cost of emissions.

The paper is organized as follows. The next section will review the literature. In section 3, the model and data used in the analysis is discussed, followed by the results in section 4. The final section concludes the paper.

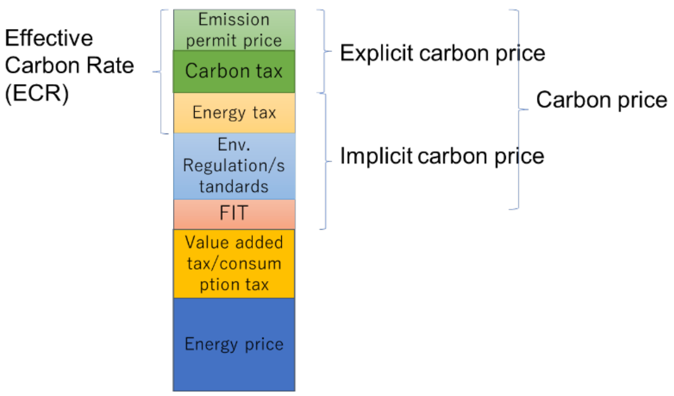
2. Literature review

2.1 Definition of Carbon price

Before reviewing the literature, which analyze the effects of border adjustment measures, we will start with the definition of carbon pricing.

The World Bank (2022) defines carbon pricing as "a price is placed on greenhouse gas emissions, which creates a financial incentive to reduce those emissions or enhance removals." The further, they categorize carbon pricing into "direct" and "indirect" carbon pricing. Direct carbon pricing refers to policy instruments that place a per unit price on greenhouse gas emissions, such as a carbon tax and emission trading schemes. Indirect carbon pricing refers to policy instruments that change the price of products in ways that are not proportional to their emissions, such as energy and commodity taxes.

Figure 1. Definition of Carbon price



Source: OECD (2013).

OECD (2013) defines carbon pricing more broadly than World Bank (2022) by including environmental regulation and standards because these raise the cost of producing goods through compliance costs. OECD (2013) differs in that direct carbon price is termed as explicit carbon price and indirect carbon price as implicit carbon price. The former refers to costs that are based on per emission basis, whereas the latter refers to other costs that are not levied on per emission basis. Thus, we could include levies on renewable energy because these levies fulfill the definition of implicit carbon price.

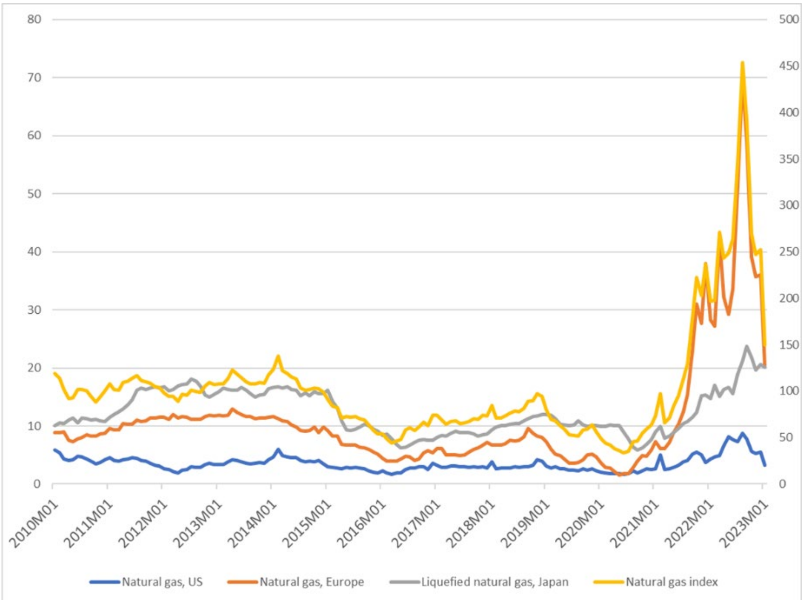
OECD (2016) follows in the line of OECD (2013), but propose the concept of effective carbon rate (ECR)[2], which is composed of emission permit price, carbon tax and energy tax.

[2] ECR is used to compare the stringency of climate policies that place a price on carbon emissions. Thus, OECD (2016) does realize that other implicit carbon prices exist, but are

ECR is an expansion of explicit carbon price, but does not take into account other implicit carbon prices.

Figure 1 provides an image of the definition of carbon pricing discussed above. It is possible to expand the definition of carbon pricing to include value added taxes and the energy price (fuel price), because countries have different value added tax rates and face different prices for the same fuel. For example, Figure 2 depicts the price of natural gas for the US, Europe and Japan. There is clearly a price difference between US natural gas prices and Japanese liquid natural gas prices. If we divide the price with the emission of CO_2, then we obtain a carbon price that is in line with implicit carbon price. However, if the definition is expanded to include value added tax and fuel prices, then the process of calculating the "accurate" carbon price will be difficult, although comparable between countries.

Figure 2. Natural gas prices (Units: USD/mmbtu)



Source: World Bank (https://www.worldbank.org/en/research/commodity-markets)

2.2 Effect of Border adjustment measures

Various approaches have been taken to predict the effect of carbon policies on the economy. For example, partial equilibrium models, gravity models, and computational general

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unable to incorporate the value of environmental regulations and standards and FITs. Caution will be needed when comparing ECR across countries, because direct and indirect energy subsidies are not accounted for, when calculating ECR's. Thus, ECR fall short in providing the "larger picture" due to technical issues, which exists in the calculation process.

equilibrium models have been used to predict mid to long term effects, whereas input-output analysis has been used to estimate the short-term impact of carbon policies.

Monjon and Quirion (2011) use a partial equilibrium model focusing on cement, iron, aluminum and electricity sector, and compare border adjustment measures with output-based allocation. They find that border adjustment measures are more effective in addressing carbon leakage than output-based allocation.

Similarly, Fisher and Fox (2012) use a partial equilibrium model to investigate the effectiveness of four different types of countermeasures for carbon leakage including border adjustments. They find that the four countermeasures can address competitiveness issues, but do not reduce the global emissions, implying that border adjustments may not stimulate emission reductions.

Kuik and Hofkes (2010) use a multi-regional CGE model to simulate the effects of boarder adjustment measures and found that the sectoral leakage from the iron and steel sectors were reduced, but the overall leakage was modest.

Böhringer et al. (2012) reports that border adjustment measures are effective in reducing leakage and the impacts on EITE industries are mitigated. However, they also report that the cost savings is relatively small.

Burniaux et al. (2013) utilizes a global recursive dynamic CGE model and find that the economic effects were small and slightly negative at the global level. They also find that border taxes do not curb the output losses for domestic EITE industries.

UNCTAD (2021) also uses a multi-regional CGE model and find that the CBAM reduces carbon leakages and trade patterns changes in favor of carbon efficient countries. This suggests that the EU-CBAM could strike harder on developing countries than their developed country counterparts.

Mörsdorf (2022) uses a multi-regional CGE model to assesses the EU-CBAM proposal, which does not cover indirect emissions, along with other possible types of border adjustments. They find that the carbon leakage is reduced to a similar degree as free allocation of permits to regulated industries. However, by switching from free allocation to CBAB, tax revenues will be created to finance low-carbon technology, which would reduce carbon emissions. They also find that by including indirect emissions and granting export rebate, the effective of CBAM will increase.

Ramadhani and Koo (2022) also use a multi-regional CGE model and focus on the effects of CBAM on Indonesia. They find that the trade will decrease between the EU and Indonesia due to the border adjustment, while global emissions are unaffected. They also find that domestic carbon pricing within Indonesia helps mitigate the adverse economic and trade distortion effects. Based on their findings, they argue that higher carbon border taxes are needed to encourage non-regulated countries to adopt carbon policies that reduce carbon emissions.

Takeda and Arimura (2023) use a multi-region CGE model to assess the impact of EU-CBAM on the Japanese economy. They find that the effect of the EU-CBAM is slightly positive for Japan as a whole, but will lower output and exports for EITE industries. They conclude that the reduction in output and exports are limited because the trade volume between Japan and the EU is limited (10.4% of total exports from Japan).

Sakai and Barrett (2016) use a multi-reginal input-output model and analyze the impact of a border tax on embodied emissions of goods. They find that the tax reduces the embodied emission from imported goods, if the tax rate is high enough. This finding contradicts with earlier finding that found small changes in emissions due to the implementation of a border adjustment tax.

Magacho et al. (2023) uses multi-regional input-output data to investigate the potential impacts of CBAM on developing countries. They find that the implementation of CBAM will lower the production of regulated products, in turn reducing jobs and damaging the economy of developing countries.

Border adjustment measures regulates specific goods and services, such as cement and fertilizer, rather than entire industries. Multi-regional models are used because they can handle international trade in detail. However, these multi-regional models are limited to 30 to 50 industries, which are highly aggregated. On the other hand, single-region model provides a detailed industrial data with over 200 industries, by reducing the details international trade.

Sugino et al. (2013) use the Japanese single region input-output table, and analyze the effect of cost containment measures when introducing a carbon tax. They find that providing tax cuts or allocating free emission permits reduces the burden on EITE industries, which prevents the trade conditions from deteriorating due to climate policies.

Acar et al. (2022) uses a similar approach to Sugino et al. (2013) by using Turkish data to calculate the embodied emissions for goods exported to the EU. Then, they estimate the cost increase due to the implementation of the EU-CBAM. They find that the cement and electricity industries are the hardest hit due to the new policy. Their analysis further utilizes an applied general equilibrium model to see the effects on trade and the economy.

The abovementioned studies have simulated the effects of carbon pricing policies along with the introduction of border adjustment measures. These studies explicitly use carbon taxes as constraints for emitting greenhouse gases. However, energy taxes and other implicit carbon prices exists. Thus, modeling the “true” difference between carbon prices between countries is essential.

3. The Model and Data

3.1 Model

We utilize the price model based on monetary data to estimate the effects of implementing a carbon tax to equalize the carbon price paid by industries regulated under the EU-CBAM. The price model starts with adding all the components in the intermediary sector and value-added sector for column j,

$$x_j = \sum_{i=1}^{n} x_{ij} + v_j \qquad (1),$$

where x_j is the total output for industry j, x_{ij} is the value of the intermediate product from industry i to industry j, and v_j is the gross value-added for industry j. This equation can be rewritten as,

$$\mathbf{x'}=\mathbf{i'A\hat{x}}+\mathbf{v'} \qquad (2).$$

Post multiplying by $\mathbf{\hat{x}}^{-1}$ and rearranging yields,

$$\mathbf{i'}=\mathbf{i'A}+\mathbf{v'\hat{x}}^{-1} \qquad (3).$$

Equation 3 shows that the price of the good is composed of the unit cost of output and the per output margin (value added). If we denote the base year index prices as $\mathbf{P'}$, the price model becomes,

$$\mathbf{P'}=\mathbf{P'A}+\mathbf{v'\hat{x}}^{-1} \qquad (4),$$

which yields,

$$\mathbf{P'}=\mathbf{v'\hat{x}}^{-1}(\mathbf{I}-\mathbf{A})^{-1} \qquad (5).$$

If we assume that the Japanese government introduces a new carbon tax, the value-added vector, $\mathbf{v'}$, is affected by the increase in indirect taxes, which is included in value-added. Thus, calculating the difference between the price of final goods and base year price for each industry gives yields the effect of the carbon price on each industry, or

$$\Delta\mathbf{P'}=\Delta\mathbf{v'\hat{x}}^{-1}(\mathbf{I}-\mathbf{A})^{-1} \qquad (6),$$

where $\Delta \mathbf{v}\hat{\mathbf{x}}^{-1}$ depicts the change in per unit carbon cost (compliance cost). The unit carbon cost is calculated by diving the total cost increase due to the carbon tax by total output. We will alter the total cost increase for each industry to investigate the impact of each policy scenario.

3.2 Data

We utilize the 2015 domestic input-output table[3] and the Nansai (2019) to simulate the effects of CBAM on the Japanese industry. The domestic input-output table is published every 5 years. The endogenous sector of the original table is composed of 509 rows and 391 columns. The number of rows exceeds the number of columns because the rows are in general more detailed than the columns. For example, the petroleum products industry (column) is decomposed into 9 products (gasoline, aviation fuel, kerosene etc.) produced in the petroleum products industry. Thus, we aggregate rows and columns so that the number of rows and columns corresponds. The final number of rows and columns after aggregation is 388.

There are no statistics, including the domestic input-output table, in Japan that lists the payment of taxes paid by each industry. Thus, we will use the tax rates for ten energy related taxes along with the carbon tax, to estimate the payment of taxes for each industry.

Furthermore, the domestic input-output table does not include emissions of pollutants such as Sulphur oxides and carbon dioxide. We can use Nansai (2019), because it calculates greenhouse gas emissions along with other air pollutants for each industry defined in the input-output table to overcome this shortcoming. This data set not only provides emission of pollutants, but the volume of fuel combusted by each industry. Therefore, we can calculate the total payment of taxes for energy use by using the tax rates for each energy source and the volume listed in Nansai (2019). This method also has one shortcoming related to electricity use.

Nansai (2019) is focused on direct emissions from production activities. Indirect emissions, emissions from producing electricity, is not considered in this approach. When calculating the effective carbon rate for each industry, the amount of electricity consumed or the total emissions associated with the consumption of electricity is a necessity. Thus, calculating the payment of electricity taxes for each industry requires the amount of electricity consumed by each industry. This data is provided in the original 2015 domestic input-output table in the supplementary "Table of values and quantities". This table lists the value and

[3] The data set is from 2015, which is the most up to date Input-Output data available in 2023. Thus, we will assume that the industrial composition and carbon intensity of industries have not changed since 2015.

estimated quantities of goods, including electricity, traded between industries. The values from this table are used to calculate the emission intensity of electricity, which is used to allocate the direct emissions from the power industry to consumer of electricity as indirect emissions.

3.3 Tax system in Japan

Japan like other countries has a complex tax system related to energy/fuel consumption. There are broadly 9 taxes that are implemented in Japan (Table 1). Petroleum and coal tax and the carbon tax[4] are collected upstream, meaning that they are taxed when extracted or imported from abroad. The gasoline tax and local gasoline tax are collected simultaneously when gasoline is transferred from the refinery to whole seller or retailer. Diesel oil delivery tax and Oil gas tax are similar to the gasoline tax, whereas power development promotion tax is levied on power transmission companies. The aviation fuel tax and the renewable energy levy is considered a downstream tax.

Japan introduced a carbon tax in October 2012, and the tax rat[5]e has been increased twice to ¥289/t-CO2 in April 2016. The renewable energy levy was also introduced in 2012 to induce electricity production from solar, wind, geothermal and other renewable sources.

Table 1. Energy related tax system in Japan

Tax	Tax implementation	Tax collector	Taxed entity	Tax usage
1) Gasoline tax (1kL)	Mid-stream	National	Volatile oil	General finances
2) Local gasoline tax (1kL)	Mid-stream	National	Volatile oil	General finances (granted to states, specified cities and municipality)
3) Oil gas tax (1t)	Mid-stream	National	Oil and gasoline for automobiles	General finances (half is granted to states, specified cities and municipality)
4) Aviation fuel tax (1kL)	Downstream	National	Aviation fuel	Aviation maintnance
5) Petroleum and coal tax	Upstream	National	Crude oil, petroleum products, gaseous hydrocarbons, and coal	Stable fuel supply measures
6) Diesel oil delivery tax (1kL)	Mid-stream	State	Diesel oil	General finances
7) Power development promotion tax (1000kWh)	Mid-stream	National	Electricity	Measure for supply location and power usage
8) Renewable energy levy (1000kWh)	Downstream	National	Electricity	Subsidize renewable energy
9) Carbon tax (1t-CO2)	Upstream	National	Crude oil, petroleum products, gaseous hydrocarbons, and coal	Measure to increase energy efficiency

The energy tax rates are fixed, with the exception of renewable energy levy that changes every year, but cost containment measures are included for specified industrial processes. For example, the Petroleum and coal tax provides tax exemptions and refunds for;

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[4] The carbon tax is technically not an independent tax, but rather a tax that is added to the Petroleum coal tax

[5] The tax rate will be set at ¥192/t-CO_2, which was the carbon tax rate in 2015, to be consistent with the Input-Output data set.

a. Imported and domestic volatile oil for petrochemical products production

b. Imported specific coal

c. Specific coal for electric generation in Okinawa

d. Imported and domestic bunker A heavy oil for agriculture, forestry and fishery

e. Domestic oil asphalt

Furthermore,

a. Imported coal used for home generation of electricity for caustic soda production in caustic soda manufacturing industry

b. Heavy oil and light oil used for domestic cargo ships and passenger ships

c. Light oil used for railway

d. Aviation fuel for domestic flight

e. Imported coal used for home generation of electricity for salt production in salt manufacturing industry by the ion exchange membrane method

f. Light oil used for agriculture, forestry and fishery

are given exemption and refunds for the carbon tax. Thus, eligible industries face lower implicit and explicit carbon prices.

3.4 Scenario

We will compare four different scenarios that reflect different responses that can be taken by the Japanese government to equalize the cost of carbon emission between Japanese and EU industries. We will assume that permit price is 80 Euros or 12,000 yen/t-CO2.

The first scenario is where the Japanese government implements a "new" carbon tax without considering the existing carbon tax. Since the existing carbon tax provides tax cuts and rebates for energy intensive industries, this scenario assumes that the new carbon tax will cover the entire economy, while simplifying the tax collection.

The second scenario assumes that the existing carbon price is increased to compatible rates with the EU-ETS permit price using the existing collection method. In this scenario, the tax rates for energy intensive industries are set higher than other industries to make up for tax cuts and rebates provided under present scheme.

The third scenario is where the carbon tax rate is increased taking into account the existing carbon tax and energy taxes imposed on energy use. This scenario is in line with the effective carbon rate (ECR) calculated by OECD (2016). ECR is calculated by adding the payment of 1) carbon tax, 2) emissions permits, and 3) energy taxes for each industry and diving by the total CO2 emissions.

The fourth scenario assumes that the Japanese government implements a carbon tax for industries that would be subject to regulation under the EU-CBAM. Since energy intensive industries are given tax cut and rebates to reduce the burden of energy taxes and carbon tax, this scenario places a specific tax on energy intensive industries.

Table 2 summarizes the four scenarios analyzed in the paper. Scenarios 1 and 2 will generate tax revenues more than 12 trillion yen, or 2.3% of GDP, while scenarios 3 and 4 will generate 6 to 8 trillion yen, or 1.2 to 1.6% of GDP.

Table 2. Comparison of scenarios

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Regulated industries	All 388 industries	All 388 industries	All 388 industries	17 industries
Carbon tax (yen/CO2)	¥12,000	¥12,000-(Carbon Tax)	¥12,000-(ECR)	¥12,000-(Carbon Tax)
Same tax rates	Yes	No	No	No
Tax revenue (1 million yen)	12,641,453	12,007,027	8,617,610	6,742,214

4. Results

4.1 Tax revenues and Effective carbon rates

Before moving on the simulation results, we will verify if the model represents the actual tax revenue. This is important because the effective carbon rate (ECR) calculated will be largely affected by the accuracy of the calculation. If we use inaccurate ECR's than the results will obtained in the analysis will be biased.

Table 3. Actual and Estimated tax revenue and tax rates

	Tax revenue (2015)		Tax rate (2015)	Tax rate (2020)
	Actual	Model		
1) Gasoline tax (1kL)	2,464,555	2,580,350	48,600	48,600
2) Local gasoline tax (1kL)	263,697	276,087	5,200	5,200
3) Oil gas tax (1t)	18,458	18,446	17,500	17,500
4) Aviation fuel tax (1kL)	76,149	85,101	18,000	18,000
5) Petroleum and coal tax	714,861	671,357	-	-
Crude oil and imported petroleum products (1kL)	431,018	397,073	2,040	2,040
Natural gas (1t)	149,236	150,210	1,080	1,080
Other gases (1t)			1,080	1,080
Coal (1t)	134,607	124,074	700	700
6) Diesel oil delivery tax (1kL)	924,579	1,071,415	32,100	32,100
7) Power development promotion tax (1000kWh)	315,711	292,416	375	375
8) Renewable energy levy (1000kWh)	1,232,045*	1,232,045*	1,580	2,980
9) Carbon tax (1t-CO2)	164,500**	247,386	192	289
Total	6,174,555	6,227,216	-	-

Note: Values for tax revenue are in million yen, while tax rates are in yen.

*The figures are estimated by multiplying the tax rate with the volume of consumption.
** Estimated figure by MOEJ.

Table 3 show the results of the total energy tax revenue calculated from the data used in the analysis using 2015 tax rates. The actual tax revenue reported is slightly lower than the tax revenue calculated from the model by approximately 1%. The tax revenue calculated in the model before implementing new carbon pricing policies show that model is relatively accurate.

Based on the tax revenue determined from the model, we next calculate the ECR for all 388 industries defined in the input-output table. Table 4 shows the actual rate of carbon tax and ECR for industries regulated under the EU-CBAM. The carbon tax rate is ¥192/t-CO_2, but the calculated carbon tax for each industry ranges from 4 to 136 yen, excluding electricity. The carbon tax for electricity is higher than the ¥192/t-CO_2, because they pay for carbon tax levied on fossil fuel combustion, but the CO_2 emissions are allocated to other industries as indirect emissions. This results in higher carbon tax payment per emission of CO_2.[6]

Table 4. Carbon tax and Effective carbon rate for selected industries (Units: Yen)

	Carbon Tax	ECR
Chemical fertilizer	99	372
Cement	4	45
Pig iron	79	210
Ferro-alloys	24	194
Crude steel (converters)	18	119
Crude steel (electric furnaces)	14	600
Hot rolled steel	15	199
Steel pipes and tubes	47	304
Cold-finished steel	34	312
Coated steel	26	355
Cast and forged steel	24	399
Cast iron pipes and tubes	38	452
Cast and forged materials (iron)	23	377
Iron and steel shearing and slitting	43	425
Miscellaneous iron or steel products	136	1,021
Aluminum	50	475
Electricity	1,141	3,738

ECR are higher than carbon tax figures because they include the energy related taxes.

[6] We could reallocate the payment of the carbon tax to the consumer of electricity to be consistent with the CO_2 accounting, but this would make the calculation and logic more difficult.

Industries that use large amount of electricity in their production process have higher ECR than other industries because of the tax levied on electricity consumption (i.e. the power development promotion tax). For example, the crude steel that uses electric furnaces pays a ¥14/t-CO_2 carbon tax but pays a total of ¥600/t-CO_2 (ECR), whereas crude steel produced by converters pays a ¥18/t-CO_2 carbon tax and a total of ¥119/t-CO_2 (ECR).

4.2 Simulation results

Table 5 reports the simulation results for the four scenarios. The price increase was predicted to reach approximately 50% for cement and pig iron in all four scenarios. The price increase was estimated around 30% for electricity and crude steel made by converters. The price increase for the aluminum industry was estimated between 3 to 6%, which was modest amongst regulated industries.

Table 5. Comparison of simulations results

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Chemical fertilizer	12.68%	12.32%	10.98%	10.71%
Cement	50.90%	50.51%	48.65%	48.71%
Pig iron	51.09%	50.39%	47.85%	45.20%
Ferro-alloys	21.01%	20.46%	18.66%	18.49%
Crude steel (converters)	34.93%	34.43%	32.56%	30.96%
Crude steel (electric furnaces)	15.72%	15.00%	12.82%	13.46%
Hot rolled steel	24.87%	24.38%	22.64%	21.72%
Steel pipes and tubes	14.94%	14.62%	13.41%	12.87%
Cold-finished steel	15.33%	14.97%	13.63%	13.17%
Coated steel	11.17%	10.85%	9.59%	9.31%
Cast and forged steel	13.34%	12.91%	11.54%	11.61%
Cast iron pipes and tubes	8.95%	8.58%	7.36%	7.32%
Cast and forged materials (iron)	14.61%	14.14%	12.48%	12.26%
Iron and steel shearing and slitting	12.33%	12.06%	10.90%	10.60%
Miscellaneous iron or steel products	16.39%	16.06%	14.53%	14.88%
Aluminum	5.57%	5.31%	3.69%	3.41%
Electricity	33.64%	30.52%	23.01%	29.31%

Although the tax revenue from the carbon tax declines from 12 trillion to 6 trillion, we cannot observe a systematic change in price of goods as the tax revenue declines. In general, however, Scenario 4 predicts the lowest price increase whereas Scenario displays the highest price increase. This is because the scope of the response measure towards the EU-CBAM is narrowed when moving from Scenario 1 to 4.

5. Conclusion

In the previous section we reviewed the simulation results. We found that the cost increase in extremely high for cement and pig iron, but modest for electricity and crude steel made from converters. On the other hand, the price increase for chemical fertilizers and other iron and steel were modest, whereas mediocre for aluminum.

These results are obtained because of the assumption that Japan will need to raise the carbon price for EU-CBAM regulated industries. However, Table 6 tells a different story. Table 6 reports the export and import ratio of each industry. Thirty-four percent of steel pipes and tubes produced in Japan are exported, while pig iron, iron and steel shearing and slitting, and electricity are exported rarely (less than 1%). Bare in mind that these figures are export to the world, rather than EU. Thus, the actual export ratio to the EU would be much smaller than these figures. If the carbon price is implemented for items that would be exported to the EU reflecting the actual value of export, then the price increase will be small or even negligible.

Table 6. Imports and Exports for each industry (Unit: percentage)

	Export	Imports
Chemical fertilizer	2.67%	23.55%
Cement	9.05%	1.31%
Pig iron	0.12%	0.51%
Ferro-alloys	8.99%	46.99%
Crude steel (converters)	0.00%	0.00%
Crude steel (electric furnaces)	20.97%	1.94%
Hot rolled steel	23.40%	3.33%
Steel pipes and tubes	34.83%	3.01%
Cold-finished steel	12.05%	2.68%
Coated steel	23.94%	5.48%
Cast and forged steel	2.76%	0.06%
Cast iron pipes and tubes	14.45%	0.27%
Cast and forged materials (iron)	1.20%	2.28%
Iron and steel shearing and slitting	0.00%	0.00%
Miscellaneous iron or steel products	3.82%	34.64%
Aluminum	2.02%	52.30%
Electricity	0.33%	0.01%

Does this mean that raising the price of carbon emissions is unnecessary? The answer is obviously no. This is because Japan has pledged to reduce emissions by 46% by 2030 and reach carbon neutrality by 2050. These targets are very ambitious considering that Japan has a low rate of explicit carbon price. However, the level of the carbon price and the timing of when the price increase needs to be carefully planned. A high carbon price will increase the price of goods produced in Japan, as shown by the results in the previous section, but a low carbon price will not contribute to emission reduction.

Raising the domestic carbon price can also be justified from the tax revenue perspective. If the Japanese government does not increase the carbon price to EU levels, then the tax revenue will be attributed to the EU, rather than the Japanese government. In other words, the opportunity of gaining the tax revenue will be lost altogether.

Do the results have any insights for policymakers? The results show that as the definition of carbon price widens, the effect of the carbon tax is curbed because the additional tax is lowered. Since the EU-CBAM only recognizes explicit carbon pricing, conducting tax reforms so that the implicit carbon price (energy tax) is transformed into explicit carbon price (carbon tax) could lower the burden of Japanese industries by reducing the carbon tax rate in the short-run.

In addition, the Japanese energy tax system is very complex as shown in section 3. This complexity makes calculation of the 'real' carbon price difficult for each industry, along with making the modeling process more complex, leading to inaccurate simulation results. In the analysis the carbon tax was treated as an explicit carbon price, but is more of an implicit carbon price in practice, because they are collected along with the petroleum and coal tax and the cost increased is passed through to the energy consumers by price increases.

In the analysis we assumed that industries do not get tax deductions for electricity use. However, there are no statistics that confirm or even provide clues. Thus, our assumption could have resulted in a downward bias, in scenario 3, due to lack of statistics.

Finally, the analysis revealed that the prices of goods manufactured by the EITE industries will drastically increase due to the implementation of a carbon tax. However, in the analysis, we did not simulate the usage of the tax revenue. One option is to provide subsidies to reduce the emission intensity of EITE industries. Another option is to provide employment adjustment subsidies for EITE industries in the transition phase. Both options will lower the cost of production, at least in the short-run, which will ease the burden of the new carbon tax. More work will be needed on the usage of the tax revenue to reduce the burden of regulated industries in the future.

In this paper, we assumed that the response of the Japanese government was to raise the carbon tax to EU levels instantly. The EU-CBAM is scheduled to go into effect after 2025, which means that industries have time to reduce the emission intensity by investing in low carbon technology. Other options include offsetting emission by purchasing carbon credits, but it is unclear if that would be deducted from the CBAM regulation. The effects of other options are needed, but will be left for future work.

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